The Diversity and Cultivation System of Saccharum edule L. and Its Role As an Edible Plant Source in Papua, Indonesia

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The Diversity and Cultivation System of *Saccharum edule* L. and Its Role As an Edible Plant Source in Papua, Indonesia

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Abstract

Papua is a home to diversity of plant species that have not been exploited and scientifically studied for their potential use. Papua is also considered as the primary center of *Saccharum* diversity. Among the *Saccharum* species that grows widely in Papua is *Saccharum edule*, which is still considered underutilized plant species. The inflorescence of *S. edule* is a delicacy for consumption for Papuan people. With the growing concerns about food production shortage, food security problem, limited supply, and the growing demand for *S. edule* in the local market, exploration and identification of this plant was conducted at the selected areas of Papua provinces, from June to September 2009. There were 77 accessions collected from Papua provinces. Some accessions produced greater protein content; while some others produced greater carbohydrate content than all other accessions. In the next trial, intercropping o *S. edule* and soybean, using a range of planting distances of *S. edule*, was carried from June to December 2010. It showed that *S. edule* with the planting distance of 200 cm x 200 cm produced better growth and yield, as shown by greater plant height, number of suckers, flower number and flower weight compared to 150 x 150 and 100 x 150 cm distances.

INTRODUCTON

Papua is a home to diversity of plant species that have not been exploited for their potential use. Among the food plant species that have not been scientifically studied is *Saccharum edule*, which is still classified as an underutilized plant species (Quartermain, 2006). *S. edule* is among the *Saccharum* species, which belongs to the same family as sugarcane (*Saccharum officinarum*). As it grows widely in the land of Papua including Papua New Guinea, Pacific islands, and Fiji, these areas are considered as the center of *Saccharum* diversity (Daniels and Roach, 1987). The genus *Saccharum* consists of six species *S. officinarum* L., *S. sinense* Roxb., *S. barberi* Jesw., *S. edule* Hassk., *S. robustum* Brandes and Jesw. *ex* Grassl and *S. spontaneum* L., of which the former four species are cultivated and the latter two species are wild (D'Hont *et al.*, 1998).

The local name for *Saccharum edule* in Papua is *sayur lilin*. It is also called *tebu terubuk* or *tebu terubus* in Indonesia. Whereas, it is called *duruka* or *fijian asparagus* in Fiji and *pitpit* in Papua New Guinea. *S. edule* has an aborted inflorescence enclosed inside the leaf sheaths that serve as an edible part for consumption (Glyn, 2004), and can be prepared in many ways (Mudaliar, 2007). In the highland areas of Papua, the leaves were used for thatching the traditional houses and floor base, while stem is used to make the traditional music instrument.

Saccharum edule had also been domesticated; however the production is generally in the hands of small subsistent farmers with no appropriate cultivation techniques. With

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future concern of food production shortage, food security problem, and limited supply and growing demand in the local market coupled with the increase of population and the decrease in land under cultivated, evaluation of underutilized crop such as *S. edule* is necessary. Added to the fact that food price has been continually increasing, the emphasis on food promotion and consumption should be based on traditional food crops.

The first exploration of *S. edule* in Papua was carried out by Widiastuti (2000), Karafir and Vokames (2003), however this only covered limited areas of Nimboran and Kemtuk districts of Papua. Widiastuti (2000) found 7 and 8 accessions of this plant in Kemtuk and Nimboran districts, respectively. It is believed that *S. edule* grow widely in Papua and its diversity needs to be preserved in order to support food security and the sustainability of biodiversity. Hence, maintaining the traditional food crop is important as many of them are coming to threat nowadays. Positive initiative should be revived to evaluate this crop not only as a promising food but also for cash income for the community.

Intercropping is a traditional farming practiced by Papuan from generation to generation. *S. edule* is commonly planted with root crops and various vegetables. However, the productivity is unstable and low due to several factors including inappropriate cultural practices. Farmers use inappropriate population density or irregular plant distances. As a consequence the plants usually suffer from poor growth and development and finally low yield.

Objective of the research was to identify *S. edule* based on morphological characters, analyze the nutrient contents of its edible inflorescence and conserve the collected plants. Research was also aimed to observe the appropriate plant distance of *S. edule* which might produce high inflorescence yield in intercropping system with soybean.

