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ABSTRACTS

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A SIMPLE GROWTH MODEL FOR SAGO PALM CV. MOLAT-AMBUTRUN AND ITS IMPLICATIONS FOR CULTIVATION

M. FLACH

Assumptions for cv. Molat-Ambutrun with a seed to seed life of c. 11 years and growing under optimum ecological conditions (adapted from Flach & Schuiling; 1989).

Rosette – stage: 45 months or 3.75 years
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 rosette-stage grown from seeds (months): 45
Stage of trunk formation: 54 months or 4.5 years
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 X p): 720
Approximate number of leaf scars visible on the bole at inflorescence initiation: 54
Total leaves in crown (24) plus leaf scars on bole (54) at inflorescence initiation: 78
Estimated duration of stage of bole formation (months): 54
Start of harvesting: 4.5 - 5 years after start of trunk formation
Stage of inflorescence development: 12 months or 1 year
Number of leaves already present at start of inflorescence initiation: 24
Number of leaves formed per month during inflorescence development: 2
Estimated total number of leaves formed during inflorescence development: 48
Stage of fruit ripening: 12 months or 1 year
Seed to seed life: 133 months or 11 years

The figures given in this table all need to be checked through research. The leaf area should also be measured as well as the longevity of the leaves. For new plantings the duration of the rosette stage is important. Possibly well-sized suckers can be raised in a nursery in polybags, just as is done for oil palm planting. Care can then be provided to plants in the nursery. However, such nurseries will be limited by the heavy weight of suckers in poly bags. Only after field planting is care needed in the field. The stage of starch production is the stage of trunk formation. Fertilizer use in this stage should aim at a high number of healthy leaves. The clumps should have full sunshine and sufficient water. Harvesting does not need to be done strictly at the time of flower initiation. The starch still increases in the first months of flower development, thus harvesting can be spread over quite a period.

DIVERSE UTILIZATION AND INDUSTRIAL DEVELOPMENT OF SAGO BIOMASS

Masanori OKAZAKI[1], Sachie TADENUMA[1] and Masaharu OHMI[2]

Sago palm can fix carbon dioxide gas to its own biomass, such as trunk, leaves, and roots. Especially sago accumulates more than 200 kg starch per palm. Sago starch, most important material for human beings, is useful for noodles, snacks, raw materials for beer and glutamate fermentation. However, sago starch extraction residue becomes the waste after sago starch is extracted from sago pith, although it still has considerable mount of starch.

By esterification in acid condition at 160 ℃ for 2 hours sago biodegradable plastics were synthesized from sago starch extraction residue and palm oil or castor oil. Esterified plastics mixed with triacetin as a plasticizer were pressed under 215 kPa at 140 ℃ for 1 hour to make plant pots with different decomposition rate. Palm oil as an esterification reagent consists of both saturated and unsaturated fatty acids; palmitic acid $CH_3(CH_2)_{14}COOH$ and stearic acid $CH_3(CH_2)_{16}COOH$ which are 50 % of total fatty acids, and oleic acid $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$ and linoleic acid $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7$ COOH which are 50 % of total fatty acids. Meanwhile, castor oil comprises ricinoleic acid $CH_3(CH_2)_5CH(OH)CH_2CH{=}CH(CH_2)_7COOH$, which is unsaturated fatty acid and around 90 % of total fatty acids. The synthesized biodegradable plastics were useful for plant pots, because they had the different decomposition rate in soil.

Both the sago biodegradable plastics made from palm oil (SBP-P) and castor oil (SBP-C) were decomposed, burying in the soil depth of 10 cm in Japan (Umbric Andosols) under the Hinoki cypress forest and in upland field from May to November of 2004, which were comparable to the plastics made from starch and polycaprolactone (Tokai-Kasei Co. Ltd.). After one month, 36 and 57 % of total weight of SBP-P and 78 and 65 % of total weight of SBP-C were decomposed. On the other hand, the starch and polycaprolactone plastics showed the low decomposition percentages of 7 and 9 % even after 5 months. This suggested that sago biodegradable plastics remarkably showed higher decomposition rate than the starch and polycaprolactone plastics.

These were corresponded to the results of cumulated carbon dioxide emission during 36 days in a laboratory at 23 ℃. The cumulated carbon dioxide emission derived from the decomposition of SBP-C was larger than those derived from the decomposition of SBP-P, which were clearly indicated in Umbric Andosols taken from Hinoki cypress forest than those from upland field. The OH group in ricinoleic acid may give one of the terminals of the microbial decomposition in soil.

Finally it is concluded that sago biodegradable plastics made from the starch extraction residue were the effective materials for plant pots with different decomposition rates and that the cost performance should be required for the commercial use.

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A CRUCIAL NEED TO EXPEDITE THE COMMERCIAL DEVELOPMENT OF THE SAGO INDUSTRY

F.S JONG

Sago starch is an all rounder multipurpose starch that can be used as native or modified starch in various industrial applications such as in the food, non-food, hydrolysis and fermentation industries. Despite the annual world starch production and demand of about 50 million tons and a starch market growth of about 7.7% per annum, the trading of sago starch in the domestic and international starch markets is rather stagnant over the past 20 years, crudely estimated at 200,000 tonnes/year.

The subjects discussed in this paper include (a) world starch production and demand (b) world sago starch production and current position of sago starch market (c) competitiveness of the sago palm and sago starch as industrial raw materials (d) some current uses and potential industrial applications of sago starch (e) specification for industrial sago starch and (f) current export prices of refined sago starch. Main issues hindering the expansion of the sago industry highlighted are (a) the reluctance of starch consumers to use sago starch mainly because of its limited and inconsistent supply and (b) the sluggishness in the expansion of sago plantations or starch processing owing to the lack of (i) project financing, (ii) suitable land, (iii) long juvenile phase of about 10 years (v) general knowledge of the crop and (iv) uncertainty in international marketing of sago starch.

Some strategies suggested to expedite the sago industry are (a) financing and/or joint venture of starch consumers and producers to expand the sago production for mutual benefits (b) government to prioritize sago as a national or provincial project and to consider financing, facilitate land or concession acquisition and other required assistances (c) especially for Papua, the vast areas of natural sago forests could be selectively rehabilitated into sustainable sago plantations soonest possible. If 20% (300,000 ha) are rehabilitated, it could mean an annual starch production of about 3 million tons or annual revenue of US$ 600 million and (d) energy, automobile and "CO_2 emitting" companies worldwide to invest into sago palm plantation or to buy the "CO_2 absorption" capability from sago palm plantations.

In view of the anticipated increase of the future petroleum price coupled with the increased awareness of environmental protection, the demand for starch in the production of environmentally friendlier products such as ethanol for fuel additives and lactic acids for biodegradable plastics are expected to grow rapidly in the 21st century. The future demand and price of starch are hence expected to hike, and sago starch price is deemed to follow a similar trend.

Keywords: commercialization, *Metroxylon sagu*, plantation, sago palm, starch industry.

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BIODIVERSITY AND PRODUCTIVITY OF SEVERAL SAGO PALM VARIETIES IN INDONESIA

Yoshinori YAMAMOTO[1)], Tetsushi YOSHIDA[1)], Akira MIYAZAKI[1)], Foh Shoon JONG[2)], Yulius B. PASOLON[3)] and Hubertus MATANUBUN[4)]

Generally, genetic variations in crops are most abundant in their centers of origin. Sago palm (*Metroxylon sagu* Rottb.) is supposed to originate in the New Guinea Island and/or Molucca (Maluku) Islands. Many accessions of sago palm (hereafter, called variety) were recorded in Papua New Guinea (PNG) as well as the Papua (Irian Jaya) Province and Maluku Islands of Indonesia. The number of sago palm varieties tends to decrease with increasing the distance from the center of origin. To know the varietal differences among sago palms is very important in order to promote the utilization of sago palm and to breed for new varieties. In this paper, the biodiversity and starch productivity among several sago palm varieties in Kendari, (South-Eastern Province of Sulawesi) and around Lake Sentani (near Jayapura of the Papua Province) are presented.

1. Varieties in Kendari

The growth and starch productivity of three major sago palm varieties in Kendari, i.e., Molat (non-spiny), Tuni (spiny) and Rotan (spiny), were compared in 1998 and 1999. Although the time taken from planting to trunk initiation is similar (3-4 years) among the varieties, Rotan is harvested earlier than Molat and Tuni. The leaf emergence rate is also similar among the varieties. On the other hand, large varietal differences in the growth rates such as trunk elongation and dry matter accumulation were observed and these were higher in the order of Molat> Tuni>>Rotan. Although the initiation of rapid starch accumulation in the pith of the trunk was earlier in Rotan than Molat and Tuni, the starch percentage at harvesting is almost same in all the varieties. This reflects that the starch content per palm at maturity was mainly determined by the weight or volume of trunk. The trunk weight and volume were larger in the order of Molat>Tuni>>Rotan at harvesting.

2. Varieties around Lake Sentani near Jayapura

BPTP Papua recorded 61 sago accessions in the Papua Province (Widjono et al. 2000). In our research in 2003 and 2004, sago farmers around Lake Sentani showed us 21 varieties (9 non-spiny and 12 spiny) and we actually recognized 15 varieties among them. These varieties showed wide variations not only in morphological characters but also in environmental adaptability, such as tolerance to fire and waterlogged conditions. The farmers also recognized variations in the starch productivity, the starch color and the quality of 'Papeda', a most popular sago starch dish in the eastern Indonesia. Among the varieties of sago palms, Rondo is unique and its pith is usually consumed directly after boiling without any processing.

