Agrotrop : Journal on Agriculture Science, 16(3): 312-320 (2026)
ISSN: 2654-4008 (Online), 2088-155X (Print)
URL: https://ejournal2.unud.ac.id/index.php/agrotrop
DOI: https://doi.org/10.24843/AJoAS.2026.v16.i03.p10
Penerbit: Fakultas Pertanian, Universitas Udayana

Morphological Characteristics of MCC 02 Cocoa on Nutrient Deficient Land in Patuk District, Gunungkidul Regency, Yogyakarta

Rizky Fadilah Siregar, Sutan Tarmizi Lubis*

Plantation Management Study Program, LPP Yogyakarta Polytechnic, **Indonesia**

**Corresponding author:* stn@polteklpp.ac.id

ABSTRACT

This study aims to characterize the morphological characteristics of MCC 02 cocoa (Theobroma cacao L.) grown in nutrient-limited soil conditions in Patuk District, Gunungkidul Regency, as initial information regarding the phenotypic characteristics of cocoa in an environment with limited nutrient availability. The method used was a descriptive survey of four selected sample plants. The results showed that the soil at the study location was acidic with relatively low organic carbon, total nitrogen, available potassium, and P_2O_5 content. In these soil conditions, the MCC 02 cocoa plants observed still showed the formation of vegetative and generative organs in the form of leaves, stems, branches, flowers, young fruit, ripe fruit, and seeds. The observed cocoa fruit weighed 403.9 g and contained 42 seeds. The results of this study provide information on the morphological characteristics of MCC 02 cocoa in a growing environment with nutrient limitations and enrich information regarding the phenotypic characteristics of cocoa in specific soil conditions.

Keywords: Cocoa, MCC 02, morphology, nutrient-deficient land, soil fertility, Gunungkidul

INTRODUCTION

Cocoa *(Theobroma cacao L.)* is an economically valuable plantation commodity that plays a role in supporting community income. Cocoa productivity is influenced by genetic factors, climate, cultivation techniques, and soil fertility. Cocoa development in Gunungkidul Regency faces land limitations, especially low organic matter and nutrient availability that can inhibit vegetative and generative plant growth (Rubiyo & Siswanto, 2012; Budihardjo, 2022). Patuk District is one of the cocoa development areas in Gunungkidul Regency. One of the clones cultivated is MCC 02, a superior clone with good growth and production potential. However, the character of the resulting plant is not only influenced by genetic traits, but also by environmental conditions. Differences in soil fertility, altitude, temperature, humidity, and rainfall can cause variations in the morphological and physiological characteristics of cocoa plants (Farhanandi & Indah, 2022).

Morphological characteristics, such as stem and branch diameter, leaf size, flower size, ovary size, and fruit size, can be used to describe plant growth. These characteristics are influenced by environmental conditions and nutrient availability (Setiari &

Nurchayati, 2009; Al-Hafidz et al., 2025). This study aims to describe the morphological characteristics of MCC 02 cocoa on nutrient-deficient land in Patuk District, Gunungkidul Regency, Yogyakarta Special Region. Aspects observed include plant morphology and soil nutrient conditions.

MATERIALS AND METHODS

Research Location

This research was conducted from November 2025 to January 2026 in Patuk District, with coordinates 7.870878396867188, 110.54273787314486, Gunungkidul Regency, Yogyakarta. The plant studied was cocoa *(Theobroma cacao L.)* variety MCC 02 (a superior variety that has been officially released and is commonly cultivated).

Research methods

This study used a descriptive survey method to obtain and collect primary data directly in the field. Data collection was carried out through observation, measurement, sampling, and recording of cocoa plant conditions and soil properties in areas with low nutrient availability.

Sampling, Data Analysis, and Observation Variables

Sampling was conducted on a 758.61 m^2 cocoa plot belonging to farmers. Six cocoa plants were observed under relatively uniform environmental conditions within a single observation plot. Four plants were then selected as primary samples based on the completeness of their plant organs and uniformity of growth conditions.

