International Journal of Multidisciplinary Sciences and Arts

E-ISSN : 2962-1658
Volume 3, Number 1, April 2024
https://doi.org/10.47709/ijmdsa.v3i1.3604

Percentage and Intensity of Stem Canker (Phytophthora Palmivora. Butler) on Cocoa Plants (Theobroma Cacao) and Its Effect on Dry Cocoa Bean Production (Kg)

[1]Yuza Defitri, [2]Ridawati Marpaung, [3]Ahmad Reza
[1,2,3]Universitas Batanghari Jambi, Indonesia
[1]yuza.defitri@unbari.ac.id, [2]ridawati.marpaung@unbari.ac.id, [3]ahmadza842@gmail.com

open access

***Corresponding Author**

Article History:
Submitted: Feb 16, 2024
Accepted: Jun 1, 2024
Published: Jun 5, 2024

Keywords:
Intensity, Disease, Percentage, Cocoa Plants

ABSTRACT

This study is to ascertain the types of diseases that affect the stems of cocoa plants (Theobroma cacao), as well as the impact of the severity and incidence of stem canker on stem canker disease. It also seeks to ascertain the percentage and intensity of P. palmivora stem canker disease. the process of making cocoa beans (T. cacao). The method used in this research is the observation method, the procedure for determining the research location was carried out by means of purposive sampling. The results of the research showed that the sample plants that were attacked by stem cancer showed symptoms of attack such as brown, purplish red stems, no holes, wet skin texture and black spots like rot. The highest percentage of stem cancer attacks was on plantation 3 at 37.78% and the lowest percentage of stem cancer attacks was on plantation 1 at 11.11%. The highest intensity of stem cancer attacks was on plantation 3 at 17.33% and the lowest intensity of stem cancer attacks was on plantation 1 (maintained) with an attack percentage of 6.39%. The results of observations on cocoa plant stem samples found a type of disease belonging to the Phytophthora palmivora fungus group at research locations 1, 2 and 3.

INTRODUCTION

The cocoa plant (Theobroma cacao L) is one of Indonesia's leading plantation commodities. The area of Indonesian cocoa plantations in 2020 was 1,506,955.00 ha with a production of 720,661 tons and around 99.4% was cultivated by the people. Cocoa production has decreased. In 2021 it will be 706,636 tons and will experience and increase again in 2022 to 732,256 tons (Directorate General of Plantations, 2022). Jambi Province is one of the cocoa producers in Indonesia from the island of Sumatra. In 2022, Jambi Province's cocoa production will be 941 tons with an area of 2,694 ha, Jambi Province's cocoa plant productivity will be 0.34 tons/ha (Directorate General of Plantations, 2022). Based on BPS data for 2022, Indonesia's cocoa production in 2021 will be 668,000 tons with a land area of 1,451,504 million hectares (Hartuti et al., 2019).

The BPS data shows that the average production of cocoa beans in Indonesia, if processed into kilograms per month, is 39 kg/hectare/month. Kumpeh Ilir District, Muaro Jambi Regency is a potential area that is being developed for cocoa cultivation. Production and planting area of cocoa plants in Kumpeh Ilir District in 2019 and 2020 were 216 tons each; 503 ha and 216 tons; 507 ha (BPS Muaro Jambi Regency, 2020). Based on survey results, in general cocoa plantations in Kumpeh Ilir District are dominated by smallholder plantations that are not maintained using traditional cultivation systems and do not meet the requirements for good cultivation, including disease control systems, so that cocoa production often experiences a decline (Firmanto et al., 2016).

One of the causes of low cocoa production is disease attacks. One of the main types of cocoa plant diseases is stem canker disease caused by Phytophthora palmivora (Butler). This disease is the most important disease in most cocoa producing countries and causes many losses (Mustafa, 2017). P. palmivora can attack the base of the stem, trunk, twigs, leaves and cocoa pods (Bowers et al, 2013). This fungus is the main agent that causes stem canker (Rubiyo et al, 2013). Several studies related to fruit rot disease have been carried out. Defitri, (2019) reported that the intensity of stem cancer attacks in Betung village caused by the fungus P. palmivora was 13%, fruit rot was 14.56%, Vascular Streak Dieback (VSD) was 10%. Matitaputty et al, (2014) reported that the intensity of stem cancer damage on cocoa plants in Taniwel District, West Seram Regency, Maluku Province was 15.1%, where the highest intensity of damage was in Mornaten Village at 32.42% (medium category) and the lowest in Uweth Village it was 3.20% (light category). Stem cancer attacks cause a decrease in productivity by 40-50% (Mustafa, 2017).

