European Journal of Scientific Research
ISSN 1450-216X / 1450-202X Vol. 120 No. 2 March, 2014, pp. 221-229
http://www.europeanjournalofscientificresearch.com

Brief Description of Aspects of Biology, Ecology, Agronomy, and Prospects for Development of Sago Palm

Barahima Abbas
Corresponding Author, Faculty of Agriculture and Technology
The State University of Papua (UNIPA), Manokwari, Indonesia
e-mail: barahimabas@gmail.com
Tel:+62 852 4469 6549, Fax: +62 896 212095

Abdul Wahid Rauf
Assesment Institut for Agriculture Technology, West Papua, Indonesia

Florentina Heningtyas Listyorini
Faculty of Agriculture and Technology
The State University of Papua (UNIPA), Manokwari, Indonesia

Munarti
Faculty of teachers training and educational Sciences
The Pakuan University, Bogor, Indonesia

Abstract

Indonesia is rich of sago palm germplasm, and has the most extensive of sago palm forest and sago palm semi cultivated in the world. Potential resources owned of sago palm need to be explored and fully utilized for the welfare of the community. Resource utilization of sago palm need to be done wisely and sustainably, so that its benefits can be felt on an ongoing basis. Collection of genetic resources of sago palm needs to be done before expriencing degradation. Data base aspects of agrotechnology, eco-physiology, harvest processing, utilization, and starch processing need to be raised through an intensive research, so that the investor will be inspired to invest their finance in the commodity of sago palm.

Keywords: Sago palm, distribution, taxonomy, utilization, cultication

Introduction

Sago palm (Metroxylon sagu Rottb.) is a plant that potential resulting large amount of carbohydrate, otherwise that have not been cultivated optimally. Carbohydrate produced by the sago palm can be used as: a staple food, ethanol (Pranamuda, et al., 1995), cyclodextrin (Solichien, 1995), as well as mixture of materials for the manufacture of pulp and paper (Kasim et al., 1995). Sago palm produce more carbohydrates than rice, maize, cassava, sweet potato, and potato. The ability of sago palm to accumulate starch in its trunk can reach 200 to 220 kg palm^{-1} (Jong, 1995). Production of dry starch from sago palm in Maluku can reach 345 kg palm^{-1} (Bintoro, 1999).

Sago palm plantation in Indonesia that is professionally managed has not been established yet. Indonesian government and Indonesian businessmen have not seen huge gains that can be obtained from sago palm, so there is not much sago palm plantation are managed by the government and businessmen in Indonesia. This article tries to peel the potential and several aspects for development of sago palm, so that the government and businessmen will be inspired to invest their finance on sago palm commudity, so there is no shortage sources of carbohydrates in the future.

Research Methods

Research is done by using observation technique and literature study. The data collected is qualitative data and quantitative data. Morphological appearance recorded by using a digital camera. Measurement data directly in the field and data from the literature is presented in the form of qualitatives and quantitatives.

The Results

1. Distribution of Sago Palm

Sago palm found growing in the countries of Southeast Asia, Oceania, and the Pacific Islands at latitude 10^o South and 10^o North (Ishizuka et al. 1996), longitude 90^o to 180^o east, and altitude up to 1000 meters above sea level (Bintoro, 1999). Sago palm forest and sago palm semi cultivated is found in Papua areas as well as Ambon and Seram. Schuiling (1995) reveals the diversity center of sago palm found in the Moluccas and New Guinea. Flach (1997) reported that New Guinea (Papua-Indonesia and New Guinea) as a center of diversity of Metroxylon sagu Rottb. McClatchey et al. (2005) believe that M. sagu Rottb. endemic in Papua-Indonesia, New Guinea, New Britain, and the islands of the Moluccas.

