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The diversity of utilizations, tapping flow discharge, and conservation of sugar palm (*Arenga longipes* Mogea) cultivated in Langkat, North Sumatra, Indonesia

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Abstract. *Fadhilla S, Hakim L, Agustian A, Lubis YS, Siregar AW. 2023. The diversity of utilizations, tapping flow discharge, and conservation of sugar palm (*Arenga longipes *Mogea) cultivated in Langkat, North Sumatra, Indonesia. Biodiversitas 24: 122-132.* Sugar palm (*Arenga longipes* Mogea) is one of the Non-Timber Forest Products (NTFPs) cultivated by the forest community in the village of Sei Limbat, Selesai Sub-district, Langkat District, North Sumatra. It is a plant with several benefits for economic development and a source of livelihood. Therefore, this research aims to determine the morphology of sugar palms through the identification of the species developed by the community, potential use, economic value, and tapping productivity. The morphological identification was used to determine the species of sugar palm developed by the community. The multiple utilization and economic values were identified and analyzed using the result of in-depth interviews through questionnaires. In this study, it was found that the diversity of uses of the palm plant included the utilization of palm sugar (consisting of large palm sugar, small palm sugar, liquid sugar and powdered sugar), utilization of black palm fiber, and conservation purposes. Based on the morphological identification, the species of sugar palm cultivated by the forest community was *Arenga longipes* Mogea. Furthermore, the tapping productivity was influenced by the panicle circumference, tree height, and flower height from the ground. The tapping productivity was calculated using daily production, which was correlated with sugar palm tree morphology. Based on the result, it can be concluded that the species identified is *A. longipes* which has a variety of uses and the tapping productivity was influenced by plant morphology.

Keywords: *Arenga longipes* Mogea, NTFPs, plant morphology, sugar palm, tapping productivity

INTRODUCTION

Several researchers have discovered that the largest sugar palm species is *A. pinnata* (Wurmb) Merr. According to Rinawati et al. (2021), *A. pinnata* has a genetic diversity derived from nine regions in Indonesia. A previous report by Mogea (2004) identified at least 4 new species of sugar palms (*Arenga* sp.), namely *A. distincta* Mogea, *A. longipes* Mogea, *A. plicata* Mogea, and *A. talamauensis* Mogea (Mogea 2004). This proves that the plant has a high diversity both by species and genetics. The sugar palm tree has also been reported for livelihood and biological conservation in the orangutan habitat (Martini et al. 2012), including some forest communities in North Sumatra. Meanwhile, the parts of the palm tree that can be used include the sap which is produced from cutting female flowers (*nira*), the fruit of sugar palm (*kolang-kaling*), and palm fibers or black fiber (*ijuk*). The sap produced from tapping is also used as raw material for making sugar and palm wine (Azhar et al. 2019) as well as a potential analgesic and anti-inflammatory agent (Sovia and Anggraeny 2019). Nuryawan et al. (2017) stated that the trunk of the sugar palm is feasible as raw material for the parquet (flooring). The other research described that the farmer's interaction with the environment, namely social and cultural aspects can influence their income (Mogea et al. 1991; Widayati et al. 2018). Therefore, the diversity of sugar palms can be in several forms, such as species, use, environment, and social community.

Although the people of Langkat District, North Sumatra Province, have been cultivating sugar palms, they have limited knowledge of the specific species that can be developed. Based on the diversity of species, the sugar palm plants cultivated in Indonesia vary according to location (Mogea 2004). Therefore, this research was carried out to identify the species of the sugar palm cultivated by the community in Langkat, through their morphological characteristics.

The different use of sugar palm parts is based on the morphological characteristics of the plant. Wardani et al. (2020) reported that morphological characteristics and productivity have a high diversity in a morphological variable. Furthermore, the tapping time, which is carried out twice daily, namely morning and afternoon has different productivity. Tapping is defined as a method of exploiting the sap of the sugar palm to be processed into several products such as bioethanol, sugar, and palm wine or consumed directly as a fresh drink. The morphological properties can be related to sap productivity. According to Nguyen et al. (2016), sap productivity is determined by the species and morphology of the plant, especially by the size of the stem and female flower stalks. It is also influenced by the reproductive features of the sugar palm (Ibrahim et al. 2018; Nirawati et al. 2020). In this research, sap productivity was calculated based on the approach to the flow discharge of saps tapping, which is defined as the amount of sap that flows per second expressed in liters.

Apart from the advantages in terms of ecology, as a non-timber forest product (NTFP), several products derived from sugar palm can generate economic benefits. In its development, different communities cultivate sugar palms using an agroforestry system. Azhar et al. (2021) described that the community around Batang Gadis National Park developed the plant by agroforestry system for economic purposes and to support conservation area.

Several investigations on sugar palm tree variability based on use have been reported (Azhar et al. 2019 and 2021; Gunawan et al. 2018; Komara and Kurniawan 2021; and Syahidah et al. 2021), but there is limited information on the relationships between sap productivity and tree morphology. *A. longipes* is the largest population cultivated in Langkat District, North Sumatra, Indonesia. Therefore, this research aims to identify the species of the sugar palm according to the determination key by Mogea (2004), and determine the morphology of the sugar palm tree cultivated in Langkat District, North Sumatra, Indonesia. The results are also expected to show the relationships between sap productivity and tree morphology of sugar palms.