The greatest damage and loss if pathogen infection occurs in young fruit that is around 2 months old before it matures, this damage causes the growth and production of cocoa beans to be hampered and decreased (International Cocoa Organization and Center for Agriculture and Bioscience International, 2014). In order to increase cocoa production in Betung village, Kumpeh Ilir sub-district, it is necessary to implement strategies to prevent and control stem canker disease. So it is necessary to know the intensity of the attack and the percentage that attacks the cocoa fruit. This information is the basis for creating strategies for preventing and controlling stem cancer (Yonathan et al., 2016)

International Journal of Multidisciplinary Sciences and Arts
E-ISSN : 2962-1658
Volume 3, Number 1, April 2024
https://doi.org/10.47709/ijmdsa.v3i1.3604

LITERATURE REVIEW

The land area at the research location is 1 ha in well-maintained garden locations, 1 ha in poorly maintained gardens and 0.5 ha in unkempt garden locations. The number of plants at research locations 1 and 2 was 600 stems and 300 stems at research location 3. Taking the number of research samples refers to Tasri, (2007), where for a plant population of more than 100 then 15% of the sample plants taken are If there are less than 100 plants then the sample plants will be 50%. The method for assigning stem sample numbers is carried out using the Simple Random Sampling method for the first stem sample and systematic sampling for subsequent stem samples. The monitoring method is carried out by transecting or surrounding the garden according to a predetermined track direction (Of et al., 2021).

Research on stem cancer of cocoa plants is carried out by directly observing cocoa plants that are already bearing fruit, then counting the number of cocoa plants affected and showing symptoms of stem cancer and documenting them. Samples of diseased plants are taken and then wrapped in damp newspaper and put in a plastic bag and given a label, then stored in the refrigerator before being analyzed in the laboratory. Observations in this study consisted of five parameters which included symptoms of stem cancer attacks, percentage of stem cancer attacks, intensity of stem cancer attacks, identification of diseases in stems affected by stem cancer and production of dry cocoa beans during the last 6 months (Nambela et al., 2020).

Identification of stem cancer at the Jambi Class 1 Agricultural Quarantine Laboratory. Observations are made by microscopically observing the prepared stem samples or observing the results of the moist chamber. The results of stem canker identification were adjusted to the fungus identification book. Identification of other diseases was carried out as an additional result in this study. Other diseases are observed microscopically using the same method as observing stem cancer. The dry bean production of cocoa plants was calculated at all research locations by collecting dry cocoa bean harvest data in the last 6 months. Production data was compared between research locations according to plantation conditions, namely well-maintained, poorly maintained and unkempt. After the data was obtained, it was tabulated using Microsoft Excel 2010. The data obtained was presented in the form of tables and figures. Data were analyzed quantitatively descriptively to be used to explain the observed parameters.

METHOD

This research was carried out from November to December 2022 in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency. Identification of the type of disease on cocoa stems was carried out at the Jambi Class I Agricultural Quarantine Plant Laboratory. The materials used in this research were cocoa plants on community plantations in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency. Samples of cocoa stems, newspapers, tape, transparent plastic, tissue paper, and labels. The tools used in this research include stationery, camera, scissors, knife, tweezers, calipers, punch tool, 100 ml Erlenmeyer, glass object, cover glass, microscope, micro pipette, pipette, inoculation needle, test tube. The method used in this research is the observation method by making observations in the field visually and in the laboratory microscopically. The procedure for determining the research location was carried out using purposive sampling, the location was determined based on the consideration that the area was one of the cocoa production centers in Jambi Province. One group of cocoa farmers in Betung Village, Kumpeh Ilir District was selected consisting of 10 farmers. Of the 10 farmers, 3 locations were determined to be used as research locations. The three research locations are differentiated by plantation conditions, namely research location 1 (well maintained), research location 2 (less well maintained) and research location 3 (not well maintained). The land area at the research location is 1 ha in well-maintained garden locations, 1 ha in poorly maintained gardens and 0.5 ha in unkempt garden locations. The number of plants at research locations 1 and 2 was 600 stems and 300 stems at research location 3. Taking the number of research samples refers to Tasri, (2007), where for a plant population of more than 100 then 15% of the sample plants taken are If there are less than 100 plants then the sample plants will be 50%. The method for assigning stem sample numbers is carried out using the Simple Random Sampling method for the first stem sample and systematic sampling for subsequent stem samples. The monitoring method is carried out by transecting or surrounding the garden according to a predetermined track direction.