Metrxylon sp found widespread in Southeast Asia, Melanesia, and some islands in Micronesia and Polynesia (McClatchey et al., 2005). Based on the available data indicate that about 2,250,000 hectares of sago palm forest and 224,000 hectares of sago palm plantations are available in the world. Estimation 1.25 million hectares of sago forest and 148,000 hectares of sago palm plantations located in Indonesia. Papua Province and West Papua province of Indonesia is estimated that there are 1.2 million hectares of sago palm forest and 14,000 hectares of sago palm plantations (Flach, 1997). Distribution of sago palm area in Indonesia is uneven. Papua Island, Indonesia territorial has the largest sago palm areas compared with other islands in Indonesia (Table 1). The data in Table 1 reveals that 92% of sago palm area is located on the island of Papua and 8% of sago palm area is in the other islands in Indonesia.

Table 1: Distribution of Sago Palm Vegetation in Indonesia

Ilands	Location of sago palm	Numbers of areas (hectares)
Papua	Jayapura	36.670
	Merauke	342.273
	Mamberamo	21.537
	Sarmi, Waropen dan Biak	25.133
	Pulau Salawati	6.137
	Bintuni, Manokwari	86.237
	Inanwatan, Sorong	498.642
	Fak-Fak	389.840
	Sub Total	**1.406.469**
Maluku	Seram	19.494
	Halmahera	9.610
	Bacan	2.235
	Buru	848
	Aru Iland	9.762
	Sub Total	**41.949**
Sulawesi	South Sulawesi	8.159
	Central Sulawesi	13.981
	Nort Sulawesi	23.40
	Sub Total	**45.540**
Kalimantan	West to South-East Kalimantan	2.795
Jawa	West Jawa	292
Sumatera	Indragiri, Bengkalis, Riau Kepulauan, and Riau Province	2.795
Total:		**1.528.917**

Source: Kertopermono, 1996

2. Taxonomy of Sago Palm

Sago palm classification base on database plant of natural resources conservation service (USDA, 2005) as follows: Kingdom is Plantae–plants, Subkingdom is Tracheobionta–vascular's plants, Superdivision is Spermatophyta–seed plants, Division is Magnoliophyta–flowering plants, Class is Liliopsida–monocotyledons, Subclass is Arecidae, Order is Arecales, Family is Arecaceae–Palm), Genus is Metroxylon Rottb., and Species is Metroxylon sagu Rottb. – sago palm).

Description of Metroxylon genus was first proposed by Beccari in 1918, then Rauwerdink 1986, and the latter by McClatchey et al. (2005) which revealed that the description of the genus Metroxylon consists of six species namely: M. amicarum (H. Wendland) Beccari, M. paulcoxii McClatchey, M. sagu Rottboell, M. salomonense (Warburg) Beccari, M. vitiense (H. Wendland) H. Wendland ex Bentham & Hooker f., and M. warburgii (Heim) Beccari.

3. Characteristics of Sago Palm

Plants with the name of sago palm are called Metroxylon sagu Rottb. Metroxylon name comes from two words namely the Metra means pith or parenchyma and xylon means xylem, while sagu is a starch. Metroxylon sagu means that plants accumulated starch in its trunk. Sago palms are flowering plants that hapaxanthic, means just once flowering in its life cycle and soboliferous, means resulting suckers in the lowest part of the trunk (Flach, 1997). The life cycle of sago palm from seeds to form a seed estimated time for a period of 11 years in four stages, namely rossette stage, trunks stages, inflorescence phase, and fruits formation stages. Rossette of the two types of sago palm those are spineless and spiny in the Figure 1A and 1B required by time 3.75 years, the formation of trunks of various type of sago palm in the Figure 2 estimated time for 4.5 years, inflorescence take time for one year, and fruits formation necessary time two year (Flach, 2005). Morphological characteristics of sago palm are presented in Table 2.

4. Habitat of Sago Palm

Sago palms are found growing naturally and semi cultivated in Maluku and Papua. Best sago palm growth at an altitude of 0 to 400 meters above sea level, being at an altitude of over 400 meters above sea level its stunted growth and low production (Bintoro, 1999). Sago palm has the ability to grow with little care or no maintenance and has the ability to grow in wetlands with pH 3.7 to 6.5 (Harsanto, 1986). Sago palms grow well in average temperature above 25°C with an average humidity of above 70 % and solar radiation 800 J cm^{-2} $hari^{-1}$ (Flach, 1997). Sago palm forest in Waropen has rainfall of 2000 mm $year^{-1}$ and sago palm forest in Sorong has rainfall 4365 mm $year^{-1}$ (Istalaksana et al., 2005).

