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AGRICULTURAL TECHONOLOGY TRENDS AND INNOVATIONS FOR ENHANCING SUSTAINABLE DEVELOPMENT IN DIGITAL ERA

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NARASI

He IC-AGREFO is an international seminar organized through a collaboration between two institutions: the Payakumbuh State Agricultural Polytechnic as the host and Andalas University as the co-host. IC-AGREFO stands for the International Conference of Sustainable Agriculture, Green Technology, Renewable Resources, and Food Security. It was held on October 25-26, 2023, at the Payakumbuh State Agricultural Polytechnic campus located in the "50 Kota" district of West Sumatra, Indonesia. The conference's theme was "Agricultural Technology Trends and Innovations for Enhancing Sustainable Development in the Digital Era." This scientific meeting aimed to facilitate the presentation and publication of the latest research findings by all parties, including academics, industry professionals, government officials, and other relevant stakeholders.

The papers presented were categorized into seven fields of study: Agricultural and Biotechnology, Sustainable Agriculture, Environmental Science, Non-Renewable Energy Sources, Food Science, Agro-Industry, Engineering, and Information Technology to support smart farming. The seminar featured keynote speakers with expertise relevant to the seminar's theme, from both domestic and international backgrounds, and was attended by 85 participants from various universities, institutions, practitioners, and organizations both within and outside the country. The seminar's publication output includes an internationally indexed Scopus proceeding and an online proceeding registered with an ISBN.

Welcome Message
Conference Chair

Assalamualaikum Wr. Wb

Good morning to our dearest keynote speakers, participants, and presenters. We would like to extend the warmest welcome to you all for attending the International Conference of Sustainable Agriculture, Green Technology, Renewable Resources, and Food Security (IC-AGREFO) that we are hosting today.

The conference proudly features outstanding experts who will present the latest issues and solutions in sustainable agriculture, green technology, renewable resources, and food security. Therefore, we would like to express our deepest gratitude to our keynote speakers as follows:

- Prof Dr. Hasil Sembiring (Indonesian Rice Research, Indonesia)
- Prof. Dr. Amelia R. Nicolas (Central Bicol State University of Agriculture, Philippines)
- Assoc. Prof. Dr. Wahyu Caesarendra (Universiti Brunei Darusalam, Brunei Darussalam)
- Prof. Dr. Esra Capanoglu (Istambul Teknik Universitesi, Turkey)
- Assoc. Prof Dr. Nik Norasma Che'Ya (Universiti Putera Malaysia, Malaysia)
- Dr. Eng. Muhammad Makky, STP, MSi (Universitas Andalas, Indonesia)
- Assoc. Prof. Dr. Veronice (Politeknik Pertanian Negeri Payakumbuh, Indonesia)
- All offline and online participants and presenters in this conference,

Ladies and gentlemen,

This conference addresses a theme of relevance in recent times, which we believe will significantly contribute to the advancement of science and knowledge. We invite you to explore innovative solutions that address society's needs, especially in the face of increasingly complex challenges we encounter daily. We now live in an era marked by rapid technological and informational growth.

We would also like to express our deepest gratitude to all our sponsors who have generously supported our conference. We hope this event serves as an excellent platform for sharing knowledge, fostering new innovations, and acting as a source of inspiration for each of us.

Thank you.

OPENING CEREMONY
DIRECTOR OF POLITEKNIK PERTANIAN NEGERI PAYAKUMBUH

Deputy directors, respected keynote speakers, fellow lecturers, and distinguished guests,

Good morning. On behalf of the State Agricultural Polytechnic of Payakumbuh's academic community, I am honored to welcome you to our International Conference on Sustainable Agriculture, Green Technology, Renewable Resources, and Food Security. We aim to delve deeply into the trends and innovations in agricultural technology, particularly those enhancing sustainable development in this digital era.

The Food and Agriculture Organization (FAO) forecasts that by 2050, the global population will reach 10 billion. Concurrently, food productivity is grappling with significant challenges, including the effects of climate change, water shortages, environmental pollution due to intensive crop and livestock production, and food safety risks. The FAO underscores the importance of employing digital technologies to boost productivity and address food safety concerns. Hence, the role of digital technology in agriculture is paramount, ensuring sustainability that encompasses economic, environmental, and social aspects.

Digital technology's influence in agriculture touches all stakeholders — suppliers, input providers, and consumers. This influence has profound links to the broader industry, necessitating innovations that offer competitive advantages. These are manifested through precise agricultural practices encompassing agricultural apps and systems, process automation, robotics, cyber-physical systems, and the analysis of vast data sets.

The benefits of integrating digital technology in agriculture are manifold:

1. Economic sustainability offers intriguing market opportunities, fostering new agricultural businesses, and creating jobs to boost competitiveness.
2. Environmental sustainability uses precision agriculture to manage the adverse impacts of climate and habitat changes. By

controlling pesticide use, conserving water, and focusing on overall environmental health, we can mitigate these challenges.

3. Social sustainability promotes social welfare, harmonizing with regional growth, especially in rural and underprivileged communities.

In this digital age, the interplay between agricultural technology and industrial sectors is pivotal. Their combined efforts ensure resilience in the face of challenges, emphasizing responsible food production and consumption, economic expansion, infrastructure development, sustainable communities, and climate change mitigation.

However, leveraging digital technology in agriculture hinges on five critical factors: strategic orientation, customer focus, ICT integration, talent and innovation, and organizational culture. Digital technologies are transforming the global economic landscape. To stay ahead, businesses must evolve their models, adopting digital strategies that respond to emerging technologies and potential threats. Embracing culture, innovation, and organization helps capitalize on these technologies for a competitive edge. This approach yields benefits like enhanced productivity, increased sales, and a customer-centric approach, which, in turn, generates new value propositions.

Yet, challenges persist. Factors like climate change, resource limitations, cost implications, and market volatility restrict both farmers and policymakers in decision-making. The evolving landscape points to a future where digital technology might outstrip human capabilities in certain tasks that traditionally resisted automation. To date, the integration of technology in agriculture has been somewhat limited, primarily focused on business sustainability.

Therefore, this seminar’s objective is to craft a cohesive concept of sustainability in science, policy, and economics, propelling agricultural innovation backed by digital technology. This is our key to achieving sustainable agricultural growth.

We look forward to many fruitful collaborations in these pivotal domains.

I wish you all success in your endeavors, and thank you for your attention.

