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Estimating Coconut Production and Productivity of Local Tall in Taliabu Island Using Drone and Sampling Population

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Abstract

The objective of this research is to know the local tall coconut population, production and productivity in Taliabu Island, North Maluku Province, which is crucial for the industry. The aerial photography method using drones has been carried out to determine the distribution of coconut diversity, palm age, production potential and local coconut productivity. Production data and coconut fruit components were carried out on 6 sample populations. The result (Arvitech) revealed that in Jorjoga, the area under coconut was 335ha out of the surveyed area of 1,066ha. The total number of coconut palms was 55.728 palms. The Geomac survey carried out in Tabona indicated there were 77,629 coconut palms in an area of 1,000ha. The fruit component analysis showed the weight of the whole fruit and the fruit without husk at the Jorjoga was 1,340-1,629g/fruit, and 805-1,033g/seed nut, and in Tabona was 1,478-1,577g/fruit and 944-966g/seed nut. The coconut production potential at Jorjoga was 9,539 nuts/ha/year, higher than that of Tabona with 7,227 nuts/ha/year. The coconut production and productivity estimation information can be used to develop a coconut replanting and rehabilitation strategy wherein selected varieties with good attributes for the tall coconut can be planted and ensure their proper maintenance, thus can be used to estimate the need for raw materials required for the establishment of the coconut industry in Taliabu Island. Determining the coconut population status can increase the production and productivity of coconut palms through rejuvenation, rehabilitation and expansion of coconut plantations using superior tall coconut seedlings.

Keywords: Local tall, drone, production, productivity, fruit component analysis

Introduction

The coconut palm is a strategic commodity that plays a significant role in people's lives because all parts of the palm are used to meet economic, social, and cultural needs. Nut production for the tall type shows the number of fruits produced under certain agronomic conditions. Meanwhile, the increase in productivity is the increase in the yield of coconut fruits as a result of an improvement in the method of production, as well as the proper utilization of resources. An estimation of coconut fruit production in a coconut plantation is useful for planning purposes to increase the productivity of tall coconuts for use in the production of various coconut derivative products with high economic value. By knowing the potential for production and productivity of the tall coconut in the upstream, the information can be used to plan for the downstream coconut industry in terms of the size of the factory to be constructed, the processing capacity, the kind of machines to be procured and installed, human resource required, and other relevant infrastructure.

For many years, the main output of the coconut sector in the international market was copra, crude coconut oil (CNO) and its derivatives. However, in the last 10 years, we have been able to see new coconut products, the so-called "non-traditional" products entering global exchanges. The market growth of these products, mainly coconut water extracted from mature or immature nuts, virgin coconut oil (VCO) cold-pressed from the fresh kernel, coconut sugar taken from the sap flowing out of the flower, is exponential. The craze for the new products has created big expectations from the consumers towards the coconut stakeholders (Prades, Salum and Pioch (2016). Studies have shown that coconut oil is effective in reducing oral microbial load and decreasing plaque and gingival indices but the number of studies remain a few (Salian, 2018). Destabilization of emulsion in coconut milk brings about the collapse of the emulsion, from which virgin coconut oil (VCO) can be obtained. The yield,

characteristics, and properties of VCO are governed by the processes used for destabilizing coconut milk. VCO is considered to be a functional oil and is rich in medium-chain fatty acids with health advantages (Patil and Benjakul, 2018). The statements of the experts above prove that the future of the coconut industry is bright. Thus, if the downstream activities run well and the coconut raw material is sufficient, then coconut production and productivity upstream must also run well and sustainably.

For the local tall coconut variety to be developed it must exhibit some superior characteristics in terms of production and productivity of coconut fruit, among others. In that regard, the coconut variety found in Hainan (*Cocos nucifera* L.) has been proved to have beneficial properties, namely high yield, strong growing stems, and wind tolerance. The local tall coconut variety is the most dominant coconut plant in Hainan Island, the main coconut producing area in China; and is one of the superior coconut varieties being developed (Pan et al., 2018). A survey conducted by Selvamani and Duraisami (2018) to collect soil samples and other basic data from 110 coconut plantations revealed that there exists a relationship between the yield and the soil properties that were determined by the use of correlation coefficient. The highest, positive and significant correlation was observed between soil depth and coconut yield. Among the physical properties studied viz., clay, silt, sand, bulk density, particle density and pore space, a significant and negative correlation was obtained between sand content and yield.

