Morphological characteristics and productivity of sugar palm saps at several levels of tapping age

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Abstract. Arenga pinnata (Wurmb) Merr is a multipurpose plant, its main product is sugar palm saps containing sugar collected by tapping the male inflorescence. The aim of the research is to evaluate the morphological characteristics, productivity, and quality of saps from three levels of tapping age (early, mid, and final tapping). The results showed that the morphological characteristics at three age levels of tapping have a high diversity in morphological variables (plant height, stem circumference, number of leaves, and number of female inflorescence). The productivity component of palm saps can be described as follows: tapping period between 15-214 days; morning saps volume between 41.30-1511 l/inflorescence; afternoon saps volume between 34.80-1139 l/inflorescence; total saps volume between 76.10-2650 l/inflorescence; morning saps discharge between 0.20-0.96 l/inflorescence/hour; afternoon saps discharge between 0.23-0.67 l/inflorescence/hour; and productivity of saps between 4.47-14.62 l/inflorescence/day. The volume productivity of the sap at the initial tapping age level is relatively low (between 323.00-614.20 l/inflorescence), increase at the mid tapping age (between 570.20-2650.00 l/inflorescence), and decrease at the final tapping age (between 76.10-445.00 l/inflorescence). The quality of palm saps are: total soluble solids between 11.00-16.80%, pH of saps between 7.00-7.10, and sugar content between 8.09-13.52%.

Keywords: afternoon saps, male inflorescence, morning saps, saps quality, saps volume

1. Introduction
Sugar palm trees are original plants from Indonesia that have been spreaded assisted by civets [1]. It spread in tropical countries such as Bangladesh, Brunei Darussalam, Cambodia, India, Indonesia, Laos, Malaysia, Myanmar, New Guinea, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam [2]. While, according to PERMENTAN 2013 [3], Indonesia has 70000 ha of sugar palm plantations in 14 provinces.

Sugar palm can grow well in mountainous areas, valleys, nearby river flow, bumpy areas, and many forests. Pandanarum District is a mountainous area with a height of 697-1200 m above sea level. There have been no reports on the identification of sugar palm trees in Banjarnegara; therefore, it is necessary
to identify the individual taxonomic characteristics of various individuals and put them into a taxon [4]. In addition, identification is useful to know the various types of sugar palm trees.

The government has issued 2 varieties of superior sugar palm trees, namely the Genjah Kutim variety and the Akel Toumuung variety. The Genjah Kutim variety is original from the Kutai Timur regency, which has been registered in the Center for Plant Variety Protection and Licensing of Agriculture No.25/pvl/2011 dated March 21, 2011 and determined to be the national superior variety through the Minister of Agriculture Decree with No.3879/Kpts/SR.120/9/2011 [5]. The Minister of Agriculture with decree No.1059/Kpts/SR.120/10/2014 released sugar palm varieties from Tomohon with the name being Akel Toumuung [6].

Most tapped palm trees gives a sap very rich in sugar. The yields are highly variable according to the species and their management. With proper management, the tapped sugar palm can reach yields of about 20 tonnes of sugar per hectare [7]. Sugar palm farmers can harvest 10-15 l/inflorescence saps in one day. 7-8 liter sugar palm saps can produce 1 kg of brown sugar, depending on the sugar content. Production of saps usually decreases in the summer and increase in the rainy season. The farmers did taking of saps in the morning and afternoon using bamboo with a length of 2.50-3.00 m [8].

Banjarnegara is one of the regencies that produce sugar palm in the Central Java Province, where the area, production, productivity have been decreasing (Table 1).

| Year | Area (ha) | Production (ton) | Productivity (ton/ha) |
|------|-----------|-----------------|-----------------------|
| 2010 | 254       | 486             | 1.91                  |
| 2011 | 247       | 471             | 1.91                  |
| 2012 | 242       | 425             | 1.76                  |
| 2013 | 233       | 410             | 1.76                  |

Source: [9]

Information about sugar palm in Banjarnegara Regency has not been widely reported on morphological characterization, productivity, and quality. The aim of this research is to know the morphological characteristic, productivity, and quality of sugar palm at several levels of the tapping age, which are suitable for crystal sugar production.