MATERIALS AND METHODS

Study area

This research was carried out in Sei Limbat Village, Selesai Sub-district, Langkat District, Province of North Sumatra, Indonesia (Figure 1). Sei Limbat Village was selected due to several factors, one of which is that most people cultivate and use palm trees as their daily livelihood. Secondly, the species cultivated by the community is not known with certainty. Lastly, the location of the Sei Limbat is home to the industrial center for the development of sugar palm and fruit (*kolang-kaling*) in Langkat District, Province of North Sumatra.

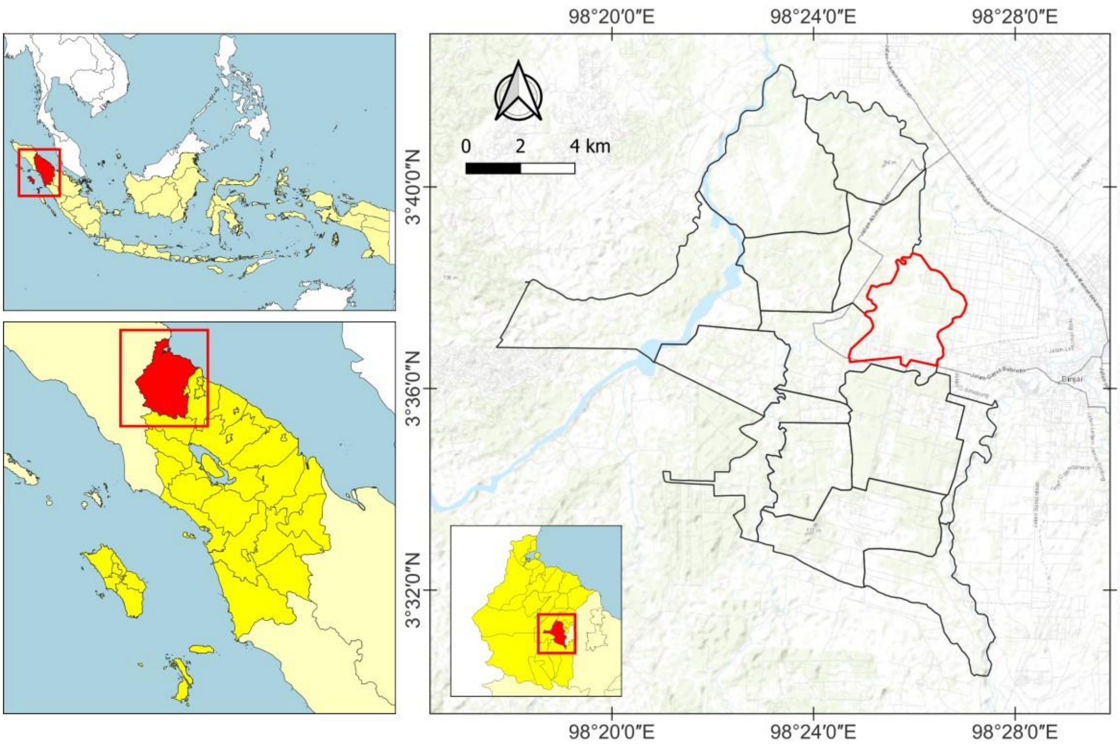

Figure 1. Study area in Sei Limbat Village, Selesai Sub-district, Langkat District, Province of North Sumatra, Indonesia

The Sei Limbat village has a total area of approximately 1012 hectares and is located 30 km from Medan, the capital of North Sumatra Province. To the north and south, the village is bordered by Mancang and Pekan Selesai Villages, respectively. Meanwhile, to the east and west, it is bordered by Suka Maju and Pekan Selesai Villages, respectively. The altitude is 30 m above sea level and has an annual rainfall of about 3560 mm/year (BPS, 2020). The topography is flat to hilly, with the land use dominated by a residential area, paddy field, oil palm plantation, and mixed plantation (agroforestry system). The sugar palm (*Arenga* sp.) cultivated in agroforestry areas is the main plant and is combined with fruits such as durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum*), duku (*Lansium domesticum*), and mango (*Mangifera indica*).

Procedures

Identification of sugar palm species

The sugar palm morphology criteria reported by Mogea (2004) were used as the basis to identify the species cultivated by the community in the Sei Limbat Village, Selesai Sub-district, Langkat District, Province of North Sumatra, Indonesia.

Multi-utilization and economic value of Arenga longipes

The identification of the multi-utilization of sugar palm trees has been conducted through direct observation of all households producing various kinds of sugar palm products in the village. The in-depth interviews were conducted with 27 households in Sei Limbat, Sub-district of Selesai, Langkat District, North Sumatra Province. The in-depth interviews involve discussion using questionnaires as a reference in equating questions to the community. The data collected include information on all parts of sugar palm use, the socio-culture of the village, and the conservation purpose of the sugar palm tree. The socio-culture data include name, gender, age, religion, education, and livelihood source. Meanwhile, the conservation purpose data include the ambient temperature, annual rainfall, and land status.