Nine varieties viz. Para, Yepah Hongsay, Y. Hongleu, Osukulu, Folo, Ruruna, Pane, Wani and Rondo were sampled at harvesting stage to compare their starch content and other related parameters. One to six palms were sampled for each of the varieties. The starch content per palm among the varieties varied widely and it is more closely related to the trunk or pith weight rather than the percentage of starch in the pith. Among the varieties, evident differences were not observed in the trunk length and diameter except for Rondo, which has shorter trunk. .

In conclusion, wide variations were observed among the sago palms in Indonesia, not only in the growth and starch productivity, but also in the starch quality. Further researches on the variations should be done in the other sago growing areas around the center of origin.

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SAGO PALM POTENTIAL, BIODIVERSITY AND SOCIO-CULTURAL CONSIDERATIONS FOR INDUSTRIAL SAGO DEVELOPMENT IN PAPUA, INDONESIA

H. MATANUBUN And L. MATURBONGS [1)]

The Moluccan Islands and New Guinea (covering The State of Papua New Guinea and the Indonesian Province Papua) had been considered as the center of diversity of *Metroxylon sagu* Rottb., due to the vast natural stands and the high genetic variation that had been found in these areas (Flach, 1997).

Flach (1997) estimated a total of 1,200,000 ha wild stands and 14,000 ha of (semi-)cultivated of sago palm in Papua (Irian Jaya). From aerial survey, the sago areas in Papua were estimated at 1,471,232 ha, divided into pure sago stands, sago associated with forest and sago associated with grasses (Kertopermono, 1996).

The vast wild and (semi-) cultivated sago areas are found in Bintuni, Lake Plane (Mamberamo), Southern Irian/Papua, Inanwatan, Salawati and other districts (Kertopermono, 1996; Flach, 1997).

The yield capacity of sago palm varies depending on wild or (semi-) cultivated, environmental conditions, and variety. Semi-cultivated varieties yield better than those of the wild stands.

Several researches had shown that in Papua alone there were a lot of sago accessions which differ in their morphological and genetic characters. Flach (1977) mentioned four varieties in Waropen; 10 varieties in Salawati (Schuiling, et.al., 1993); 14 varieties in Wasior; 9 varieties Inanwatan, 3 varieties in Onggari and 35 varieties in Sentani (Widjono *et al.*, 2000); 16 varieties in Kaureh (Matanubun *et al.*, 2005); 5 varieties in Windesi (Mulyanto *et.al.*, 2001).

Regarding the Sentani area, recent studies by Yamamoto *et al.* (2005) had found 21 varieties and Matanubun (2005) mentioned 22 varieties and 19 sub-varieties. Hence Sentani area has the highest sago variability.

Development of sago industry in Papua involved three stake holders, i.e. the local government, the local community as the land right owner and the investor. The local community as the right owners have an important role for the sustainability of the industry. From the studies done in Jayapura (Matanubun *et al.*, 2005), Waropen (Istalaksana *et al.*, 2005) and Inanwatan (Luhulima *et al.*, 2005), concluded that the utilization of the sago resources were supported by the local community provided that the government and the investor must consider and act on the following four socio-cultural aspects. (1). A good perception of the community to the establishment of a commercial sago palm plantation; (2). The owner's right of the community on the natural sago forest could be transferred to the other, such as an investor; (3). The compensation claims that had to be settled by the investors due to the utilization of the natural sago forest should be rational; (4). Although the accessibility of the local community to the sago forest was very low, but potentially could be developed and utilized by the investor.

Keywords: sago palm, biodiversity, socio-cultural considerations, sago industry, Papua

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FEASIBILITY STUDY OF THE NATURAL SAGO FOREST CONVERSION TO THE SUSTAINABLE SAGO PALM PLANTATION AT SOUTH SORONG PAPUA, INDONESIA

F. LUHULIMA, Karyoto S.AMAT, Yunus ABDULLAH, Djuliati DAMPA[1)]

About 40 % of the sago vegetation in Papua is the productive sago area, which can be readily harvested. It has been reported that the natural sago vegetation in Inanwatan is 53.000 ha, while the larger site of sago vegetation around 94.600 ha is located along Kais River and Metamani of South Sorong. The native local people consumed the sago by using the traditional method.

The objective of this study was to observe the condition of the sago forest located in Inanwatan, South Sorong and its feasibility for commercial sago plantation or for agribusiness orientation.

South Sorong where the sago forest is located belongs to the wet climate zoned A according to the Oldeman classification (1980). An average of rainfall was 4365 mm/year, with a monthly mean temperature 27 - 29° C and a mean of relative humidity 84,3%. The physiographic of this area is mostly organic marshland with histosol soil type. Soil water inundation was higher toward the eastern area; hence the quality of soil water as well as river water was very poor.

A total of 100 – 150 matured sago plants per hectare can be harvested yearly. The sago plant density reached 296 plants/hectare/year for the tree phase and the total individual plant for the entire growth of development stage reached 5686 with an approximately 417 sago clusters/ha. There were 4 types of sago plants : Bosairo, Mola/Igo, Edidau and Bibewo (king sago). Bibewo has the greatest cluster density (382 clusters/ha) and contained 4898 seedlings.

The social and cultural aspects of the native local people allow the possibility of converting the natural sago forest into a commercial sago plantation. This can be justified by a good perception of the native people toward the positive value of commercial sago plantation ; as long as it give a right compensation for their traditional entitlement, or a rational compensation mechanism from investor to the local native people in handling or improving the accessibility of commercial sago cultivation.

The economical and financial outcome may demonstrate that the development of conversion from the natural sago forest into thee commercial sago plantation could withstand by 10% of the reduction value, however it did not withstand by 20% of the reduction value. In summary, with the utilization of sago forest resources and other local resources may result in a greater economical transfer to the remote areas, and thus may give a direct influence toward improving the financial of the local people and economy of the district areas, in general.

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FEASIBILITY STUDY OF THE NATURAL SAGO FOREST FOR THE ESTABLISHMENT OF THE COMMERCIAL SAGO PALM PLANTATION AT KAUREH DISTRICT, JAYAPURA, PAPUA, INDONESIA

H. MATANUBUN, B. SANTOSO, M. NAUW, A. ROCHANI, M. A. P. PALIT, D. N. IRBAYANTI, A. KURNIAWAN [1)]

A study on the feasibility of the natural sago forest for the establishment of a commercial sago palm plantation had been carried out at Kaureh District, Jayapura, Papua, Indonesia. This study was to reveal the feasibility of bio-physic, social culture, and financial economics. The research area was determined based on Land Sat interpretation and information from the local people which indicated an area of about 92,514.332 hectares seldom used by the local people.

The results showed that the topography was flat with the climate and soil were suitable for the grown of sago palm. The annual rainfall, mean temperature, mean relative humidity about 2,118 mm; 26°C, and 83 percent respectively. The soil was classified as Endoaquepts derived from alluvium deposit and recently developed. The soil texture varied from silt clay to silt clay loam. The N and K content were low, whereas P, Ca, and Mg were relatively high. Therefore the application of N and K fertilizers will be necessary. The land suitability was classified as marginally suitable (S3-f); the limiting factor was soil pH (medium alkaline). To increase the land suitability to medium suitable (S2), the application of ammonium sulphate as acid reaction fertilizer could be done.

According to the local people there were 11 varieties; three of them had high starch content. The density of sago population per hectare were 380 clusters, which was considered medium high so that thinning should be done to obtain maximum starch yield. The average numbers of harvestable trees were 60 trunks per hectare per year, with an average yield of 175 – 350 kg of wet starch per trunk. This is adequate to supply a sago starch factory with a capacity of 2,000 tons dry starch per month. The other type of vegetation found around the sago forest could be used for the establishment of the factory and supporting facilities.

The social condition of the local communities as the right owners of the natural sago stands supports the feasibility of a commercial sago palm plantation establishment. Four socio cultural aspects that supports this feasibility had been identified, i.e. : (1) A good perception of the community to the establishment of a commercial sago palm plantation; (2) The owner's right of the community on the natural sago forest could be transferred to the other, such as an investor; (3) The compensation claims that had to be settled by the investors due to the utilization of the natural sago forest were very rational; (4) The accessibility of the local community to the sago forest was very low, but potentially could be developed for the utilization by an investor.

Financially, the rehabilitation of the natural sago forest to a sustainable agribusiness was a feasible operation and relatively resistant to the total cost increase of 15 % and a decrease in production or benefit of 10%. Economically, the rehabilitation of the sago forest was feasible, because there will be a reasonable financial transfer from the company to the community due to the utilization of local resources. Beside that, there will be an increased of the local economy due to the multiplier effects of the business operation. A conductive climate was needed in form of government policies attractive to investors such as investments security, security stability, customary land rights compensation, minimum regional salaries, supporting facilities, etc. The investors should be accountable for every activity of the sago rehabilitation operation, such as planting, harvesting and processing which affects the benefits and costs structure. The role of the local government was needed in the utilization of local resources, including maximum involvement of local labour.

