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Breaking Resistance of Sago Palm Leaflets

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Abstract: Sago palms (*Metroxylon sagu* Rottb.) are still abundantly present in Leyte and Cebu provinces in the Philippines and are being utilized in the production of flour/starch and thatches. This study tried to elucidate the breaking resistance of sago leaflets to determine the durability of leaflets for making thatches. The mean values of the maximum breaking resistance of the total number of sago leaflets (4 years after transplanting) with and without the main (central) vein (midrib) (n = 10) taken in 2009 were 513 ± 514 gf (gf = 0.00980865 N) and 18.4 ± 7.0 gf, respectively. The mean maximum breaking resistance of sago leaflets 5 years after transplanting showed higher values than those of sago leaflets 4 years after transplanting. The maximum breaking resistance of sago leaflets with and without the vein increased with increasing leaflet weight, suggesting that the main vein of the sago leaflet regulated its breaking resistance. The maximum breaking resistance of sago leaflets followed a polynomial approximation, which indicated the physical development of sago leaflets accompanied by maturation.

Key words: breaking resistance, durability, midrib, sago leaflet, thatch

Introduction

Almost all the biomass of the sago palm (*Metroxylon sagu* Rottb.) has been utilized by human beings, especially the sago leaf and leaflet, which are very useful for thatch (Kiew, 1980; Yamamoto, 1998; Toyoda, 2010). Flach and Schuiling (1991) showed that the sago leaf consisted of a rachis, petiole with leaflets, and sheath, of which surface areas reached 4 to 10 m^2 per leaf, depending on the sago variety. The sago leaflet ranged from 0.2 to 0.3 mm in thickness and a large amount of mesophyll cells, large vascular bundles and small vascular bundles between the epidermises (Yamamoto, 1998). In the cell biological study of Maeda (1986) using optical and electron microscopes, mesophylls and tannins were present in the sago leaf cells. Abe (1994) reported that the durability of sago leaflet was related to leaflet structure, which was comprised of a large earthen pipe-type mesophyll covered with fibrous materials. On the other hand, Goto and Nakamura (2004) suggested that aside from the sago leaf structure, the position and angle of leaflets were responsible for its durability.

In the Philippines, sago cultivation is supposed to spread out widely, but due to population pressure, most of the sago growing areas were converted to other crops, such as rice. Thatches made of sago leaflets could last for 5 to 9 years, while thatches made of nipa (*Nypa fruticans* Wurmb) could only last for 2 to 3 years.

Sago and nipa thatches are among the roofing materials used in rural areas of the Philippines. The survey in some places of Leyte and Cebu provinces revealed that the durability of sago and nipa shingles is partly due to the angle of inclination and distance between shingles (unpublished). The possible reasons why sago shingles lasted for 5 to 9 years were their resistance and thickness of folded leaflets (Okazaki et al., 2009, 2011; Quevedo et al., 2011). The correlation of loading resistance and breaking resistance of the rice plant has been studied (Sakata, 2005). Breaking resistance is one indicator of the durability of sago and nipa leaflets. However, there is no data on sago leaflet resistance ability against weather conditions (temperature, dryness, and so forth). The chemical quality of sago leaflets also has not yet been determined, especially nitrogen content, regulating the hardness of sago leaflets.

The objective of this study is to elucidate the theoretical basis for outgoing utilization of sago biomass and roofing materials for increasing the income of sago producers.

Materials and Methods

1. Preparation of sago palm leaflet samples

Sago leaflet samples were taken at the 5th leaflet from the basal portion of 5- and 6-year-old palms planted at the Pangasugan sago growing area of Visayas State University on Aug. 29, 2009, and Aug. 24, 2010. Nipa leaflet samples taken at the 5th leaflet from the basal position were collected as reference.