Table of Content

Modification of Nata De Coco Manufacturing Using Food-Grade Urea as a Practical Material in the Post-harvest Processing Laboratory

Maizarni[1], R. Guswira[2], A. Ulhaq[3]

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Nata de coco is a product obtained by fermenting coconut water with acetic acid bacteria (Acetobacter xylinum). The formation of nata requires nitrogen, which can be obtained from urea. The use of urea as one of the substrates for making nata has stirred some controversy, causing it to be necessary to adopt urea specifically used for food known as food-grade urea. The objective of this study was to determine the optimal concentration of dietary urea in the production of nata de coco with the consideration of the yield and sensory characteristics of nata. This concentration will allow for the development of the right formulation as a reference for student practicum. The study was conducted using a randomized design involving three concentrations of food-grade urea (1, 2.5, and 5 g/L), repeated four times, with a fermentation period of 10 days at 27 °C using Acetobacter xylinum. The results of the study showed that the coconut water contained edible urea. This had a significant impact on the production and organoleptic properties of nata ($p < 0.05$). Maximum nata production was obtained with the urea concentration of 2.5 g/L. Panelists liked the color, aroma, and chewiness of nata obtained with the urea concentration of 2.5 g/L.

Keywords: *fermentation, food grade urea, nata de coco, production, sensory properties*

INTRODUCTION

Nata de coco is made by fermenting coconut water with *Acetobacter xylinum*. Coconut water contains some of the required nutrients, but the need for macro-substrates such as C and N sources must still be met for optimal nata production. Therefore, the necessary nutrients that are missing must be added during fermentation. Sucrose, glucose, fructose, and flour can be added as carbon sources. Meanwhile, nitrogen, which is required for nata formation, can be obtained from urea. However, the use of urea as a substrate in nata de coco production has been controversial, not only among the general public, but also among food technologists. The use of non-food-grade urea has impacts and risks. Therefore, it is necessary to adopt urea which is specifically used for food which is known as food-grade urea.

METHODS

The study was conducted using a completely randomized design with three levels of urea concentration (1, 2.5, and 5 g/L) and four replications. The fermentation procedures were carried out using *Acetobacter xylinum* at room temperature (27 ºC) for 10 days.

The steps in equipment preparation were as follows. a) All pieces of equipment were thoroughly washed and sterilized with warm water and labeled. b) Newsprint was sterilized over a boiling pot. c) The coconut water used was obtained from Tanjung Pati, Lima Puluh Kota, West Sumatra. d) The coconut water was filtered using a filter cloth and a fine sieve to remove any shell fragments, coir fibers, or other impurities. e) Every four liters of coconut water was added with 40 grams of sugar and heated to boiling at 100 °C with continuous stirring until homogeneous. Food-grade urea was added at 1, 2.5, and 5 g/L coconut water to each boiling pot. After homogeneity was achieved, 10 mL/L glacial acetic acid was added. f) The substrate was poured into a 1500 ml sterile tray and covered with newsprint. The coconut water was then left to cool. g) Inoculation was carried out by adding 200 mL/L *Acetobacter xylinum* starter. h) Fermentation was carried out for 10 days. The resulting nata was washed and soaked for 4–5 days, and water changing was conducted every day during soaking. i) This was followed by cutting, boiling, and adding sugar and citric acid solutions. j) The nata de coco was poured into a container to serve as a sample in the organoleptic test.

RESULTS AND DISCUSSION

Nata de coco contains protein and carbohydrates. Every 100 mL of coconut water contains 0.2 g of protein, 0.03 g of nitrogen, 3.8 g of carbohydrates, 8 g of phosphorus, and 0.2 g of iron (Rukmana and Yuniarsih, 2001). Carbohydrates function as a carbon source for the growth of nata-forming bacteria. Muhtadi (1997) revealed that *A. xylinum* bacteria metabolize sugar into cellulose.

Nata de coco production

The results showed that the addition of dietary urea to coconut water had a significant effect on productivity ($p < 0.05$). Figure 1 shows that the average nata yield obtained with the average urea concentration of 2.5 g/L was much higher than with the urea concentrations of 1 g/L and 5 g/L. The weight of the nata de coco produced using food-grade urea at the concentration of 2.5 g/L was not significantly different from the weight of the nata de coco produced using the urea concentration of 5 g/L. Therefore, the urea concentration of 2.5 g/L was considered to yield the best result. When two treatments give results that are not significantly different, the use of food-grade urea at a lower concentration is better than the use at higher concentrations. In this case, with a smaller concentration of 2.5 g/L, it could produce nata weight that was not significantly different from the weight of nata obtained using the concentration of 5 g/L.

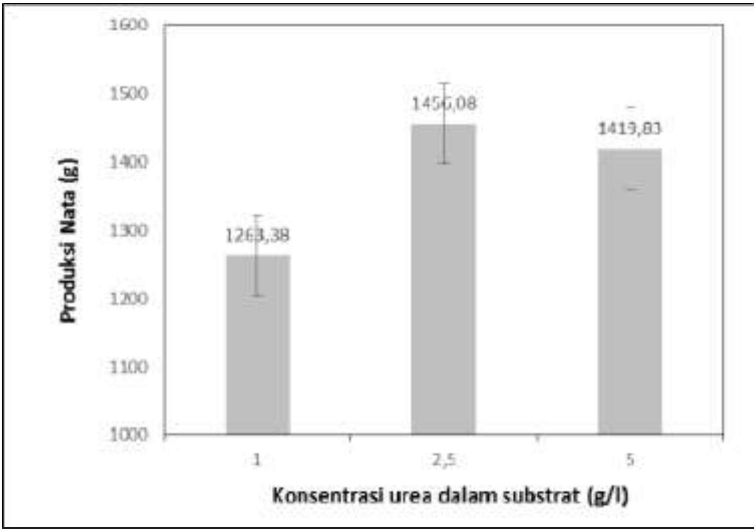

Figure 1. Nata production with different element concentrations in coconut water medium, yielding significantly different mean values ($p < 0.05$).

Organoleptic Test of Nata

The use of food-grade urea in substrate had a significant effect ($p < 0.05$) on the color, aroma, and firmness (texture) of nata. Figure 2 shows that the average color of nata obtained with the urea concentration of 2.5 g/L differed significantly from the color of nata obtained with the urea concentration of 1 g/L, but there was no significant difference from the color of nata obtained with the urea concentration of 5 g/L. The same held true for the aroma and chewiness of nata.

