

Soil Characteristics and Candlenut Plants Production in Community Forests in Bakubakulu Village Palolo District Sigi Regency Central Sulawesi

Gilang Ramadhan Syahputra¹, Wardah², Hasriani Muis²

^{1,2}Program Magister, Studi Ilmu-Ilmu Pertanian, Universitas Tadulako, Palu, Indonesia

Article Info

Article history:

Received : Jul 24, 2024

Revised : Sept 08, 2024

Accepted : Oct 18, 2024

Keywords:

Aleurites moluccana wild;
Chemical soil properties;
Production.

ABSTRACT

This research is conducted to examine the condition of soil chemical characteristics and production of candlenut stands at community forests in Bakubakulu Village, Palolo District, Sigi Regency. The analysis of soil sample was carried out in the soil science laboratory, Faculty of Agriculture, Tadulako University. This research was conducted on March to May 2021. This research was a survey on the candlenut plantation community forest through selecting soil samples from candlenut stands at an altitude of <500 masl and > 500 masl on gentle slope, slightly steep and steep slopes which were then analyzed at soil science laboratory. To obtain data on the production of candlenut stands, interviews were conducted with land owners. The results show that the average pH value of H₂O at an altitude of <500 masl is 6.5 and at an altitude of >500 masl it is 6.73. C-Organic <500 masl is 3.69% and >500 masl is 4.21%. N-Total <500 masl which is 0.22% and >500 masl which is 0.28%. CEC <500 masl is 26.12 (Cmol(+)kg⁻¹) and >500 masl is 28.12 (Cmol(+)kg⁻¹). K-Available <500 masl i.e. 1.31 (Cmol(+)kg⁻¹) and >500 masl i.e. 1.34 (Cmol(+)kg⁻¹). P-Available <500 masl which is 13.41 (ppm) and >500 masl which is 17.31 (ppm). The average value of candlenut stands production at an altitude of <500 masl is 68.18 kg/ha and an altitude >500 masl is 79.82 kg/ha. Furthermore, the results of the regression analysis reveal that there was a significant effect of soil chemical characteristics on the production of candlenut stands.

This is an open access article under the [CC BY-NC](https://creativecommons.org/licenses/by-nc/4.0/) license.



Corresponding Author:

Gilang Ramadhan Syahputra

Program Magister, Studi Ilmu-Ilmu Pertanian, Universitas Tadulako

Jl. Soekarno Hatta No.KM. 9, Tondo, Kec. Mantikulore, Kota Palu, Sulawesi Tengah 94148

Email: gilang.r.syahputra@gmail.com

1. INTRODUCTION

Candlenut (*Aleurites moluccana*) is one of the industrial plants from the Euphorbiaceae family that is spread in tropical and subtropical areas. The main candlenut cultivation areas for the Indonesian region can be found in the provinces of North Sumatra, West Sumatra, South Sumatra, Bengkulu, Lampung, West Java, West Kalimantan, South Kalimantan, East Kalimantan, Bali, South Sulawesi, Maluku and East Nusa Tenggara, with a total area reaching 205,532 ha (Direktorat Budidaya Tanaman Tahunan, 2012).

Candlenut plant (*Aleurites moluccana*) is a plant that has many benefits. This plant is often found growing in various places in Indonesia including in Bakubakulu Village, Palolo District, Sigi Regency, Central Sulawesi. From various sources of information, the fruit of the candlenut plant can be used

as a cooking spice to make food delicious (Narmaizah, 2014). Then from the health aspect, there are many benefits of the candlenut plant, one of which is as a hair fertilizer (Christy & Darniati, 2022). Furthermore, other benefits include as a coloring agent, decoration, building material and other benefits for humans (Krisnawati et al., 2011).

With the increasing enthusiasm of the community for the results of this plant, of course the area of land used by the community to grow candlenut plants will also increase. This increase in land area has resulted in an increase in the number of candlenut plant production in Indonesia, especially in Bakubakulu Village. Thus, it is only right that the community, especially farmers, need good information and knowledge in managing candlenut plants. In plant management, one thing that needs to be considered is the fertility and quality of the soil in the land. Therefore, in order to increase candlenut plant production, comprehensive information is needed for the community, especially farmers about soil quality and fertility in supporting candlenut plant production.