All samples stocked in the vinyl bag and kept in the refrigerator at 4 °C were brought to Japan and stored again in the refrigerator at 4 °C. All of the samples taken on Aug. 29, 2009, were air-dried. The air-dried samples were packed in paper bags, stored for 1 year at room temperature, and analyzed for breaking resistance. The samples with and without a midrib were snipped using a pair of scissors for determination of the maximum breaking resistance (Okazaki et al., 2010). These samples were stocked in paper bags before analysis. The mean total nitrogen content in sago leaflets (n = 27) taken in 2010 was 17.5 ± 0.27 g kg^{-1} DW. Sample preparation was done to make dumbbell and rectangular shapes using scissors in consideration of large and small vascular bundles to form the midrib (Fig. 1).

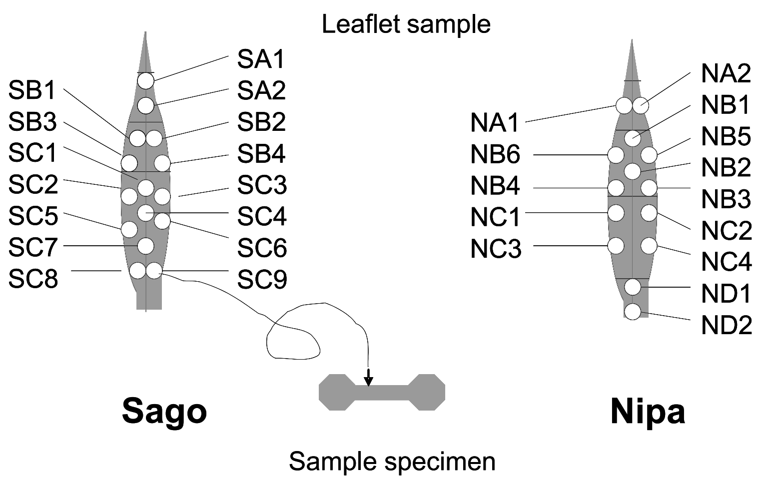

Fig. 1. Test piece of sago and nipa leaflet samples taken in 2009

2. Determination of maximum breaking resistance of leaflet samples

The sago leaflet samples with 60 mm in length and 10 mm in width were used for the determination of the breaking resistance (gf unit) by A & D Company Tensilon RTM-25 at a load speed of 100 mm min^{-1}, chart speed of 500 mm hr^{-1}, and a maximum load of 5 kg on Sep. 2, 2010 and Feb. 22, 2011 (Fig. 2). The breaking resistance determination of sago and nipa leaflet samples was carried out at least 10 in 2009 and 30 in 2010. Breaking resistance curve showed 2 peaks; elastic limit and maximum breaking resistance.

3. Determination of total nitrogen in leaflet samples

The sago leaflet samples were oven-dried in the ventilated oven-drying apparatus at 70 °C for 48 hours and ground using a mill (Retsch MM 301). About 5 mg of the samples was weighed in a small tin cup for the

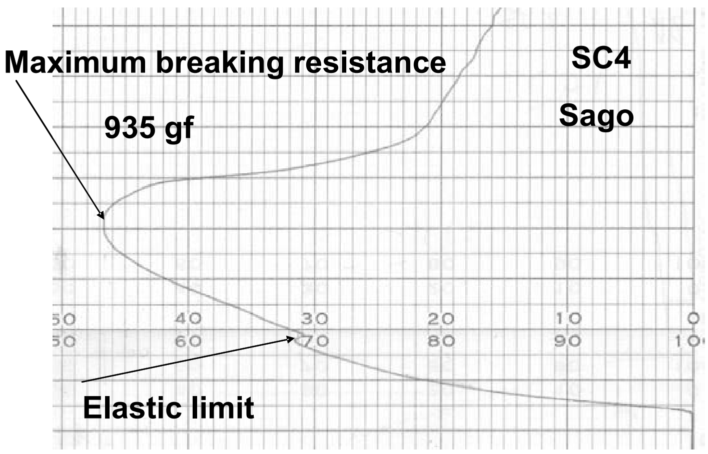

Fig. 2. Maximum breaking resistance of sago leaflet samples

determination of total carbon and nitrogen. The analysis of total carbon and nitrogen was performed by a carbon and nitrogen analyzer (Perkin Elmer 2400II CHNS/O analyzer) as a reference of cystine using an auto-sampler. The analytical condition for nitrogen was as follows: combustion column temperature, 950 °C; reduction column temperature, 640 °C; He as the carrier gas.