The addition of urea can increase the amount of polysaccharides formed, but an excessive addition (more than 1%) can cause a decrease in yield and a decrease in the degree of whiteness in the nata produced. This is thought to be because too high a concentration will reduce the optimum pH, which can cause disruption to bacterial growth and affect the bacterial cellulose formed. The result of this research showed that the optimum concentration of urea to be used in nata production was 2.5 g/L.

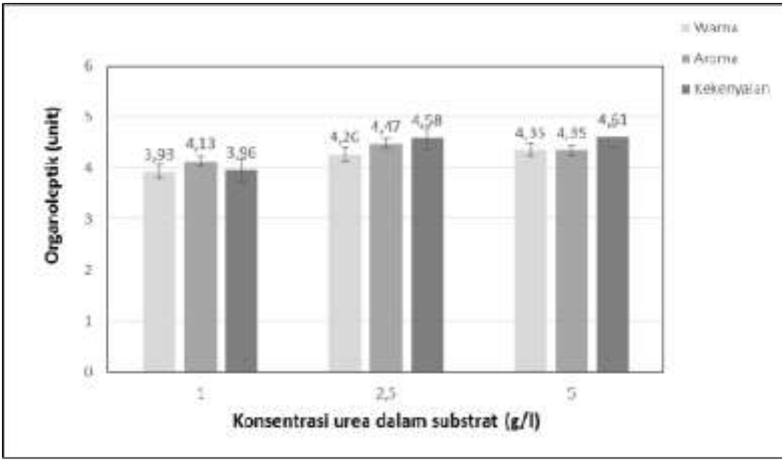

Figure 2 ($p < 0.05$). Organoleptic characteristics of nata made with various concentrations of food-grade urea in coconut water medium. The mean values were significantly different. The organoleptic characteristics included color (5 = clear; 4 = slightly white; 3 = white; 2 = slightly yellow; 1 = yellow), chewiness (5 = chewy; 4 = slightly mushy; 3 = mushy; 2 = slightly crushed; 1 = crushed), and aroma (5 = none; 4 = slightly sour; 3 = sour; 2 = slightly pungent; 1 = pungent).

The results of this study suggested that optimum color, aroma, and chewiness of nata were obtained with the use of food-grade urea at the concentration of 2.5 g/L. According to Winarno (2004), because color is the first thing the eye sees, the determination of food quality is often based on color. Aroma (odor) refers to the perceived and actual taste of food. Odor is caused by chemicals released into the nasal cavity when food enters the mouth. The panelists preferred the organoleptic properties of color, aroma, and elasticity (texture) of the nata de coco produced with the urea concentration of 2.5 g/L.

CONCLUSION

From this study it can be concluded that the amount of dietary urea added to the coconut water substrate had a significant effect on the production and sensory properties of nata de coco. Food-grade urea could be used as a nitrogen source in the production of coconut water. The optimal concentration of added urea was 2.5 g/L.

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The Impact of Changes in Rainfall Intensity on Horticulture Productivity in South Sulawesi Province

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Abstract. *Climate change poses a significant impact to horticulture, affecting key factors such as rainfall intensity, temperature, and humidity. This study focuses on the horticultural production of Chinese cabbages, tomatoes, and carrots in Enrekang, South Sulawesi, Indonesia. Regression analysis was applied to the data collected to establish the connections between climate data and commodity production. It was figured out from the analysis that rainfall intensity did not significantly affect horticultural production, suggesting that other factors like soil type and cultivation techniques might play a more dominant role in horticulture productivity.*

This study found that the improvement of vegetable productivity in South Sulawesi requires a comprehensive approach involving various agricultural practices, technology adoption, and community engagement. Among specific strategies to enhance vegetable productivity is to implement soil health and water management. Soil health management is implemented by conducting regular soil tests to assess soil fertility and pH levels. Organic compost and green manure should be employed to improve the soil. Additionally, crop rotation should be practiced to prevent soil exhaustion and enhance soil biodiversity. Meanwhile, water management is implemented by investing in efficient irrigation systems such as drip irrigation to conserve and provide water consistently. Rainwater storing techniques can be applied for agricultural use during dry periods, allowing agriculture cycles not to depend on rainfall intensity.

.

Keywords: Vegetables Farming, Climate Change, Rainfall Intensity.

INTRODUCTION

1.1 Background

One of the most critical environmental issues the humanity faces today is climate change. Climate scoring largely relies on the presence of several parameters such as precipitation, temperature, wind speed, and humidity, and it is supported by the geographic position of a region. Increasing global temperatures, irregular rainfall intensity, and more frequent occurrences of extreme weather events are happening worldwide. These extreme weather changes disrupt the Earth, which is the habitat for living organisms, from functioning optimally. This, of course, has a negative impact on various sectors, including the agricultural sector (Surmaini et al., 2011).

The parity of agricultural sector is influenced by many factors. Plant growth is influenced by various factors, both internal and external. Internal factors are those that originate from the plant itself, such as hormonal and genetic factors (Maghfiroh, 2017). On the other hand, external factors are those that originate from outside the plant, specifically from the environment. External factors that affect growth include light, nutrient availability, water, humidity, and temperature (Hidayati, 2005).

The agricultural sector is highly vulnerable to climate change because climate factors play a crucial role in determining productivity and the availability of natural resources needed for agricultural activities. Changes in rainfall intensity, rising temperatures, and disruptions in seasons can directly impact crop growth and complicate planting and harvesting processes. Therefore, climate change can have significant impacts on agricultural yields and the well-being of farmers.

Among important agricultural commodities are Chinese cabbages, tomatoes, and carrots. These three crops have significant economic value and are essential parts of daily diets. However, with ongoing climate change, the production of these commodities may be gravely affected. Therefore, it is crucial to explore the impact of climate on the production of Chinese cabbages, tomatoes, and carrots to develop effective mitigation and adaptation plans and strategies.

In this study, a comprehensive analysis was conducted on historical climate data and commodity production data that were collected over a relevant time span. Based on this analysis, this study then identified the relationships between climate factors such as temperature, rainfall intensity, humidity, and extreme weather events and the production of Chinese cabbages, tomatoes, and carrots.

This research is expected to provide significant benefits to both the agricultural sector and the general public. The results of this study offer a better understanding on how climate change affects the production of Chinese cabbages, tomatoes, and carrots in South Sulawesi Province. These data can then be used to develop relevant adaptation and mitigation strategies for addressing climate change in the future. Additionally, this research can serve as a basis for better decision-making for local governments and other related stakeholders in agricultural planning, climate risk management, and food policies.