Morphological data of MCC 02 cocoa plants were analyzed descriptively and observationally through a quantitative field survey. Morphological analysis included plant height, leaf length and width, main stem diameter, primary, secondary, and tertiary branch diameter, and fruit condition. Data from four sample plants were tabulated, then the average value was calculated to describe the morphological characteristics of MCC 02 plants observed at the research site in Patuk District, Gunungkidul Regency.

Observation variables were stem diameter. The diameter of the main stem was measured 50 cm above the ground surface. The circumference of the stem was divided by 3.14 to obtain the diameter. Primary, secondary, and tertiary branches were measured 50 cm from the base using a caliper, then recorded in millimeters. Leaf length was measured from the base to the tip of the leaf blade following the main leaf vein, while the width was measured at the widest part. Observations were made on young, mature, and old leaves, then the results were recorded in centimeters (cm). Observations of cocoa fruit included shape, skin color, base and tip of the fruit, surface texture, seed shape, and number of seeds. The number of seeds was counted after the fruit was split and the seeds were separated. Flower length was measured from the base to the tip, while width was measured at the widest part. Measurements were made on fully bloomed flowers using a ruler and recorded in centimeters (cm). The observed nipples must be healthy, not wilted, not damaged, and still attached to the plant. Observation parameters included length, width, shape, color, tip shape, and surface grooves. Measurements were made using a ruler and recorded in centimeters (cm).

RESULTS AND DISCUSSION

Land Characteristics

Climate data from 2016–2025 shows that rainfall at the study site fluctuates, averaging 2,466.22 mm per year. The lowest rainfall occurred in 2019, at around 1,670 mm, while the highest occurred in 2025, at around 2,960 mm. Changes in rainfall can affect water availability, vegetative growth,

flowering, and cocoa production (Ardiani et al., 2022; Jayanti et al., 2013).

Average air humidity reaches 84%, while the annual temperature is relatively stable at 26.3–27.0°C. These temperature and humidity conditions can affect the photosynthesis process, transpiration, and stomatal activity of cocoa plants (Farhanandi & Indah, 2022; Al-Hafidz et al., 2025). In general, the climatic conditions at the research location are quite supportive of the growth of MCC 02 cocoa. However, plant growth can still be hampered if the soil has a low organic matter and nutrient content. Therefore, the addition of organic matter and appropriate fertilization are necessary to support the morphological and physiological growth of cocoa plants (Agussalim, 2016; Erwiyono et al., 2006).

Soil Characteristics

Based on Table 1, the analysis results showed that the soil at the study site had a pH of 5.36 H_2O and a pH of 4.79 KCl, making it acidic, but still suitable for cocoa growth. The organic C content of 1.92% and total N content of 0.18% were low, while the C/N ratio of 10.46 was on the low to moderate range. These conditions indicate that the availability of organic matter and nitrogen is still limited, which can inhibit vegetative growth, leaf formation, and plant chlorophyll content. Soil acidity can also reduce nutrient availability and inhibit the activity of soil microorganisms (Bakhtiar et al., 2021; Irsyam et al., 2025; Andari & Lesmana, 2025).

Table 1. Soil Test Results

Test Parameters	Unit	Land	Method	Information (Source: Soil Research Center, 2005)
pH (H2O)		5.36	Technical Instructions 2 2012 Land Research Institute I.3 (Electrometry)	Sour
pH (KCL)		4.79	Technical Instructions 2 2012 Land Research Institute I.3 (Electrometry)	M acid
C- organic	%	1.92	Technical Instructions 2 2012 Land Research Institute I.10 (Spectrophotometer ri)	Low
N-total	%	0.18	GUIDANCE GUIDANCE 2 2012 Land Research Institute I.11 (Spectrophotometer ri)	Low
C/N Ratio		10:46	Calculation	low-to-medium
K is available	Cmol(+)kg $^{-1}$	0.11	Am.Acetate 1N pH 7, AAS	Low
P2O5	Ppm	14.72	Technical Instructions 2 2012 Land Research Institute I.7 (Spectrophotometer ri)	Low
Total Ca	%	0.19	HNO3, HCIO4,AAS	Cannot be classified as Ca-dd
Total mg	%	0.29	HNO3, HCIO4,AAS	Cannot be classified as Mg-dd