Results

1. Changes in breaking resistance with growth of sago palm

The mean maximum breaking resistance and standard deviation of the total number of sago leaflet samples with and without the main (central) vein (midrib) (n = 10), which were taken and determined in 2009, were 513 ± 514 gf (gf = 0.00980865 N) and 18.4 ± 7.0 gf, respectively (Figs. 3 and 4). The mean maximum breaking resistance and standard deviation of nipa leaflet samples with and without the midrib (n = 9), which were taken and determined in 2009, were 1060 ± 997 gf and 17.4 ± 20.6 gf, respectively (Figs. 3 and 4). These results indicated that the maximum breaking resistance of the nipa leaflets corresponded to that of the 5-year-old sago leaflets after transplanting of the suckers, even though these samples were stocked at room temperature. The sago

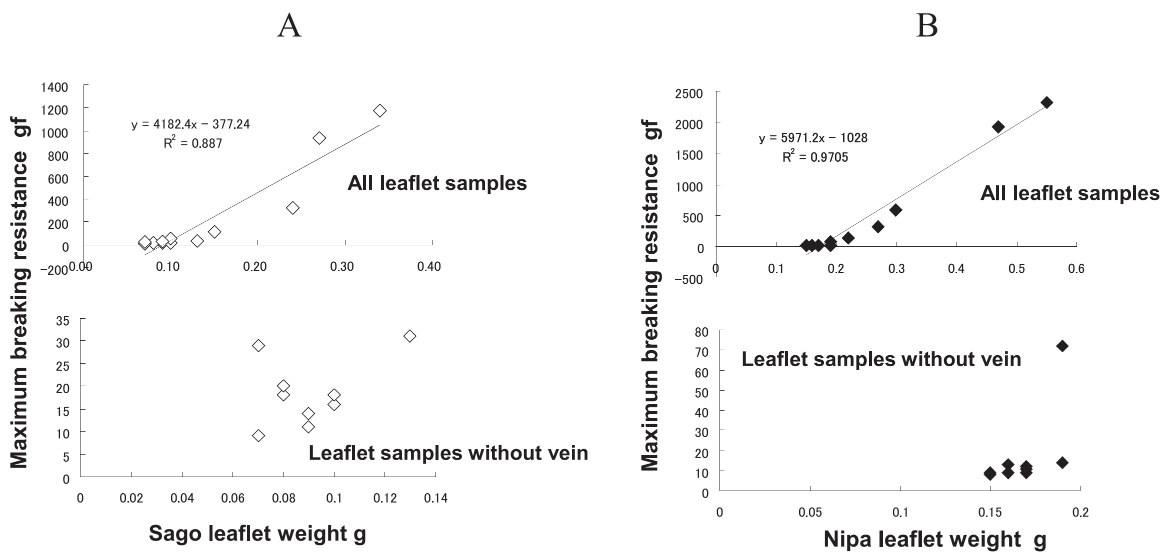

Fig. 3. Maximum breaking resistance of sago and nipa leaflet samples taken in 2009
A: Sago leaflet samples
B: Nipa leaflet samples