2. Materials and methods

2.1. Determination of samples of palm trees

The samples for the trees were determined in Pringamba Village, Banjarnegara. The sampling technique used was non probability sampling type: purposive sampling, with predetermined criteria. The sampling result was obtained 15 palm trees grouped into 3 tapping groups: 1) Early tapping (inflorescence to 1-4), 2) Mid tapping (inflorescence to 5-8) and, 3) Final tapping (inflorescence number >8). The position of the tapping number is calculated from the topmost inflorescence, because the sugar palm tree is a hapaksantik plant (its reproductive phase limits the growth of the stem, meaning after the female inflorescence almost simultaneously, followed by the male inflorescence starting from the top of the tree to the base of the stem). The observation parameters of morphological characteristics are: plant height (m), stem girth 0.50 and 1.50 m above sea level (cm), leaves number, female inflorescence number, male inflorescence number in tapping, inflorescence number position, male inflorescence height (m) and, tapping circumference (cm). The observation of productivity comprises: tapping days number, morning sap volume (l/inflorescence), afternoon saps volume (l/inflorescence), productivity of saps (l/inflorescence/day), total saps volume (l/inflorescence), morning saps discharge (l/inflorescence/hour), and afternoon saps discharge (l/inflorescence/hour). The observation parameters of quality are: total soluble solids (%), pH of saps, and sugar content (%).
2.2. Measurement of sugar palm saps productivity
Measurement of sugar palm was done in the morning and in the afternoon. Morning saps were collected from 04:00 pm-06:00 am, while afternoon saps were collected from 06:00 am-04:00 pm. The time of collection of saps to the container was done from 06:00-08:00 am (morning saps) and at 04.00-06.00 pm (afternoon saps). Each time after sap collection the surface of the wounded stalk was cut again taking away a slice of 1-2 mm thickness to keeps the sap flowing. Sugar palm farmers participated in this research to measure saps volume; they also maintained the natural quality on saps; and kept the sample trees for 9 months.

2.3. Measurement of sugar palm saps content
The sampling for the saps test was done in the morning. From a total of 9 sample, 3 were for early tapping, 3 were for mid tapping, and 3 were for final tapping. The sugar sample test was used to determine the sugar content using High Performance Liquid Chromatography.

2.4. Analytical data
Morphological character data, productivity and the quality of palm saps were analyzed using a descriptive method by describing each sample tree. The Tukey test was used several variables on a 5% level to compare the diversity between sample trees. Furthermore, a correlation analysis using Statistical Tool for Agricultural Research (STAR) 2.1 was used to determine the relationship of the two variables.

3. Results and discussion

3.1. Morphological characteristics and the productivity of sugar palm saps
The morphological characteristics are important to know regarding the sugar palm varieties for plant selection. The results showed that sugar palm trees at several age levels of tapping have variation of morphological characteristics (Table 2).

The morphological characteristics of sugar palm research will be compared with the description of sugar palm varieties issued by the government, such as Genjah Kutim varieties and Akel Toumuung varieties. According to Tenda et al. [10], Genjah Kutim varieties have a plant height of 10.43 m, while according to Tenda [11], Akel Toumuung varieties have a plant height of between 13.58-15.40 m. As it related to plant height, sugar palm trees in Banjarnegara have similar characteristics to Akel Toumuung varieties.

Sugar palm trees unique, because he they have a bulging stem in the middle, while the coconut trees have the largest stem size at the base. The heigher of coconut, the smaller the size of the coconut stem. According to Tenda et al. [12], Mastutin varieties in Sumbawa has a stem girth of 20 cm above ground level is 171.45 cm, while the stem girth of 1.50 m above ground level is 103.25 cm.

Production of morning sugar palm saps and afternoon sugar palm saps are very different. The result of the research obtained the volume of collection on afternoon (morning tapping of saps) more than volume of collection on morning (afternoon tapping of saps) (Figure 1).