Relationship between morphology and productivity of palm sap

The technique used was non-probability sampling with the 15 sugar palm trees found in Sei Limbat Village. The tapping of sap palm observations was divided into 2 times, namely morning (07.00 am) and afternoon (04.00 pm). The observation of the inflorescences productivity of palm sap was conducted for 5 repetitions days. The sampling method and the number of sample repetitions were carried out based on the method developed by Wardani et al. (2020). The productivity was measured by accommodating the flow of sap palm for one minute (ml per minute). The identification of the morphology includes the height of the tree, the diameter of the stem, the height of male inflorescence from the ground, the number of fronds, palm panicle circumference, and the number of male inflorescences. Linear Regression was used to analyze the relationships between morphology and sap palm productivity of *A. longipes.* The statistical analysis was performed using Microsoft Excel Version 2019.

The quality of the palm sap was measured based on the Indonesian National Standard (SNI 01-2891-1992), which consists of the moisture content and the pH value. The moisture content of the sap palm is defined as the weight loss of the liquid in the oven at 105°C for 2 hours. To measure the moisture content, 2 g of palm sap sample (W0) was put into a weighing bottle with known weight in the oven. Subsequently, the bottle containing the sample was put in an oven at 105°C for 2 hours and weighed (W1). The moisture content of the palm sap was determined using the equation below:

$$\mathrm{MC} = \frac{W0}{W1} x100\%$$

The measurement of the acidity level of palm sugar was carried out using a pH indicator paper and a digital portable pH meter (water tester 4 in 1, model: EZ-9908, Taiwan).

RESULTS AND DISCUSSION

Identification of sugar palm tree

The identification of sugar palm based on the main characteristics presented by Mogea (2004) is the size, shape, petiole, and length of the male inflorescence stalk, as well as the petiole, female inflorescence, and part of the inflorescence stalk. Based on the results of observations and identification, the sugar palm plant in this study is a species of *Arenga longipes* Mogea, with a height ranging from 8 m to 12 m. Komara and Kurniawan (2021) reported that the *genjah* sugar palm from Borneo (Kutai Nasional Park, Indonesia) has only a height of 1.67 m, while Wardani et al. (2020) stated that *A. pinnata* has 9-18 m. The stem diameter of *A. longipes* is 37-60 cm bigger than *A. pinnata,* which has a stem diameter of 30-40 cm (Gunawan et al. 2018). The leaf length of *A. longipes* is 50-250 cm longer than *A. pinnata* and Genjah sugar palm, which is 40-180 cm and 50-210 cm, respectively.

The identification results also show that the sugar palm has a male inflorescence with a length dimension of 1.5 cm and a male sugar palm flower stalk has a length of 33 cm. Meanwhile, a female sugar palm flower has a length of 2 cm, the petiole of the flower is 1.5 cm long, and the inflorescence stalk has a length of 67 cm. According to Mogea (2004), *A. longipes* has a male inflorescence that is stemmed at the top of the plant stem and sometimes appears in the middle. Figure 2 shows the morphological parts of the sugar palm plant.