With a deeper understanding of how climate alters the production of commodities like Chinese cabbages, tomatoes, and carrots, it is presumed that one can identify appropriate plans and strategies to address the challenges of climate change in the agricultural field. This, in turn, will make the agricultural sector better prepared to face the impacts of climate change and continue to produce sustainably.

1.2 Problems Statement

Based on the introduction above, this research proposed the following problems:

1. What is the impact of climate on the production of Chinese cabbages, tomatoes, and carrots?
2. How can vegetable productivity in South Sulawesi Province be improved?

1.3 Research Objectives

The objectives of this study are as follows:

1. To analyze the influence of climate on the production of Chinese cabbages, tomatoes, and carrots.
2. To determine methods for enhancing vegetable productivity in South Sulawesi Province.

1.4 Research Benefits:

The benefits of this study are as follows:

1. To understand the impact of climate on the production of Chinese cabbages, tomatoes, and carrots.
2. To provide a better understanding of the relationship between rainfall intensity and vegetable productivity in South Sulawesi Province.

3. To offer valuable information for farmers and vegetable producers in South Sulawesi Province to manage their vegetable production effectively.

LITERATURE REVIEW

2.1 Factors Affecting Plant Growth

The growth of plants, specifically vegetables, in South Sulawesi, Indonesia, is influenced by a combination of environmental and agricultural factors specific to the region's climate and conditions. Here are some key factors that affect vegetable growth in South Sulawesi:

Climate: South Sulawesi has a tropical climate with distinct wet and dry seasons. The timing and duration of these seasons can impact vegetable planting and growth. Different vegetables have varying temperature and moisture requirements, so understanding the local climate patterns is crucial.

Rainfall: The distribution of rainfall during the year can affect vegetable growth. Adequate and well-distributed rainfall during the wet season is essential for irrigation and soil moisture. Insufficient or excessive rainfall can lead to water stress or diseases in plants.

Soil Type and Quality: Soil composition, fertility, and pH levels are critical for vegetable growth. South Sulawesi has diverse soil types, including volcanic soils. Soil testing and appropriate soil amendments can help ensure the right conditions for specific vegetables.

Topography: The region's topography, including elevation and slope, can impact temperature and moisture levels. Low-lying areas may experience higher humidity, while upland areas may have cooler temperatures.

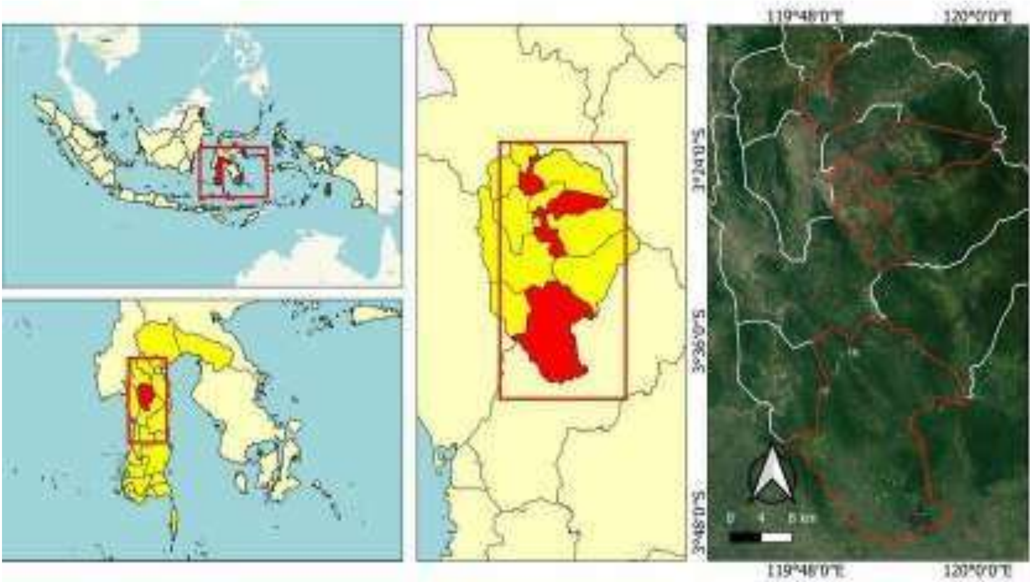
Crop Selection: Choosing the right vegetable varieties that are well-suited to the local climate and conditions is essential. Some vegetables are better adapted to South Sulawesi's specific microclimates and soil types.

Pest and Disease Pressure: South Sulawesi may experience specific pest and disease attacks that can affect vegetable crops. Integrated pest management (IPM) practices can help control these issues.

2.1.1 Rainfall Intensity

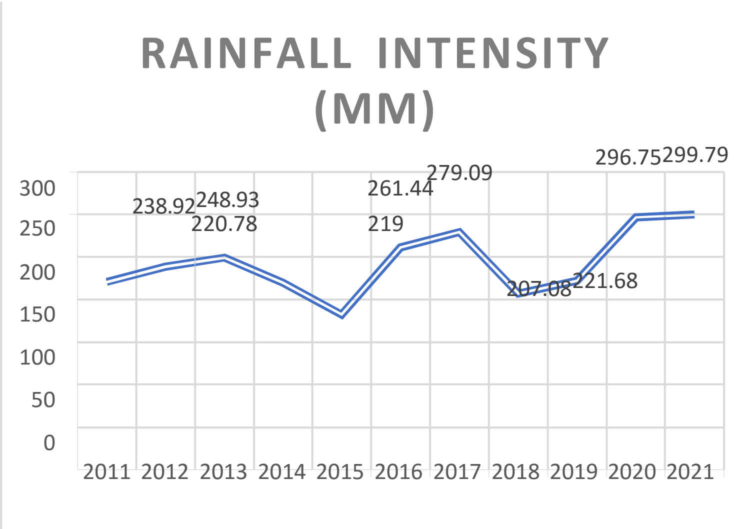
Indonesia is an archipelagic country located in tropical zone with a large area, hence the varied rainfall between regions. Rainfall intensity is one of the critical factors that influence plant growth. Adequate water availability is crucial for photosynthesis, nutrient transportation, and root growth processes. Plants receiving sufficient rainfall have the potential to grow well and produce satisfactory harvests. Conversely, insufficient or excessive rainfall can have adverse effects on plant growth and productivity.