There is a time difference in the collecting of saps in the container between morning tapping of saps with morning tapping of saps for 2-3 hours. Morning saps are collected between 04:00 pm-06.00 am with the duration spanning 12-14 hours, while the afternoon saps are collected between 08.00 am-04.00 pm with the duration spanning 8-10 hours.

The tapping days number at several levels of tapping showed different times, because the condition of each circumference of tapping was different. Based on the result of research, tapping data is most available on mid level of tapping age (Table 3).
Table 2. Morphological characteristics of sugar palm at several level of tapping age

| Level of tapping | Code | Description of sugar palm trees at several levels of tapping age |
|------------------|------|---------------------------------------------------------------|
|                  |      | TT       | LB1       | LB2       | JD | JIB | JIJ | PNI | TIJ | LTS |
| Early            | AP1  | 16.50    | 110.00    | 150.00    | 12 | 3   | 1   | 3   | 16.20 | 35.00 |
|                  | AP2  | 9.90     | 60.00     | 70.00     | 7  | 2   | 1   | 2   | 9.00  | 20.00 |
|                  | AP3  | 15.75    | 140.00    | 175.00    | 12 | 4   | 1   | 2   | 14.70 | 30.00 |
| Mid              | PP1  | 12.50    | 90.00     | 120.00    | 8  | 4   | 1   | 6   | 8.25  | 20.00 |
|                  | PP2  | 15.50    | 170.00    | 170.00    | 10 | 3   | 2   | 6 and 7 | 7.80  | 25.00 |
|                  | PP3  | 18.50    | 195.00    | 210.00    | 12 | 4   | 2   | 8 and 9 | 11.25 | 30.00 |
|                  | PP4  | 17.25    | 165.00    | 175.00    | 12 | 4   | 2   | 7 and 8 | 10.50 | 28.00 |
|                  | PP5  | 16.75    | 155.00    | 175.00    | 10 | 4   | 2   | 7 and 8 | 10.02 | 25.00 |
|                  | PP6  | 9.50     | 170.00    | 180.00    | 8  | 3   | 1   | 5   | 5.25  | 25.00 |
|                  | PP7  | 10.50    | 140.00    | 150.00    | 10 | 3   | 1   | 6   | 5.60  | 28.00 |
|                  | PP8  | 12.00    | 150.00    | 160.00    | 12 | 5   | 1   | 6   | 8.25  | 32.00 |
|                  | PP9  | 12.75    | 90.00     | 100.00    | 8  | 4   | 1   | 6   | 8.80  | 28.00 |
| Final            | SP1  | 13.25    | 105.00    | 120.00    | 11 | 3   | 1   | 10  | 5.75  | 28.00 |
|                  | SP2  | 17.00    | 125.00    | 100.00    | 8  | 4   | 1   | 12  | 6.55  | 25.00 |
|                  | SP3  | 16.80    | 165.00    | 170.00    | 10 | 3   | 1   | 11  | 5.20  | 32.00 |

Tukey test α 5% 1.51 1.14 1.49 - 0.99 - - - 0.66

Notes: TT: Plant height (m); LB1: stems girth 0.50 m above ground level (cm); LB2: stems girth 1.50 m above ground level (cm); JD: leaves number; JIB: female inflorescence number; JIJ: male inflorescence number; PNI: inflorescence number position; TIJ: male inflorescence height (m); LTS: tapping circumference (cm)

Figure 1. Comparison between morning saps volume with afternoon saps volume

According to Nguyen et al. (2016), starch accumulates in xylem parenchyma cells by late October. During the winter and early spring, this reserve is converted into dissolved sucrose, which is believed to protect the trees from frost damage. Consequently, xylem sap can be exuded by drilling holes into the trunk. Because of differences in structure and sap transportation, palm sap tapping is very different.