RESULT

Symptoms of stem canker attack

After observing the sample plants that were attacked by stem canker, the symptoms of the attack included brown, purplish red stems, no holes, wet skin texture and black spots that looked like they were rotting. Referring to the disease identification guidebook, this disease attack on cocoa stems is caused by P. palmivora (Butler).

Percentage of stem cancer attacks (%)

The results of observing the percentage of stem canker attacks on cocoa plants in the 3 research locations can be seen in Table 1 below.

Table 1. Percentage of stem canker attacks on sample plants in 3 research locations in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency

Research sites	∑ sample plants (stems)	∑ samples attacked by stem cancer (stems)	Percentage of stem cancer attacks (%)

International Journal of Multidisciplinary Sciences and Arts
E-ISSN : 2962-1658
Volume 3, Number 1, April 2024
https://doi.org/10.47709/ijmdsa.v3i1.3604

Location 1 (maintained)	90	10	11,11
Location 2 (less well maintained)	90	26	28,89
Location 3 (not maintained)	45	17	37.78

Source: Direct observation at the research location (gardens 1, 2 and 3)

Intensity of stem cancer attacks (%)

From the results of observations at 3 research locations in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency, the intensity of stem cancer attacks can be seen in Table 2 below.

Table 2. Intensity of stem canker attacks on sample plants at the research location in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency

Research location	Attack Intensity (%)
Garden 1 (Well Maintained)	6,39
Garden 2 (Poorly Maintained)	14,44
Garden 3 (Not Maintained)	17.33

Source: Direct observation at the research location (gardens 1, 2 and 3)

From Table 2, it can be seen that the intensity of stem canker attacks on sample plants at the research location showed different results. The highest intensity of stem cancer attacks was found in garden location 3 (not well maintained) with an attack percentage of 17.33%, followed by garden 2 (poorly maintained) with an attack percentage of 14.44%. The lowest intensity of stem cancer attacks was found in garden location 1 (maintained) with an attack percentage of 6.39% Identify diseases on the stem. Observation of the morphology of the fungus that grew after 14 days of incubation was carried out with the help of a binocular microscope at 40x magnification. The results of the analysis on all samples were then matched with the disease identification book. The form of the fungus that was identified can be seen in Figure 3. The results of observations on samples of cocoa plant stems found a type of disease belonging to the Phytophthora palmivora fungus group at research locations in gardens 1, 2 and 3. The results of the observations showed that the color of the colonies was white on the surface, the base was white with center black spots, colony surface flat. Sporangiospores are round, single-celled, golden brown in color. Identify other illnesses from the results of observations in the laboratory, another type of disease that was identified apart from the main disease in the cocoa stem samples was a disease from the fungus Fusarium acuminatum. Morphological form of disease due to fungal attack according to reference to Arfani et al, (2013). These results were found in garden stem sample 3 (not maintained) sample number 145 (Ediwirman, 2022) and (Defitri, 2019).

Production of dry cocoa beans

From the results of interviews with three cocoa plantation nursery farmers in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency, the production of dry cocoa beans from June to November 2022 can be seen in Table 3 below.

Table 3. Average production of dry cocoa beans from June to November 2022 in 3 research locations in Betung Village, Kumpeh Ilir District, Muaro Jambi Regency

Research sites	**Production of dry cocoa beans per hectare in the th month (Kg)**						**Average (kg/month)**
	June	July	August	September	October	November	
Garden 2 (Well Maintained)	75	82.2	53	55	56	75	**66.03**
Garden 2 (Well Maintained)	30	51	50	38	42	55	**44.33**
Garden 3 (Well Maintained)	18	20	21	23	20	25	**27.00**

Source: Interview results from cocoa plantation owners

From the table it can be seen that dry bean production for six months starting from June-November 2022, well-maintained cocoa gardens produced 66.03 kg of dry cocoa beans, less well-maintained plantations amounted to 44.33 kg, while the lowest cocoa bean production was found in unkempt garden locations. namely 27.00 kg. The average production of dry cocoa beans in plantation location 1 (maintained) is higher than plantations 2 and 3.