Keywords : Feasibility Study, Natural Sago Forest, Sago Palm Plantation, Papua Indonesia

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CONVERSION OF THE NATURAL SAGO FOREST TO THE SUSTAINABLE SAGO PALM PLANTATION AT MASIREI DISTRICT, WAROPEN, PAPUA, INDONESIA: FEASIBILITY STUDY

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The aim of the study is to know the feasibility of conversion natural sago forest into sustainable sago palm plantation with agribusiness orientation. The study was addressed on technical (biology, physics, and chemical), socio-culture, and financial-economic feasibility.

The study indicated that the natural sago forest is suggested to be developed as sago palm plantation. The climate is feasible for the growth of sago with rain fall 2000 millimetres per year. The area is formed by mineral soil (Endoaquepts) and peat soil (Haplofibrists). Sago land feasibility study indicated that mineral soil is classified as sub class S2-n or moderately available with limit factor of N and K- available, and peat soil is S3-f or marginal feasible with limit factor is soil pH whereas mix mineral and peat soil is categorized as moderately available with limit factor of K- available.

Swamp forest in study area is dominated by relatively high density of natural sago palm and reaches the minimum area of 10.000 hectare required for development natural sago forest for commercial interest. Clump density per hectare and number of sago trees per hectare fulfill the optimal population through rehabilitate activity. Sogo clump and tree pruning are not suggested in rehabilitation but woody plant. It was indicated that the natural sago with slightly maintenance, its dried starch per hectare is able to provide raw material continuously for mid-scale capacity of sago factory larger than 2000 ton dried starch per month per unit.

Recommended commercial sago plantation area located on Ruambak-Botawa Watershed area distributed in Botawa and Mambai Villages become a feasible area according to positive perception of custom society. It is also supported by clan member of the society to release their custom right for other communities to involve in the sago plantation. Compensation is facing no difficulty to be realized unless the mechanism is arranged together with the custom community.

According to financial analysis, conversion natural sago forest into sustainable sago palm plantation with agribusiness orientation becomes unfeasible to be conducted. It is shown that existing condition is highly sensitive to total expense increase and degradation of benefit as small as any changes. On the other hand, economic analysis indicated that the activity will be feasible due to greater fund transfer from company to the community because of natural resources utilization. In addition, the economic activities will be improved by "multiplier process".

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ENVIRONMENTAL FACTORS LIMITING SAGO PRODUCTION AND GENETIC VARIATION IN *METROXYLON SAGU* ROTTB.

H. EHARA[1], H. NAITO[2] and C. MIZOTA[3]

We studied sago production of various local varieties from western to eastern archipelago of Indonesia. Field surveys were conducted on Siberut located in west of Sumatra, in west and south Sumatra, Java, west and southeast Sulawesi, and northern and central Maluku. The plant materials contained spiny type and spineless type that included varieties having a weak black or brown band on the back of the petiole and rachis, and bandless varieties were included as well. Large variation in morphological characteristics indicating plant size existed among the local varieties, and pith dry-matter yield was estimated at 51 to 921 kg. The difference in pith dry-matter yield was mainly attributable to trunk diameter and dry-matter percentage of pith. Trunk diameter was positively correlated with soil pH. There was large variation also in starch yield estimated at 28 to 710 kg. A highly positive correlation between starch content in pith and stomatal density on the abaxial side of the leaflet was found, and the stomatal density was positively correlated with exchangeable Ca content in soil. Sago palm production might be affected by growth environment such as some properties indicating natural fertility of soil.

Random amplified polymorphic DNA (RAPD) analysis was carried out to estimate the relationships between the geographical distribution and genetic distance of sago palms growing in the Malay Archipelago that is Indonesia, Malaysia and the Philippines. The plant materials contained 38 populations, which included 16 spineless and 22 spiny populations. The polymerase chain reaction (PCR) was performed using nine 10-mer primers. A total of 77 PCR products were scored from all the primers. Out of 77 products, five were shared by all the populations and 72 were polymorphic. A cluster analysis using the UPGMA method was conducted. From the dendrogram, two groups were found. The cluster of one group consisted of the populations collected in the eastern area of the Malay Archipelago. The other group included a sub-group consisted of the populations collected on Sulawesi and Mindanao formed and the other sub-group mainly consisted of the populations collected in the western area of the Malay Archipelago. The genetic distance of sago palm populations grown in the Malay Archipelago was considered to be related to geographical distribution. Moreover, the presence or absence of spines on the petiole and rachis did not correspond with genetic distance.

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ANATOMICAL LEAF STRUCTURE RELATED TO PHOTOSYNTHESIS AND CONDUCTIVE ACTIVITIES IN SAGO PALM

NITTA, Y.*[1)], MATSUDA, T.[1)], MIURA, R.[1)], NAKAMURA, S.[2)], GOTO, Y.[3)] And WATANABE, M.[4)]

Sago palm (*Metroxylon sagu* Kottb.) has great plant length and flesh weight. Its stem accumulates much starch. Great attention has come to be focused on many aspects of its leaf structure, where photosynthesis takes place: the leaf and leaflet number, plastochrons, leaf and leaflet areas, photosynthesis, and conductive activities of water and solutes. This study examines the anatomical and morphological structures in sago palm leaves as a basis for characterizing the physiological properties of starch production.

Materials and Methods

Field investigations were carried out in mineral soil of a farmer's field in Mukah, Sarawak, Malaysia in September 2003. We chose a plant with 5 yr trunk formation that had 13.7 m length and 14 fully expanded leaves. The middle part of leaflets attached to the center of each leaf axis were collected in upper (14th leaf counted from the base), middle (7th) and lower (1st) leaves. These leaf samples were fixed and stored in 70% ethanol; then they were brought to Japan. Small samples, 3 mm long and 5 mm wide, from fixed leaves were submerged in 40% ethanol for 6 h, submerged in water for 4 h, then frozen rapidly with nitrogen slush (-210°C) followed by vacuum freeze-drying (–60°C, 10^{-3} Pa). Cross sections of dried materials were made using a razor blade. Then they were coated with OsO_4 so that the dissected surfaces were exposed. Specimens were viewed with a scanning electron microscope (JSM6301F; JEOL, Japan). Straight or curved-line length, cross-section areas of cells and tissues were measured using a personal computer with specialized software (WinROOF; Mitani Corp., Japan).

Results and Discussion

Sago leaves consist of four layers from the adaxial to the abaxial side: 2–4 cell layers of multiseriate, 3–4 cell layers of palisade tissues, 2–4 cell layers of spongy tissue, and 2–4 cell layers of multiseriate. The multiseriate seems to serve as protection from intrusion. The leaf thickness (250–300 □m) and mesophyll tissues (200–240 □m) depend mainly on the thickness of spongy tissues. Their differences seem to cause photosynthetic activities. Large vascular bundles (LV) run in the center area of the leaf; small vascular bundles (SV) run in spongy tissues. They were distinguishable in each leaf by their respective sizes. Between LVs, 3–6 SVs were typically situated. In each LV, a layer of vascular bundle sheath cells consists of large parenchyma cells (ca. 17–21 cells) arranged circumferentially, except at its adaxial and abaxial sides. In a contrasting structure, a layer of vascular bundle sheath cells (ca.-7–10 cells) surrounded SVs. Among leaves and leaflets, little difference was shown in either the cross sectional area of LV and SV or the distance between LVs and SVs. This fact shows that conductive activities of water and solutes per unit leaf area do not differ among leaves and leaflets. Further investigation is needed to clarify the fine structures and physiological functions of vascular bundles.

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SAGO PALM (*METROXYLON SAGU* ROTTB.) CULTIVATION TRIAL IN TANZANIA, AFRICA

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After several attempts to introduce sago palm (*Metroxylon sagu* Rottb.) into Tanzania, a glamorous success has been observed at the end of the tunnel. In December 2003 a consignment of 60 seeds and three seedlings from Indonesia via Japan were received at Sokoine University of Agriculture in Tanzania. The seeds were scarified for two and a half months by washing with water on a daily basis (3/12/03 to 15 February 2004) to remove germination inhibitors. During this period the seeds were put in a germination incubator at a constant temperature of 30°C. Several of the seedlings showed signs of germination but later they aborted in the water. By the end of the scarification period seeds were left in the incubator for 20 days, i.e. 15 February to 5 March 2004 without further washing or changing the water in the beakers. The water got smelly so we had to discard them on 5 March 2004. Instead of throwing them in the garbage bag they were we put in a mud slurry for further observations. By 25 May 2004, eight (8) seeds had germinated: 5 on 20 April 2004, 1 on 28 April 2004, 1 on 1 May 2004 and the last one on 25 May 2004. The germinated seeds were transferred into pots containing cocas growth medium where they were allowed to grow into fully developed seedlings after which they were transferred into 20-litre buckets. The small pots were placed under a shade house transmitting only 10% PAR as determined by a light-measuring device (AccuPAR ceptometer). The 20-litre pots were placed under a shade house transmitting 33% of PAR and a temperature range of between 30 – 40° C. The seedlings were transferred into 20-litre pots on different dates as follows: 16 July 2004 (2), 25 July 2004 (1), 12 August 2004 (4) and 8 September 2004 (1). All the pots and buckets were holed at the bottom to allow for water drainage. Seedlings in buckets were supplied with 5 g of urea/pot/month on a regular basis until they were transplanted into the field, starting from 11 March 2005. The transplanting holes had dimensions of 1 m x 1 m x 1 m to allow for enough area for water storage and early root penetration. During the transplanting period, new seedlings (2 weeks old) were received from Indonesia via Japan. These were again grown in cocas medium in medium pots and will be transferred into 20-litre buckets at 2-true leaves growth stage. For the previous seedlings, some data were recorded, including plant height, leaf number per plant at different times, leaf length and some meteorological data (as summarised in the main text). Tentatively we are concluding that sago palm seeds have been successfully germinated in Africa and we are optimistic that sago palm plants will grow successfully under field conditions in Africa.