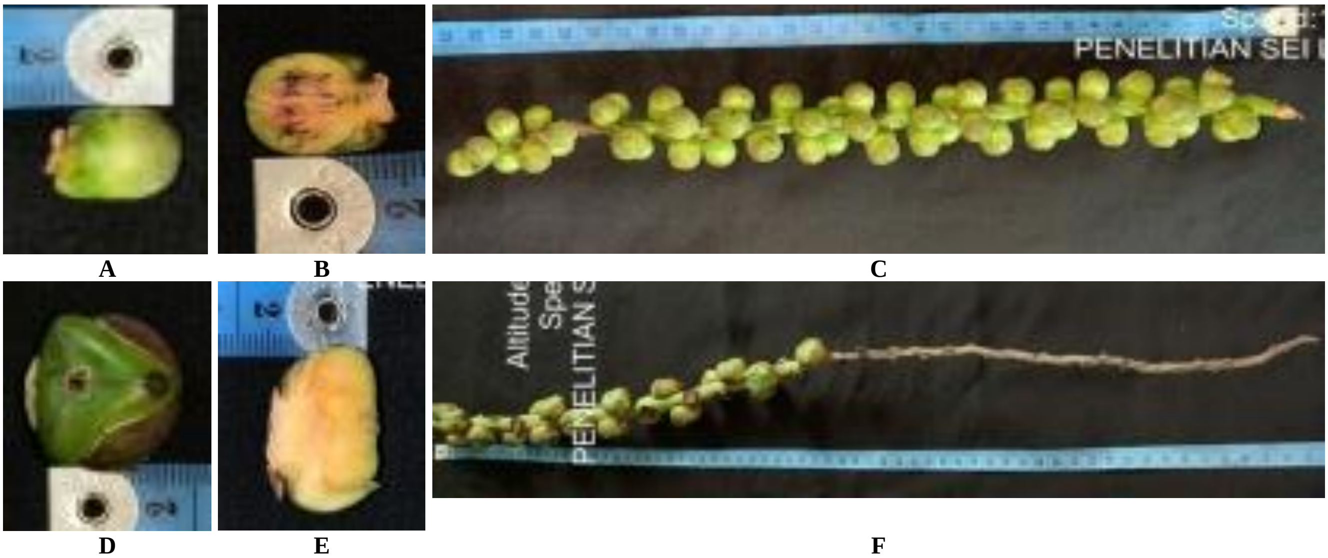

Figure 2. Part of sugar palm morphology. A. Male inflorescence, B. Inside of male inflorescence, C. Length of the male inflorescence stalk, D. Male inflorescence, E. Inside of male inflorescence, F. Length of the male inflorescence stalk

Multi-utilization and economic value of Arenga longipes

The people of Sei Limbat Village use parts of the sugar palm tree as a source of livelihood in the home industry. These include sap palm, locally known as *nira* from the male inflorescence, which is processed into big and small molded, powder (*gula semut*), and liquid brown sugar. The female inflorescence is also processed into *kolang-kaling* (fruit bunch). The palm black's fibers, which are locally called *ijuk* can be use as raw materials for making brooms and water filters. Gunawan et al. (2018) and Haryoso et al. (2020) reported that there are at least 10 parts of sugar palm that can be used with economic value, namely leaf, young leaf, black fibers, rachis, stalk, bark, inflorescence, trunk/stem, fruit bunch, and root. Moreover, their use is also influenced by the culture, local wisdom, economy, and environment of the region. Widayati et al. (2018) reported that the sugar palm farmer empowerment model depends on the social value and sustainability of area function. In this village, the majority of the community is moslem; therefore, the use of sap is processed into sugar palm, which is *halal* food. The other areas in North Sumatra, such as Aek Nauli Village, Simalungun District, use sap as raw material for making palm wine because the community does not consider halal food products (Azhar et al. 2021).

The use of nira *for making brown sugar*

The *nira* is the result of tapping from the male flower panicles of the sugar palm tree produced through the inflorescence. *Nira* is a raw material for making brown sugar. The tapping process was carried out twice, namely in the morning at 06.30 am and in the afternoon at 04.30 pm. The *nira* is accommodated in a container with a capacity of 5-10 liters. Before storing the sap, the container was filled with the bark of raru wood extraction to protect the sap from being acidic. This is because the bark functions as an antioxidant which can inhibit the fermentation process (Sinaga et al. 2020). Figure 3 shows the stages of the *nira* tapping process in Sei Limbat Village. These stages include *first,* washing the container until it is clean and putting raru liquid as an anti-fermentation. The raru liquid is an extraction of raru wood (*Cotylelobium* sp.) which has the effect of slowing down the fermentation process. *Second,* climbing the tree by bamboo ladder to the panicle part at the top of the tree. *Third,* opening bark and inflorescence to clean the fiber bark and dirty material to reduce contamination with substances that accelerate fermentation. *Fourth*, the panicle was swinging and hitting to obtain optimal sap with good quality. Panicle swinging is also believed to open the tissue pores, which can produce more sap. *Fifth*, panicles are cut as part of the tapping process to drain the sap from the tree into the container. *Finally,* accommodate the sap into the container and bring it to the production of sugar palm in the household. There is no significant difference between the tapping process by the Cipanggulaan community, Karyamukti village, Cianjur District, Province of West Java (Gunawan et al. 2018). This is because the tapping process involves four stages, namely climbing the sugar palm, opening the bark, swinging and beating, as well as cutting the panicle. The difference between tapping in Sei Limbat and Cipanggulaan village is the initial process that uses anti-fermentation substances.

Figure 4 shows the sequence of the manufacturing process and the form of the brown sugar. Traditionally, brown sugar is cooked for approximately 2 hours with the addition of cooking oil and the viscosity level is checked before forming as needed. Generally, the cooking of sap into sugar palms consists of several stages. *First*, put the sap from containers into a cooking pan that has been prepared over firewood. The process of pouring the liquid sap is carried out by filtering to clean the impurities contained in the sap. *Second*, cooking oil was added to prevent the palm sugar that forms from sticking to the cooking pan. *Third*, the liquid sap was boiled for approximately 2 hours and stirred periodically with the wooden spoon. A white-brown form will be produced during stirring, which needs to be removed to obtain good-quality products. *Fourth*, the liquid sap, after 2 hours of boiling, will start to thicken and change color to darker brown, then the boiling continues for 30 minutes with low fire. *Fifth*, after 30 minutes, the liquid viscosity is prepared to be molded into the bamboo mold. The bamboo molds consist of 2 sizes, namely large with a diameter of 10 cm and a height of 5 cm, and small size with a diameter of 1.5 cm and a height of 1 cm. *Sixth*, cool and harden of sugar palm for 2-3 days until dry, followed by wrapping and storing in a dry container.