The NICO (Natural Indococo Organic) company one of the estate crops companies in Indonesia has a coconut plantation of around 2,000 hectares in Taliabu Island (Taliabu Regency), North Maluku Province. To obtain accurate coconut production data that is close to real, it is necessary to collect the data at several sample points that are randomly selected, and are representative of the production and productivity of the tall coconut in a plantation. This data is very important to the NICO company to enable proper planning and establish an integrated coconut industry in Taliabu Island.

The purpose of the research was to identify, evaluate and estimate the production and productivity of local tall coconut in Taliabu Island. The information gathered will be used to increase coconut production and productivity by using high input technology to enable the coconut palm to produce high yields per unit area and hence ensure the sustainability of the integrated coconut industry.

Materials and Methods

Study area

The research was conducted in Taliabu Island, Taliabu Regency, and North Maluku Province. The activity was carried out from 1st to 12th February 2021. The location of observation is the Jorjoga site (North of Taliabu Island) and Tabona site (South of Taliabu Island) has around 1,000 hectares or a total of 2,000 hectares. Both of these sites are located near the sea, with an altitude of 5-20 m height from sea level. Some

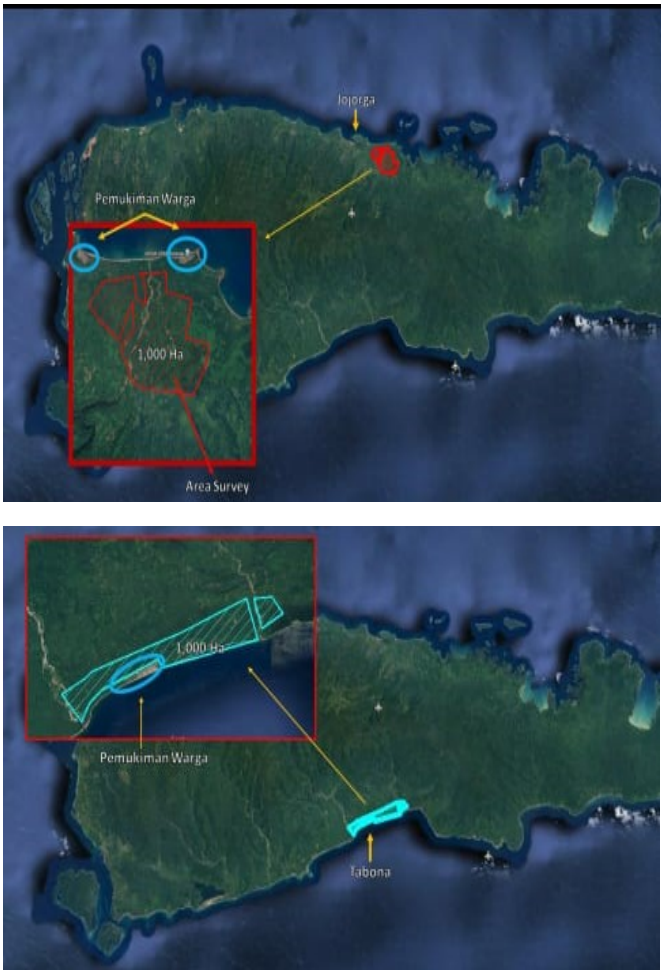

Figure 1. Sites of the survey of the coconut expanse in Jorjoga (left) and Tabona (right) in the North and South of Taliabu Island, Taliabu Regency, North Maluku Province

areas (40-60%) is still consist of secondary forest, bush, and topography a bit hilly.