Maps of South Sulawesi and Enrekang Regency location in South



Sulawesi Province
(Source: ResearchGate)

Chart 1 Annual rainfall intensity (2011–2021) in Enrekang, South Sulawesi Province



2.1.2 Effort to enhance horticulture productivity

Farming technology and efficiency must be continuously enhanced, the diversity of agricultural commodities should always be aligned with market demand and production costs, and the quality of agricultural land, workforce skills, and farm equipment should adapt according to needs (Wongkar et al., 2023).

2.2 Climate in South Sulawesi

According to the climate classification by Oldeman (1992), South Sulawesi Province has five climate types, namely types A, B, C, D, and E.

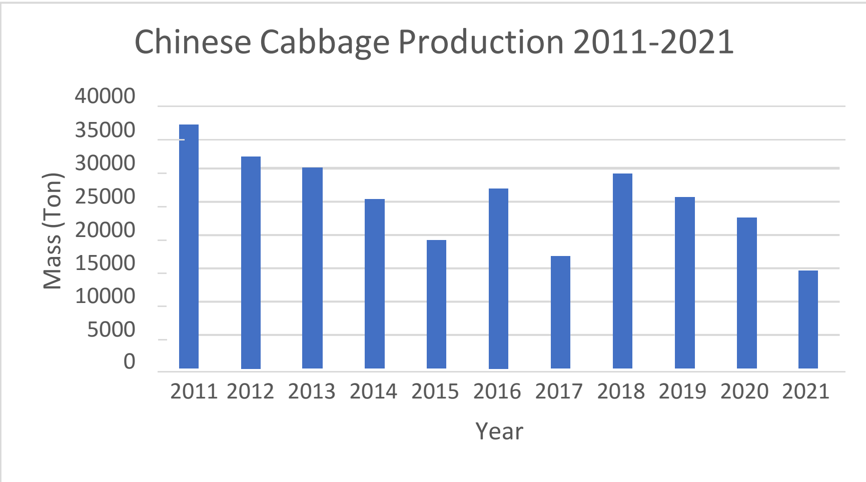
Climate Types	Rainfall Intensity (mm)	Areas
A	3500–4000	Enrekang, Luwu, Luwu Utara, and Luwu Timur Regencies
B	3000–3500	Tana Toraja, Luwu Utara, Luwu Timur, Gowa, Bulukumba, and Bantaeng Regencies

C	2500–3000	Wajo, Luwu, Tana Toraja, Bulukumba, Bantaeng, Barru, Enrekang, Maros, Jeneponto, Pangkep, Sinjai, Gowa, and Selayar Regencies and Makassar and Parepare Cities
D	2000–2500	Wajo, Bone, Soppeng, Luwu, Tana Toraja, Enrekang, Sinjai, Maros, Bulukumba, Gowa, Pangkep, Jeneponto, and Takalar Regencies dan Makassar City
E	1500–2000	Maros, Bone, Enrekang, Bantaeng, and Selayar Regencies

2.3. Correlation between Climate Change and Horticultural Production

2.3.1. Correlation between Climate and Chinese Cabbage Production

Chart 2 Annual Chinese cabbage production (2011–2021) in South Sulawesi Province

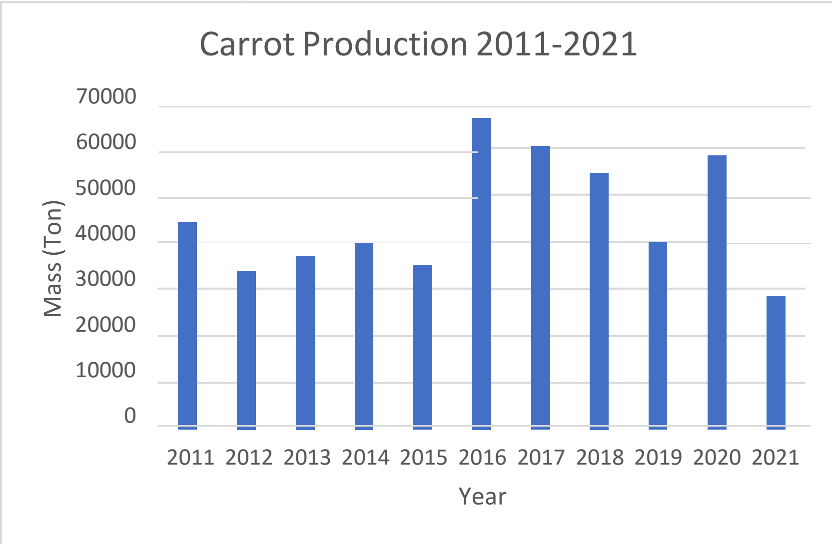


The influence of climate change, particularly in terms of rainfall intensity, on Chinese cabbage plants was highly significant. Since Chinese cabbage belongs to the Brassicaceae family or leafy greens that require specific weather conditions for optimal growth and development, several factors affect its growth and production, including rainfall intensity. Chinese cabbage needs stable rainfall in order to thrive. It prefers regions with moderate to high rainfall intensity, around 500–1000 mm per year. However, Chinese cabbage can also grow in drier conditions with sufficient irrigation (Setiawati et al., 2007).

2.3.2 Correlation between Climate and Tomato Production

This sub-chapter explores the correlation between climate change and tomato production. Some data are shown in the chart below:

Chart 3 Annual carrot production (2011–2021) in South Sulawesi Province

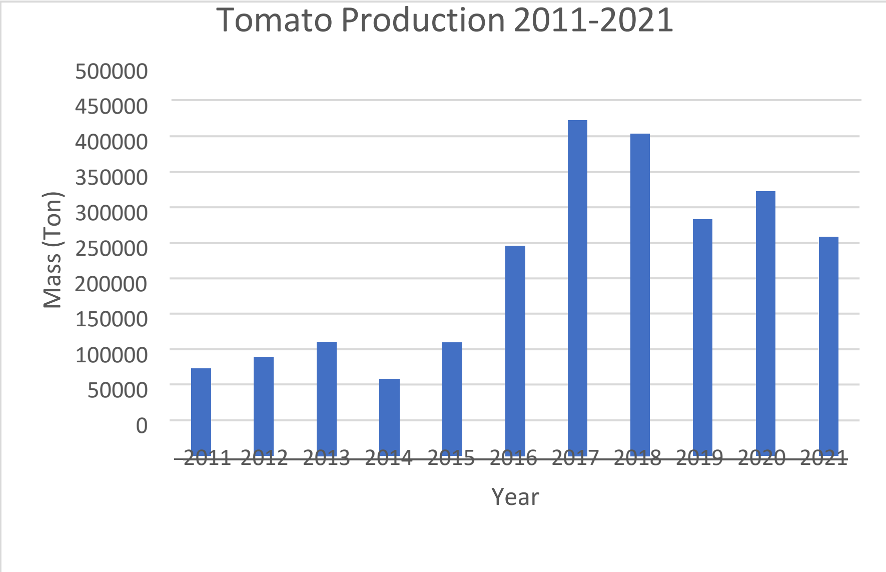


Climate has a significant influence on the growth and productivity of tomato plants (Onggo et al., 2017). One of the climatic factors that plays a role in influencing the growth of tomato plants is rainfall intensity.