International Journal of Multidisciplinary Sciences and Arts
E-ISSN : 2962-1658
Volume 3, Number 1, April 2024
https://doi.org/10.47709/ijmdsa.v3i1.3604

DISCUSSION

Stem canker is an important disease for cocoa plants caused by infection of the fungus Phytophthora palmivora (Butler) on the stems and branches of cocoa plants. The fungus P. palmivora (Butler), which also causes fruit rot disease on cocoa plants, often attacks damp and dark cocoa gardens (Mustafa, 2017). This disease often causes significant losses to cocoa plants. The cause of disease that is often found in cocoa plants is fungus (Defitri, 2019). Almost all parts of the cocoa plant can be attacked by fungi. The research results of Arfani et al, (2019) show that cocoa plants in Pesawaran Regency are attacked by various kinds of fungal diseases and are found on the fruit and leaves. The fungal diseases that attack belong to the classes Oomycetes, Zygomycetes, and Deuteromycetes. Types of disease identified include Phytophthora palmivora (Butl), Botrytis cinerea Pers. Ex Pers, Botryodiplodia theobromae Sacc, Fusarium acuminatum Ellis and Everhart (Aswan et al., 2019) and (Aswar Musa et al., 2022).

The results of the research showed that all research locations showed the same symptoms of disease attack on the stems of the diseased cocoa plants, namely brown, purplish-red stems, no holes, wet skin texture and black spots that looked like they were rotting. Symptoms on these stems were observed directly at the research location. These attack symptoms indicate that the cocoa plant stems were attacked by the fungus P. palmivora (Butler). The results of this study are also strengthened by previous research where the symptoms of stem cancer attacks found were the same as the results of this study. The research results of Matitaputty et al, (2014); Mustafa et al, (2017) and Defitri (2019) show that the stems of cocoa plants infected with P. palmivora (Butler) disease swell on the trunk or branches and are blackish/dark in color and there are parts that are rotting and wet, and emit a reddish liquid. like a layer of rust. If this rotting layer is scraped/cleaned, a purple red layer will appear. Apart from the symptoms of attack, there is another factor that differentiates between research locations, namely the size of the stem area affected by the disease.

The agronomic condition of the garden at the research location can be seen based on garden care management. Based on the survey results at the research locations, there are differences in garden care management at each research location, especially in the fertilization process, weed control, pruning and sanitation. In garden 1 (maintained), garden maintenance is carried out by fertilizing using urea, KCL and organic fertilizer, weed control is done manually, pest and disease control is carried out and pruning is carried out by removing overlapping branches or cocoa twigs and reducing the crown circumference. plants that are too dense so that sunlight can enter the garden and the fruit harvest is controlled at intervals. In garden 2 (poorly maintained) garden maintenance is carried out by fertilizing using only urea fertilizer, weed control is done manually, pest and disease control is not carried out, pruning is carried out and the harvested fruit is not controlled at intervals. In garden 3 (not well maintained), almost no garden maintenance is carried out, fertilization is not carried out, weeds, pests and diseases are not controlled, pruning is not carried out and the harvested fruit is not controlled at all (Pascarella et al., 2004).

The results of this research show that the percentage of cocoa plant stems that are attacked differs between research locations. The highest percentage of cocoa plant stems affected by stem cancer was in plantation location 3 (not well maintained) at 37.78% followed by plantation 2 (less maintained) at 28.89%, while the percentage of cocoa plant stems affected by stem cancer was the lowest. found in plantation location 1 (maintained) at 11.11%. The results of this research were also reported in previous research that stem cancer attacks could reduce production by up to 40% (Mustafa, 2017).

This result is the same as the intensity of attacks where the highest intensity of stem cancer attacks was found in plantation location 3 (not well maintained) at 17.33% followed by plantation 2 (less well maintained) at 14.44%, while the lowest intensity of stem cancer attacks was at plantation location 1 (maintained) it was 6.39%. Differences in the percentage and intensity of attacks are caused by biotic factors, namely pathogenicity that causes disease and abiotic factors including weather, temperature, minerals, toxic compounds, and other causes (garden care/plant maintenance management) (Sutarman, 2017). The spread of stem canker disease is directly proportional to the spread of fruit rot disease and will accelerate if the rainy season and/or if garden conditions are too humid (Mustafa, 2017). The results of this research are also supported by previous research where the percentage of cocoa plant stems attacked by stem cancer ranged from 20-30% with the attack intensity ranging from 12-15%, the percentage and intensity of disease attacks on the stems were caused by Phytopthora palmivora disease (Defitri, 2019).