The brown sugar was produced from sap in solid, liquid, and powder forms. Meanwhile, the liquid form is one of the diversifications of sugar palm products, which is used as a mixture of food and drinks that can easily be mixed and melted immediately. However, the liquid sugar still has a shelf life of 7 days and a high value of water content, an excellent medium for fungi to grow, reduces its durability. The powder form is also currently popular and its manufacturing process consists of crystallizing large sugar palms and reducing the water content by frying to obtain crystals and powder. This product has a high economic value compared to the solid form because the use is very simple and easily reacts with water as a drink.

The use of kolang-kaling *fruit:*

Kolang-kaling is part of the flesh of young female fruit that is used as a food source. The female fruit does not produce sap; therefore, it is used as *kolang-kaling*. Pictures of female palm fruit and processing methods to obtain *kolang-kaling* are shown in Figure 5. The stages of processing palm fruit into *kolang-kaling* are carried out in several stages. *First*, the selection of female palm fruit that is green in color and is still in a half-ripe condition. *Second*, the separation of the fruit from the stalk using a knife and collected together in a container. *Third*, boil the fruit using a large wood-fire stove for approximately 1-2 hours until the skin color changes from green to brown. After the condition of the fruit skin is brown, the boiling is stopped and cooling is carried out followed by draining. The purpose of this boiling is to remove the sap that is still attached to the skin of the *kolang-kaling* shell. *Fourth*, after the draining process is complete, the skin of the *kolang-kaling* fruit is peeled using a knife. Based on standards, good fruit and fro are white, oval in shape, and chewy. *Fifth*, the process of flattening the fro by pounding the fruit and fro using a hammer made of wood to make the shape of the *kolang-kaling* thinner and wider. *Sixth*, after the flattening process, a washing process is carried out to remove the remaining dirt off the fruit skin that is still attached. *Seventh*, the soaking process is also carried out using lime water for 2-3 days to make the texture of the *kolang-kaling* chewier. *Eighth*, the packaging of *kolang-kaling* fruit traditionally uses burlap sacks for market distribution.

Use of black fiber (Ijuk)

The black fiber *(Ijuk*) is part of the frond, which covers the main stem of the sugar palm. The plants can usually produce fibers at the age of 5 years. The use of fibers is a side job carried out by the community and the quality is determined based on the size of the rolls of fibers taken from the stems of the plant. The community of Sei Limbat divides into 2 fiber size, namely large and small roll sizes. These fibers are used as raw materials for making water filters, brooms, ropes, and roofing houses. Figure 6 is a palm fiber produced from the sugar palm plant cultivated by the Sei Limbat community with large and small roll sizes.


A B C

Figure 3. *Nira* tapping process. A. Raru bark extract filling, B. Climbing and tapping, C. Cutting and accommodating of sap

Figure 4. Process of making brown sugar: A. Cooking by firewood, B. Adding the cooking oil, C. Checking the viscosity, D. Forming the palm sugar, E. Big molded palm sugar, F. Small molded palm sugar, G. Liquid palm sugar, H. Powder palm sugar

Figure 5. Processing methods to obtain kolang-kaling. A. Female flower, B. Sorting, C. Cooking, D. Stripping, E. Flattening, F. Washing, G. Immersion, H. Packaging

A B C

Figure 6. Black fiber. A. *Ijuk* roll, B. Small roll of *ijuk*, C. Big roll of *ijuk*

Quality of saps

The water content of the sap affects the quality of the palm sugar produced. Based on the results, the values of water content and pH of sap are 1.04% and 6-7, respectively. The water content of the sap from *A. longipes* has a small value; therefore, a low value will produce good palm sugar. The high water content in sugar palms causes the texture of the sugar to become mushy and can lead to mold growth, which reduces the life use of the product (Radam et al. 2014). Table 1 shows the water content and pH of the harvested sap.

The pH value is between 6-7 which is an ideal and neutral pH. The pH value of the sap must be in the range of 6-7.5 to be processed into good and safe palm sugar (Victor and Orsat 2017; Syahidah et al. 2021) The pH below 6 contains high acid and easily fermented will have low quality if used as raw material for palm sugar. Kurniawan et al. (2018) reported that a low pH will be easily contaminated by the activity of *Saccharomyces cerevisiae* which causes increased acidity.

Relationships between age, tapping time, and flow discharge of tapping of *Arenga longipes*