2.3.3 Correlation between Climate and Carrot Production

The growth and development of carrots are significantly influenced by climate factors. The tomato production in South Sulawesi Province in the 2011–2021 period is presented in Chart 4:

Table 4 Annual tomato production (2011–2021) in South Sulawesi Province



Rainfall intensity also plays an important role in the growth of carrot plants (Suryanto, 2019). Carrot plants require an adequate amount of water during the period of root growth and development. Water deficiency (drought) can hinder the growth of carrot plants and result in small and poor-quality roots. On the other hand, excess water (waterlogging) can lead to root rot and diminish the quality of carrot roots.

RESEARCH METHODOLOGY

3.1 Research Method

This research utilized descriptive methods and statistical analysis to identify the relationship between climate and the productivity of cabbages, tomatoes, and carrots in South Sulawesi Province.

3.2 Place and Time of Research

This research was conducted in Enrekang Regency, which was purposively chosen as a horticulture production center in South Sulawesi Province. The study took place over a period of two months from July to August 2023.

3.3 Data Analysis

Climate data and data related to plant growth and productivity were analyzed using statistical analysis techniques, particularly regression analysis. Regression analysis was used to identify the relationship between climate (independent variable) and plant growth and productivity (dependent variable). Additionally, other statistical analyses were used to interpret the results and draw conclusions from this research.

3.4 Population and Sample

The population in this study consisted of Chinese cabbage, carrot, and tomato plants growing in specific regions (such as districts or sub-districts). Samples were drawn from this population using purposive sampling techniques, which involved selecting samples based on specific criteria, such as healthy growth and reaching a certain age. Several agricultural locations representing various climatic conditions were chosen as samples for this research.

3.5 Research Instruments and Variables

The instruments used in this research included observation sheets, temperature measuring devices, rainfall gauges, and air humidity measurement tools. The research variables consisted of:

1. Independent Variable
   The independent variable in this research was rainfall intensity, measured in millimeters using a rainfall gauge.
2. Dependent Variable
   The dependent variable in this research was plant growth, which involved three plant commodities, namely Chinese cabbage, carrot, and tomato commodities.

RESULTS AND DISCUSSION

4. 1 Commodity Data for Chinese Cabbages, Tomatoes, and Carrots

The following are data on the average production of Chinese cabbages, tomatoes, and carrots in South Sulawesi Province in 2011–2021 obtained from Statistics Indonesia (BPS).

1. Chinese Cabbages

Results of the SPSS linear regression test using Chinese cabbages as the dependent variable and rainfall intensity as the independent variable can be seen in the following table.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	43337.762	13046.871		3.322	.009
	Rainfall 2011–2021	-73.847	53.043	-.421	-1.392	.197

a. Dependent Variable: Chinese Cabbage Production in 2011–2021

The results of the linear regression analysis for Chinese cabbage production indicate that the rainfal intensity from 2011 to 2021 did not have any significant influence on Chinese cabbage productivity The significance value (sig.) of 0.197 in the coefficient table indicates that there was no significan relationship between rainfall intensity and Chinese cabbage production during that period.

2. Tomatoes

Results of the SPSS linear regression test using tomatoes as the dependent variable and rainfall intensity as the independent variable can be seen in the following table.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-96049.032	264904.388		-.363	.72
	Rainfall 2011–2021	1488.322	1076.987	.418	1.382	.20

a. Dependent Variable: Tomato Production in 2011–2021

The results of the linear regression analysis for tomato production indicate that the rainfall intensity from 2011 to 2021 did not have any significant influence on tomato productivity. The significance value (sig.) of 0.200 in the coefficient table indicates that there was no significant relationship between rainfall intensity and tomato production during that period.

3. Carrots

Results of the SPSS linear regression test using carrots as the dependent variable and rainfall intensity as the independent variable can be seen in the following table.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	24438.988	26410.946		.925	.379
	Rainfall 2011–2021	85.743	107.376	.257	.799	.445

a. Dependent Variable: Carrot Production in 2011–2021

The results of the linear regression analysis for carrot production indicate that the rainfall intensity from 2011 to 2021 did not have any significant influence on carrot productivity. The significance value (sig.) of 0.445 in the coefficient table indicates that there was no significant relationship between rainfall intensity and carrot production during that period.

CONCLUSION AND SUGGESTIONS

5.1 Conclusion

This study generally investigated the influence of rainfall intensity on the productivity of Chinese cabbage, tomato, and carrot plants in South Sulawesi Province using the multiple linear regression equation approach. The data analysis results indicate that rainfall intensity ratios were not one of the determining factors for the productivity of Chinese cabbage, tomato, and carrot plants in this region. The highest correlation coefficients found were 0.197, 0.200, and 0.445 for Chinese cabbage, tomato, and carrot plants, respectively.

These results imply several important findings as below:

In this study of Chinese cabbage, tomato, and carrot plant productivity in South Sulawesi Province, it was evident that rainfall intensity did not significantly impact the growth and harvest yields of these plants. This lack of influence was observed across all dependent variables, highlighting that other factors, such as soil type, cultivation techniques, or water management, might play a more dominant role in determining the productivity of these crops in the region. Therefore, the study suggests that a comprehensive understanding of these alternative factors is essential in assessing and enhancing the overall agricultural productivity of Chinese cabbage, tomato, and carrot crops in Enrekang, South Sulawesi Province.

Improving vegetable productivity in South Sulawesi Province requires a comprehensive approach involving various agricultural practices, technology adoption, and community engagement. Some specific strategies to enhance vegetable productivity in the region are suggested below.