Source: Center for the Implementation of Agricultural Instrument Standards (BPSIP) Yogyakarta

The available K content of 0.11 cmol(+) kg^{-1} and P_2O_5 of 14.72 ppm are relatively low. Deficiencies of these two elements can affect photosynthesis, stomatal regulation, root development, flowering, and cocoa fruit formation. The total Ca content of 0.19% and total Mg of 0.29% only indicate the reserves of elements in the soil and cannot be used to determine the level of availability for plants. Overall, soil fertility can be improved through liming, composting or manure, and balanced nitrogen, phosphorus, and potassium fertilization based on soil analysis results (Agussalim, 2016; Karmawati et al., 2010; Gunawan et al., 2019).

Morphology of Cocoa Plant MCC 02

Cocoa Leaves

Based on Figure 1, the observation results, the cocoa plant (Theobroma cacao L.) clone MCC 02 has elliptical leaves in all developmental phases, starting from young leaves, mature leaves, to old leaves. The similarity of the shape indicates that the elliptical shape is a relatively stable morphological character in the MCC 02 clone. The base of the leaf is also consistently tapered, while the tip experiences slight changes, namely long tapering on young leaves and becoming short tapering on mature leaves and old leaves. These results are in line with the characterization of Ilyas, (2023) who stated that MCC 02 leaves are elliptical, have a tapered base, short tapered tip, and wavy leaf surface.

Based on Table 2, the leaf size of MCC 02 cocoa increases with leaf development. The average length of young, mature, and old leaves is 21.1 ± 2.08 cm; 25.4 ± 1.79 cm; and 29.0 ± 0.35 cm, respectively, while the width is 7.1 ± 0.42 cm; 8.4 ± 0.91 cm; and 10.3 ± 1.2 cm. The length of old leaves has the most uniform size, while the length of young leaves shows the greatest variability. Differences in leaf size can be influenced by environmental conditions, especially light intensity and the presence of shade plants (Farhanandi & Indah, 2022). Despite growing on nutrient-poor soil, MCC 02 plants are still able to **experience leaf blade development and expansion.**

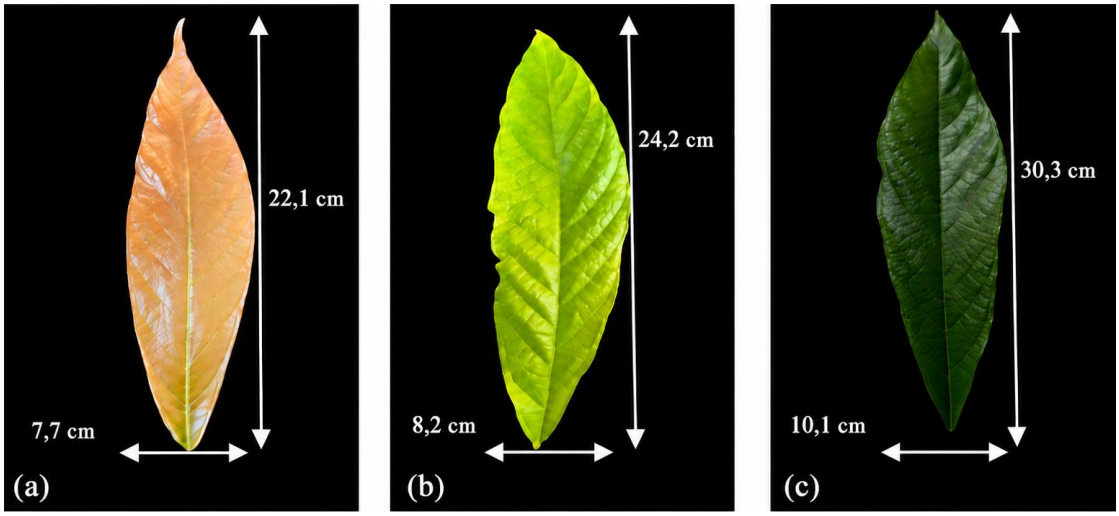


Figure 1. Morphology of MCC 02 Cocoa Leaves (a) Young Leaves, (b) Mature Leaves, (c) Old Leaves