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MORPHOLOGICAL CHARACTERISTICS OF LEAF SURFACE IN *METROXYLON* PALMS

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It is considered that stomatal density is one of the important factors which affect photosynthetic rate through CO_2 uptake. The difference in stomatal densities among leaves and leaflets at different positions in *M.sagu* were investigated by Omori et al.(2000). However, differences of stomatal density and leaflet surface structure among species are unknown. Stomatal densities and leaflet surface structures in six *Metroxylon* species were investigated in this study.

Material and Methods

Stomatal densities in all *Metroxylon* species(*M.sagu*, *M.warburgii*, *M.salomonense*, *M.amicarum*, *M.vitiense* and *M.upolense(M.paulcoxii)*) were measured in this study. Three middle-part leaflets attached to middle leaf were used for the measurement. Stomatal densities of adaxial and abaxial side were measured about replica of stomata with video micrometer. It was determined by the mean of three leaflets. Leaflets were also used for the morphological observation of leaflet surface by scanning electron microscopy. Collected leaflets were fixed with 70% ethanol and dehydrated with a graded series of ethanol(80,90,95,99.5 and 100%) . After the replacement of ethanol with t-butyl alcohol, leaflets were dried by freeze-drying method. Dried leaflets were coated with gold-palladium for the observation by scanning electron microscopy.

Results and Discussion

Stomatal densities on both abaxial and adaxial surface at the seedling stage were lower than those in the adult palms. On the other hand, stomatal density at just before trunk formation in *M.warburgii* is almost same at adult palms. This result indicates that stomatal density increase until at trunk formation. Stomatal densities on adxial surface were lower than those on abaxial surface in all *Metroxylon* species. Stomatal density on adaxial surface in *M.sagu*(333/mm^2) was higher than those in the other *Metroxylon* species(22~80/mm^2). Stomatal density on abaxial surface was 1232/mm^2 in *M.amicarum*, 900/mm^2 in *M.salomonense*, 891/mm^2 in *M.sagu*, 848/mm^2 in *M.vitiense*, 670/mm^2 in *M.warburgii*, 504/mm^2 in *M.upolense*. It was showed that species with larger body size has higher stomatal density in abaxial surface.

By the morphological observation with scanning electron microscopy, stomata on the abaxial surface were observed at behind of the extended cuticlar wax layer in *M.warburgii* and *M.upolense*. Abaxial surface in *M.vitiense* was more rugged than those in the other species. Stomata on adaxial side in *Metroxylon* species except *M.sagu* were in the small depressions in leaf surface.

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POTENTIAL USE OF SAGO STARCH FOR INSTANT NOODLE PRODUCTION

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Noodle is a popular food made from either starch or flour. Sago starch production in Indonesia has been mainly used for starch noodle. Small proportion of sago starch is added to rice flour to produce rice noodle.

The production and consumption of noodle in general and instant wheat noodle in particular are growing to take a place as a staple food. The increasing demand for instant rice noodle gives an opportunity to sago starch as a substitute.

An experiment on sago starch incorporation on the production of instant rice noodle at commercial scale was carried out to find out the level of substitution. The result showed that the substitution at 25% level gave an acceptable product.

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FREE-LIVING NITROGEN FIXING BACTERIA ARE COLONIZING DIFFERENT PARTS OF SAGO PALM (*METROXYLON SAGU*)

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Different parts (root, midrib, leaflet, bark, trunk and starch) were collected from sago palm trees in Leyte, Cubu and Aklan islands, the Philippines and nitrogen fixing activity of them was measured using the acetylene reduction assay (ARA). All most all the samples showed positive reaction in ARA, except for leaflet samples, suggesting that nitrogen fixation may occur in sago palm. The starch samples showed the highest activity and the root samples showed moderately high activity. In the midrib samples, ARA was quite variable: some showed high, but others very low, suggesting heterogeneous distribution of nitrogen fixing bacteria. Nitrogen fixing bacteria were isolated by aerobic cultures using a N-free Rennie medium from the samples showing high ARA activity after surface sterilization with 70% ethanol. Homology search of 16S rDNA sequences revealed that the nitrogen fixers belonged to *Klebisiella pneumoniae, K. oxytoca, Pantoea agglomerans, Enterobacter cloacae, Burkholderia* sp., *Stenotrophomonas maltophilia* and *Bacillus megaterium.* Some of the strains were confirmed by physiological tests using API20E and API20NE and there were strains in which phylogenic and physiological identification did not match. These species, except for *Stenotrophomonas* sp. and *B. megaterium,* have been frequently isolated from different plants as nitrogen fixing bacteria. The relationship between ARA and carbon sources showed that all the isolates preferred simple compounds, like glucose, sucrose and mannitol as an energy source while they showed very low activity in pectin, starch and hemicelluose media. This study demonstrated extensive colonization of sago palms by different types of nitrogen fixing bacteria for the first time. However, further research is still necessary, especially on estimate of the amount of biologically fixed nitrogen, contribution of anaerobic nitrogen fixing bacteria and collaboration of nitrogen fixers and non-nitrogen fixers.

Keywords: biological N fixation, endophyte, N nutrition

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DEVELOPMENT OF TRANSPARENT NOODLE TO PROMOTE CONSUMPTION OF SAGO IN INDONESIA

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Noodle is the most popular food product for the Indonesian people. It could be served conveniently without inferior image. Development of transparent noodle would promote consumption of sago. Therefore, sago image as staple food would increase as superior as rice grain or wheat. The objectives of the research were to evaluate transparent noodle quality made of various ago starch type and its acceptability by consumer (case : South Sulawesi).

Noodle was prepared by mixing the dry sago starch with "*binder*" (completely gelatinized starch and additive) into dough. The dough was pressed manually through a container with holes in the base (simple extruder). Wet noodle was boiled into water and taken out of the, water as soon as the strain of the noodle were floated, and were immediately transferred into cold water, where they held for a time before drained.

Vegetable oil was added to avoid stickiness. Sago (*Metroxylon* sp.) starch were obtained from Pancasan-Bogor and Palopo respectively, while those of *Arenga* sp was obtained from Bogor (known as *sagu aren*). Three formulas (additives) were developed in this study. Noodle was then analyzed for its quality characteristics. Noodle product was also introduced to the consumers in South Sulawesi. They were represented by elementary school students (n=40), adults (n=40) and housewife (n=28).

The result indicated that the physical and chemical characteristics of sago starch originated from Palopo, Pancasan and Aren starch were alike. However, they were different in term of its starch pasting characteristics. Starch (sago) formula as well as the combination of starch/formula was significantly effected the physical and chemical characteristics of noodle. The highest noodle yield (312%), was obtained form Formula 1 (potash alum as additive). Based on its raw material, Palopo starch showed the highest yield.

Noodle texture in term of hardness, potash alum containing formula (F1) was comparable with those of vegetable oil containing formula (F2). Less hard noodle was observes from potash alum/vegetable oil combination formula (F3). It was observed that raw material was the sago starch shoed contributing to the tensile of the noodle. Noodle made of Pancasan sago starch showed the highest tensile value.

Consumer acceptability study indicated hat transparent sago noodle was well accepted by more than 70% of consumers. The product contributed approximately of 7% of the daily calorie intake (based on 2000 kkal RDI for Indonesian).

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REGENERATION OF SOMATIC EMBRYOS OF SAGO PALM (METROXYLON SAGU ROTTB.) ON SOLID MEDIA

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Sago palms (*Metroxylon sagu* Rottb.) are generally propagated by suckers. However, the limited availability of uniform suckers is a major constraint in the establishment of cultivated sago plantations. Tissue culture has the potential for large-scale mass clonal propagation of superior genotypes of sago palm. *In vitro* culture of sago palm has been developed through somatic embryogenesis. Embryogenic callus derived from shoot tip was cultured on a modified Murashige and Skoog (MMS) medium with 30 g/L sucrose, 2 g/L Gelrite as a gelling agent, 1 g/L activated charcoal, 5 mg/L 2,4-D, and 0.1 mg/L kinetin to induce somatic embryos. Almost all the callus clumps formed somatic embryos within 3 weeks. In the subsequent culture, 0.3 g initial callus produced approximately 150 somatic embryos of different developmental stages. All stages of developing embryos with different sizes were present at any one time over one passage of culture. It was found also the occurrence of secondary embryogenesis. The cotyledonary-stage somatic embryos were then cultured on a solid MMS medium with half-strength macro-salts and added with 0 to 10 mg/L IAA, 0.1 mg/L BAP and 0.1 mg/L GA_3. About 80% of the somatic embryos were able to develop to germinate in 4 weeks. Transfer of these germinates to solid media without plant growth regulators led to the development of normal plantlets.