Management of candlenut plants can run well if supported by soil fertility and the type of soil that grows (Amarullah et al., 2023). Therefore, knowing the quality and fertility of the soil in candlenut stands needs to be done to support the development of candlenuts so that management efforts and knowledge in the growth of candlenut plants can be known.

In Bakubakulu Village, Palolo District, Sigi Regency, most of the people depend on the results of candlenut plants for their livelihoods. Candlenut planting activities have long been carried out by farmers in Bakubakulu Village. Candlenuts are planted by the community with agroforestry patterns and monoculture patterns with various variations in height and slope.

The people in Bakubakulu Village mostly work as farmers. Bakubakulu Village, Palolo District, Sigi Regency is one of the business development areas that generates income from candlenut seeds that are growing and one of the largest incomes for the surrounding community. Bakubakulu Village has enormous opportunities and potential to be used as a model for managing areas for the utilization of non-timber forest products.

Candlenut is a superior commodity for farmers in the village Bakubakulu, Palolo District, Sigi Regency, this is because the results of candlenut plants have a direct impact on the needs and welfare of the community. However, based on its potential, data on production and soil quality in candlenut plants at various heights and slopes in Bakubakulu Village have not been listed properly and comprehensively. Of course, in terms of candlenut plant production, good soil quality is needed as a medium for a plant to grow and develop. While the height and slope of the place where the plant grows will greatly affect the quality of the soil. Therefore, a study of soil quality in order to achieve increased candlenut plant production at different heights and slopes needs to be carried out.

Based on the background that has been described above, the formulation of the problem in this study is: How is the chemical condition of the soil in candlenut stands at different heights and slopes?; How is the production of candlenut plants at different heights and slopes in community forests in Bakubakulu Village, Palolo District, Sigi Regency?; How do the chemical characteristics of the soil affect the production of candlenut stands?.

2. METHOD

This study is a type of survey research on the community forest of candlenut plantations by taking soil samples that are done intentionally (Purposive Sampling), with considerations based on the altitude of the place >500 masl and <500 masl, and the slope is gentle, rather steep and steep. Candlenut fruit production data were obtained through interviews with landowners regarding the amount of production per tree based on the plots that had been determined on each gentle, rather steep and steep slope at an altitude of <500 and >500. Furthermore, soil sample analysis was carried out in the laboratory of the soil science unit, Faculty of Agriculture, Tadulako University.

This research was conducted for three months, namely from March to May 2021, located in Bakubakulu Village, Palolo District, Sigi Regency. Meanwhile, soil analysis was carried out at the Soil Science Laboratory, Faculty of Agriculture, Tadulako University.

The soil sampling technique is the number of plots for soil sampling as many as 30 plots. Plot making is based on the difference in height, namely <500 masl and >500 masl. At the two heights, there are 15 plots each spread over 3 slopes, namely 5 plots of gentle, 5 plots of rather steep and 5 plots of steep. Soil sampling was carried out by purposive sampling, soil sampling of chemical properties was carried out at a depth of 0-30 cm. Where in each plot 5 soil sample points were taken which were then composited. The distance between points is adjusted to the conditions in the field (Figure 2). Soil sampling was carried out by cleaning the surface of the soil at the location/point of

soil sampling from plants and litter. Then the soil was taken using a shovel to a depth of 30 cm. Then the soil was cleaned of plant debris and root pieces. At an altitude of >500 masl and below <500 masl, each slope was gentle, rather steep and steep. The weight of the soil taken at each point was 1000 grams, so the total soil sample taken for each research location was 5000 grams. After the compositing was considered homogeneous, 1000 grams of soil samples were taken from each research location. Then the soil samples were put into plastic bags and labeled. After that, the samples were taken to the laboratory for analysis.