Table 2. Average Leaf Size Data and Standard Deviation (cm)

CLONE	Length (cm)			Width (cm)		
	Young Leaf Length	Mature Leaf Length	Old Leaf Length	Young leaf width	Adult Leaf Width	Old Leaf Width
MCC02	21.1± 2.08	25.4 ±1.79	29 ± 0.35	7.1 ± 0.42	8.4±0.91	10.3 ±1.2

Cocoa Flower

Figure 2 shows the Cocoa flowers are perfect or hermaphrodite because the male and female reproductive organs are found in a single floret. The male organs consist of five fertile stamens and five staminodes, which are generally dark purple in color, while the rest of the flower can be white, cream, pale yellow, red, or purple, depending on the cultivar and growing conditions (Farhanandi & Indah, 2022). The MCC 02 cocoa flower in the photo is small, measuring 3.5 cm long and 2.4 cm wide, and has a slender stalk. The symmetrical, star-shaped flower consists of five creamy to pinkish petals and five creamy-white petals with pale yellow ligules. In the center are five dark red to blackish-purple staminodes surrounding the pistil and ovary. The flower appears to be in full bloom, although there is slight folding in the petals due to the picking process and observation.

The presence of fully bloomed flowers indicates that MCC 02 cocoa is still capable of generative growth on nutrient-poor soil. This condition indicates the plant's adaptive ability to allocate photosynthesis and energy reserves to the development of reproductive organs.

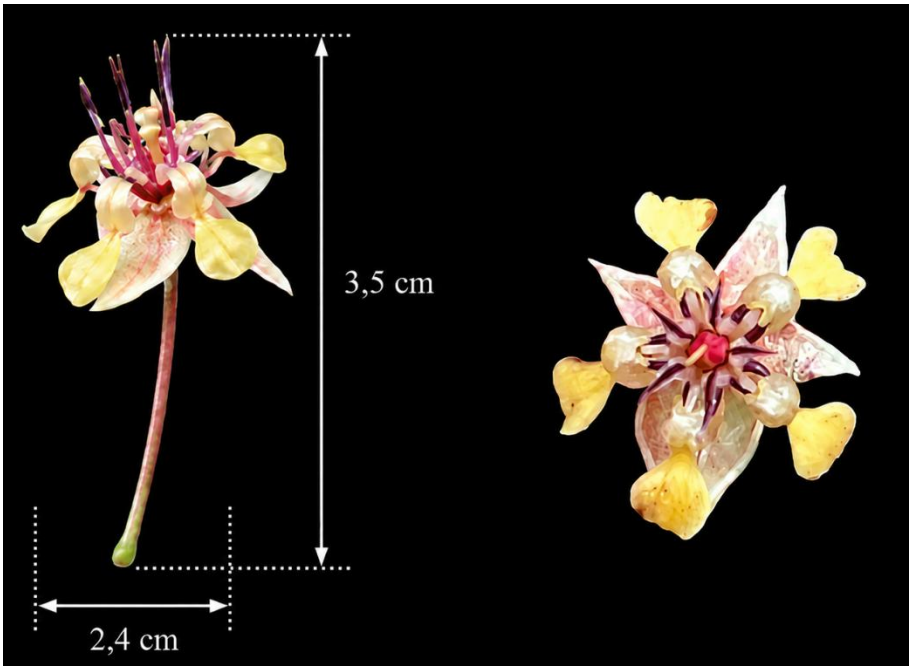


Figure 2. Morphology of MCC 02 Cocoa Flowers

Cocoa Stem

Figure 3 shows Cocoa Stem, Stem Criteria, Main Stem and Primary Branches, Secondary Branches, and Tertiary Branches. Table 3 result stem diameter is an important parameter for describing vegetative growth and plant structural strength because it is related to stem tissue formation (Elviani & Situmorang, 2026). The main stem had the largest average diameter, at 374.9 ± 36.04, indicating its function as the primary support and pathway for transporting water, nutrients, and photosynthesis products. The standard deviation value indicates variation in diameter between the observed stems.