Keywords: *Metroxylon sagu*, sago palm, somatic embryogenesis, tissue culture

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BIODIVERSITY OF SAGO PALM IN INDONESIA,AND CONSERVATION STRATEGY

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Indonesia has a biggest genetic diversity of sago palm in the world. The problem facing in the field is the rate of genetic erosion increase year by year. The main causes were change of function sago area to other food crops or housing and over exploitation. Strategies to conserve germ plasma diversity of sago palm are: In-situ conservation by using superior type with rehabilitation technique and thin out the sucker, and Ex-situ conservation we suggested establishing Sago Field Gene Bank in Koya Barat – Jayapura, Indonesia to become International Sago Genetic Resources Center. The potential productions of sago will increase around 360 % if using superior type and rehabilitation method.

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DYNAMICS OF CARBON AND NITROGEN IN SAGO-TROPICAL PEAT ECOSYSTEMS AS EXAMINED BY STABLE ISOTOPE ANALYSIS

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Even though the 30 million ha of tropical peat swamp is only about 6% of the world's natural wetland, it contains approximately 20% of global terrestrial organic carbon (Batjes, 1996). In spite of its importance for productive use especially as Sago plantation, there is little studies on carbon and nitrogen (C and N) dynamics in the tropical peat swamps. We investigated stable isotpic ratio of C and N in the tropical peat and Sago plant samples as well as its extracted starch samples. Peat soil samples (surface and subsurface as 0-10cm 10-20cm depth, respectively) in Jambi, Sumatra, Indonesia, under different land-uses, were used to determine total C and N, and approximately 100 ug C or N per samples each was analyzed for ^{13}C and ^{15}N abundances by stable mass spectrometer (Integra CN). Sago plant samples and extracted starch samples were also analyzed similarly. Results were expressed as; delta ^{13}C or ^{15}N = (Rsample / Rstandard - 1) x 1000 (o/oo) where $R=^{13}C/^{12}C$ or $^{15}N/^{14}N$ Delta ^{15}N of peat samples varied from –2.9 to 7.4, being lower in surface samples than in subsurface. It was also influenced by land-use change from wet paddy field>wet forest>dry paddy field>cassava field. Sago plant and starch samples showed higher delta ^{15}N values, implying atmospheric N_2 fixation was occurred in Sago system. Further analysis of delta ^{13}C and ^{15}N revealed C and N dynamics in Sago-peat ecosystems in the tropics.

Reference

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PLANTATION MANAGEMENT:

THE RISK, PREVENTION AND CONTROL OF FIRE OUTBREAKS IN SAGO PALM (*M. SAGU* ROTTB) PLANTATIONS

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Introduction

In the main sago palm growing areas in Riau, the outbreak of fire in sago palm plantations or gardens is not unusual during long droughts. Potential causes of fire are cigarette butts; fires spread from adjacent land clearing by slash and burn or improperly extinguished fire used by jungle produce collectors, fishermen, hunters and so on.

Unprecedented fire damage to sago gardens in Riau

During a prolonged drought from mid November 2004 to march 2005, sago palm plantations and smallholders amounting to several thousands of hectares were raged in the Riau Province. In gardens cultivated in a non-intensive manner, fire spread was beyond control because of the lack of equipment, access infrastructure and water sources.

Management measures to prevent and control fire

In the NTFP sago plantation, about 1400 out of the 12,000 ha was blazed. Fire control was hindered by the inadequate water supply. Nonetheless, the designed canal system, available equipment, access infrastructure and the use of reversed burning strategy managed to salvage 88% of the plantation. Reversed burning and combined fire-fighting efforts from villagers and NTFP staff successfully halted further fire spread in smallholder sago farms, saving thousands of hectares of smallholder sago palms from ablaze.

The experience gained, strategies employed and various measures undertaken in controlling the sago plantation fire in NTFP are discussed. An effective strategy to curb fire spread by reversed burning is also highlighted.

Discussion

In view of the increasingly unpredictable weather pattern, crop and forest plantations are now more susceptible to fire damages during extraordinary droughts. Apart from sago palms, other plantations especially those cultivated on peat like pulp, oil palm, rubber and coconut are also increasingly vulnerable. As such, in the planning and designing of such plantations, the provision of essential infrastructure, water source, equipment and manpower are essential in preventing or controlling the potential risks of fires in plantations.

The planting of sago palms in 50-hectare blocks each surrounded by a closed canal system has shown promising result in controlling fire spread in NTFP.

References: Riau Pos (Rantau Riau, 21st Feb. 2005): 700 hektare lahan HTI hangus. Kebakaran PT AA tinggal 5%. Page 1 & 20

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HAPLOTYPE DIVERSITY OF SAGO PALM IN PAPUA BASED ON CLOROPLAST SIMPLE SEQUENCE REPEAT (CPSSR) DNA

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Sago palm is a major crops producing high carbohydrate content in their trunk. These crops are found mainly growth in Papua Island, Indonesia. The genetic diversity and dispersed of these crops very important to understand. The objectives of this study were achieved genetic diversity and dispersion of sago palm in Papua Island. Three loci of the cpSSR DNA were used to analyze the haplotype diversity of sago palm from East Papua (region I), Central Papua (region II), and West Papua (region III). Each region was sampling two population and all of population were sampling 64 individual of sago palm. The molecular variance (AMOVA) analysis showed that sago palm samples from Papua has high percentage of variant within population (96.26), but it has low percentage of variant both among population within the regions (groups) and among the regions (1.3 and 2.44 respectively). The fixation indices were shown that high degree differentiation within population (Φ_{ST}=0.0374) than both among the region and among the population within the region (Φ_{CT} = 0.02439 and Φ_{SC}=0.01333, respectively). The phylogenetic tree showed that the individuals of sago palm samples were formed three cluster and the individuals origin were diffused together in each of all three cluster.

Keywords: Genetic diversity, molecular variance, sago palm, region, population, and haplotype

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DYNAMIC MODEL SIMULATION OF SAGO STARCH TO SUPPORT FOOD SECURITY: CASE STUDY IN PAPUA

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Sago (*Metroxylon sp*) plays an important role in Indonesia, especially in Papua Province. It is consumed as staple food. Despite in a high production potential, there is an increase in exploitation of sago palm in Indonesia due to the increasing population and the rapid growth in processing and technology utilization. On the other hand, the rehabilitation efforts of the natural population are not fast as the rate of its exploitation. Dynamic model simulation is one of the tools available to analyze the performance of sago system for supporting the policy maker to apply the scenario analysis. The objectives of the research to analyze the availability and sustainability of the sago starch in order to support food security and to formulate policy alternatives in Indonesia.

Research results showed that the dynamic model has been successfully used to analyze the availability of sago and its implication to policy alternatives for supporting technology development both for consumption and industrial need. The simulation model has been used to make a decision for more comprehensive sago development. Based on the scenario-1, the availability of sago is terminated in 2044 if there is no effort for conservation through expansion, intensification and rehabilitation. Scenario-2 is used to solve the case of scenario-1 through the effective use of land resources. It is found that through the annual expansion of 3% the sago plantation can be extended. Scenario-3, with production of 50 kg/crop has been able to extend the life span of sago till 2050. The result of scenario-4 is almost the same as scenario-2. Scenario-5 showed that the sago availability can be shortened with the assumption of consumption and industrial demand. Scenario-6 is the combination of the whole scenario, and it showed that through intensification, expansion, land use change and diversification influenced significantly the sago availability for 50 years. Food self-sufficiency can be achieved from the land available if the local community aware to preserve their sago plant and apply an appropriate harvest schedule. The role of local government in monitoring and controlling the sago plantation need to be increased.

Keywords: Sago, dynamic model, simulation, food security.

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CHEMICAL CHARACTERISTICS AND METAS CONCENTRATION OF SAGO STARCH FROM SAGO PALM TREE GROWING IN NATURAL AND TAILINGS HABITATS IN TIMIKA PAPUA

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Research was conducted to assess starch chemical characteristics and metals concentration from sago palm growing in natural habitats and tailings areas in Timika, Papua. Studies were conducted from October-November 1999. Iwaka village was chosen as an area of natural habitat, geomorphologically free from tailings influence; MP 18 where sago cluster can be found, is located inside the tailings deposition area was chosen because it has been subjected to flooding and tailings deposition for more than 7 years. Starch extraction and preparation for analysis was done at the Timika Environmental Laboratory of PTFI in Timika, Papua.

The objective of this research was to investigate if there was any metal accumulation and changes in starch chemical characteristics in sago palm trees that grow in tailings areas. Sago that grows in natural habitats free from tailing influence was used as a control. Estimate of starch production was also conducted per volume or per trunk.