The relationship between the age of the sugar palm plant and the production of sap is shown in Figure 7. Based on the results, it was discovered that the productivity of the sap has the highest value of flow discharge from tapping sap at the age of 9 years of 0.35 liter/second at morning tapping. The sugar palm tapping is done only on male inflorescence which starts growing at the age of 6-7 years, at the beginning of the growth, male flowers still produce a little sap along with increasing age will produce more sap. Generally, the maximum production of sap is at the age of 9 -15 years (Mogea et al. 1991). Meanwhile, the lowest flow discharge was obtained at the age of 7 years of 0.03 liter/second at afternoon tapping. According to Victor and Orsat (2017), the productivity of sap in the *A. pinnata* is achieved at the age of the plant between 7-10 years with a productivity of 10-15 liters/day/tree. *A. longipes* produced the most sap at the age of 9 years with 30 liters/day/tree productivity based on calculations of flow discharge of tapping. Based on the tapping time, the productivity of tapping in the morning has a greater value than in the afternoon. The reason that can be given why there is more morning tapping than afternoon tapping is that the duration of morning tapping is longer than afternoon tapping. Ibrahim et al. (2018) stated that many factors contributed to variations in the productivity of sap tapping, including the duration of tapping, genetics, environment, and soil fertility. In this study, it is suspected that only duration provides variation in productivity because other conditions are homogeneous. The morning tapping was collected at 06.00 am with duration saps between 05.00 pm-06.00 am and approximately for 13 hours. Meanwhile, the afternoon tapping was at 05.00 pm with a duration between 06.00 am-05.00 pm and approximately for 10 hours. There was a duration time collection of saps in the container between morning tapping and afternoon tapping about 3 hours. Therefore, tapping sap in the morning is more than tapping in the afternoon. Saputro et al. (2019) stated that the productivity and quality of sap sugar palm are influenced by time duration, tree variety, maturity of inflorescence, climate, as well as soil fertility.

Table 1. Water content and pH value of sap

Characteristic	Value
Water content	1.04%
pH	6-7

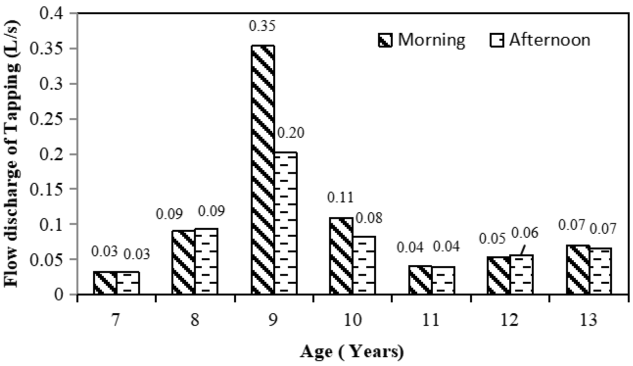

Figure 7. Sugar palm age and productivity

The results indicate that maximum productivity is achieved at the age of 9 years, while the age of plants above 9 years has decreased. Widarwati et al. (2017) stated that the best tapping conditions occurred in sugar palm that was 8-9 years old when the mayang flowers had come out. According to Fatriani et al. (2012), the decline in sap productivity was due to the age of the palm trees getting older, thereby reducing the productivity of the sap produced.

Relationships between stem diameter and flow discharge of tapping of *Arenga longipes*

The relationship between sugar palm stem diameter and sap productivity is shown in Figure 8. The productivity of sap has varied values based on the results obtained, which indicated that the highest sap productivity is found in sugar palm stem diameters above 60 cm, while the lowest is in sugar palm stems with 50-100 cm diameter. These data fluctuated, therefore, there was no definite trend that stem diameter affected the productivity of sap.

The results are in line with the research by Harahap (2017), which stated that any increase in stem diameter does not improve the production of sap. Generally, monocot plants have uniquely achieved the ability to grow in thickness through an extraordinary secondary vascular meristem called the monocot cambium for their diameter development. Therefore, secondary development in monocot plants only occurs flatly and usually, the diameter from the bottom to the top of the trunk is not much different. The correlation value (R^2) on morning productivity is 0.1227, which implies that the effect of the diameter variable on the productivity of sap in the morning is 12.27%. The sap productivity in the afternoon is 0.0185 of 1.85%, while the rest is influenced by factors other than the diameter of the palm stem.

The relationship between palm fronds and sap productivity is shown in Figure 9. Based on the results, sap productivity has a variable value. The highest sap value is found in the number 19 and above, which is 0.35 liters/second, which indicates that the productivity of sugar palms is influenced by the number of fronds. Wardani et al. (2019) reported that the photosynthesis process requires several leaves, which increases the productivity of carbohydrates. Nurmayulis et al. (2021) also stated that the number of leaves would affect the growth and yield of plants, especially in productivity. This indicated that sugar palms with more fronds produced more sap productivity than those with less number of fronds. Statistically, the correlation value (R^2) on morning productivity is 0.475. This showed that the influence of the leaf sheath variable on sap productivity in the morning is 47.5%, while the productivity of sap in the afternoon is 0.4623 by 46.23%, with the rest being influenced by other factors.

The relationship between sugar palm panicle circumference and sap productivity is shown in Figure 10. The results showed that the sap productivity is varied, where the highest value is found in the panicle circumference of sugar palms with a size above 37 cm, while the lowest is found in a panicle circumference of 13-18 cm. It was also discovered that the larger the panicle circumference on the palm tree, the greater the amount of sap produced in the tapping process. According to Wardani et al. (2019), the wider the panicle circumference, the higher the panicle productivity produced. The correlation value (R^2) on the productivity of the sap in the morning is 0.5, which means that the effect of the variable in the form of panicle circumference on the productivity of the sap in the morning is 50%, while the correlation value (R^2) on the productivity of the sap in the afternoon is 0.9404 which means the influence of the panicle circumference variable on the productivity of the sap in the afternoon is 94.04%. Naemah et al. (2022) also stated that the more panicles on the sugar palm plant, the more sap obtained.