The average diameters of primary, secondary, and tertiary branches were 71.1 ± 16.87; 49.4 ± 9.81; and 36.8 ± 7.14, respectively. These results indicate a pattern of decreasing diameter as the branching distance from the main stem increases. These differences in size are related to tissue formation, cell enlargement, accumulation of photosynthetic products, and morphological diversity influenced by cultivar and environmental conditions (Putri et al., 2016; Farhanandi & Indah, 2022).

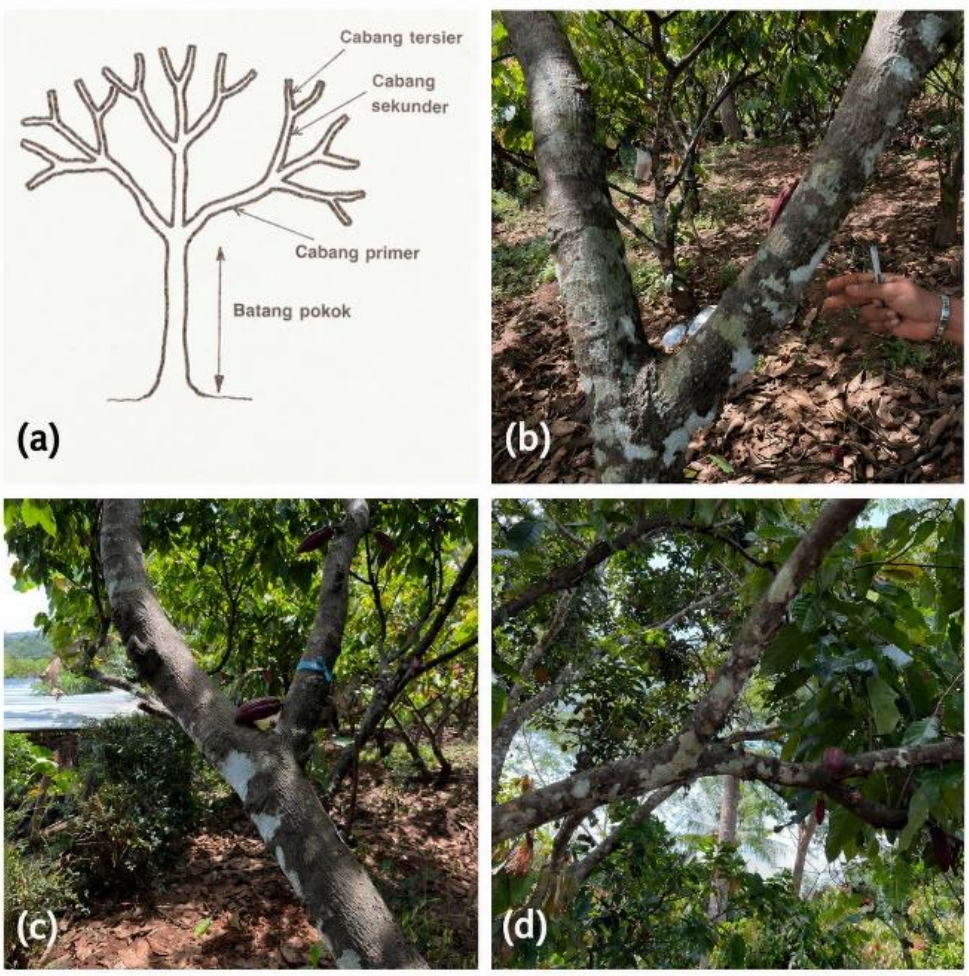


Figure 3. MCC 02 Cocoa Stem (a) Stem Criteria, (b) Main Stem and Primary Branches, (c) Secondary Branches, (d) Tertiary Branches

Table 3. Mean ± Standard Deviation of Stem Diameter (mm)

Stem	Average Stem Diameter ± SD
Main stem/tree	374.9 ± 36.04
Primary branch	71.1 ± 16.87
Secondary Branch	49.4 ± 9.81
Tertiary branch	36.8 ± 7.14

Cocoa Fruit

Figure 4 shows based on observations, the cocoa fruit weighs 403.9 g, is 18.5 cm long, and 9.5 cm wide. The fruit is elongated oval with both ends slightly tapered. The skin of the fruit is predominantly orange-red to reddish-yellow, has a rough and uneven texture, and has clear longitudinal grooves from base to tip. Ilyas (2023) stated that young cocoa fruit is generally green or red, then changes to yellow or orange when ripe. Cocoa fruit reaches maturity in about six months with a length of 10–30 cm, depending on the cultivar and environmental conditions.