According to Gafsi et al. [13], at the beginning of the sap collection, the dry matter content for male and female inflorescence matches the average levels of several species of palms varying approximately between 10 and 15% according to the period of sap collection and the palm tree. In addition, the dry matter content in male inflorescence was higher than that of female (15.895% and 11.47%). After the tapping period, the dry matter content decreases significantly in both male and female inflorescence. In fact, the daily tapping procedure not only imposes an exhaustion of nutritious elements of the trunk, but also prevents palms from rebuilding their reserves through photosynthesis reaction by depriving them of most of their productive leaves.
The production of sugar palm saps is an important in morphology and selection for government recommendation in support of the movement of crop cultivation, in addition to being a benchmark for sugar crystal agribusiness. The results showed that the highest productivity of sugar palm saps was 14.62 l/inflorescence/day at the early tapping, total saps volume being 2650 l/inflorescence at mid tapping, the highest of morning saps discharge being 0.96 l/inflorescence/hour at the mid tapping, and the highest of afternoon saps discharge being 0.67 l/inflorescence/hour at the early tapping (Table 4).

Sugar production during tapping slowly increased at the beginning of the tapping period. The mobilization of starch taking some time to increase as a result of the tapping taking away carbohydrates from the ripening fruits near the top of the palm. The decrease in sugar production after the peak may indicate the decrease in available starch to be converted into sucrose. The constant sugar production at the last period of tapping indicates that the photosynthetic product is converted into sucrose and transported directly towards the wounded inflorescence stalk [14].

Government issued comparisons between the results of research with the sugar palm varieties aims to know the character of similarities for selection. Sugar palm trees in Pringamba village have similarities with Genjah Kutim varieties of the stem’s circumference, female inflorescence, and tapping circumference. The sugar palm trees in Akel Toumuung varieties have similarities tree height and leaves number (Table 5).

### Table 3. Duration of tapping on several levels of tapping age

| Level of tapping | Code | I | NP | Time of tapping |
|------------------|------|---|----|-----------------|
|                  |      |   |    | TPN | Aug-2016 | Sep-2016 | Oct-2016 | Nov-2016 | Dec-2016 | Jan-2017 | Feb-2017 | Mar-2017 | Apr-2017 |
| Early            | AP1  | 3 | 42 |     |          |          |          |          |          |          |          |          |
|                  | AP2  | 2 | 50 |     |          |          |          |          |          |          |          |          |
|                  | AP3  | 2 | 37 |     |          |          |          |          |          |          |          |          |
|                  | PP1  | 6 | 95 |     |          |          |          |          |          |          |          |          |
|                  | PP2a | 6 | 39 |     |          |          |          |          |          |          |          |          |
|                  | PP2b | 7 | 105|     |          |          |          |          |          |          |          |          |
|                  | PP3a | 8 | 59 |     |          |          |          |          |          |          |          |          |
|                  | PP3b | 9 | 67 |     |          |          |          |          |          |          |          |          |
|                  | PP4a | 7 | 141|     |          |          |          |          |          |          |          |          |
| Mid              | PP4b | 8 | 144|     |          |          |          |          |          |          |          |          |
|                  | PP5a | 8 | 67 |     |          |          |          |          |          |          |          |          |
|                  | PP5b | 5 | 89 |     |          |          |          |          |          |          |          |          |
|                  | PP6  | 6 | 214|     |          |          |          |          |          |          |          |          |
|                  | PP7  | 6 | 214|     |          |          |          |          |          |          |          |          |
|                  | PP8  | 6 | 121|     |          |          |          |          |          |          |          |          |
|                  | PP9  | 6 | 135|     |          |          |          |          |          |          |          |          |
| Final            | SP1  | 10| 15 |     |          |          |          |          |          |          |          |          |
|                  | SP2  | 12| 17 |     |          |          |          |          |          |          |          |          |
|                  | SP3  | 11| 60 |     |          |          |          |          |          |          |          |          |
| Tukey test α 5% | -    |   | 4.63|     |          |          |          |          |          |          |          |          |