Experiments were conducted using a "Randomized Complete-Block Design" and included the following factors: 1) habitat: tailings and non-tailings areas; 2) trunk position on the tree: top, midle, base; 3) pith location in the trunk: inner and outer pith. Tri plicate samples were collected for metal analysis, and duplicates were collected for analysis of chemical characteristics. Metal content of the sago starch samples were analysis for Mn, Fe, Cu, Zn, Cr, Mo, Ni, Cd, Pb, Co, Se, As, and Hg in the Australian Government Analytical Laboratory (AGAL). Analysis of chemical characteristics of the same starch samples were conducted for protein content, fat, coarse fibres, ash, carbohydrate, amylose, and amylopectin; analyses were conducted at the Institute for Research and Development of Agro based Industry (IRDABI) in Bogor. Resulting data were analyzed statistically using Analysis of Variance: Multiway Classification, to determine factors influencing those parameter results. The Duncan Multiple Range Test was used to test differences between influencing factors.

Sago starch production from natural habitats ranged from 26.19 kg/tree to 107.24 kg/tree, whereas from tailings areas ranged from 68.00 kg/tree to 150.03 kg/tree with a moisture content of approximately 6%. The growing environment (tailings and non-tailings) had a significant influence on carbohydrate content, and the concentration of Mn, Fe and Cr. Growing media also very significantly influenced protein and amylose content. Trunk position (top, middle and base) had a significant effect on copper concentration and had very significant influence on amylopectin content as well as Mn and Cr concentration. Pith position in the trunk had a significant influence on protein, carbohydrate, amylopectin content, and Cr concentration. Interaction between factors only occurred between habitat locations and trunk position in conjunction with manganese (Mn) concentration.

Metals content in starch was within permissible limits for food as dictated by the Directorate General of Food and Drug Administration, Ministry of Health, Republic of Indonesia; and Food Standards Code, National Health and Medical Research Council, Australian Government.

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TECHNIQUE AND MANAGEMENT OF RAISING LOCAL POULTRY ON SAGO PALM BASED IN PAPUA

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Most of area among sago forest has not been used to increase the farmer's income. These area have a lot of poultry feeds i.e. insects, worms and by product of sago. However, raising poultry in this area is limited where not all kind of poultry can be raised, depends on the conditions of sago forest. If this area is swampy, duck and muscovite are suitable, but if this area is dry, native chicken is suitable. Raising system of poultry is reared among sago palm. Penn is constructed either for duck/muscovite or for native chicken. Particularly for native chicken needed to build the perch because sago's fern is not comfortable to perch. Beside poultry fed from sago area, is necessary to provide the additional feeds such as worms and by product of sago fermented to complete the poultry need. The advantages of raising poultry among sago area not only increase the farmer's income but also produce the manure as source of organic fertilizer to sago palm.

Keywords : Raising system, Duck/Muscovy, Native chicken, Sago forest.

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STUDY ON SAGO LEMPENG FORMULATION TO IMPROVE ITS FLAVOR AND NUTRITION VALUE

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Sago (*Metroxylon* sp) is one of the staple foods for the people live in east of Indonesia. It can be processed in small scale to be several traditional foods. In fact, as a staple food, sago has been substituted with rice and wheat flour. As a source for carbohydrate, sago should be developed for a main food for the people living in the eastern region of Indonesia, in order to optimize food diversifications. One of the most popular sago processed is sago lempeng. The specific form of sago lempeng is slim, square shape, hard, light, plain, unhydrocophies, and quick enlarge if soak into water or drink. The product is very dry, therefore it is able to be kept for such a long time as a reserve food.

The taste of sago lempeng that made by sago starch are plain and low nutrient. Sago starch contain 353 calori, 0,7% protein, 0,2% fat, 84,7% carbohydrate dan 14% water (Haryanto dan Pangloli, 1991). According to Adam (2000) the supplementation of soybean in sago lempeng processing not only increased the nutritional value of the product, but also increased the acceptance of panellists on colour, flavour, taste; however, it had shelf life only for three weeks. Rahayu (2000) reported that even though the addition of fish meal into the sago lempeng formula could increase the nutritional value, but the aroma and taste was rather dislike by panellists and it had short shelf life compare with another sago lempeng without adding other substances. The objective of this study is to find the sago lempeng formula with high nutritional value and flavour.

Sago lempeng was made under several formulas with mix ingredients composed of wheat flour, soybean, skim milk and coconut, on certainty composition and produce 20 formulas. The products was analysed by sensories include texture, colour, taste and flavour. The Attributes of sensory analysis included texture, color, aroma, taste, and performance using 20 semi-trained panellists (Soekarto and Hubeis, 1992). Results of the sensory test would be ranked based on the acceptance level of panellists from the extremely like to the extremely dislike, then there would be selected the best five formulas of sago lempeng. The best sago lempeng formula would be analyzed with using proximate analysis that consisted of water content by oven method (AOAC, 1995), ash (AOAC, 1995), fat by soxhlet method (Apriyantono et al., 1989), protein by khejedal method (Apriyantono et al., 1989) carbohydrate *by different* (Winarno, 1997), and crude fiber by acid method (Apriyantono, 1989). Result data will be analyzed using Analysis of Variance at 5% level, then follows with Duncan Test at 5% level.

In making of sago lempeng, the starch of formulated sago was still containing water about 25%, and with the heat from "vorna" which had been baked, it could form solid gel, yet after soaked into the water it produced a soft texture. Generally, all formula could produce a good sago lempeng, except F10 (sagu 70% and skim milk 30%). In this formula, the texture of sago lempeng was less compact because joining and binding among the granules of sago starch were not formed. This formula also generated the dark brown color by the form of caramel because of the heat of lactose which was contained in skim milk, particularly the parts that contacted with the vorna. Lactose is disaccharide which is sweeter than sucrose (Muchtadi dan Sugiyono, 1992). According to Winarno (1997), if sugar were heated over its melting point, there would be a caramelization (Winarno, 1997). The caramelization caused sago lempeng sticking on vorna so it was difficult to be removed. It was the reason that F10 had not been studied furthermore.

Formulation with using wheat flour, soybean, coconut and skim milk was significantly affected in increasing of the panellists' acceptance on colour, aroma, taste, and overall evaluation, as well as the nutrition of sago lempeng.

Formulation of sago lempeng with the flavour that is more preferred are 1). sago 70% and coconut 30%; 2). Sago 80%, wheat flour 10%, and coconut 10%; 3). Sago 70%, wheat flour 10%, soybean flour 10%, and skim milk 10%; 4). Sago 70%, wheat flour 10%, skim milk 10%, and coconut 10%; 5). Sago 70%, soybean flour 10%, skim milk 10%, and coconut 10%. Chemical composition of sago lempeng was done on five selected formulas, i.e. FA, FB, FC, FD, FE and control as shown on Table 5. Choice of ingredients for adding to sago lempeng may be determined by consumer preference, availability of ingredients and specific nutritional requirements.

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ANALYSIS THE ROLE OF SAGO AS A MAIN FOOD (HOW ITS CONSUMPTION AND ALTERNATIVE FOR THE DEVELOPMENT)

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To realise food sustainability at the nation, region and household levels is a government commitment. One of the potential food commodities is sago. The availability of this commodity is continuously increasing. On the other hand, sago is well known by the people as a main or alternative food especially for those who live in the Eastern part of Indonesia.

Data of SUSENAS collected by CBS in 1996, 1999 and 2002 were used to analyse the role of sago as a main food. Rice, corn, cassava, sweet potatoes and sago were the commodities analysed according to areas (town/village), province and according to income (low, average and high).

Results showed that 1) the household expenditure for sago was smaller than other commodities. The expenditure was found smaller at the town than at the villages. Those with high income tend to spend more on sago than those with the average and low income. In case of Mollucas and Papua, the income expenditure for sago was higher than for corn or sweet potatoes. 2). Proportion of the number of people consume sago (participative) was also lower than other commodities, except for the people with high income was found higher than those with the average and low income. As for rice, corn and sweet potatoes, participative rate for sago during the economic crises experienced decreasing. Sago consumption level during 1996 to 2002 was relatively the same with only 0.1 kg/capita/year even though in South East Celebes and Mollucas, sago consumption was found relatively high. In the village area of Papua sago consumption was 28.8 kg/capita/year. 3). during 1996 – 2002, the main food pattern of Indonesia was on rice and there was no difference following the income categories. Sago food pattern (not as a main food) was found only in the Central and South East Part of Celebes, Mollucas, and Papua.

Efforts to increase the role of sago as a main food in the Eastern and Western Part of Indonesia through sago industry with its products (taste, nutrient quality, packaging, price and so on) should meet the taste of consumer. The government policy should support those efforts.

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SMALLSCALE PROCESSING EQUIPMENT OF SAGO: AN ALTERNATIVE TOOLS TO OPTIMIZE SAGO RESOURCES UTILIZATION IN PAPUA

DARMA

Indonesia has the largest sago forest in the world. More than 50 % of the total world sago field (mostly natural sago forest) are in Indonesia, especially in Papua Province. Sago starch is not only as a staple food for several people in some parts of Indonesia, but also for basic material of industries such as paper, plywood, hardboard, and also food industries. About 90% of Indonesian's sago field are in Papua but unfortunately, sago starch production in this area is very low. Most of the sago trees were not harvested and just loss back to natural every year.

The problem to increase sago starch production is processing that is still carried out traditionally. The effort to increase sago starch production could be carrying out by introducing mechanical equipment (traditional to mechanized processing).