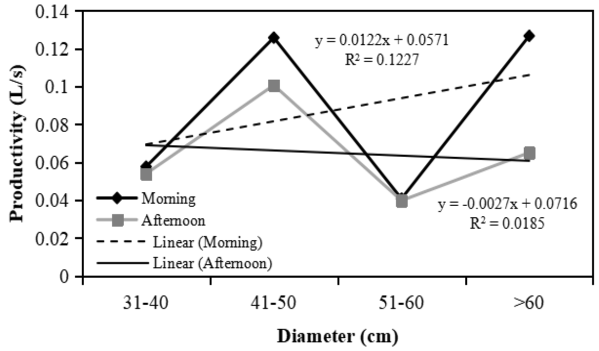

Figure 8. Relationships between stem diameter and productivity

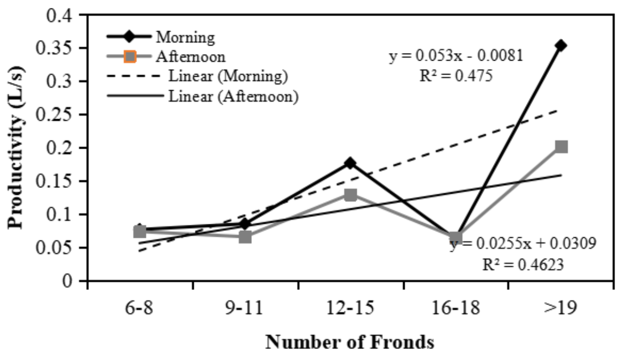

Figure 9. Relationships between frond and productivity

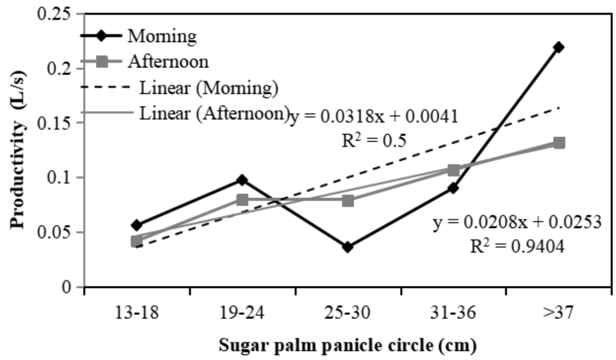

Figure 10. Relationships between sugar palm panicle circle and productivity

The relationship between male inflorescence and sap productivity is shown in Figure 11. The results showed that the sap productivity is variable, where the highest value is found in the number of palm trees that have male inflorescence of 9 and above, which is 0.2 liters/second, while the lowest is in the number of palm trees. Sugar palm tree that has 3-5 male flowers are equal to 0.05 liters/second. Based on the tapping time, sap productivity in the morning has a greater value than in the afternoon. The correlation value (R^2) in morning productivity is 0.356, which implies that the influence of the male flower variable on the productivity of sap in the morning is 35.6%. Meanwhile, the productivity of sap in the afternoon is 0.3441 at 34.41 %. The more male flowers that the sugar palm has, the higher the productivity of the sap is.

The relationship between tree height and sap productivity is shown in Figure 12. The results showed that the highest sap productivity is found in sugar palm trees with a height of 6-8 m, while the lowest is in a height above 12 m. Based on the tapping time, the productivity of tapping in the morning has a greater value than in the afternoon. Furthermore, sugar palm trees with shorter heights produced sap water with higher productivity. Savage et al. (2017) reported that the transportation of sugar in plants is played by phloem tissue which transports sugar from the leaves to the roots. Gravity and turgor pressure will affect the flow rate of sugar in the phloem tissue. The shorter the plant, the stronger the pressure of the flow of sugar in the tree. This is why the productivity of a tree with a height of 7 meters is greater than that of a tree with a height of 9 meters. The correlation value (R^2) on morning productivity is 0.9919, which implies that the effect of tree height on sap productivity in the morning is 99.19%, while in the afternoon is 0.9529 95.29%. Harahap (2017) stated that along with the development of plant height, the production of sap produced would decrease.

The relationship between male inflorescence height and sap productivity is shown in Figure 13. The results showed that the lower part of the male inflorescence gave high productivity of sap. Yamamoto et al. (2021) reported that stem elongation growth had been completed around the appearance of the first female inflorescence at age 9-10 years. Meanwhile, the emergence of the first male inflorescence is at age 12-15. Therefore, the optimal tapping time for sap production is considered to be around the appearance of the first female flower. This phenomenon has the implication that the productivity of sap at a low level of male inflorescence is higher than at a high level. The highest productivity value is found in sugar palm, which has a male inflorescence height of 4-6 m in the morning productivity with the amount of sap 0.12 liters/second. Meanwhile, the lowest productivity is found in sugar palm, which has a male inflorescence height of >10 m with an amount of sap 0.07 liters/second in the afternoon. This showed that the correlation value (R^2) in morning productivity is 0.7267, which implies that the effect of the variable height of interest on the productivity of sap in the morning is 72.67%.