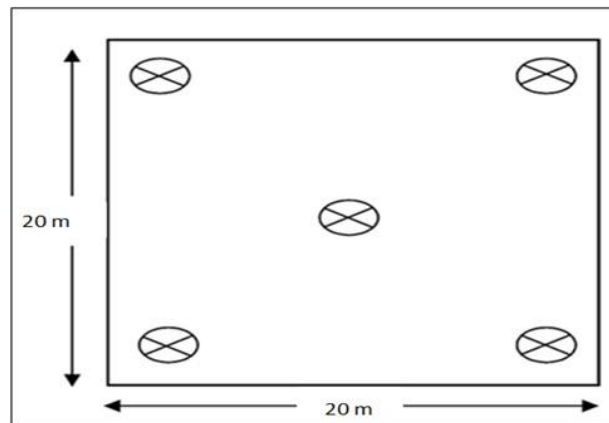


Figure 1. Soil Sampling Chemical Properties, Composite Soil Samples with Diagonal Pattern

The data obtained are primary data and secondary data. Primary data is based on laboratory observations, namely soil chemical properties including soil pH, organic C, Nitrogen (total N), Phosphorus (available P), Potassium (available K) and Cation Exchange Capacity (CEC). While secondary data is data obtained through casual interviews with landowners to obtain information including location, amount of fruit production, land area, and existing literature.

Analysis of candlenut fruit production was carried out using the following formula method:

$$P = \frac{Q/L}{t} \quad (1)$$

P = Productivity (ton/ha/year)

Q = Production quantity (tons)

L = Production Land Area (ha)

T = Production Period (years)

Analysis of the influence of soil characteristics on candlenut fruit production was carried out using a multiple linear regression formula (Sugiyono (2020:203), 2018), with the following approach:

$$Y = B_0 + X_1 + B_2 \dots + bnXn \quad (2)$$

Information:

Y : Dependent variable

Y1 : Production.

X : Independent variable

X1 : Ph H₂O.

X2 : C-Organic.

X3 : N-Total.

X4 : KTK.

X5 : K-Available.

X6 : P-Available.

A : Markconstant

B (1,2,3, . .) : Regression coefficient value.

3. RESULTS AND DISCUSSION

3.1 Soil Chemical Characteristics

The results of laboratory analysis research on the chemical conditions of soil in candlenut stands at altitudes of <500 masl and >500 masl on gentle, slightly steep and steep slopes in Bakubakulu Village, Palolo District, Sigi Regency, including pH (H₂O), Organic C, Total N, CEC, Available K, Available P are presented in Table 1.

Table 1. Soil chemical conditions in candlenut stands at altitudes of <500 masl and >500 masl in Bakubakulu Village, Palolo District, Sigi Regency.

Parameters	Altitude <500 meters above sea level				Elevation >500 meters above sea level			
	Ramp	A bit steep	Steep	Average	Ramp	A bit steep	Steep	Average
pH (H ₂ O)	6.48	6.48	6.17	6.38	6.64	6.52	7.03	6.73
C-organic (%)	3.39	4.14	3.53	3.69	2.73	4.78	5.08	4.20
N-Total (%)	0.14	0.21	0.25	0.20	0.22	0.32	0.33	0.29
CEC (cmol(+)/kg)	24.34	27.4	26.61	26.12	22.62	29.72	32.05	28.13
K-dd (cmol(+)/kg)	1.45	1.36	1.13	1.31	1.09	1.51	1.44	1.35
P-Available (ppm)	24.55	3.94	11.73	13.41	23.44	11.68	16.85	17.32

3.1.1 Soil pH Reaction (H₂O)

Based on Table 1 regarding soil analysis at various altitudes and slopes, it shows that the average value of soil pH reaction at altitudes >500 meters above sea level of 6.73 with a gentle slope value of 6.64, slightly steep of 6.52 and steep of 7.03. While the average value of soil pH at an altitude of <500 is 6.5 with a gentle slope value of 6.48, slightly steep of 6.84 and steep of 6.17. The soil pH value at both altitudes shows that the soil pH reaction is classified as slightly acidic to neutral. In acidic soils, the number of H⁺ ions is higher than OH⁻, but if the H⁺ content is the same as OH⁻ then the soil reacts neutrally Rukmi et al., 2017 also said that the higher the level of H⁺ ions in the soil, the more acidic the soil is. In Indonesia, the soil generally reacts from acid to neutral. In wet tropical areas, soils that have a high pH are dominated by various soils such as saline soils, sodic soils and alkaline soils. In the USDA classification, alkaline soils are Mollisol, Vertisol, Aridisol, and some soils that contain a lot of sulfur. Apart from that, we know the term salty soil which consists of saline, sodic and saline sodic soils.