Identification of the type of disease was carried out on samples of affected cocoa plant stems, at each research location, namely plantation 1 had ten samples, garden 2 had ten samples and garden 3 had five samples. Observations were carried out microscopically with a microscope with 40 x magnification. The results of observations on the sample are then matched with the identification book. Based on the identification results, the type of disease found in the cocoa plant stem samples was Phytopthora palmivora. This type of disease is discovered based on morphological characteristics in samples seen under a microscope and identification books. The morphological characteristics are white colony color on the surface, white base with black spots in the center, flat colony surface, sporangiospores are round, single-celled, golden brown in color. These results were confirmed by Muzuni et al, (2022) who stated that the colony character of P. palmivora is round, yellow, the surface of the colony is white and the bottom surface is brown, the texture of the colony is like cotton, the edges of the colony are uneven, there is zoning, there are radial lines. and the colony diameter was 90.73 mm (Hartuti et al., 2019).

E-ISSN : 2962-1658
Volume 3, Number 1, April 2024
https://doi.org/10.47709/ijmdsa.v3i1.3604

Apart from the P. palmivora type of disease, the results of this research also found another type of disease in the same sample, namely Fusarium acuminatum. This type of disease was found based on the morphological characteristics of the sample seen under a microscope and an identification book. The morphological characteristics are that the conidia are crescent-shaped, with a pointed tip like a fishing hook, 3-7 compartments, and have 3 compartments. This identification result is also supported by previous research where P. palmivora and Fusarium acuminatum disease types were also found in cocoa fruit samples (Arfani et al, 2013). The existence of this disease confirms previous variables that the attack symptoms, percentage and intensity of attacks that cause damage to cocoa plant stems are caused by the fungus P. palmivora. The presence of the P. palmivora fungus also has a big influence on the production of dry cocoa beans at the research location. Based on the results of interviews with cocoa farmers at each research location, it shows different production results. During the last six months, the highest production of dry cocoa beans was at plantation location 1 (well maintained) with an average production of 66.03 kg, followed by plantation location 2 (less well maintained) at 44.33 kg, while the lowest production of dry cocoa beans was at plantation location 3 (not maintained) namely 27.00 kg (Firmanto et al., 2016).

Based on BPS data for 2022, Indonesia's cocoa production in 2021 will be 668,000 tons with a land area of 1,451,504 million hectares. The BPS data shows that the average production of cocoa beans in Indonesia, if processed into kilograms per month, is 39 kg/hectare/month. So the average production of cocoa beans at research locations 1 and 2 is still above national production. Meanwhile, the average production of cocoa beans at research location 3 is below national production. Cocoa production at the research location can be increased by making improvements to the management of cocoa cultivation Yonathan et al., 2016) and (Rubiyo et al., 2020).

Differences in garden conditions result in different dry bean production for cocoa plants, the more well-maintained the cocoa garden produces the highest dry bean production. Differences in garden conditions can be seen from the indicators of garden care carried out by farmers. Indicators include fertilization, weed control, pest and disease control, pruning and sanitation. Temperature and humidity conditions at research location plantation 1 with an average temperature and humidity of 30,300C; 85.33. At garden location 2 the average temperature and humidity is 30,270C; 83.33. Meanwhile, at garden location 3 the average temperature and humidity was 29,230C; 88.00. The temperature and humidity at the research location are still within the range of cocoa plants (Ediwirman, 2022).

CONCLUSION

Based on the research results, it can be concluded that: 1) The highest, medium and low percentage and intensity of Phytophthora palmivora (Butler) stem canker attacks were found in plantations 3, 2 and 1, respectively 37.78% and 17.33%; 28.89% and 14.44% ; 11.11% and 6.39%. The types of disease identified in samples of affected cocoa plant stems were the fungi Phytophthora palmivora (Butler) and Fusarium acuminatum. 2) The average production of dry cocoa beans during the last six months (June-November 2022) in plantation 1 (well maintained) was 66.03 kg, plantation 2 (less well maintained) was 44.33 kg and plantation 3 (not well maintained) was 27.00 kg. Cocoa bean production at research locations 1 and 2 is still above national production, namely 39 kg/hectare/month.