Methodology

A survey was carried out by two teams (only for using Drone) namely the Avirtech Survey Team that made observations in the Jojorga site, North Taliabu District, and the Geomac Survey Team that conducted its work in Tabona site, South of Taliabu District. Both surveys were carried out by use of aerial photography with a special drone to find out map patterns, topography, number of coconut palms, the health of coconut palms, the types of plants available, the height of the coconut palms, and estate mapping. A third survey team, the HALP Team from NICO company was specifically formed to make direct observations of the coconut plants using the observation methods of STANTECH COGENT (Santos et al., 1997) in Jorjoga and Tabona sites respectively. Materials and equipment used by the teams to make the observations on the coconut plants

Figure 2. Aerial photography by a drone showing the expansiveness of the coconut population with high, medium and low density at the Jorjoga location, and the Tabona location

include a drone, a digital sighting scale, a meter rule, field desk, paint/Phylox, machetes and coconut meat extraction tools. For the Jorjoga site, the survey was conducted in Tanjung Una Village, while for the Tabona site, it was carried out in Maluli Village.

Observations on the production and other components of the tall coconut fruit were carried out by using coconut overlay blocks as a sampling population by the same team. Each location of the survey area (Jojorga and Tabona) was assigned 3 (three) coconut expanse locations randomly and evenly distributed over the area, with the criteria of coconut population at low, medium and high-density growth rates, based on a visual overview of aerial photographs with a drone (Figure 1), After the sample coconut expanse was determined, each coconut expanse was assigned with an area of about one hectare. Thereafter, 30 tall coconut palms of the same age were randomly selected using a diagonal system method. Hence, for the two sites; (Jojorga and Tabona), there were 6 sample coconut populations with a total of 180 palms. All the selected sample palms were marked with colored Phylox paint, with numbers 1 to 30 on the tree trunk, and on the sample fruit for each coconut population sample.

In addition, the following characteristics were observed for each sample palm as per the protocol developed by Santos et al., 1997:

- The number of bunches per palm was done by counting from fully open fruit bunches to the lowest fruit bunch.
- The number of fruit in a bunch is determined by counting the number of fruits in the three oldest bunches of fruits and determining the average.
- The number of fruits/palm/year, namely the number of bunches/year times the average number of fruits/bunch.
- The Fruit component analysis was done by selecting one ripe fruit from each sample palm, and the following parameters for each fruit were recorded:
  - » Fruit shape,
  - » Weight of the whole nut,
  - » Weight of nut without husk,
  - » Weight of nut without water,
  - » weight of meat or endosperm,
  - » Thickness of the coconut meat.

The various parameters of the fruit were determined as follows:

- Weight of whole fruit (g): weighed and calculated the average weight of whole coconuts from sample coconuts,
- Weight of fruit without husk/weight of coconut kernels (g): peeled and husked the nut, then weighed individually and the average weight of the fruit without husk was calculated,
- Weight of seed nut without water (g): coconut seed nuts were split open, the juice was extracted and then weighed,
- The weight of the meat (g): the meat from the coconut which has been split is extracted out using a copra chopper, and then being weighed,
- Husk weight (g), is the difference between the weight of the whole fruit and the weight of the seed nuts,
- The weight of coconut water (g) is the difference between the weight of the whole nut and the weight of the split nut.
- Shell weight (g) is the difference between the weight of the seed nuts and the weight of the coconut meat,
- Thickness of coconut meat (cm), was done by measuring the thicknesses of several nuts and the average was calculated using a sigmat or meter roll.
- Data analysis was performed to determine the average value, standard deviation, and coefficient of variance.