MATERIALS AND METHODS

Exploration was conducted in selected regencies of Papua, Indonesia, namely Manokwari, Yapen, Jayapura, Wamena, Fak-fak and Kaimana regencies, represented the lowland and highland areas. Study was carried out from June to September 2009. Sampling strategy in plant collection was based on the information of native people and village tribal chiefs, related to its abundance. Data were also supported by direct interview with the local people, the village chiefs, and staffs of the agricultural extension services. Interview was also conducted to obtain the information of *Saccharum's* local name and the local knowledge related to the use of *S. edule* by using the descriptive method.

Identification of *S. edule* covered the characters of morphology, inflorescence nutrient contents and supported by an agro-ecology of *S. edule*. Morphological and agronomical characters were recorded at the exploration sites, whereas analysis of the proximate and mineral contents was done for selected accessions using An Association of Official Analytical Chemist (AOAC; 1990) method and Vadanat–Molibdat method at the Agriculture Technology Laboratory, Papua State University.

Data of proximate and mineral elements were analyzed using tabulation method, whereas the diversity and genetic proximity of all accessions was examined using cluster analysis with the UPGMA method using NTSYS programs.

The collection of *S. edule* was conserved ex situ, by growing the plants (or keeping the seeds) at the Agriculture Faculty, Papua State University.

Intercropping Field Trial

A field trial was planted, where *S. edule* was intercropped with soybean with different *S. edule* planting distances (P1=100 x100 cm; P2=150 x150 cm; P3=200x200 cm). The experimental design was Randomized Complete Block Design with 4 replications. Data were collected on plant height, fresh weight, sucker number per plant, and weight of *S. edule* inflorescence. Data of seed weight per plant and per plot for soybean was also collected. The data were analyzed using analysis of variance. The Duncan's Multiple Range Test (DMRT) was used as the mean comparison among treatment means.

RESULTS AND DISCUSSION

The Diversity of Saccharum edule

S. edule grows widely from the lowland to highland with approximate height of 0 - 1750 m above sea level. The optimum temperature laid between 25 – 30 ^{0}C, with minimum and maximum temperature of 12 and 35 ^{0}C, respectively. The plants grow profusely under intense sunlight.

The diversity of plant characters was studied by clustering the plants, both within and between populations. Ranges of plant characteristics within population are unique among individuals present at the same population and at the same time, whereas character diversity between populations was presented among individual of different population (Mawikere, 2005). In this research, population of *S. edule* illustrate group of individual *S. edule* grown at the location, or at the same region and at the same time.

Based on the identification, the diversity of morphological characters was not only revealed at the individual among different regions (among population), but it was also observed in individuals at the same region (within population).

The cluster of 77 individuals of *S. edule* from 11 different locations is presented in the dendogram (Figure 1). Based on the similarity analysis, the lowest similarity of morphological characters accounted for 45 % which is appeared in two distinguished clusters : (1) Regions of Jayapura, Yapen and Manokwari, and part of Amban Pantai, and (2) regions of Wamena, Fak-fak, Kaimana, and Manokwari (Prafi, Mandopi, Saukori, Pami and a part of Amban Pantai). Each cluster generated sub clusters of population based on the same growth location. Individuals came from the same original growth location normally cluster in proximity or in a close distance. This cluster pattern suggests a closer genetic relation among population of similar areas compared to the different location. It means that each location had unique plant characters, and therefore 11 population of *S edule* were indigenous in each original location. This phenomenon supports the theory that the closer the geographical areas between two individuals or two population, the shorter the genetic distance between those two individuals and population.

The different characters of *S. edule* among regions were due most likely to the ecological and geographical isolation (ecogeographic). Ecogeographic isolation is induced by the external factors such as climate, water, soil and topography. This factors function as catalyst in inducing barrier for gene exchange among population, and hence each population in particular ecosystems provides unique characters in each region.

The individual of *S. edule* or in population that withstand due to the ecological isolation have specific habitat and specific environment. From this point of view, inherit population will not adaptive if it is grown at the different habitat from those of parent habitat. They will only grow at the similar parent habitat or in between habitat of both parents population (Grant, 1971). According to Paterson (1978), it is difficult to explain the relation between characters diversity due to geographical factors with different ecology. However because of the geographical isolation, many of the characters are well adapted and can be clearly described. Characters that cannot well adapt will be lost and perhaps are altered or modified with other relevant characters. When the characters are stable, it will be transferred to offspring, and creating new plant population in the region (Mawikere, 2005).