The Aims of this research is to optimize sago resource utilization with the application of mechanical sago processing equipment. The specific aim is to design sago rasper and sago extractor machine. The result of this research is prototype of mechanical sago processing machine (both rasper and extractor). Application of this machine to the sago farmer will transform agricultural system from subsistence to commercial. It means that increasing of farmer economic income.

The method used in this research is experimental. This research consists of two experiments: (1). Design and performance test of mechanical sago rasper, and (2). Design and performance test of mechanical sago extractor. Independent variables of experiment 1 are rotation speed of rasper cylinder (RPM), arrangement pattern of rasper teeth on cylinder surface and teeth diameter. In experiment 2, independent variables are rotation speed of mixing shaft, number of mixing blade, processing time interval, and screen hole size. Observation is done to the effective field capacity (Kg/hour) and efficiency of equipment, and quality of sago starch produced. Analysis of variance was used to see the effect of independent variables on dependent ones. Regression analysis is also used to demonstrate relationships between independent variables and dependent variables.

It was designed a small scale of mechanical sago rasper, and results show that both characteristic of the teeth and rotation speed (RPM) of the cylinder influence effective capacity.

Keywords : Sago, Mechanical, Processing, Exatract, Rasper

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THE UTILIZING BY PRODUCT OF SAGO AS FEED FOR POULTRY IN PAPUA

Muflin NGGOBE[1)]

Sago is potential plant in Papua Province not only as food for human but also as feed for poultry. However, feeding to poultry or others livestock competed with human need. Potential of by product of sago is proximately 7,500 kg/20 stems and in which can be fed around 200-300 poultry/year. The problem of by product of sago is high of fibre. Nutrients of by product of sago can be enriched by fermenting technology. Moreover, by product of sago fermented has low quality of protein so that feeding to poultry needed additional protein in ration to reach the optimum growth. Abundance of by product of sago provided of chance to raise poultry in sago palm based. Beside, the farmers earned from sago, also they earned additional income from poultry.

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SAGO HANDLING AND PROCESSING

Atjeng M. SYARIEF[1)]

It has been "The Expert Consultation on the Development of the Sago Palm Products" held in Jakarta 21 years ago. The author believe that the series of scientific and businesses meeting have been held ever since. However, the results of such consultation have been monumental that should be brought into consideration, again, in "The 8th International Sago Symposium" in which be held at the Governor Office of Papua Province, 4th - 6th August, 2005.

This paper will highlight the points those important to be discussed again for further development in the sago handling and processing that the agro-industrial system of sago can be laid out. The subjects such as 1) starch fermentation, 2) starch conversion into ethanol, 3) processing routes alternatives, 4) conversion into liquid sugars, 5) techno-economic optimization, and the last but not the least, 6) sago processing and utilization in general will be discussed rigorously.

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ROADMAP FOR SAGU DEVELOPMENT

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Sago palms are abundant and found in swampy areas in Indonesia. Sago palms are still under utilized and most of them are used for the production of sago starch. Many of the sago starch processing factories are small establishments which use traditional methods of extraction. A systematically effort is needed to position sago as a strategic economic as well as regional development especially in Papua. Roadmap approach has been applied to develop various products of sago. Technology road mapping is a planning process driven by the projected needs of tomorrow's markets. Therefore the process begins with identification of market trend and is followed by identification, selection and development of technology options to satisfy future service, product or operational needs. The paper will discuss how a road mapping technique can be applied to develop sago as the prime mover of economic as well as regional development. Furthermore, the forward and also backward linkages are also demonstrated in this paper.

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ENHANCEMENT OF RESISTANT STARCH FORMATION IN SAGO STARCH AND SAGO/CORN STARCH MIXTURES VIA DEBRANCHING AND HYDROTHERMAL TREATMENTS

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Resistant starch has drawn broad interest for both potential health benefits and functional properties. A method using debranching and hydrothermal treatments to enhance the formation of resistant starch (RS3) in sago starch and in sago/corn starch mixtures (in ratios of 19:1 & 9:1) is described. Sago starch and mixtures of sago/corn starch slurries (20%, w/w) were enzymatically debranched with pullulanase for several hrs. The enzyme modified starches containing high amylose content (about 60%) were then subjected to a combination of thermal and cooling treatments: autoclaving at 121°C for 1 & 2 hr; cooling at 4°C for1 hr; annealing at 75, 85, and 95°C for 24, 48 and 72 hr and recooling at 4°C for 24 and 48 hr. The subsequent formation of RS3 was investigated.

In this study the effects of autoclaving time, annealing temperatures and incubation time on the formation of RS3 in enzyme-modified sago starches and sago/corn starch mixtures were studied. RS values obtained in the treated sago starch fractions were between 15.6% - 20.4%. Addition of corn starch (5 and 10%, w/w) to the mixtures did not show any significant increase in RS content compared to sago starch mixtures only. In general, RS content of the enzyme-modified starches increased with higher temperatures and longer incubation times. It was observed that longer recooling time at 4°C of 48 hr compared to 24 hr increased RS content. However, annealing at higher temperatures for a longer time prior to recooling gave a more significant contribution to the increase in RS content compared to longer recooling time. The results showed that samples autoclaved for 1 hr, annealed at 95°C and incubated for 72 hr gave the highest RS yield of 20.5%. The presence of RS in these modified starch fractions was also investigated by x-ray diffraction studies. X-ray patterns of the B-type crystalline structure were observed in all samples having a peak at $2\theta = 22\text{-}24^0$, with its intensity increasing with higher annealing temperatures and longer incubation times. This implies the increase in crystallinity of the modified starches. Enzyme debranching treatment of sago starch produces more free linear chains which could participate in crystal formation followed by annealing for longer time that promotes starch crystals perfection, thus leading to increase in RS3. Through these physical treatments, it can be concluded that the formation of RS is affected by the annealing temperatures and incubation times.

Keywords: debranching, resistant starch, annealing, sago starch

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STUDY ON TROPICAL SWAMP FOREST DETERIORATION AND ITS EFFECT TO THE SAGO PALM (*METROXYLON SP.*) DEGRADATION USING HISTORICAL LAND COVER CHANGES[1)]

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The island of Borneo is widely known as the largest island in the Indo-Malay region which 70% of the area is covered by tropical rain forest. This island politically belongs to three countries of Indonesia, Malaysia and Brunei. Two third of the island is part of Indonesia and namely as Kalimantan. Land conversion in Borneo is mainly due to logging operation or agricultural activities. In Indonesia, tropical rain forest, through 1970s and 1980s was the main source of revenue for the state and become target for plantation development, agricultural field expansion as well as for settlement expansion to support transmigration program. The sago palm (*Metroxylon sp.*), forest which is mainly grown in fresh to slightly brackish water swamp ecosystem across Southeast Asia, including Borneo Island, has also been target for land conversion. These prolong land clearing has lead to bring tropical rain forest deterioration. It was reported that forest fire become one of the most problems following destruction of tropical swamp forest in Kalimantan of Indonesia and in Sabah, Malaysia particularly during El Niño drought in1983 and 1997.

Although it has experiencing ever land clearing over tropical rain forest in Kalimantan, degradation of the Sago Palm (*Metroxylon sp.*) forest ecosystem both in spatial and temporal are poorly reported. The Sago Palm (*Metroxylon sp.*) forest, which is widely distributed in Indonesia -particularly in Papu, Maluku and Kalimantan Islands- has been receiving much attention in recent year in Indonesia to be alternative as the future source of food and feed. Recognizing the important of swamp forest in natural ecosystem and be anxious that the destruction on these forest can contribute also to the stagnancy of a source of carbohydrate producing palm trees (Sago as forest product non timber) have awaken many agencies in Indonesia to save the remaining swamp forest, and control the continuation of deforestation, including the sago palm (*Metroxylon sp.*) forest. For the shack of monitoring purpose, the National Coordination for Surveys and Mapping (Bakosurtanal) has intensive produced land cover map at various scale derived from satellite imageries since 1997. In this paper, the land cover map has been used to analyze historical land cover change and forest fragmentation in order to understand the tropical swamp forest clearance and its effect to the sago palm (*Metroxylon sp.*) forest degradation.

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THE USE OF SAGO (*METROXYLON SAGU* ROTTB.) WASTE ONE MONTH DECOMPOSITION FOR CONTROLLING *MIKANIA MICRANTHA* HBK

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The objective of this experiment was to know the use of one month sago waste decomposition for controlling *Mikania micrantha* HBK. The planting of weeds were conducted at Cikabayan experimental field, Bogor. The chemical analysis of sago waste was conducted in laboratory at Centre Research of Spice and Medical Institute, Bogor. The experiment held from September 2003 to February 2004.

The experiment was arranged in Randomized Complete Design one factor and three replications. The treatment consists of: L1 (100% fresh sago waste), L2 (75% fresh sago waste + 25% plant compost), L3 (50% fresh sago waste + 50% plant compost), L4 (25% fresh sago waste + 75% plant compost), and for control is L5 (gravels). The treatments were applied to *M. micrantha* HBK as mulches with $\pm$ 5 cm thickness.