3.1.2 C-Organic (%)

The results of the analysis of soil organic matter content at various heights and slopes of the place show that the average value of C-organic content at an altitude of >500 is 4.21% with a gentle slope value of 2.73%, slightly steep 4.78% and steep 5.08%. While at an altitude of <500 it is 3.69% with a gentle slope value of 3.39%, slightly steep 4.14% and steep 3.53%. This shows that at both altitudes >500 and <500, C-organic is quite high. Soil organic matter plays a very important role physically, chemically and biologically, thus determining the fertility status of a soil Brady et al., 2008 states that the organic matter content in the form of C-Organic must be maintained in the soil at a minimum of 2% so that the organic matter content in the soil does not decrease over time due to the mineralization decomposition process, so when processing the soil, the addition of organic matter must be given every year. The amount of litter found on the forest surface originating from fallen leaves of candlenut plants provides input for organic matter in the soil. The soil at the research location at both altitudes is thought to be Andisol soil. According to Nursyamsi, 2005 Andisol soil is a soil that is rich in organic matter compared to other soils. Organic C levels tend to increase with increasing altitude.

3.1.3 Nitrogen (N-total %)

The results of the study of Nitrogen content in the soil at the research location of the candlenut stand appear to show that the average value at an altitude of >500 is 0.28% with a gentle slope value of 0.22%, slightly steep at 0.32% and steep at 0.33%. While at an altitude of <500 it has an average value of 0.22% with a gentle slope value of 0.14%, slightly steep at 0.21% and steep at 0.25%. At the two altitudes >500 and <500 the candlenut stand shows that the nitrogen content falls into the moderate criteria. The element N plays a role as a component of all proteins, chlorophyll and nucleic acids and plays an important role in the formation of coenzymes. Soil nitrogen is used by microorganisms to decompose materials or compounds in the soil.

The availability of N in the soil is not only determined by the amount of total N in the soil, but is also closely related to the content of soil organic matter, especially its decomposition rate (C/N). If the carbon that enters the soil as fresh organic matter is large while the amount of nitrogen is relatively small, then the C/N ratio becomes high. Conversely, if the carbon that enters the soil as fresh organic matter is very large while the amount of nitrogen is relatively high, then the C/N ratio becomes low. This is because some of the available N is used by microorganisms in the decomposition of organic matter (Rusdiana & Lubis, 2012).

3.1.4 Cation Exchange Capacity

Cation Exchange Capacity (CEC) indicates the ability of the soil to retain exchange cations and exchange them. Thus, it can be used as an indication of nutrient provision. Soil with high CEC has a high capacity in storing nutrients (Nugroho, 2009). Based on the results of research on CEC content, it shows that the average value at an altitude of >500 is 28.12 (Cmol(+) kg^{-1}) with a gentle slope value of 22.62 (Cmol(+) kg^{-1}), rather steep 29.72 (Cmol(+) kg^{-1}) and steep 32.05 (Cmol(+) kg^{-1}). Meanwhile, at an altitude of <500 it is 26.12 (Cmol(+) kg^{-1}) with a gentle slope value of 24.34 (Cmol(+) kg^{-1}), rather steep at 27.4 (Cmol(+) kg^{-1}) and steep at 26.61 (Cmol(+) kg^{-1}). The CEC content at both altitudes >500 and <500 shows a high criterion. The amount of CEC is greatly influenced by various factors, including: soil reaction, soil texture or the amount of clay and organic matter. The tendency for high CEC values on slopes is due to the leaching of bases and clay and organic matter from the back to the slope. Soil containing high clay and organic matter tends to have high CEC values (Utomo, 2016).