Different characters among individuals in one species apart from the environmental factors or geographical isolation are also induced by migration, mutation, and hybridization. The migration of individuals or plant population from one continent to other continents or from one region to other regions, and followed by geographical isolation and hybridization may result to the gene flow. Gene flow among plant population increases the consequences of evolution and also may increase the character diversity. These create new gene combination and raising the adaptability in location from one to other population (Nagi, 1997).

Based on the identification *S. edule*, the most noticeable diversity of morphological characters among regions or among population within a region in Papua and West Papua is plant number per cluster, plant height, stem color, internode length and flower color. Based on the geographical location, the pattern of population cluster could not isolate *S. edule* population collected from Papua and West Papua. This was indicated by the morphological character similarity among region (45%), which some of *S. edule* (accession GAM, GAKCM, GAH) collected from the site of Amban Pantai of Manokwari regency (West Papua province) were close to the population collected from Jayapura and Yapen regencies (Papua province). On the other hand, population of *S. edule* collected from Fak-fak, Kaimana and Manokwari regencies (Saukori, Mandopi, Pami, Prafi) of West Papua province were close to population from Wamena regency (Papua province). Papua and West Papua provinces, together with Papua New Guinea (PNG) is an island of New Guinea, and classified in the demarcation zone of East Melanesia. Plants in the similar demarcation zone tend to have similar characters (Mawikere *et al*., 2007).

The greatest similarity characters accounted for 88%, which appeared in 2 individuals of *S. edule*, collected from the same regions of LN-1 (Lismau Ngu-1) and LN-2 (Lismau-Ngu-2). Both individuals originated from Kali Tembakau, Prafi district of Manokwari regency (West Papua province). The characters similarity between both individuals showed similarity in nearly all observed morphological characters, and only 18 % of the characters were different between both individuals. The morphological characters that varied between those 2 individuals are stem color (yellowish brown and yellowish red), stem circle (6.5 cm and 8 cm), number of internode per plant (27 and 40), and internodes length per plant (7 cm and 5 cm).

The proximate and mineral composition of *S. edule* inflorescence varied among the accessions (Table 2 and 3). The values for moisture content ranged from 86.42 % - 89.41 %, which showed Yu Kefye having the highest value (89.41 %), maintaining all accessions more prone to deterioration since foods with high moisture content are easily rotten. Values of moisture of *S. edule* inflorescences confirmed with Mudaliar (1997) for water content of *S. edule* (89.3 %). The high ash content is a reflection of the mineral contents preserved in the food materials. Of all the inflorescence samples, accession of Yu Nggang had relatively highest ash content (1.91 %), followed by Yu Mencang (1.71 %). Crude fat ranged from 1.03 % - 1.91 %, while crude protein and carbohydrate contents ranged from 4.50 % - 7.23 % and 1.41 % – 6.06 %, respectively. Yu Kwam accession had the highest protein content (7.23 %) despite produced the lowest carbohydrate content (1.41 %), on the other hand Yu Mencang had the highest carbohydrate content (6.06 %) followed by Yu Ming (5.39 %).

Comparing with sweet potato tubers as main staple food for the indigenous Papuan, the edible part of *S. edule* produced greater protein and fat contents. Sweet potato fresh tubers normally contained 0.38 – 1.09 % of protein (Nuraeni, 2008) or 2.15 % based on the sweet potato nutrient fact reference and 0.77 – 0.94 % of fat content or 0.39 % based on the sweet potato nutrient fact reference. On the other hand, *S. edule* produced lower carbohydrate content (Table 1) compared to sweet potato (11.67 – 13.99 %) (Nuraeni, 2008) or 31.56 % based on the sweet potato nutrient fact reference.

Table 1 shows the mineral contents of *Saccharum edule*. The results of nutritionally valuable minerals shows that Yu Nggang produced the highest Mg content (97.10 ppm) and P content (0.34 %), whereas the lowest Mg and P content produced by Yu Ming (84.56 ppm) and Yu Mencang (0.19 %), however Yu Ming produced the greatest Fe content (20.29 %). Yu Brop followed by Yu Nggang produced the highest Zn content (16.91 ppm and 16.34 ppm, respectively). All accessions produced similar value of K content (0.03 %).