The content of sago waste is high in phenol, lignin, and C/N ratio but low in nutrients. Adding plant compost can reduce the content of C/N ratio, phenol, and lignin but it can increase nutrient. At the end of observation the treatment with the highest content of sago waste (100% sago waste) gave the lowest result for height, number of leafs, number of branches and weight of *M. micrantha* HBK. The inhibit growth of *M. micrantha* HBK caused by 100% sago waste mulching showed that sago waste mulching can help reducing the work of mechanical weed control.

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Keywords: Sago (*Metroxylon sagu* Rottb.) waste, *Mikania micrantha* HBK, decomposition

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MULTI-SPECIES CULTIVATION IN THE SAGO GROWING AREA OF PAPUA NEW GUINEA

Yukio TOYODA[1)]

In the Sepik area of Papua New Guinea, where sago is the staple food, gardens are created by the slash and burn method. We see there a lot of species grown in a single plot at the same time. Even when we find only one species in the garden, the people distinguish many types, and they give different local names to each variety. Research has been conducted in Nuku area of Sandaun Province in Papua New Guinea, in order to investigate the situation of multi-species cultivation, and the logic of why they grow a lot of varieties at the same time in their garden. The research has been conducted from the standpoint of anthropology, and mostly through intensive interview with those elderly people who have traditional knowledge about local crops.

The Kwanga people in Nuku area have 9 varieties of sago palm, and 77 of yam (*D. alata* or *D. esculenta*), 26 of taro, and 65 of bananas. These crops are differentiated according to their forms, colours, tastes, and agronomic features, such as the way they swell.

Why these people try to keep many varieties is not easy to define. We might expect that growing many varieties could minimize the risk of losing the crops to plague. We could lower the risk by keeping many varieties in the hope that we could keep some varieties even if others are damaged. However, the people do not agree with this logic. They usually emphasize that they keep so many varieties because they want different tastes. Eating only a few varieties of food crops makes their meals monotonous and dull, they say, but they can enjoy different tastes if they have many varieties in their gardens.

Keywords: anthropology, multi-species cultivation, Papua New Guinea, Sepik area

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NITROGEN DYNAMICS IN WETLAND SOIL-PLANT-MICROBES ECOSYSTEM IN KASUMIGAURA, JAPAN

Takeshi Mitomi*[1], Kazuyuki Inubushi[2], Hirokatsu Utagawa[3], Mirai Watanabe[1] and Noriko Takamura[3]

In recent years, sago plantation area is attracting for its function, food problem and environment. Environment is one of important issues because some sago plantation area was broken by economical development. Therefore, we get hold of environmental advantages of sago plantation once more. Especially nitrogen dynamics is critical because nitrogen pollution is big problem in many places. It has been found that denitrification bacteria was present in the bio films on plant surface in wetland. However, very few attempts have been made *in-situ* estimation of denitrification in vegetation area and such device for estimation has not been established. In this study, we conducted an *in-situ* field experiment to measure the denitrification in vegetation area of wetland and to assess nitrogen dynamics in controlled experiment. We used a closed chamber with acetylene inhibition technique, which was located at the ponds connected to the Lake Kasumigaura, the second largest freshwater lake in Japan. The acetylene inhibition technique was confirmed to be applicable to this system, since differences of N_2O concentrations were clearly observed inside the chambers, with and without the addition of acetylene. The results showed that higher N_2O concentrations was found in the chambers with vegetations than without vegetations, denitrification activity varied in different season, and ratio of NO_3^- removal by denitrification varied also seasonally. The laboratory measurements showed that samples taken from withered plant surface had higher denitrification activities, and higher population of denitrification bacteria than fresh plant surface. It is suggested that presence of vegetation was important to nitrogen dynamics.

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TRADITIONAL PROCESSING OF SAGO STARCH IN PAPUA
A COMPREHENSIVE REVIEW BASED ON A STUDY MADE IN MANOKWARI, BIAK AND JAYAPURA

DARMA

The sago palm (Metroxylon sagu) has long been an important source of nutrition throughout the South East Asian archipelago. Numerous studies have been done to extract starch from this palm, but up until now little quantitative information has been available for comprehensive appraisal of traditional sago starch processing. In order to study in depth the traditional sago processing in Papua, a study was carried out at Manokwari, Biak, and Jayapura. Quantitative data obtained in this study about Characteristics of ready harvested trees, processing tools (equipments) used, number of person involve, time required in each route, and quantity and quality of starch produced.

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PRODUCTION AND CHARACTERIZATION OF GLUCOSE SYRUP OF PAPUA SAGO STARCH

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The objective of this research was to study production and characterization of syrup glucose from sago starch of Papua by acid hydrolysis. The method of the research by experimet method and use observation technic. Glucose syrup was made by acid hydrolisis where the hydrochloric acid (HCl) 1 N added in 30% starch solution, then put it on autoclave at 45-50 PSi pressure during 30 minute. After that the product of hydrolysis was neutralization by sodium hydroxide (NaOH) 1 N, then purity by active carbon 0.5%, filtered and evaporated. The syrup glucose product would be analyzed of yield, consisted of water content by oven method (Apryantono *et al.*, 1989), ash content (Apryantono *et al.*, 1989), dry material content, invert sugar (SNI 01-2891-1992)and dextrose equivalent (DE) (SNI 01-2891-1992). This research conclude that sago starch from Papua potential to produce glucose syrup with yield 53.00 %, water content 5.78 %, ash 1.37 %, dry matter 94.22 %, invert sugar 48.05 %, and dextrose equivalent (DE) 51.00. Glucose syrup from sago starch of Papua was suitable with glucose syrup SNI (Indonesian National Standard) standard include odourless, sweet, colourless, water content max. 20%, ash max. 1% and invert sugar min. 30%.

Keywords: sago, starch, glucose syrup, and acid hydrolysis

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THE GROWTH HABITAT OF SAGO PALM IN KAUREH DISTRICT,JAYAPURA, PAPUA [1]

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Climatic and soil conditions were suitable for sago palms at Kaureh. Soil, on which sago palms grew, was a recent mineral soil (Endoaquept). The soil had little profile development. Three types of sago habitats existing at Kaureh were dryland, wetland and very wetland. The fertility status of the soil of the sago habitats was considered medium. Under the existing growing conditions, two types of sago stands were found, i.e., (1) sago palms, which produce suckers, grew in clusters, (2) sago palm, which did not produce suckers, grew as single trees. Sago plants growing in clusters mostly grew on wetland and highly wetland habitats. The single stands, however, grew on relatively dryland habitat, which was close to a river or a natural drainage.

The average number of sago palm trees growing in this area was considered high, 2 120 trees per ha of different stages of growth. Of which, 75% was in seedling, 6.31 % in sapling, 3.54 % in young trunk and 14.39 % was in mature palm. Of which, 11.56% was in mid trunk and the rest (2.83%) was in full trunk. The average number of full trunk sago palm per ha was 60 trees.

Under the existing growth habitats, the fresh sago starch production per palm tree was 175 – 350 kg.

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[1] Poster presented in The 8th International Sago Symposium, 4th – 6th August 2005, Sasana Krida Building Governor Office, Jayapura, Papua Province.

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THE POTENCY OF SAGO PALM AT INANWATAN DISTRICT, SOUTH SORONG, PAPUA, INDONESIA

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High density of natural sago forest widely distributed from west to north along eastside of Metamani River closed to Odeari Village has an area of 72.234 hectare. It was recorded that there are four cultivars of *metroxylon sagu* growth in the area, Mola (Igo), Bosairo, edidau and Bibewo (Sagu Raja). Mola, an introduced species, was classified as spineless sago found nearly the village. Bosairo, Edidau and Bibewo, the local species, were identified as spine sago. Among the latest, Bibewo showed the high potential in growth therefore this cultivar is usually utilized. The density of natural sago forest in the area was predicted about 417 clumps per hectare. Each clump contained 51 numbers of sago. Composition of clump was differentiated based on stage as followed: 3 in tree stage, 1 in pole stage, 4 in sapling stage and 40 in seedling stage. On the average, 75 trunks per hectare produced un-dried starch about 13 to 21 ton per hectare. In conclusion, the natural sago forest in Inanwatan is potentially developed as commercial sago plantation industry.

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GROWTH AND POTENCY OF THE NATURAL SAGO PALM IN MASIREI AND SOUTH WAROPEN DISTRICTS, WAROPEN, PAPUA, INDONESIA

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The objective of this study was to obtain information on the growth and potency of the natural sago palm in Masirei and South Waropen Districts, the regency of Waropen, Papua. The potential sago forest for the commercial use in these two districts is found in the vicinity of Ruambak River and Botawa, covers an area of approximately 50,316.63 Ha. There are three different local names for sago palm, known as: May (spiny), Umbeni (spineless) and Ndosa (spiny), the later is recognized as Sakambai when it is cultivated. The results showed that there were four growing phases of sago palm and the composition of sago palm in one hectare based on their phase is consisted of ± 46,818 seedlings, 172.73 saplings, 90.91 poles and 125 trees. The amount of cluster per hectare is 125 and the amount of plants based on their phase per cluster is consisted of 1-2 seedlings, 0-3 saplings, 0-2 poles and 1-2 trees. The number of sago palm for each cluster based on their phase is in the range of an ideal growing condition. The dry sago starch production per trunk is 74.24 – 400.67 kg (the average of 222,9 kg) and for one hectare is 5.18 – 27.25 tonnes.

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