The inside of the fruit contains 42 seeds arranged around a central axis and covered with a milky white to creamy pulp. The pulp has a soft, thick, slippery, and slimy texture and serves to protect the seeds during fruit development. The number of 42 seeds is still within the general range for cocoa beans, which is around 30–50 seeds per fruit (Sihotang & Marbun, 2024). The seeds are 4.2 cm long and 2.8 cm wide, oblong or oval in shape, slightly flattened, with one end tapering and the other more rounded. The surface of the seeds appears slippery, moist, and slightly uneven because they are still covered in pulp.

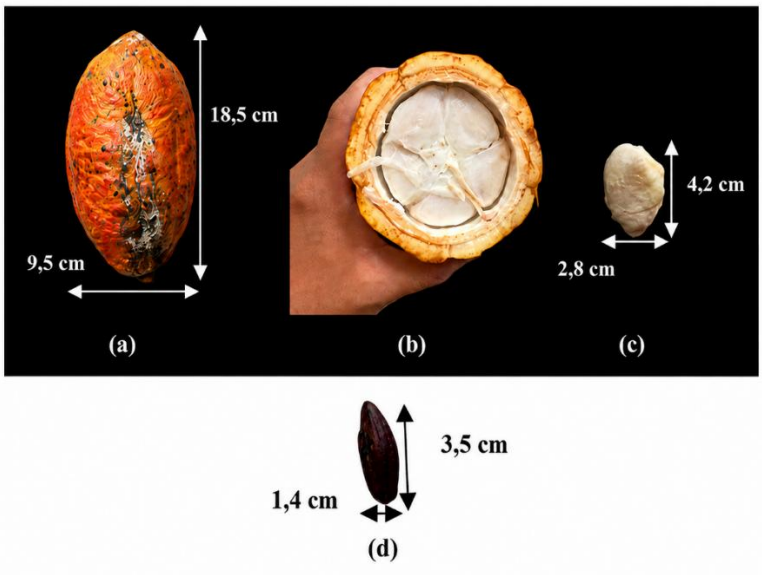


Figure 4. Morphological characteristics of cocoa fruit from clone MCC 02: (a) whole cocoa fruit (b) cross section of fruit showing the arrangement of seeds and pulp, (c) cocoa seeds, (d) ovary or cocoa nipple

The pod, or ovary, is 3.5 cm long and 1.4 cm wide. It is elongated and oval in shape with a tapered tip and a surface that begins to show longitudinal grooves from base to tip. The pod skin is dark red to purplish red. Differences in color, shape, groove depth, and tip shape of young pods are influenced by genetic characteristics or plant cultivars. These characteristics can be used as morphological characteristics to identify and differentiate cocoa cultivars (Farhanandi & Indah, 2022).

CONCLUSION

The results of the study showed that the MCC 02 cocoa clone plants observed in Patuk District exhibited vegetative and generative morphological characteristics in acidic soil conditions with low organic C, total N, available K, and P_2O_5 content. Vegetative characters were shown through variations in leaf size in the young, adult, and old phases, as well as a pattern of stem diameter that decreased from the main stem to the primary, secondary, and tertiary branches. These observation results illustrate the morphological conditions of MCC 02 plants at the research location with limited nutrients.

ACKNOWLEDGMENTS

Thanks are also extended to the landowners and cocoa farmers in Patuk District, Gunungkidul Regency, who granted permission and assisted with the observation and sampling activities. The authors also extend their thanks to the Center for the Implementation of Agricultural Instrument Standards (BPSIP) Yogyakarta for conducting the soil sample analysis, as well as to the supervising lecturer and all parties who provided direction, assistance, and support during the completion of this research and the preparation of this article.