S. edule produced greater mineral of Mg, Fe and Zn than that of sweet potato tubers based on the sweet potato nutrient fact reference (33, 0.81, 0.40 mg, respectively). Therefore, this plant considered as a healthy source of delicate vegetable.

Intercropping *S.edule* with Soybean

Significant reduction in plant height was observed when plant spacing was reduced (Table 3). P3 produced taller plants, followed by P2 and P1, respectively. P3 also significantly produced greater biomass weight and number of plant suckers than P2 and P1. With increasing number of plants per unit area, interplant competition for soil and other resources and light increased. As a result, under shorter plant distance (higher population density) mutual shading increased, reducing biomass weight and restricted the growth of *S. edule* suckers.

Plant distance did not influence the number of flowers per plant but it affected the weight of inflorescence (Table 4). Increased plant density produced greater weight of inflorescence per plant. Plant density plays an important role in intercropping, because it is related to the light penetration into the canopy. Limited penetration of sunlight into the canopy might be one of the reasons for lower weight of inflorescence. This might due to the higher the population density, the greater the effect of shading in intercrop system, as observed by Hang *et al* (1984).

Different *S edule* plant spacing did not significantly influence seed weight of soybean per plant (Table 5); however there was a significant reduction in seed weight per plot area with increasing plant density of *S. edule*. With increased *S. edule* plant distance, population density of soybean increased, as there was interplant competition for light, water and nutrients resulted to decreased seed weight of soybean in close distance.

CONCLUSIONS

Saccharum edule grow widely both in the lowland and in the highland of Papua. At present there have been 77 *S. edule* accessions collected from the Papua and West Papua regions. Jayapura and Wamena are considered as the areas with the most *S. edule* diversity. The morphological characters that mostly present among regions or among population within region of Papua and West Papua are plant number per cluster, plant height, stem color, internode length and flower color.

Among all other accessions, Yu Nggang produced higher protein content and had the greatest P, Mg, Fe, Zn contents, whereas accession Yu Mencang and Yu Ming produced greater carbohydrate content than all other accessions. This indicates that the inflorescence of *S. edule* offer tremendous nutrition. Further research is needed to develop this plant, particularly in the cultivation and food processing techniques.

S. edule with the density of 200 cm x 200 cm produced highest plant weight, fresh biomass weight, number of sucker, flower number and weight under intercropping system with soybean. Soybean seed weight per plant and per plot area increased with decreasing population number or reducing plant density.

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and institutional policies in Papua New Guinea that directly or indirectly affect the use of currently underutilized species of crops for food and agriculture.

Tables

Table1. Proximate composition of *Saccharum edule* inflorescence.

Accession	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein (%)	Carbohydrate (%)
1. Yu Nggang	88.14	1.91	1.03	6.57	2.36
2. Yu Mru	89.34	1.72	1.27	4.63	3.04
3. Yu Kwam	88.63	1.51	1.22	7.23	1.41
4. Yu Ming	86.44	1.63	1.26	5.30	5.39
5. Yu Mencang	86.42	1.73	1.30	4.50	6.06
6. Yu Brop	89.10	1.58	1.35	5.46	2.54
7. Yu Krea	88.13	1.42	1.32	5.53	3.60
8. Yu Kefye	89.41	1.43	1.22	5.52	2.41

Table 2. Mineral composition of *Saccharum edule* inflorescence.

Accession	P (%)	K (%)	Mg (ppm)	Fe (ppm)	Zn (ppm)
1. Yu Nggang	0.34	0.03	97.10	19.72	16.34
2. Yu Mru	0.20	0.03	95.91	18.62	16.10
3. Yu Kwam	0.24	0.03	90.19	15.88	12.10
4. Yu Ming	0.22	0.03	84.56	20.29	12.56
5. Yu Mencang	0.19	0.03	87.89	16.00	10.51
6. Yu Brop	0.22	0.03	90.88	17.19	16.91
7. Yu Krea	0.24	0.03	94.56	18.77	16.14
8. Yu Kefye	0.21	0.03	87.61	17.70	14.59

Table 3. Plant height, fresh biomass weight and number of sucker per plant of *S. edule* intercropped with soybean under different *S. edule* plant distances

Treatment	Plant height (cm)	Biomass weight (gr)	Sucker number/plant
P1 (100 cm x 100 cm)	89,8 c	82,3 c	3,8bc
P2 (150 cm x 150 cm)	117,7ab	111,3b	4,5ab
P3 (200 cm x 200 cm)	130,1a	147,0a	5,0a
Monoculture	90,2	82,4	3,8

In a column, treatment means having a common letter are not significantly different by DMRT at α = 5%.