Notes: TPN = Tapping days number, I = Inflorescence, NP= number position

3.2 Quality of sugar palm saps

The quality of sugar palm is used to know the early data for the making of sugar. Sugar palm saps would have suffered damage if they possess an acidic, bubbly, and slimy taste. The formation of foam and mucus result reduced clarity of the sap. The flavor of saps caused by the chemicals composition was contained in it [15]. The results showed that the pH of sugar palm saps and the highest of total soluble solid is 16.80% at the mid level of the tapping age, and the highest of sugar palm saps volume is 14.62% at the early level of the tapping age (Table 6).
Table 4. Comparison between productivity and saps discharge at several levels of tapping age

| Level of tapping | Code  | Saps discharge | Productivity (l/i/d) | Total saps volume (l/i) |
|------------------|-------|----------------|----------------------|-------------------------|
|                  |       | Morning (l/i/h) | Afternoon (l/i/h)    |                         |
| Early            | AP1   | 0.72           | 0.67                 | 14.62                   | 614.20                  |
|                  | AP2   | 0.57           | 0.54                 | 11.68                   | 584.00                  |
|                  | AP3   | 0.49           | 0.32                 | 8.79                    | 323.00                  |
|                  | PP1   | 0.68           | 0.39                 | 11.74                   | 1116.00                 |
|                  | PP2a  | 0.96           | 0.35                 | 14.62                   | 570.20                  |
|                  | PP2b  | 0.62           | 0.28                 | 10.02                   | 1052.80                 |
|                  | PP3a  | 0.76           | 0.34                 | 12.34                   | 728.20                  |
|                  | PP3b  | 0.69           | 0.37                 | 11.62                   | 778.90                  |
|                  | PP4a  | 0.58           | 0.31                 | 9.75                    | 1375.00                 |
|                  | PP4b  | 0.47           | 0.27                 | 8.09                    | 1165.50                 |
|                  | PP5a  | 0.57           | 0.39                 | 10.32                   | 692.00                  |
|                  | PP5b  | 0.70           | 0.41                 | 12.05                   | 1073.00                 |
|                  | PP6   | 0.58           | 0.59                 | 12.38                   | 2650.00                 |
|                  | PP7   | 0.48           | 0.52                 | 10.52                   | 2251.00                 |
|                  | PP8   | 0.36           | 0.30                 | 7.05                    | 853.00                  |
|                  | PP9   | 0.28           | 0.55                 | 9.25                    | 1248.80                 |
| Mid              | PP1   | 0.58           | 0.31                 | 9.75                    | 1375.00                 |
|                  | PP2a  | 0.96           | 0.35                 | 14.62                   | 570.20                  |
|                  | PP2b  | 0.62           | 0.28                 | 10.02                   | 1052.80                 |
|                  | PP3a  | 0.76           | 0.34                 | 12.34                   | 728.20                  |
|                  | PP3b  | 0.69           | 0.37                 | 11.62                   | 778.90                  |
|                  | PP4a  | 0.58           | 0.31                 | 9.75                    | 1375.00                 |
|                  | PP4b  | 0.47           | 0.27                 | 8.09                    | 1165.50                 |
|                  | PP5a  | 0.57           | 0.39                 | 10.32                   | 692.00                  |
|                  | PP5b  | 0.70           | 0.41                 | 12.05                   | 1073.00                 |
|                  | PP6   | 0.58           | 0.59                 | 12.38                   | 2650.00                 |
|                  | PP7   | 0.48           | 0.52                 | 10.52                   | 2251.00                 |
|                  | PP8   | 0.36           | 0.30                 | 7.05                    | 853.00                  |
|                  | PP9   | 0.28           | 0.55                 | 9.25                    | 1248.80                 |
| Final            | SP1   | 0.28           | 0.37                 | 6.70                    | 101.20                  |
|                  | SP2   | 0.20           | 0.23                 | 4.47                    | 76.10                   |
|                  | SP3   | 0.39           | 0.29                 | 7.42                    | 445.00                  |