Results and Discussions

Avirtech and Geomac surveyor teams

The first team of the Avirtech Survey reported that the total area that was covered at the Jorjoga location was 1,066ha. The types of plants that were dominant in the area were coconut palms, some cocoa plants, cloves, bananas, other fruit trees and secondary timber forests and shrubs. The area under coconut palms was 335ha, while the remaining area of 731ha had no coconut palms. The results of the aerial photo analysis showed that the height of the coconut palms varied between 1 and 22.23m, with an average height of 7.29m. The number of coconut palms in the area of 335ha was 55,728 trees. The health of coconut palms can be identified from the color of the crown, if the green color is more than 70% it is categorized

Table 1. Observation result of production characters and components of tall coconut fruit with low, medium and high coconut density in Jorjoga and Tabona locations, Taliabu Regency, North Maluku Province

Characteristics	Location of coconut population					
	Jorjoga with level population			Tabona with level population		
	Low	Medium	High	Low	Medium	High
Number of bunches/palm	12	12	13	10	10	10
Fruit/bunch (nuts)	8	8	9	8	7	9
Fruit/palm (nuts)	102	97	110	90	73	89
Weight of whole nut (g)	1,629	1,356	1,340	1,577	1,478	1,507
Weight of nut (g)	1,033	850	805	966	944	994
Weight of husk (g)	596	505	535	612	534	513
Weight of shell (g)	238	204	193	236	244	257
Weight of coconut water (g)	364	270	244	305	289	300
Thick of meat (cm)	1.16	1.15	1.00	1.27	1.16	1.24
Weight of meat (g)	431	380	368	430	411	432

as health, whereas if it is less than 70% it is categorized as poor health.

The second survey team of Geomac on the other hand reported that the total land area that was surveyed was 1,000ha in the Tabona location, North Taliabu District. The coconut palms were sparsely distributed in the upper areas and densely distributed near the river bank. Some areas were covered by the undergrowth of secondary forest trees and other plants. The topography of the area is generally flat and is close to the sea. The altitude is about 5-20m above sea level. The survey, therefore, revealed that the number of palms obtained from the photoshoot was 77,629 trees.

The total number of coconut palms in both sites (Jorjoga and Tabona) was estimated at 133,357 palms. The results of the observations made with aerial photography using the drone can be used for future planning of the land in the two sites for expansion of the area under coconut palms, rehabilitation of existing palms and replanting with superior coconut seedlings among others.

Assessment of coconut palms production and productivity in Jorjoga and Tabona sites

In each location, three sample coconut populations were determined using the criteria of Low, Medium and High coconut palm density. Their growth rates based on aerial photographs with drones are as shown in Figure 2.

The population density per unit area or land stretch is influenced by various factors such as coconut spacing, planting distance, intercropping of plantation crops and the number of palms that are died as a result of pests and diseases, being struck by lightning, or parts of land that are not suitable for palm production, as well as the age of the palms in relation to replanting without logging the old coconut plants.

1. Coconut fruit production and fruit components analysis

The results of observations made on the production and components of coconut fruit at the Jorjoga and Tabona locations are presented in Table 1. From the table it can be seen that the parameters observed starting from the number of bunches per tree, number of fruits per bunch, number of fruits per palm and the weight of the fruit components starting from the whole fruit, weight of fruit without husk, the weight of husk, shells, coconut water, coconut meat and thickness of the coconut meat in the coconut expanse with Low, Medium and High-density levels were recorded. The results showed that the average number of fruit bunches per palm in Jorjoga was between 12-13, while in Tabona the average was only 10 bunches per palm. This number is low especially for Tabona location. In general, Tall coconut palms produce one leaf every month with a fruit bunch at each leaf axil. Hence under normal circumstances, the number of fruit bunches in a coconut should be at least 12 bunches per year.

In certain coconut varieties that are growing on fertile land and sufficient water is available with good cultivation practices, the productivity of coconut palms can be as high as 14-16 bunches per tree per year for the tall coconut varieties.

Furthermore, for the parameter on the number of fruits per bunch at the Jorjoga site, an average of 8-9 nuts per bunch was recorded, while the Tabona site recorded between 7-9 nuts per bunch. The figures on the number of fruits per bunch in the two sites are quite high compared to the acceptable figure of 7 fruits per bunch. In that regard, if for example, the productivity of the coconut palm is at least 12 bunches per palm, then the production of tall coconut is 84 nuts per palm per year, which is considered good.