5.2 Suggestions

In addition to valuable insights, this study provides some suggestions that can be considered not only to enhance our understanding of the relationship between rainfall intensity and plant productivity, but also to be used for further research:

1. Improve Prediction Accuracy: This research should be enhanced to obtain more accurate prediction equations. Using more comprehensive and accurate data on rainfall intensity as well as other environmental factors can enhance the reliability of the research findings.

2. Perform Further Studies with Different Approaches: Subsequent studies can employ different approaches or models to analyze the impact of rainfall intensity on plant productivity. This may involve using more complex statistical models or alternative modeling approaches.
3. Include Other Climate Parameters: In future studies, it is advisable for researchers to include other climate parameters alongside rainfall intensity, such as air temperature, relative humidity, or sunlight, which can also influence the growth and harvest of Chinese cabbages, carrots, and tomatoes.

By conducting further research with a more meticulous approach and a consideration of additional factors, researchers can gain a better understanding of the relationship between climate factors, such as rainfall intensity, and plant productivity. This understanding can serve as a foundation for improving agricultural practices in South Sulawesi Province.

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SIMPLE EQUIPMENT DESIGN AS A STANDARD FOR PERFORMANCE TESTS IN SPRINKLER IRRIGATION SYSTEMS

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Abstract

Optimal sprinkler irrigation performance is the result of good irrigation system design and management. In the Water Resources Engineering laboratory, practical performance tests of sprinkler irrigation systems are hampered by the absence of a riser pipe standard. The aim of this research was to design a simple tool as a standard for testing the performance of sprinkler irrigation systems (discharge, beam distance, and sprinkler beam uniformity) with different riser pipe heights. The method used in designing was a descriptive method, by which each component is explained structurally and functionally. To test the performance of the tool, the discharge was measured by the volumetric method. The beam distance was measured using a meter from the center point to the furthest water jet produced by the sprinkler. Meanwhile, the uniformity coefficient (Cu) was measured by installing several water storage containers at a certain distance. The results showed that in Treatment I the beam distance was 4.5 m, the discharge was 0.118 L/sec, and the Cu was 88.9%; in Treatment II the beam distance was 4.6 m, the discharge was 0.116 L/sec, and the Cu was 80.2%; and in Treatment III the beam distance was 5.3 m, the discharge was 0.103 L/sec, and the Cu was 69.0%. Based on observations, the best performance test results were yielded by Treatment I, with a riser pipe height of 100 cm, and the lowest performance test results were yielded by Treatment III, with a riser pipe height of 200 cm.

***Keyword**: Sprinkler, Riser, Discharge, Beam Distance, Cu*

INTRODUCTION

Irrigation is the provision of water to meet plants' water needs. Water is provided with a particular irrigation system to suit the type and water needs of each plant. One water-saving irrigation technology is a bulk or sprinkler irrigation system. Bulk or sprinkler irrigation is a method of providing water over plants or soil in a manner alike to rainfall.

Bulk irrigation systems allow for even and efficient water provision to a planting area, with an amount and rate that are less than or equal to the amount and rate of water absorption into the soil (infiltration capacity). According to Kurniati (2007), this bulk irrigation technology can increase the efficiency of irrigation water use and the uniformity of irrigation by more than 80% and reduce land loss due to the installation of irrigation facilities.

One very important component of a bulk irrigation system is the nozzle or sprayer as a water distributor. Factors that influence water distribution in bulk irrigation systems are the nozzle diameter and the height of the watering can. With the plethora of types of sprinkler devices on the market, more specific testing will certainly be needed so that the advantages of each sprinkler can be identified before being applied to plants.

The performance of bulk or sprinkler irrigation is expressed in five parameters, namely sprinkler discharge, jet distance, water distribution pattern, jet uniformity coefficient (Cu), and droplet size.

Optimal sprinkler irrigation performance is the result of good irrigation system design and management (Sheikhemaeili et al., 2016 in Dewa I, 2021).

To test the performance of the sprinkler equipment, a standard is needed for the riser pipe, which will determine the height of the riser pipe and nozzle. The standard height will affect the five parameters of the sprinkler's performance. However, in the Water Resources Engineering laboratory, there is currently an absence of a standard for riser pipes, which causes the practical testing of the performance of bulk irrigation systems to be hampered. Therefore, a simple tool is needed to overcome this drawback. The author conducted a research study entitled "Simple Equipment Design as a Standard for Performance Tests in Sprinkler Irrigation Systems."

METHODS

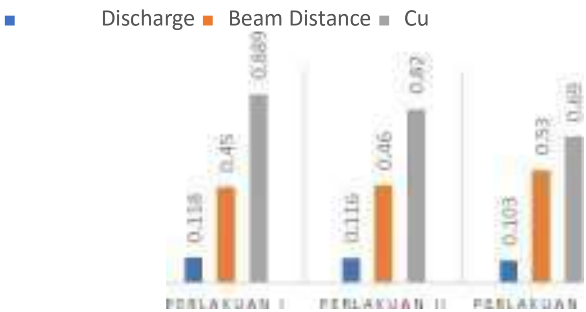
This research was carried out for six months, starting from July to December 2023, at the Water Resources Engineering Laboratory of Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota Regency, West Sumatra. This research used a completely randomized design (CRD) with three treatments, with riser heights of 100 cm, 150 cm, 200 cm. Observations in this research were conducted on the sprinkler discharge, beam distance, and beam uniformity coefficient (Cu).

RESULTS AND DISCUSSION

The data from the observations in this research are showed in the table below:

No	Treatments	Discharge (L/sec)	Beam Distance (m)	Uniformity Coefficient/Cu (%)
1	I	0.118 L/sec	4.5 m	88.9%
2	II	0.116 L/sec	4.6 m	80.2%
3	III	0.103 L/sec	5.3 m	69.0%

GRAPH OF OBSERVATION



A. Discharge

The discharge in bulk irrigation is the volume of water that comes out of the sprinkler per certain unit of time. Based on the results of observations provided in the table above, it can be seen that using different riser pipe heights can cause the discharge released by each sprinkler to also be different. In

Treatment I, with a riser height of 100 cm, the discharge released was 0.118 L/second. In Treatment II, with a riser height of 150 cm, the discharge released was 0.116 L/second. In Treatment III, with a riser pipe height of 200 cm, the discharge released was 0.113 L/second.

The graph above shows that the highest discharge was yielded by Treatment I, which used the lowest riser pipe height. According to Gultom et al. (2012), this is because the higher the riser pipe the lower the discharge produced because the pressure on the sprinkler decreases. They also explained that the thing that influences the bulk irrigation discharge is the mass flow rate of water coming out of the sprinkler, which is determined by the flow and the diameter of the sprinkler.