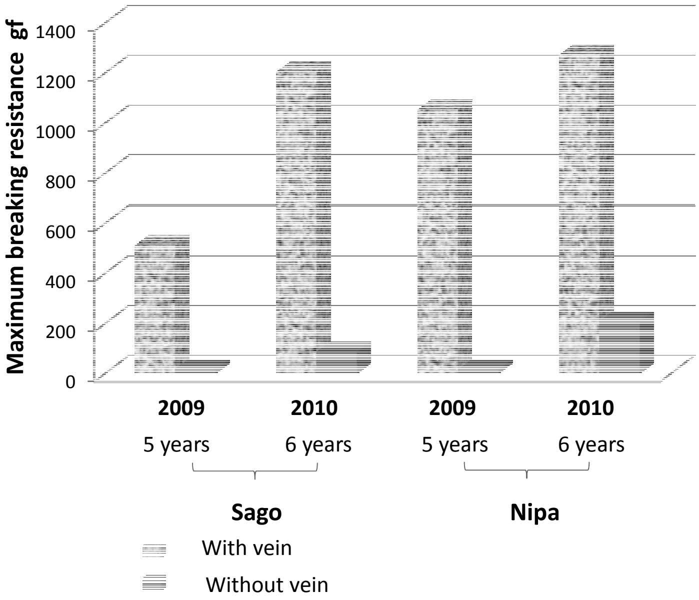

Fig. 4. Mean maximum breaking resistance of sago and nipa leaflet samples in 2009 and 2010 sampling dates

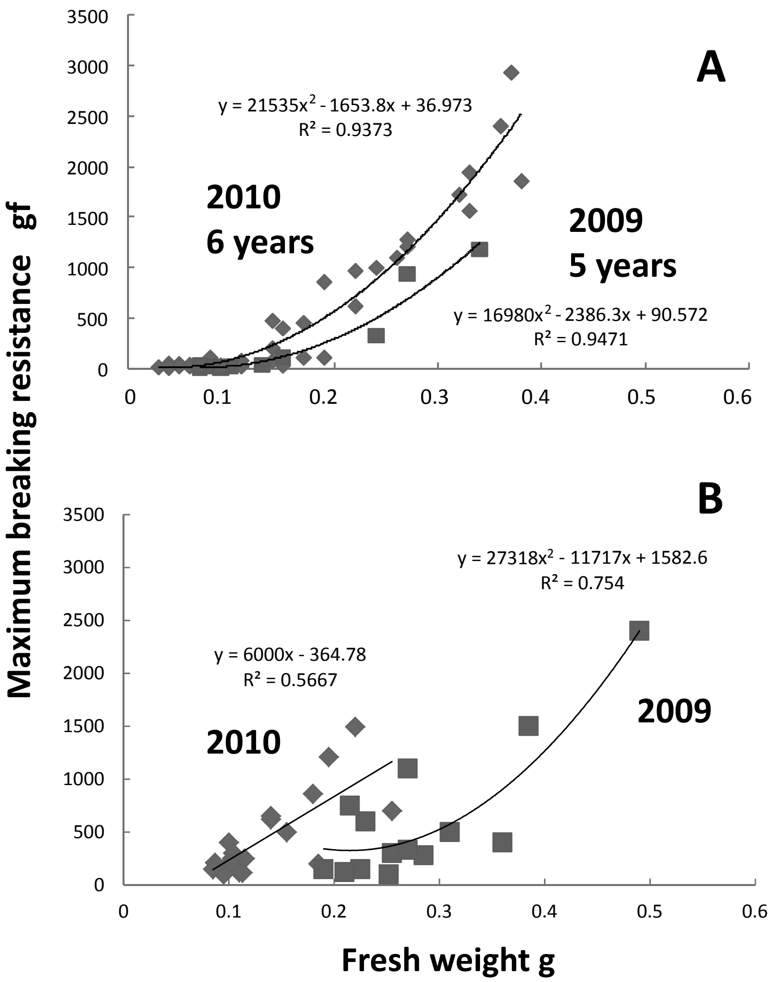

Fig. 5. Relationship between fresh weight and maximum breaking resistance of sago and nipa leaflet samples
A: Sago leaflet samples
B: Nipa leaflet samples