Sago palms can grow in marsh land, peats land and minerals land. Habitats of sago palm in Jayapura are dry lands, wetlands and very wet lands (Mofu et al., 2005). Naturally, sago palm found growing in swampy areas. Kertopermono (1996) estimate of 37 to 40 million hectares of wet land in Indonesia, approximately 700,000 to 1,500,000 ha covered by sago palm. Growth and production of sago palm on soil minerals, peat lands and marsh lands showed that sago palm on mineral soils is grow faster and produce more starch than sago palm that grow in peat lands or marsh lands (Benito et al . 2002). Dry starch production of sago palm in Maluku is reach 345 kg $tree^{-1}$ on the tropaquept soil and is only reaches 153 kg $tree^{-1}$ on the sulfic flufaquent soil (Bintoro, 1999). Istalaksana et al. (2005) found that sago palm forest in Waropen, Serui growing in soil Endoaquepets (mineral soil) and Haplofibrists (peat land).

Table 2: Morphological Characteristic of Sago Palm

Organ	Parts of organ	Numbers	Characters	References
Canopy	Frond (petiole)	6 to 24	Pinnate leaves	Flach, 1997
	Length of frond (m)	5 to 8		and Observe
	leaflet per frond	100 to 190		by Authors
	Total Frond	168		
Inflorescence				
	Branch of the main axis	15 to 25	The times of flowers	Jong, 1995
	Branch of the second axis	15 to 22	bloom for females	and Observe
	Branch of the third axis		and males are not	by Authors
	Stamen per flower	7 to 10	the same	
	Ovule in ovary	6		
		3		
Fruits	Fruits formation (Month)	19 to 23	Scaly	Jong, 1995
	Numbers of fruits	2174 to 6675		
	Diameter (cm)	35 to 60		
Trunks	Trunk Formation (Month)	54	elliptic	Flach, 2005
	Epidermal tick (cm)	1 to 3	log	
	Pith diameter (cm)	30 to 55	Hards	Observe by
			soft (sites of starch accumulation)	authors
Roots	Main roots (diameter)	6 to 11 mm	Attach to the epidermal	Nitta *et al*., 2002
	Secondary roots (diameter)	4 to 6 mm	Attach to main root, grow laterally	
Spine	Spinless	No spine	all stages of growth In russet stage only	Observed by authors
	Short spine	2 to 5 cm	In all stages	
	Long spine	5 to 9 cm	Red-purple and Pale-green	
Leaves	Spear	2 types	Green	
	leaflet	1 type		

Photograft of sago palm canopy (Fig. 3A), inflorescence stages (Fig. 3B), Fruits ripening stages (Fig. 4A) vertical section of fruits (Fig. 4B)

Figure 1: Appearance of sago palm growth at the time of russet stage. Spineless type (1A) and spiny type (1B).

Figure 2: Morphological appearance of sago palm in the trunk stage. Spineless (2A), short spines (2B), and long spines (2C).

Figure 3: Appearance of sago palm canopy at the end of the growth stage of the trunk (3A) and the flowering stage (3B)

Figure 4: Appearance of fruits maturity of sago palm (4A), vertical section of sago palm fruit (4B).

5. Cultivation of Sago Palm

Cultivation generally includes the selection of plant material, nursery, land preparation, planting, maintenance, and eradication of pests and diseases. The selection of plant material for cultivating of sago palm generally use suckers as plant material (Schuiling, 1995) with consideration has the same characters as its parent. Seedlings from seeds are taked a relatively long time for its germination and growing. Seed germination takes between 35 to 80 days (Ehara et al., 2001). Aspects of sago palm cultivation are presented in Table 3.