RESEARCH LIMITATIONS

This study has limitations because it was conducted at a single location with a limited number of sample plants. Therefore, the results describe the specific conditions of MCC 02 plants at the observation location and cannot yet be used to conclude the level of tolerance or adaptation of MCC 02 to all nutrient-deficient land conditions.

REFERENCES

Agussalim. (2016). Effectiveness of organic fertilizer on cocoa plant productivity in Southeast Sulawesi. *Journal of Agricultural Technology Assessment and Development, 19*(2), 167–176.

Al-hafidz, N. N. K., Zahirah, N. L., Azzahra, T. A., & Wulaningsih, R. D. (2025). Analysis of stomata characteristics of *Rhoeo discolor* leaves based on different collection times. *Journal of Biology Science & Education 2025, 14*(1), 45–53.

Andari, L., & Lesmana, R. (2025). Fertilization recommendations for cocoa plants (*Theobroma cacao* L.) in the generative phase for farmers assisted by PT PKN in Metun Sajau Village, Tanjung Palas Timur District. *Journal of Humid Tropical Agroecotechnology, 8*(1), 56–62.

Ardiani, F., Wirianata, H., & Noviana, G. (2022). The effect of climate on cocoa production in Gunungkidul Regency. *Journal of Plantation Agro Industry, 10*(1), 45–52.

Bakhtiar, Anwar, & Munawir. (2021). Evaluation of land suitability for cocoa plants in the Salu Paku Sub-Das, North Luwu Regency. *Agrotek Journal, 5*(2).

Elviani, Y. D., & Situmorang, H. (2026). The effect of market compost on cocoa seedling growth. *Journal of Agriculture Science, 4*(1), 17–27. https://doi.org/10.34007/cultivate.v4i1.1131

Erwiyono, R., Sucahyo, A. A., Suyono, & Winarso, S. (2006). Effectiveness of potassium fertilization through foliar application on flowering and fruiting of

cocoa plants. *Pelita Perkebunan Journal, 22*(1), 13–24.

Farhanandi, B. W., & Indah, N. K. (2022). Morphological and anatomical characteristics of cocoa plants (*Theobroma cacao* L.) growing at different altitudes. *LenteraBio Journal, 11*(2), 310–325.

Gunawan, Wijayanto, N., Wilarso, S., & Budi, R. (2019). Characteristics of soil chemical properties and soil fertility status in *Eucalyptus* sp.-based vegetable agroforestry. *Journal of Tropical Silviculture, 10*(2), 63–69.

Ilyas, M. R. (2023). Morphological characterization of cocoa (*Theobroma cacao* L.) clones that are resistant to VSD at the Jember Cocoa Research Center. *Maliki Interdisciplinary Journal, 1*(6), 191–203.

Irsyam, A., Saida, & Robbo, A. (2025). Analysis of soil fertility status in cocoa plants (*Theobroma cacao* L.) in Herlang District, Bulukumba Regency. *AGrotekMAS Journal, 6*(1), 2723-620X.

Jayanti, D. S., Goenadi, S., & Hadi, P. (2013). Evaluation of land suitability and optimization of land use for cocoa (*Theobroma cacao* L.) plant development (case study in Batee and Padang Tiji Districts, Pidie Regency, Aceh Province). *AGRITECH, 33*(2), 208–218.

Karmawati, P. D. I. E., Mahmud, P. D. I. Z., Syakir, D. I. M., Munarso, D. I. S. J., Ardana, D. I. I. K., & Rubiyo, D. I. (2010). *Cocoa cultivation & post-harvest*. Center for Research and Development of Plantation Rights.

Putri, Y. O., Islan, & Saputra, S. I. (2016). Application of cocoa pod husk compost and coconut water on the growth of cocoa seedlings (*Theobroma cacao* L.) application. *Jom Faperta Vol., 3*(2), 1–14.

Rubiyo, & Siswanto. (2012). Increasing cocoa (*Theobroma cacao* L.) production and development in Indonesia. *RISTRI Bulletin, 3*(1), 33–48.

Setiari, N., & Nurchayati, Y. (2009). Exploration of chlorophyll content in several green vegetables as alternative basic ingredients for additional foods. *BIOMA Journal, 11*(1), 6–10.