REFERENCES

Aswan, A., Effendy, S., Ridwan, K., & Oktarini, O. (2019). Rekayasa Peralatan Upgrading Batubara Peringkat Rendah Dalam Upaya Peningkatan Nilai Kalor Menggunakan Oli Sebagai Stabilisator Engineering Equipment of Upgrading Brown Coal To Increase Calorific Value Using Lube Oil As Stabilizer. *Jurnal Kinetika*, *10*(02), 14–19. https://jurnal.polsri.ac.id/index.php/kimia/index

Aswar Musa, M., Kartini Parawansa, A., & Ralle, A. (2022). Resistance Of Some Clones Of Cocoa (Theobroma cacao L.) Against Stem Cancer ofPhytopthora palmivora. *Jurnal AGrotekMAS*, *3*(2), 18–25. https://jurnal.fp.umi.ac.id/index.php/agrotekmas18

Defitri, Y. (2019). INTENSITAS BEBERAPA PENYAKIT UTAMA PADA TANAMAN KAKAO (Theobroma cacao, L.)DI DESA BETUNG KECAMATAN KUMPEH ILIR. *Jurnal Media Pertanian*, *4*(2), 81. https://doi.org/10.33087/jagro.v4i2.86

Ediwirman, E. (2022). The Appearance of Cocoa Clones Tolerant to Infection Phytophthora palmivora. *Jurnal Agronomi Tanaman Tropika (Juatika)*, *4*(2), 184–193. https://doi.org/10.36378/juatika.v4i2.2270

Firmanto, H., Aklimawati, L., & Abdurrizal, B. S. (2016). Performance of Roasted Cocoa Bean Winnower For Small Holder Chocolate Producers. *Pelita Perkebunan (a Coffee and Cocoa Research Journal)*, *32*(2), 120–129. https://doi.org/10.22302/iccri.jur.pelitaperkebunan.v32i2.211

Hartuti, S., Bintoro, N., Karyadi, J. N. W., & Pranoto, Y. (2019). Characteristics of Dried Cocoa Beans (Theobroma cacao L.) Color Using Response Surface Methodology. *Planta Tropika: Journal of Agro Science*, *7*(1), 82–92. https://doi.org/10.18196/pt.2019.097.82-92

Nambela, J. B., Rouw, A., & Sipi, S. (2020). Evaluation of Cocoa Agribusiness in South Manokwari Regency, West Papua, Indonesia. *Pelita Perkebunan (a Coffee and Cocoa Research Journal)*, *36*(3), 277–289. https://doi.org/10.22302/iccri.jur.pelitaperkebunan.v36i3.406

Of, Q. C., Garden, B., & Regency, J. (2021). *Jurnal Sosial Ekonomi dan Kebijakan Pertanian QUALITY CONTROL OF EDEL COCOA (COCOA PRECIOUS)*. *5*(November), 75–88.

E-ISSN : 2962-1658
Volume 3, **Number** 1, April 2024
https://doi.org/10.47709/ijmdsa.v3i1.3604

Pascarella, E. T., Pierson, C. T., Wolniak, G. C., & Terenzini, P. T. (2004). First-Generation College Students: Additional Evidence on College Experiences and Outcomes. *The Journal of Higher Education*, *75*(3), 249–284. https://doi.org/10.1353/jhe.2004.0016

Rubiyo, Dewi, Y. A., Imran, Salim, A., Baharudin, Indrawanto, C., & Ratule, M. T. (2020). Evaluation of yield and pest and disease resistance of cocoa clones in Kolaka District, Southeast Sulawesi, Indonesia. *Biodiversitas*, *21*(12), 5698–5707. https://doi.org/10.13057/biodiv/d211215

Yonathan, K. H., Lintong, P. M., & Durry, M. F. (2016). Pengaruh pemberian ekstrak biji kakao (Theobroma cacao) terhadap jumlah pigmen melanin kulit tikus Wistar (Rattus novergicus) yang dipapar sinar matahari. *Jurnal E-Biomedik*, *4*(2). https://doi.org/10.35790/ebm.4.2.2016.14710