Table 3: Aspects of Sago Palm Cultivation

Cultivation aspects	Types	Requirement	Condition	References
Preparation material for seedlings	Suckers	Weight 2 kg Acompany with rhizome	healty at least 5 cm of rhizome	Jong 1995 and Observe by authors
	Seeds	Physiological maturity	no defects	
	Tissue culture	Growing points	meristematic	Observe by authors
Nursery	Floating on the water	the hump side into the water	Good sirculation water	Flach 1997
	Polybag	40 x 40 cm	4 Month shading and 4 Month no shading	Observe by authors
Areals for planting	Land clearing	No trees and bush	Triangular	Bintoro 1999
	Planting distance (meter)	(6 x 6) to (10 x 10)		
	Planting hole (cm)	40 x 40 x 30		
Maintanance	Weeding	circumference of clumps	If needs	
	Suckers elimanation	remaining 4 suckers in different positions	Healty and fertile	Bintoro 1997
	Fertilization	Based on soil condition	Peat land needs kalium and	Flach 1997
	Pest (*)	Based on attack condition	phospor fertilizer Seriously Attack	Flach 1997
	Disease	Micro organism	Not reported	Flach 1997
		Phyisiologis	Yellow spot of leaves, smaller sizes of hump, and numbers of leaves slightly	Flach 1997
Harvesting	Based on sago palm types	Maximum development of the trunk and entering to the inflorescence stage	Frond become smaller and shorter to fully develop of the the flower	Jong 1995 and also observe by authors

Notes(*): Pests that found attack of sago palm are *Botronyopa* spp, *Coptotermes* spp, *Rhynchophoprus* spp, wild boar and monkeys

6. Utilization of Sago Palm

Sago palm starch can be used as food ingredients, non-food, hydrolysis, and industry fermentation (Jong, 2005). Community in Papua and Maluku using sago starch as a staple food. Sago palm starch and other parts of sago palm can be used as raw material for various purposes (Table 4).

Table 4: Benefits of Starch and Other Parts of Sago Palm

Type	Processing	Utility	References
Starch of sago palm	Conventional	Staple food, Traditional snack (Bagea, Cendol, Sinole, Pappeda, Sago lempeng, sugar sago, Sago Asar, and Sagu tumbuk)	Flach 1997 Rusliana 1979
	Modern technology	instant's noodles noodles Alcohol Etanol Cyclodextrin Biodegredable plastic Glucose syrup Cake, bread, and pizza	Haryadi 2005 Suryani and Haryadi 1998 Haska 1995 Pranamuda *et al.* 1995 Solichien 1995 Okasaki *et al.* 2005 Sarungallo and Murtiningrum 2005 Obeserve by Authors
Frond and epidermal	Modern technology	Pulp for paper	Castrate *et al* . 1995
Extraction dregs	Semi modern technology	Compost Growing media of Mushrooms Bioherbisida Biogas*	Rumawas *et al* . 1996 Abbas et al., 2011 Utami et al. 2005 Doelle 1998
Upper pith	Conventional	Animal feed Sago caterpiras	Nggobe 2005
	Conventional	Tall protein source	Flach 1997

Notes: * 1 m^3 extraction dregs can be resulting 1 m^3 biogas that contains 70% methane and 30% CO_2

7. Potency of Sago Palm

Advantages of sago palm development based on an agronomy aspect in terms of: (a) can grow in swamps and peat areas (Watanabe, 1986) which generally crops can not be grown, (b) tolerant to low pH, and high concentrations of Al, Fe, and Mn (Tan, 1982), (c) can be harvested at any time after reaching the age of about 8 to 11 years, (d) can be harvested continuously without renewing planting as a resulting of many suckers (Watanabe, 1986), (e) have the ability to produce high starch, and (f) are not required intensive maintenance as well as other crops and vegetables.

The potential of sago palm resulting starch can reach 200-220 kg $tree^{-1}$ (Jong, 1995). Dry starch production of sago palm in Maluku reach 345 kg $tree^{-1}$ (Bintoro, 1999). When the spacing of 9 m x 9 m then there are 123 trees ha^{-1}, so if calculated the amount of sago starch obtained 42 tons per hectare (ha) after a period of eight to eleventh years which will further generated 42 tons ha^{-1} $year^{-1}$, assuming that only one tree can be harvested per clump per year.