leaflet samples taken in 2010 showed larger maximum breaking resistance values (1210 ± 723 gf for leaflets with midrib and 87.1 ± 44.3 gf for leaflets without midrib) than those of the leaflet samples taken in 2009 (Fig. 5). The nipa samples (1270 ± 692 gf for leaflets with midrib and 210 ± 151 gf for leaflets without midrib) also showed larger values than those taken in 2009. No significant difference (Tukey-Kramer's HSD test at 95% level) in the mean maximum breaking resistance between sago and nipa leaflets was observed. The breaking resistance of sago leaflets with and without a midrib increased with increasing leaflet weight, suggesting that the midrib of the sago leaflet regulated its breaking resistance. The maximum breaking resistance of sago leaflets in 2009 and 2010 rapidly increased with a polynomial approximation, which indicated the physical development of sago leaflets that accompanied maturation. However, the significant difference (Tukey-Kramer's HSD test) between the mean maximum breaking resistance of sago leaflets sampled in 2009 and 2010 was not present. Air-drying for a year at room temperature increased the maximum breaking resistance of sago leaflets from 514 gf to 966 gf in the mean value.

2. Changes in breaking resistance with 1-year storage

After 1 year, the mean maximum breaking resistance of the sago leaflet samples stocked in the storage room at room temperature was 966 ± 828 gf and 28.8 ± 24.0 gf for the leaflets with and without the midrib for the sago palm and 937 ± 620 gf and 86.4 ± 54.3 gf for nipa leaflets, respectively (Fig. 6). The drying and hardening of sago leaflet samples gave rise to increments of breaking resistance, clearly for the samples with a midrib and slightly for the samples without a midrib.

From these results we can suggest that the breaking resistance of sago leaflets increased with increasing leaflet weight, which was regulated by the presence of a midrib in the leaflet. The leaflet samples of sago and nipa passed 1 and 2 years after sampling did not show a large difference in breaking resistance.

Conclusion

In spite of their differences in durability as roofing materials, there was no clear difference in the mean maximum breaking resistance between sago (5 and 6 years after transplanting) and nipa leaflets (with and without midrib) as determined by A & D Company Tensilon RTM-25. The maximum breaking resistance

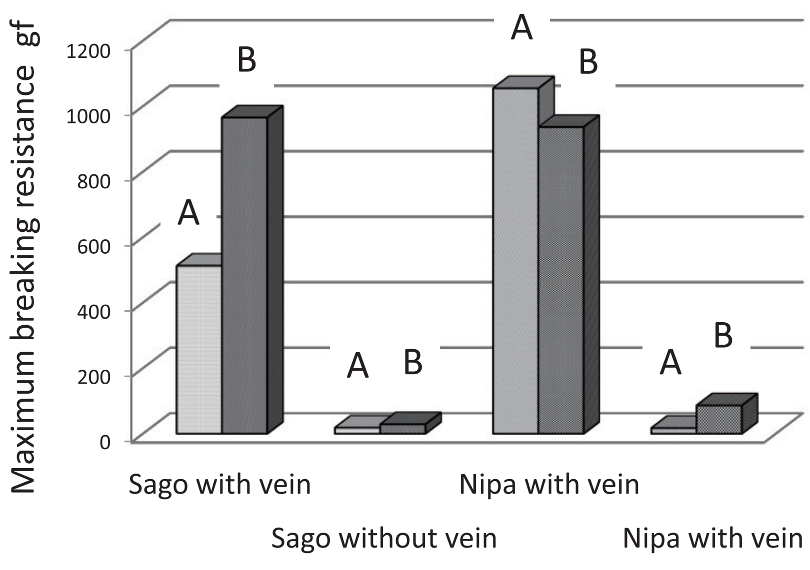

Fig. 6. Maximum breaking resistance of sago leaflet samples with and without a vein stored for 1 year at room temperature

of sago and nipa leaflets under field conditions should be determined.

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