3.1.5 Potassium (K-Available)

Based on the research results, it shows that the average value of the height >500 is 1.34 (Cmol(+) kg^{-1}) with a gentle slope value of 1.09 (Cmol(+) kg^{-1}), rather steep 1.51 (Cmol(+) kg^{-1}) and steep 1.44 (Cmol(+) kg^{-1}). While at an altitude of <500 it is 1.31 (Cmol(+) kg^{-1}) with a gentle slope value of 1.45 (Cmol(+) kg^{-1}), rather steep 1.36 (Cmol(+) kg^{-1}) and steep 1.13 (Cmol(+) kg^{-1}). It can be seen that the potassium content at both altitudes >500 and <500 has a very high criterion. The availability of K will also be influenced by the level of weathering of K-bearing minerals, the more intensive the more K is released so that it becomes more available to plants. Trisnawati, 2022 stated that the supply of potassium in the soil can be reduced due to three things, namely the uptake of potassium by plants, leaching of potassium by water, and soil erosion. Widowati et al., 2012 also stated that the level of potassium availability is also greatly influenced by pH and base saturation. At low pH and high base saturation, potassium is bound by Ca. Potassium is the third nutrient after nitrogen and phosphorus that is absorbed by plants in the form of K^+ ions. The positive charge of potassium will help neutralize the electric charge caused by the negative charge of nitrate, phosphate, or other elements (Melsasail et al., 2019).

3.1.6 Phosphorus (P-Available)

Based on the analysis results at an altitude of <500 and an altitude of >500, it shows that the average value of Phosphorus content (Available P) at an altitude of >500 is 17.31 (ppm) with a gentle slope value of 23.44 (ppm), rather steep at 11.68 (ppm) and steep at 16.85 (ppm). This shows that the Phosphorus content at an altitude of >500 is classified as high. While at an altitude of <500 it is 13.41 (ppm) with a gentle slope value of 24.55 (ppm), rather steep at 3.94 (ppm), and steep at 11.73 (ppm). This shows that the Phosphorus content at an altitude of <500 is classified as moderate. The difference between moderate and high in the availability of Available P elements is thought to be influenced by soil pH and C-Organic content. P is not available to plants because it is bound by Al (Firnia, 2018).

3.2 Candlenut Plant Production

The results of the study on the production of candlenut stands showed that there were various differences in production values at altitudes <500 masl and altitudes >500 masl on each slope. The highest average production value was at an altitude of >500 masl of 79.82 kg/ha while at an altitude of <500 masl it was 68.18 kg/ha. At an altitude of <500 masl the production value in gentle slope of 54.72 kg/ha. Furthermore, rather steep of 71.76 kg/ha and steep of 78.07 kg/ha. Furthermore, at an altitude of >500 masl the production value on gentle slopes is 76.59 kg/ha, rather steep 81.75 kg/ha and steep 81.12 kg/ha. The difference in production levels of candlenut stands can be seen in (Figure 2) the following bar diagram.

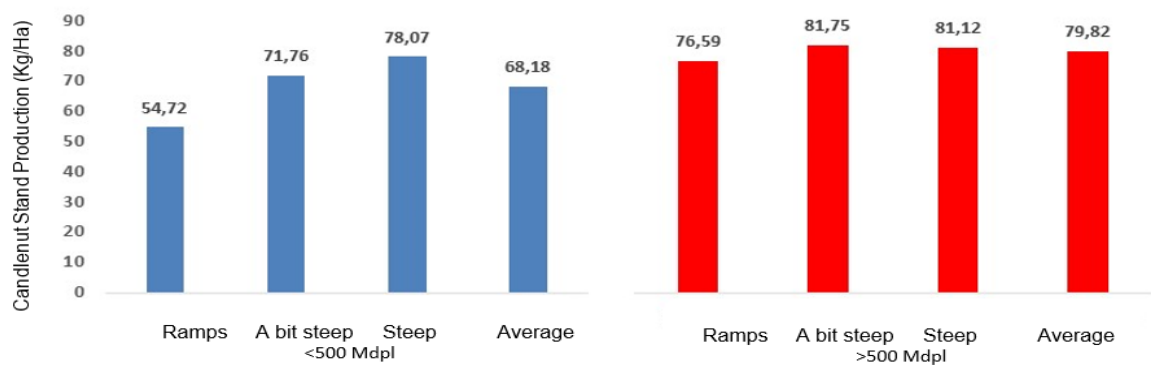


Figure 2. Bar chart of the number of candlenut stands produced

The difference in production at altitudes >500 masl and <500 masl on each slope is thought to be caused by several factors, namely plant health factors, light intensity and also the age of the candlenut plant. In line with research Power, 2013 which states that the production of candlenuts produced will decrease because it is influenced by the age of the plant that has passed the productive limit. Other factors that influence are the health condition of the plant, the fertility condition of the land and the level of intensity in managing the land and maintaining the plants.