Table 4. Flower number and weight of *S. edule* intercropped with soybean under different *S. edule* plant distance

Treatment	Number of flower/plant	Weight of inflorescence/plant
P1 (100 cm x 100 cm)	3,3a	80,1b
P2 (150 cm x 150 cm)	3,3a	101,9b
P3 (200 cm x 200 cm)	3,8a	144,6a
Monoculture	3,4	90,2

In a column, treatment means having a common letter are not significantly different by DMRT at α = 5%.

Table 5. Yield component of soybean intercropped with *S edule* under different *S. edule* plant distances.

Treatment	Seed weight/plant	Seed weight /plot area
Intercropping		
P1 (100 cm x 100 cm)	26,3a	1012,8c
P2 (150 cm x 150 cm)	27,3a	1693,1b
P3 (200 cm x 200 cm)	27,3a	3028,9a
Monoculture	28,6	3328,0

In a column, treatment means having a common letter are not significantly different by DMRT at α = 5%.

Figures

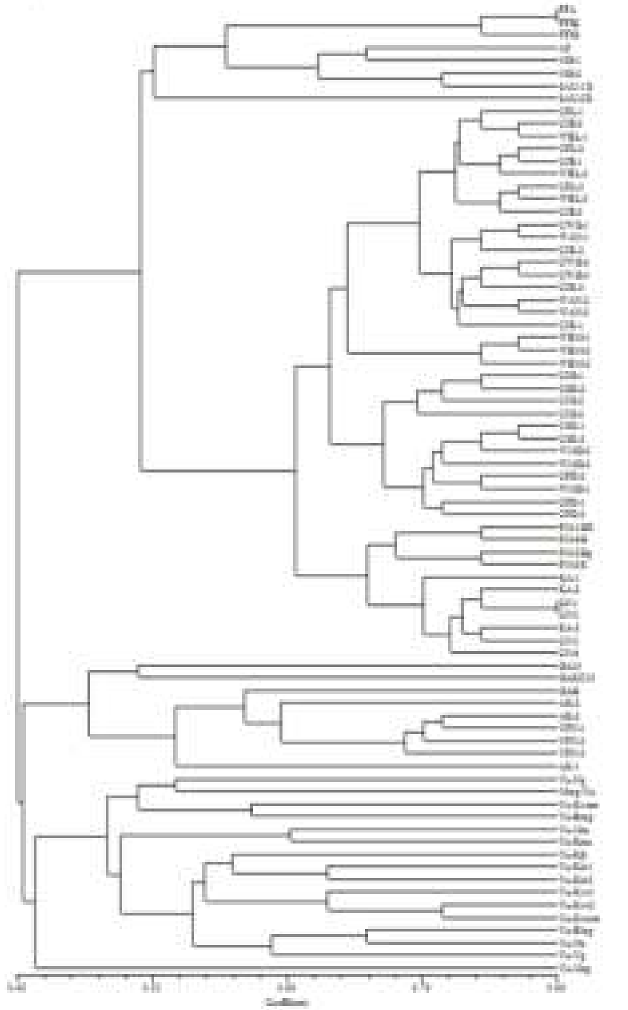

Figure 1. UPGMA dendogram of 77 accession of *Saccharum edule* grow at Papua regions.

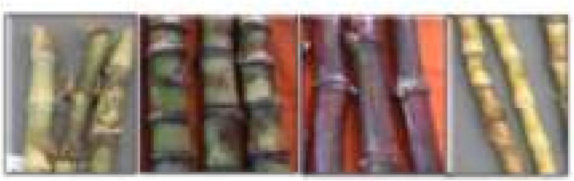

Figure 2. The diversity of *S. edule*'s stem color.

The Diversity and Cultivation System of Saccharum edule L. and Its Role As an Edible Plant Source in Papua, Indonesia

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