It is remarkable potential of sago palm as a producer of high carbohydrate which has excluded or not been explored and cultivated optimally. Indonesia estimated has 21.3 million ha of peatlands, if 20% of that peatlands suitable for cultivating sago palms will resulting 176,400 tons of sago starch after a period of eight years and beyond will produce 176,400 tons year^{-1} continously. Jong (2005) predicts sago starch price of USA$ 200 ton^{-1}. If the starch production of 176,400 tons is sold USA$, it will obtain the money as much as USA $ 35,280,000 year^{-1} (thirty-five million two hundred eighty thousan dollars per year).

Conclusions

Based on direct observation in the field and literature studies that have been done can be concluded that: 1) Indonesia is rich of sago palm germplasm, and has the most extensive areas of sago palm forest and sago palm semi-cultivation in the world; 2) Potential resources owned of sago palm need to be explored and fully utilized for the welfare of the community; 3) Utilization of sago palm resources need to be done wisely and sustainably, so that its benefits can be felt on an ongoing basis; 4) Collection of sago palm genetic resources needs to be done before experiencing degradation; 5) Data base aspects of agro-technology, eco-physiology, and agronomy needs to be raised through an intensive research, so that the infestor inspired to invest their finanance in commodities of sago palm.

Acknowledgements

Thanks go to the project managers of MP3EI number 286/SP2H/PL/DitLitabmas/VII/2013 of DIPA DP2M DGHE Fiscal Year 2014 for providing and supporting the research funding, so that this script can be realized as it should. A big thank you is also extended to all those who are involved in this study.

References

[1] Benito, H.P., K. Kakuda, H. Ando, J.H. Shoon, Y. Yamamoto, A. Watanabe, and T. Yoshida. 2002. Nutrient availability and response of sago palm (*Metroxylon sagu* Rottb.) to control release N fertilizer on coastal lowland peat in the tropics. Soil Science Plant Nutrition 48(4): 529-537.

[2] Bintoro, M.H.D. 1999. Empowerment of sago palm as a producer of alternative food and raw material potential of agro-industry in order to increase national food security. Oral presentation of scientific papers to be remain professor in the field of crops plantation. Faculty of Agriculture, Bogor Agricultural University. 70p. (in Indonesian language)

[3] Doelle, H.W. 1998. Socio-economic microbial process strategies for a sustainable development using environmentally clean technologies: sago palm a renewable resource. Mircen-Biotechnology Brisbane and Pacific Regional Network.

[4] Ehara H, Morita O, Komada C, and Goto M. 2001. Effect of physical treatment and presence of the pericarp and sarcotesta on seed germination in sago palm (*Metroxylon sagu* Rottb.). Seed Sci and technol. 29:83-90.

[5] Flach, M. 1997. Sago palm *Metroxylon sagu* Rottb. Promoting the conservation and use of underutilized and neglected crops. IPGRI. 76p.

[6] Flach, M. 2005. A simple growth model for sago palm cv. Molat-Ambutrub and its implications for cultivation. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[7] Haryadi. 2005. Potential used of sago starch for instant noodle production. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[8] Haska, N. 1995. Alcohol production from sago starch granules by simultaneous hydrolyzation and fermentation using a raw starch digesting enzyme from *Aspergillus* Sp. No. 47 and *Saccharomyces cereviceae* No. 32. ISHS Acta Horticultura. International Sago Symposium. http://www.actahort.org/books/ 389/V. International sago Symposium.

[9] Ishizuka, K., S. Hisajima, and D.R.J. Macer. 1996. Traditional technology for environmental conservation and sustainable development in the Asian- Pacific Region. Proceedings of UNESCO. University of Tsukuba, Japan.