3.3 The Influence of Soil Characteristics on Candlenut Production

3.3.1 Regression Analysis of Determination Coefficient (R^2) Value

From the regression analysis, the coefficient of determination value shows that there is the influence of soil chemical characteristics on the production of candlenut stands which have an R value which is 0.719. This shows that the influence of soil chemical characteristics on candlenut stand production has a strong relationship criteria. Furthermore, the simultaneous contribution or contribution to (Chemical Properties) namely X1 (pH H₂O), X2 (C-Organic), X3 (N-Total), X4 (CEC), X5 (K-Available) and X6 (P-Available) to the Y variable (Production) with an R^2 Square value of 52% while the remaining 48% is influenced by other factors not included in the model.

By using the help of the excel program, the contribution of each independent variable to the dependent variable can be calculated. By dividing each regression coefficient value by the total regression coefficient value. multiplied by 100, the contribution of the independent variable to the dependent variable can be obtained in Table 2.

Table 2. The amount of contribution of the independent variable (X) to the dependent variable (Y)

Independent variables	Regression Coefficient Value	Contribution (%)
X1 pH (H ₂ O)	0.999	3.76%
X2 C-organic (%)	0.297	1.12%
X3 N-Total (%)	24.06	90.47%
X4 CEC (cmol(+)/kg)	0.097	0.36%
X5 K-dd (cmol(+)/kg)	1,098	4.13%
X6 P-Available (ppm)	0.042	0.16%
Total	26,593	100.00%

3.3.2 Multiple Regression Analysis Significance Value

Based on the regression analysis of the influence of soil chemical characteristics on the production of candlenut stands, the significance value (Sig) obtained was $0.006 < 0.05$, this shows that soil chemical characteristics have a significant influence on the production of candlenut stands.

3.3.3 Partial Multiple Regression Analysis

Partial test is conducted as a further test. The results of multiple regression analysis partially (alone) on the effect of soil chemical characteristics on the production of candlenut stands are known to influence (Chemical Properties) variables X1 (pH H₂O), X2 (C-Organic), X3 (N-Total), X4 (CEC), X5 (K-Available) and X6 (P-Available) on variable Y (Production) which is tested partially. From the results of multiple regression analysis, the regression coefficient values obtained are $B_0 = 21.457$, $B_1 = 0.999$, $B_2 = 0.297$, $B_3 = 24.06$, $B_4 = 0.097$, $B_5 = 1.098$ and $B_6 = 0.042$. Thus, the multiple regression estimation model can be made into the following equation.

$$Y = 21,457 - 0,999 X_1 - 0,297 X_2 + 24.06 X_3 - 0,097 X_4 - 1.098 X_5 - 0,042 X_6 \quad (3)$$

The equation above can be used to make estimates of candlenut production at a location.

research, if other growth factors have shown drastic changes. From this partial regression model, it shows that a significant relationship occurs in the variable X3 (N-Total) to the variable Y (Production). Thus, the nitrogen content in the candlenut stands is thought to be caused by the candlenut stand land receiving a lot of light intensity which can produce more litter that falls to the bottom of the soil surface so that it can be decomposed in the soil into organic matter. Plants shed leaves and twigs into organic matter that will be decomposed again by microorganisms with the nitrogen cycle so that it can be reused by plants (Rukmi et al., 2017).