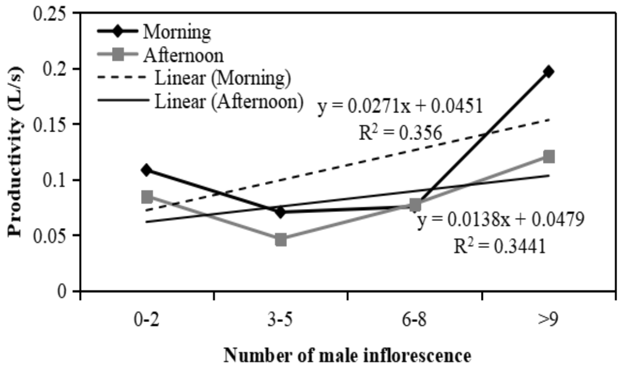

Figure 11. Relationships between the number of male inflorescence and productivity

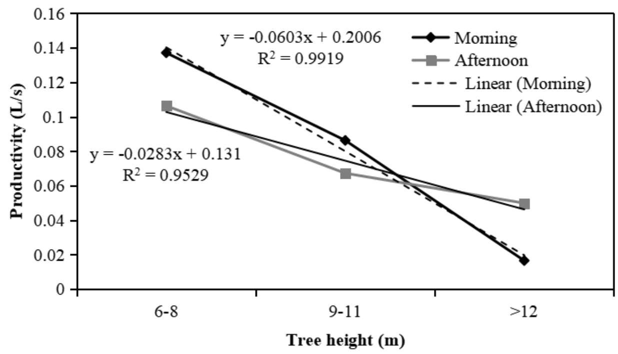

Figure 12. Relationships between tree height and productivity

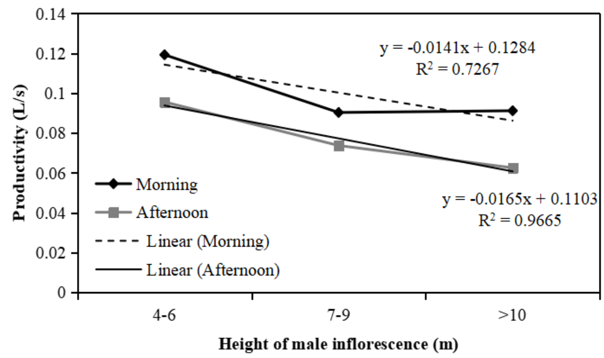

Figure 13. Relationships between flower height and productivity

Conservation purpose

Sugar palm functions as a conservation plant that can prevent soil erosion, mainly because the roots have good enough strength to grip the soil. Smith (2004) stated that the root of sugar palms could reach a depth of approximately 6 m. This root system plays an important role in soil and water conservation efforts, where the fibrous roots bind more water. Since the shallow and wide roots bind the soil properly, the sugar palm trees are suitable for planting in areas with steep slopes and can prevent landslides (Gunawan et al. 2018). Furthermore, sugar palms can also be used as rehabilitation plants because they grow in various soil conditions. These trees have the longest and are most able to hold the volume of 1-2 liters of rainwater for several hours (Kali et al. 2015). The presence of midrib from the base of the trunk to the tips of the tree gives the soil under the tree a long time to absorb more water and store the most groundwater (Idris et al. 2020). This makes it possible for sugar palm plantations to have a good hydrological function.

The sugar palm trees in Sei Limbat Village grow naturally and semi-naturally in home gardens and mixed gardens. According to Krissetya et al. (2021), sugar palm is one of the agroforestry plants that is easy to grow in mixed garden areas or forests in the wild. Natural growth only relies on seedlings that come from old female flower seeds, which fall and grow to maturity to replace unproductive trees. Semi-natural growth is carried out by moving the seedling tree to be planted on other lands. The community of Sei Limbat has not cultivated sugar palms intensively. Therefore, the production of palm sap only relies on the number of existing plants.

In conclusion, the identification results showed that the sugar palm species in the village of Sei Limbat, Subdistrict of Selesai, Langkat District, North Sumatra Province, is the *A. longipes*. The main characteristics of this plant include a height between 7 to 12 m and male flowers at the top of the plant stem, which sometimes appear in the middle of the stem. The productivity of sap on *A. longipes* is influenced by the morphology of the panicle circumference, tree height, and flower height from the ground. Therefore, the larger the panicle circumference, the higher the productivity of sap is and the taller the male plants, flowers, and the productivity. The linear regression equation of the relationships between morphology and panicle circumference, tree height, as well as flower height from the ground, were $y=0.0208x+0.0253$; $y=-0.0603x+0.2006$; $y=-0.0165x+0.1103$, respectively. Most of the people of Sei Limbat village use the plants as a livelihood to produce sugar palms through diversification into large, small (coins), liquid, and powdered forms.

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