[10] Istalaksana, P., A. Rochani, Y. Gandhi, P. Hadi, Suprihadi, and Nurwidianto. 2005. Conversion of the natural sago forest to the sustainable sago palm plantation at Masirei district, Waropen, Papua, Indonesia: Feasibility study. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[11] Jong, F.S. 1995. Research for the development of sago palm (*Metroxylon sagu* Rottb.) cultivation in Sarawak, Malaysia. Dept. Agriculture, Kuching, Sarawak, Malaysia. 139p

[12] Jong, F.S. 2005. A crucial need to expedite the commercial development of the sago industry. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[13] Kasim, J., P.M.D Tahir, H. Shari, and T. William. 1995. Soda anthraquinone pulping of sago palm (*Metroxylon sagu* Rotb.) Fronds. ISHS Acta Horticulturae. http:/www.actahort.org/ books/389/389-16.htm.

[14] Kertopermono, A.P. 1996. Inventory and evaluation of sago palm (*Metroxylon* Sp) distribution. Sixt International Sago Symposium. Pekan Baru 9 – 12 Desember 1996. 59-68.

[15] McClatchey, W., H.I. Manner, and C.R. Elevitch. 2005. *Metroxylon amicarum*, *M. paulcoxii*, *M. sagu*, *M. salomonense*, *M. vitiense*, and *M. warburgii* (sago palm). Species Profiles for Pacific Island Agroforestry. www.traditionaltree. Org. Diakses pada bulan Januari 2006

[16] Mofu, W.Y, J. Rahawarin, and Soenarto. 2005. The growth of sago palm in Kaureh District, Jayapura, Papua. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[17] Nggobe, M. 2005. The utilizing by product of sago as feed for poultry in Papua. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[18] Nitta, Y., Y. Goto, K. Kakuda, H. Ehara, H. Ando, T. Yoshida, Y. Yamamoto, T. Matsuda, F.S. Jong, and A.H. Hassan. 2002. Morphological and anatomical observation of adventitious and lateral roots of sago palms. Plant Production Science 5(2):139-145.

[19] Okasaki, M., S. Tadenuma, and M. Ohmi. 2005. Diverse utilization and industrial development of sago biomass. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science

[20] Pranamuda, H., T. Kamogawa, T. Ozawa, and H. Tanaka. 1995. Ethanol production from raw sago starch under un sterile condition. http:/www.actahort.org/ books/ 389/389-15.htm.

[21] Rumawas, F., A. Astono, S.A. Azis, and R.E. Ririhena. 1996. Utilizing sago press cake as compost. Sixt International Sago Symposium 165-169.

[22] Rusliana L. 1979. Sago as a food source. Indonesian Forestry 6:12-14 (in Indonesian language)

[23] Sarungallo, Z.L. and Murtiningrum. 2005. Production and characterization of glucose syrup of Papua sago starch. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[24] Schuiling, D.L. 1995. The variability of the sago palm and the need and possibilities for its conservation. ISHS Acta Horticulturae http://www. actahort.org/books/389.

[25] Solichien, B. 1995. Sago starch as a substract for cyclodextrin production. ISHS Acta Horticulturae. http:/ www.actahort.org/books/389/389-12.htm.

[26] Suryani, C.L dan Haryadi 1998. Whitening and crosslinking of sago starch and its use for material substitution in the manufacture of bihun. Agritech 18(4):20-23. (in Indonesian language)

[27] Tan, H,T. 1982. Sago palm review. Tropical Agriculture 8(9): 9-23.

[28] USDA. 2005. *Metroxylon sagu* Rottb. sago palm. Natural resources conservation service http://plants.usda.gov:8080/plants//nameSearch?keywordquery=met-roxylon+ sagu&mode=sciname. Assessed in Januari 2006.

[29] Utami, K.A, M.H.D. Bintoro, Hariyadi, M. Syakir, Y. Yamamoto, H. Ehara, and K. Saitoh. 2005. The used of sago (*Metroxylon sagu* Rottb.) waste one month decomposition for controlling *Mikania micrantha* HBK. Abstracts of The Eight International Sago Symposium in Jayapura, Indonesia. Japan Society for the Promotion Science.

[30] Watanabe, H. 1986. A view on density management of sago palm in Batu Pahat, Malaysia. p71-74. *In* N. Yamada *et al.* (eds.) Sago. Sago Symposium Tokyo, Japan. May 20-23, 1985.