Tukey test α 5%

Notes: h: hour; i: inflorescence; l: liter

Table 5. Comparison between the results of research with descriptions of other sugar palm varieties

| Description | Genjah Kutim varieties | Akel Toumuung varieties | Result of research |
|-------------|------------------------|-------------------------|--------------------|
| Location    | Kandolo, Kutai Timur   | Tomohon Regency         | Pringamba, Banjaranegara. |
| Original species | Selection from natural population | Selection from natural population | Selection from natural population |
| Plant height (m) | 7.50-9.00                  | 14.50              | 9.50-18.50          |
| Stem girth (cm) | 139.20                | 106.80           | 60-210             |
| Female inflorescence number | 7                        | 8                     | 3-5                |
| Leaves number | 23                      | 14                   | 7-12               |
| Male inflorescence number | 8                      | 8                    | 2-3                |
| Tapping circumference (cm) | 29.00                | 13.40              | 20.00-35.00        |
| Source       | Tenda et al. (2011)      | Tenda and Mahayu (2015), BALITKA (2015) |

The saps pH was affected by the conditions of weather. Pringamba village has short irradiation of 2.23-4.80 hours [16]. Pandanarum district has an annual rainfall of 4165 mm/year, the Koppen-Geiger climate classification is Af, and the annual average temperature is 21.30 °C.
The content of total soluble solids is higher due to the addition of pectin and sucrose, because they are the constituent components of total soluble solids. It of a material includes reducing sugars, non-reducing sugars, organic acids, pectins, and proteins [17]. The fluctuation of total soluble solids was caused by the amount of starch contained in the tapping rod.

### Table 6. Quality of sugar palm saps at several level of tapping age

| Level of tapping | Code | Total soluble solids (%) | Acidity of saps (pH) |
|------------------|------|--------------------------|----------------------|
| Early            | AP1  | 12.25                    | 7.10                 |
|                  | AP2  | 11.75                    | 7.00                 |
|                  | AP3  | 11.50                    | 7.00                 |
|                  | PP1  | 11.75                    | 7.00                 |
|                  | PP2  | 12.30                    | 7.00                 |
|                  | PP3  | 12.60                    | 7.00                 |
|                  | PP4  | 11.93                    | 7.00                 |
|                  | PP5  | 12.08                    | 7.00                 |
|                  | PP6  | 11.75                    | 7.00                 |
|                  | PP7  | 16.57                    | 7.00                 |
|                  | PP8  | 13.50                    | 7.00                 |
|                  | PP9  | 16.80                    | 7.00                 |
| Mid              | PP1  | 11.75                    | 7.00                 |
|                  | PP2  | 12.30                    | 7.00                 |
|                  | PP3  | 12.60                    | 7.00                 |
|                  | PP4  | 11.93                    | 7.00                 |
|                  | PP5  | 12.08                    | 7.00                 |
|                  | PP6  | 11.75                    | 7.00                 |
|                  | PP7  | 16.57                    | 7.00                 |
|                  | PP8  | 13.50                    | 7.00                 |
|                  | PP9  | 16.80                    | 7.00                 |
|                  | PP6  | 12.30                    | 7.00                 |
|                  | PP7  | 16.57                    | 7.00                 |
|                  | PP8  | 13.50                    | 7.00                 |
|                  | PP9  | 16.80                    | 7.00                 |
| Final            | SP1  | 12.00                    | 7.10                 |
|                  | SP2  | 11.00                    | 7.00                 |
|                  | SP3  | 13.00                    | 7.00                 |
|                  | Tukey test α 5% | 13.46 | 1.20 |

3.3 Composition of sugar palm saps

The factors affecting the different sugar compositions on sugar palm saps, include tapping age, location, tapping techniques, and environmental factors. Sugar production can be enhanced using consortium enzyme, by using the saccharification process on sago pith. However, when fermentation occurs, the S. elipsoides used tend to convert glucose to organic acid [18]. Sucrose is commonly regarded as the main transport form of carbohydrates in many plants. Phloem sap of palm species contains this sugar. Gibbs reported that all bleeding saps of A. pinnata, C. nucifera, and C. utan consist of sucrose and almost no reducing sugars [19]. Sugar palm saps have the highest sugar composition in the form of sucrose. It is disaccharide with one α-D-glucose molecule bound by a single β-D-fructose molecule. Sucrose doesn’t reduce sugar because there is no free carbonyl group. Glucose and fructose are the monosaccharides of sucrose compounds and includes the reducing sugar. The reducing sugar affects the process of sugar crystallization [20]. The higher reducing of sugar content in saps, more it will be inhibiting the process of sugar crystallization. While the reducing sugar is lower, it will speed up the process of sugar crystallization [21]. The results showed a lower production of sugar content than sucrose content, so sugar palm saps in Banjarnegara can be made into crystal sugar (Table 7).