In Table 1, it is found that the production of local tall coconut at the Jorjoga location is between 97-110 per palm per year, and in the Tabona location between 73-90 nuts per palm per year. When viewed from the differences in the productivity

Table 2. Average, standard deviation and coefficient of variance of production characteristics and fruit components of coconut at Jorjoga and Tabona locations, for low, medium and high coconut population density levels on Taliabu Island, Taliabu Regency, and North Maluku

Characteristics (Jorjoga)	Parameter		
	Mean	SD	CV (%)
Number of bunches/palm	12.32	2.39	20
Fruit/bunch (nuts)	8.40	2.32	25
Fruit/palm (nuts)	103	35.83	34
Weight of whole nut (g)	1,442	270	19
Weight of nut (g)	898	180	20
Weight of husk (g)	543	207	38
Weight of shell (g)	211	41	20
Weight of coconut water (g)	294	100	34
Thick of meat (cm)	1.10	0.14	12
Weight of meat (g)	393	68	17

Characteristics (Tabona)	Parameter		
	Average	SD	CV (%)
Number of bunches/palm	10.26	1.51	15
Fruit/bunch (nuts)	8.03	1.92	24
Fruit/palm (nuts)	84	28	34
Weight of whole nut (g)	1,521	338	22
Weight of nut (g)	968	203	21
Weight of husk (g)	553	212	39
Weight of shell (g)	246	63	26
Weight of coconut water (g)	298	126	42
Thick of meat (cm)	1.2	0.12	9
Weight of meat (g)	424	72	17

of the coconut expanse location based on the density level of Low, Medium and High, it is not that significant.

The weight of the whole fruit in the Jorjoga location is between 1,340-1,629g/fruit, and the weight of fruit without husk is between 805-1,033g/nut. On the side of Tabona location, the weight of the whole fruit ranged between 1,478 and 1,577 grams per fruit, and the weight of fruit without husk was between 944 and 966 grams per nut.

2. Variability of Production and Fruit Component Analysis

The diversity of coconut characters, including the production characters and coconut fruit components, will show how much variation in production and productivity between coconut palms. Table 2 shows the average, standard deviation and coefficient of the diversity of the characteristics of tall coconut at the Jorjoga and Tabona locations. The percentage coefficient of variance (CV%) below 20% indicates a fairly uniform character from each other for coconut palms, whereas if it is above 20% it is classified as having high. The size of the CV value is determined by the size of the standard deviation (SD) to the average value of a character for the plant.

Based on these criteria, it can be said that the characteristics of the coconut population at the Jorjoga location have a CV value of above 20% are those of fruit/bunch, fruit/palm, the weight of husk and weight of coconut water. This means that the diversity of that characters is large enough among the coconut palms. And the other characters, such as weight of the whole nut, the thickness of meat and weight of meat had CV values of 19%, 12%, and 17% respectively, indicating that they are almost similar to each other.

The diversity of production and fruit components of coconut at the Tabona location is almost the same as in the Jorjoga location. In general, characters with a CV value above 20% were found in the number of fruit per bunch, the number of fruits per palm, the weight of husk and the weight of coconut water. The other characters that were below 20% of the CV value, included thickness of meat and weight of meat with CVs of 9% and 17% respectively. Figure 3 shows the diversity of fruit shapes and sizes of fruits for the coconut population at the Jorjoga and Tabona locations. It can be seen visually that the coconut fruit samples at the Jorjoga location are more diverse in shape and size compared to the coconuts sampled from the Tabona location which are somewhat more uniform. The fruit shapes are almost round.

3. The production and productivity of coconut population in Taliabu Island

The average value of each coconut productivity observation location at the Jorjoga and Tabona locations for the three coconut density levels are presented as Low, Medium and High density of coconut are as shown in Tables 3 below. Coconut production in the Jorjoga location was higher than in the Tabona location and stood at 9,539.