4. CONCLUSION

The soil pH conditions at altitudes >500 and <500 in the candlenut stands indicate that the soil pH reaction is classified as slightly acidic to neutral with an average value of >500, namely 6.73 and <500, namely 6.5. Furthermore, C-Organic shows that at altitudes >500 and <500, the C-organic content is classified as quite high with an average value of >500, namely 4.21 and <500, namely 3.69. Furthermore, N-Total at altitudes >500 and <500 shows that N-Total is classified as moderate with an average value of >500, namely 0.28 and <500, namely 0.22. Furthermore, CEC at altitudes >500 and <500 shows that it is in the high criteria with an average value of >500, namely 28.12 and <500, namely 26.12. Furthermore, K-Available at altitudes >500 and <500 shows very high criteria with an average value of >500, namely 1.34 and <500, namely 1.31. Furthermore, P-Available shows moderate to high criteria with an average value of >500, namely 17.31 and <500, namely 13.41. The highest average production value of candlenut stands is at an altitude of >500 masl at 79.82 kg/ha. While at an altitude of <500 masl at 68.18 kg/ha. On a gentle slope of <500 masl at 54.72 kg/ha and >500 masl at 76.59 kg/ha. A rather steep slope of <500 masl at 71.76 kg/ha and >500 masl at 81.75 kg/ha. A steep slope of <500 masl at 78.07 kg/ha and >500 masl at 81.12 kg/ha. From the results of the chemical characteristics of the soil on the production of candlenut stands, there is a strong relationship between variable X (Soil Chemistry) and variable Y (Production) with a value of 52% (R Square Value) while the remaining 48% is influenced by other factors not included in the model. Furthermore, the regression analysis of the significance value (Chemical Properties) of variables X1 (pH H₂O), X2 (C-Organic), X3 (N-Total), X4 (CEC), X5 (K-Available) and X6 (P-Available) on variable Y (Production) obtained a sig value <0.006 which indicates that the chemical characteristics of the soil have a significant effect on the production of candlenut stands. Furthermore, partial regression analysis shows that there is 1 variable, namely X3 (N-total) which has a significant effect on variable Y (Production).

REFERENCES

- Amarullah, A. M., Adiwena, M., & Arifin, F. R. (2023). *Teknologi Budidaya dan Produksi Tanaman*. Syiah Kuala University Press.
- Brady, N. C., Weil, R. R., & Weil, R. R. (2008). *The nature and properties of soils* (Vol. 13). Prentice Hall Upper Saddle River, NJ.
- Christy, J., & Darniati, D. (2022). PROSES PEMBUATAN MINYAK KEMIRI PUTIH DENGAN METODE FERMENTASI. *JUITECH: Jurnal Ilmiah Fakultas Teknik Universitas Quality*, 6(2), 65–69.
- Direktorat Budidaya Tanaman Tahunan. (2012). *Budidaya Tanaman Kemiri (Aleurites Moluccana Wild)* (Vol. 1, pp. 1–6).
- Firnia, D. (2018). Dinamika unsur fosfor pada tiap horison profil tanah masam. *Jurnal Agroekoteknologi*, 10(1).
- Krisnawati, H., Kallio, M., & Kanninen, M. (2011). *Aleurites moluccana (L.) Willd.: ekologi, silvikultur dan produktivitas*. Cifor.
- Melsasail, L., Warouw, V. R. C., & Kamag, Y. E. B. (2019). Analisis kandungan unsur hara pada kotoran sapi di daerah dataran tinggi dan dataran rendah. *Cocos*, 2(6).
- NARMAIZAH, R. (2014). *PENGOLAHAN CITRA PENGENALAN REMPAH DAUN BERBASIS BENTUK*. Universitas Muhammadiyah Gresik.
- Nursyamsi, D. (2005). Sifat-sifat Kimia dan Mineralogi Tanah serta Kaitannya dengan Kebutuhan Pupuk untuk Padi (*Oryza sativa*), Jagung (*Zea mays*), dan Kedelai (*Glycine max*). *Indonesian Journal of Agronomy*, 33(3).
- Rukmi, R., Bratawinata, A. A., Pitopang, R., & Matius, P. (2017). Sifat Fisik Dan Kimia Tanah Pada Berbagai Ketinggian Tempat Di Habitat Eboni (*Diospyros celebica* Bakh.) Das Sausu Sulawesi Tengah. *Jurnal Warta Rimba*, 5(1).
- Rusdiana, O., & Lubis, R. S. (2012). Pendugaan korelasi antara karakteristik tanah terhadap cadangan karbon (carbon stock) pada hutan sekunder. *Journal of Tropical Silviculture*, 3(1).
- Sugiyono (2020:203). (2018). Metode Penelitian. *Metode Penelitian*, 32–41.
- Trisnawati, A. (2022). Analisis Status Kesuburan Tanah Pada Kebun Petani Desa Ladogahar Kecamatan Nita Kabupaten Sikka. *Jurnal Locus Penelitian Dan Pengabdian*, 1(2), 68–80.
- Utomo, I. M. (2016). *Ilmu Tanah Dasar-Dasar dan Pengelolaan*. Kencana.