### Table 7. Composition of sugar at several levels of tapping age

| Level of tapping | Code | Fructose (%) | Glucose (%) | Sucrose (%) | Sugar content (%) |
|------------------|------|--------------|-------------|-------------|-------------------|
| Early            | AP3  | 0.42         | 0.43        | 12.67       | 13.52             |
| Mid              | PP6  | 0.04         | 0.04        | 8.01        | 8.09              |
| Final            | SP3  | 0.94         | 1.69        | 10.19       | 12.82             |

There is a significant difference on brix content among sugar palm sap which was tapped from different altitudes and seasons. Seasons ultimately contribute to protein content. There is no significant
difference on the phosphorus content between sap which was harvested from different altitudes and seasons. Seasons and altitude provide a significant impact on Magnesium and Calcium content in sap. Altitudes significantly affect Potassium content [22].

The results showed that the highest sugar content at the early level of tapping age is 13.52%, with a sucrose content of 12.67% (Table 7). The sugar content of sugar palm saps on Akel Tournuang varieties is 13.60% [12]. However according to Tenda et al. [10], the sugar content of sugar palm saps on Genjah Kutim varieties is 12.81%. Alisaputra [23] showed that sugar content of sugar palm saps in Cianjur is 12.47% and Naknean et al. [24] depicted that sugar content in Songkhla Province, Thailand amounted to 11.21%. Sugar palm saps can be processed into crystal sugar with a pH of 5.80-6.80, and a sucrose content of 12.00-15.00% [25].

### 3.4. Correlation between morphological characteristics with productivity of sugar palm saps

Morphological characteristic data with sugar palm saps productivity data were analyzed by correlation using Pearson correlation to know the relationship between two variables related to sugar palm morphology with sugar palm productivity further. The correlation analysis that has the most significant effect is at the final level of the tapping age, while the correlation between the variables that have the most significant effect is the afternoon sugar palm saps discharge with the productivity of sugar palm saps (Table 8). This is because saps was out each hour in 1 inflorescence determine the sugar palm saps productivity each inflorescence.

### Table 8. Correlation analysis on some observed variables at the early, middle, and final of tapping age

#### a) Early tapping

| Correlation | LB1 (cm) | LB2 (cm) | JD | JIB | LTS (cm) | JH | VNP (l/i) | VNS (l/i) | VT (l/i) | DNP (l/i/h) | DNS (l/i/h) | PN (l/d) |
|-------------|---------|---------|----|-----|---------|----|-----------|-----------|---------|-------------|-------------|---------|
| TT          | 0.88**  | 0.95**  | 0.99** | 0.41 | 0.97**  | -0.88 | -0.29     | -0.34     | -0.32   | 0.22        | -0.17       | -0.32   |
| LB1         | 0.98**  | 0.93**  | 0.78* | 0.76* | 0.76*   | -0.70 | -0.74     | -0.72     | -0.25   | -0.61       | -0.72       |         |
| JD          | 0.97**  | 0.84**  | -0.98 | -0.59 | -0.63   | -0.61 | -0.10     | -0.48     | -0.61   |             |             |         |
| JIB         | 0.50    | 0.94**  | -0.92 | -0.39 | -0.44   | 0.41  | 0.12      | -0.27     | -0.42   |             |             |         |
| LTS         | 0.08    | 0.99**  | -0.74 | -0.06 | -0.12   | -0.09 | 0.44      | 0.05      | -0.09   |             |             |         |
| JH          | 0.71*   | 0.75*   | 0.73  | 0.26  | 0.62*   | 0.73  |           |           |         |             |             |         |
| VNP         | 0.99**  | 0.86**  | 0.99** | 0.99** | 0.99**  | 0.99** |           |           |         |             |             |         |
| VNS         | 0.99**  | 0.83**  | 0.98** | 0.99** | 0.99**  | 0.99** |           |           |         |             |             |         |
| VT          | 0.85**  | 0.98**  | 0.92** | 0.85** | 0.98**  | 0.98** |           |           |         |             |             |         |
| DNP         | 0.98**  | 0.98**  | 0.98** | 0.98** | 0.98**  | 0.98** |           |           |         |             |             |         |
| DNS         | 0.98**  | 0.98**  | 0.98** | 0.98** | 0.98**  | 0.98** |           |           |         |             |             |         |