Nuts per hectare per year compared to 7,227 nuts/ha/year. Based on the analysis of local tall coconut data at the Jorjoga location which represents the coconut population of North Taliabu District, and the Tabona location which represents South Taliabu District, it can be estimated that the average productivity of the two locations is around 8,383 nuts/ha/year (Table 3). This result is higher compared to the average

Figure 3. Coconut fruits sample from the location of Jorjoga (left) and Tabona (right), Taliabu Island

Table 3. The average number of characters for production and fruit components analysis of local tall coconut at Jorjoga and Tabona locations, Taliabu Regency, North Maluku Province

Characteristics	Average of fruit component analysis		
	Jorjoga	Tabona	Average
Number of bunches/palm	12	10	11
Fruit/bunch (nuts)	8	8	8
Fruit/palm (nuts)	103	84	94
Weight of whole nut (g)	1.142	1.521	1332
Weight of nut (g)	911	968	940
Weight of husk (g)	545	553	549
Weight of shell (g)	212	246	229
Weight of coconut water (g)	293	298	296
Thick of meat (cm)	1,10	1,22	1,16
Weight of meat (g)	393	424	408
Total palm/ha (trees)	186	173	180
Estimation palm productive/ha (nut) x 50%	93	86	90
Estimation production/ha (nut)	9.539	7.227	8.383

productivity of the Indonesian National coconut which is around 4,155 nuts per hectare per year (Alouw, 2020).

If the coconut palms in the Jorjoga and Tabona locations are still in the productive age of 10-50 years, then with good cultivation practices, such as weeding, fertilization, irrigation, control of pests and diseases, it is still possible to increase coconut productivity. Coconut plantations in these two locations appear to be lacking maintenance in several areas, and at the same time, many coconuts grow independently as a result of mature nuts that fall off from the trees and germinate to become young plants of varying age groups within the plantations. These wild-growing plants also have irregular spacing. Weeds and other shrubs on the other hand appear to be growing wild on some of the coconut plantations due to lack of proper routine maintenance. However, some coconut fields are well maintained and with good spacing.

Figure 4 shows an expanse of two coconut plantations in which one of them is quite well maintained and the other one is poorly maintained. Again, Figure 5 shows two sets of coconut palms with high fruit productivity and low fruit productivity respectively.

Coconut productivity can be improved optimally by using improved seed, improved cultural practices, and breeding activities. The breeding program includes selection, evaluation, and utilization of coconut germplasm. The selected good accessions can be released as high-yielding varieties (Novarianto, 2020). In the future, if both locations of Jorjoga and Tabona can be well-developed with a coconut plantation covering an area of 2,000ha, it is estimated that the productivity of coconuts can be increased to a minimum of 10,000 nuts/ha/year. Hence the potential for production in both locations can reach 2,000ha x 10,000 nuts/ha = 20,000,000 nuts/year. The amount of coconut as a nucleus is sufficient for the initial process of building an integrated coconut industry and can absorb coconuts from smallholder farmers. The initial results on farmer perception on the impact of technology intervention, with direct and indirect links to several biological and socio-economic limiting factors, indicate significant improvement across several parameters influencing crop productivity (Thamban et al., 2019). The collaboration between the coconut farming community as plasma and the coconut industry as the nucleus is expected to increase the incomes and welfare of the coconut farmers and the coconut industry, as well as sustainable coconut farming.

Figure 4. Coconut plantations that are well-maintained with regular spacing and that are poorly maintained with varying spacing, and many wild coconuts grow with various age levels of the plant

Figure 5. Coconut palms (left) with high fruit productivity, and coconut palms (right) with low fruit productivity

Conclusion

The drone technology combined with classical sampling population increased the data collection efficiency in tall coconut palms. The technology can cover the data of total areas, types of plants, total areas planted with coconut palms, the phenotypic characteristics such as height of the coconut palms, number of coconut palms, and coconut vigor (healthy, attacked by pests or infected by pathogens). The results of the observations showed that the coconut productivity was about 7.227 to 9.539 nuts /ha/year. The selection of coconut mother trees as a good source of local tall seed nuts can be done on 133,357 coconut palms in both locations (Jorjoga and Tabona, Taliabu Island).

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