- Widowati, W., Asnah, A., & Sutoyo, S. (2012). Pengaruh penggunaan biochar dan pupuk kalium terhadap pencucian dan serapan kalium pada tanaman jagung. *Buana Sains*, 12(1), 83–90.
- Amarullah, A. M., Adiwena, M., & Arifin, F. R. (2023). *Teknologi Budidaya dan Produksi Tanaman*. Syiah Kuala University Press.
- Brady, N. C., Weil, R. R., & Weil, R. R. (2008). *The nature and properties of soils* (Vol. 13). Prentice Hall Upper Saddle River, NJ.
- Christy, J., & Darniati, D. (2022). PROSES PEMBUATAN MINYAK KEMIRI PUTIH DENGAN METODE FERMENTASI. *JUITECH: Jurnal Ilmiah Fakultas Teknik Universitas Quality*, 6(2), 65–69.
- Direktorat Budidaya Tanaman Tahunan. (2012). *Budidaya Tanaman Kemiri (Aleurites Moluccana Wild)* (Vol. 1, pp. 1–6).
- Firnia, D. (2018). Dinamika unsur fosfor pada tiap horison profil tanah masam. *Jurnal Agroekoteknologi*, 10(1).
- Krisnawati, H., Kallio, M., & Kanninen, M. (2011). *Aleurites moluccana (L.) Willd.: ekologi, silvikultur dan produktivitas*. Cifor.
- Melsasail, L., Warouw, V. R. C., & Kamag, Y. E. B. (2019). Analisis kandungan unsur hara pada kotoran sapi di daerah dataran tinggi dan dataran rendah. *Cocos*, 2(6).
- NARMAIZAH, R. (2014). *PENGOLAHAN CITRA PENGENALAN REMPAH DAUN BERBASIS BENTUK*. Universitas Muhammadiyah Gresik.
- Nursyamsi, D. (2005). Sifat-sifat Kimia dan Mineralogi Tanah serta Kaitannya dengan Kebutuhan Pupuk untuk Padi (*Oryza sativa*), Jagung (*Zea mays*), dan Kedelai (*Glycine max*). *Indonesian Journal of Agronomy*, 33(3).
- Rukmi, R., Bratawinata, A. A., Pitopang, R., & Matius, P. (2017). Sifat Fisik Dan Kimia Tanah Pada Berbagai Ketinggian Tempat Di Habitat Eboni (*Diospyros celebica* Bakh.) Das Sausu Sulawesi Tengah. *Jurnal Warta Rimba*, 5(1).
- Rusdiana, O., & Lubis, R. S. (2012). Pendugaan korelasi antara karakteristik tanah terhadap cadangan karbon (carbon stock) pada hutan sekunder. *Journal of Tropical Silviculture*, 3(1).
- Sugiyono (2020:203). (2018). Metode Penelitian. *Metode Penelitian*, 32–41.
- Trisnawati, A. (2022). Analisis Status Kesuburan Tanah Pada Kebun Petani Desa Ladogahar Kecamatan Nita Kabupaten Sikka. *Jurnal Locus Penelitian Dan Pengabdian*, 1(2), 68–80.
- Utomo, I. M. (2016). *Ilmu Tanah Dasar-Dasar dan Pengelolaan*. Kencana.
- Widowati, W., Asnah, A., & Sutoyo, S. (2012). Pengaruh penggunaan biochar dan pupuk kalium terhadap pencucian dan serapan kalium pada tanaman jagung. *Buana Sains*, 12(1), 83–90.