#### b) Mid tapping

| Correlation | LB1 (cm) | LB2 (cm) | JD | JIB | LTS (cm) | JH | VNP (l/i) | VNS (l/i) | VT (l/i) | DNP (l/i/h) | DNS (l/i/h) | PN (l/d) |
|-------------|---------|---------|----|-----|---------|----|-----------|-----------|---------|-------------|-------------|---------|
| TT          | 0.44    | 0.48    | 0.59* | 0.25 | 0.14    | -0.25 | 0.23      | -0.43     | -0.52   | 0.68*       | -0.46       | -0.84   |
| LB1         | 0.97**  | 0.64*   | -0.18 | 0.40 | 0.37    | 0.48  | 0.29      | -0.18     | 0.24    | 0.21        | -0.52       |         |
| LB2         | 0.63*   | -0.11   | 0.30  | 0.28  | 0.44    | 0.27  | -0.09     | 0.31      | 0.26    | -0.48       |             |         |
| JD          | 0.43    | 0.70*   | -0.59 | -0.58 | -0.63   | -0.48 | -0.29     | -0.58     | -0.33   |             |             |         |
| JIB         | 0.12    | -0.11   | -0.04 | -0.59 | -0.47   | -0.25 | -0.25     | -0.44     |         |             |             |         |
| LTS         | 0.79*   | 0.93**  | 0.45  | -0.04 | 0.75*   | 0.20  |           |           |         |             |             |         |
| JH          | 0.95*   | 0.69*   | 0.35  | 0.54  | 0.55    | -0.06 |           |           |         |             |             |         |
| VNP         | 0.68*   | -0.09   | 0.93** | 0.46  |         |       |           |           |         |             |             |         |
| VNS         | 0.08    | 0.84**  | 0.78* |       |         |       |           |           |         |             |             |         |
| VT          | -0.03   | -0.28   | 0.59* |       |         |       |           |           |         |             |             |         |
| DNP         |         |         |       |       |         |       |           |           |         |             |             |         |
| DNS         |         |         |       |       |         |       |           |           |         |             |             |         |
The results showed that there was a correlation between stem circumference and plant height. According to Hafidz et al. [26], giving shade (32, 56, and 64%) to sugar palm seedlings can increase stem circumference by 22.3% compared to seedling that are not shaded. Gatti et al. [27] also stated that the stem circumference and plant height had a positive correlation, the greater the stem circumference the higher the plant height.

The sugar palm farmers in Pringamba Village beat do the sugar palm bunches in the morning and afternoon for 30 minutes for 3-4 weeks per palm tree. The beating of sugar palm bunches was determined by the duration of tapping and sugar palm saps volume. The aim of beatings is to loosen filter vessels in inflorescence to supply saps. The number of midribs could have an effect on palm oil production, particularly on average bunch weight and production of fresh fruit bunches. Setting the number of stems left behind each period can determined the difference in the yield of oil palm production [28].

4. Conclusions
Palm trees in Banjarnegara at three age levels of tapping have a high diversity in morphological variables of plant height, stem circumference, number of leaves, and number of female inflorescence. The volume productivity of the sap at the initial tapping age level is relatively low (between 323.00-614.20 l/inflorescence), increase at the mid tapping age (between 570.20-650.00 l/inflorescence), and decrease at the final tapping age (between 76.10-445.00 l/inflorescence). The quality of palm sap in Banjarnegara has total dissolved solids of 11.00-16.80%, pH of the saps between 7.00-7.10, and sugar content between 8.09-13.52% by having lower reducing sugars than sucrose.

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