B. Beam Distance

Based on the observation data in the table above, the beam distance was influenced by the height of the riser pipe, which varied by treatment. Treatment I, with a riser height of 100 cm, produced a beam distance of 4.50 m. Treatment II, with a riser height of 150 cm, produced a beam distance of 4.60 m. Treatment III, with a riser pipe height of 200 cm, produced a beam distance of 5.30 m. Based on the graph above, the farthest beam distance was produced by Treatment III. According to Negara (2021), the greater the riser pipe's height the farther the discharge distance.

C. Uniformity Coefficient (Cu)

The uniformity coefficients for bulk irrigation based on the observation data in the table above were 88.9%, 80.2%, and 69.0% in Treatments I, II, and III, respectively. Based on the classification by Suryanto (2018), the uniformity coefficients produced by treatments I and II, which used riser pipe heights of 100 cm and 150 cm, respectively, are classified as good as they fell within the range of 80–90%. This means that riser pipe heights of 100 cm and 150 cm could provide good and uniform water discharge from the sprinkler. Meanwhile, the uniformity coefficient produced by Treatment III is classified as poor as it fell within the range of 60–70%, which means that the level of uniformity was very low and the water discharge from the sprinkler was uneven.

The uniformity coefficient (Cu) is influenced by the average value of the discharge released and the deviation value. If the deviation value is greater, the uniformity value (Cu) will be smaller. The deviation value becomes larger due to the uneven distribution of water from each sprinkler (Merriem et al., 1981 in Gultom et al., 2012). This can be seen from the analysis of observational data in the graph above, which shows that the Cu value was inversely proportional to the height of the riser pipe and the distance of the jet, but it was directly proportional to the discharge released.

CONCLUSION

From this research it can be concluded that the simple tool designed for testing the performance of bulk irrigation with different riser pipe heights worked well and was in accordance with its function. The efficiency of bulk irrigation can be measured based on the uniformity of the water jet from the sprinkler. The best performance test results were produced by Treatment I, which used a riser pipe height of 100 cm, with a coefficient of uniformity (Cu) of 88.9%, a discharge of 0.118 L/second, and a jet distance of 4.5 m. Meanwhile, the lowest performance test results were produced by Treatment III, which used a riser pipe height of 200 cm, because even though the discharge distance was the farthest, the coefficient of uniformity (Cu) was very low and the discharge released was also small compared to other treatments.

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In-Vitro Antagonism of *Beauveria bassiana* Against *Colletotrichum acutatum*

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Abstract. Anthracnose disease in chili is caused by a seed-borne pathogen called *Colletotrichum acutatum*. The endophytic fungus *Beauveria bassiana* can inhibit the growth of the pathogenic fungus *Colletotrichum acutatum* is the aim of this study. A completely randomized design (CRD) with six treatments and five replications was employed in the study. Control and five different types of *B. bassiana* isolates (PD114, TD312, WS, BbKo, KT2B21) made up the therapy. Utilizing both the double culture and steam culture methods, endophytic *B. bassiana* isolates were tested for their antagonistic properties against the fungus *C. acutatum*. The findings demonstrated that the fungus *C. acutatum* could not develop when exposed to the *B. bassiana* endophyte, with an inhibitory percentage ranging from 67.26% to 72.36%. Endophytes of *B. bassiana* were able to prevent the widespread

INTRODUCTION

Colletotrichum species are the pathogens that cause anthracnose. The facultative parasitic fungus *Colletotrichum* spp. belongs to the order Melanconiales and is characterized by conidia arranged in an aservulus, an asexual structure common to parasitic fungi. The class Sodariomycetes includes fungi belonging to the genus Colletotrichum (Sudirga, 2016). *Colletotrichum* species encompass a range of species kinds. *Colletotrichum Colletotrichum capsici, Colletotrichum acutatum, Colletotrichum gloeosporioides, Colletotrichum coccodes,* and *Colletotrichum dematium* (Kambar et al., 2013). According to Than, Prihastuti, and Phoulivong (2008), three different species of *Colletotrichum* spp. have been identified as chili plants pathogens in Indonesia : *C. gloeosporioides*, *C. acutatum*, and *C. capsici*.

Techniques controll anthracnose, including not using pathogen infected, technical culture, and chemicall fungicides, have been used but have not been effective. An alternative control used to reduce pathogen attacks is biological control using endophytic fungi (Rachmawati et al., 2016).

Plant infections can be controlled by the endophytic fungus *Beauveria bassiana*, which has also been shown to control insect pests (Gothandapani et al., 2014). According to Batson et al. (2000) *Rhizoctonia solani* controlled *in vivo* by seed treatment of cotton plants with the fungus *Beauveria bassiana*,. According to Azadi et al. (2015), *B. Bassiana* was successful in slowing the decline of the pathogen on tomato plants. Bucarei et al. (2019), *Botrytis cinerea* on tomato and chili plants could be controlled by the endophytic strain of the *B. Bassiana* fungus. Trizelia et al. (2018) reported that the fungus B. bassiana isolate PB211 endophyte of chilli stems had antagonistic activity against the pathogenic fungus C. gloeosporioides with an percentage 59.08%. Agustina (2020) also reported that the endophytic fungus B. Bassiana was able to inhibit the growth of C. capsici at the age of 11 days after inoculation with an percentage 14.23-15.76%. Furthermore, Jaber and Salem (2014) reported that the endophytic colonization ability of B. Bassiana was able to inhibit the ZYMV (Zucchini yellow mosaic virus) disease in Cucurbitaceae plants. Yuliana (2020) also reported that soaking chilli seeds in B. bassiana (PB211) for nine hours was the best time to suppress the attack of seed-borne pathogenic fungi Colletotrichum spp. and increase the growth of chilli seedlings. Meanwhile, Cyntia (2020) discovered that the endophytic B. bassiana isolate PD114 and isolate TD312 had a higher potential to suppress seed-borne pathogens attack caused by Colletotrichum spp and were also able to induce the growth of chilli seedlings in vivo compared to isolate PA221.

The entomopathogenic fungus Beauveria sp. has been reported antagonizead phytopathogens in vitro (Deb et al. 2017), inhibiting the growth of pathogenic F. solani through an antibiosis mechanism (Halwiyah et al. 2019) and exhibiting effective anti-fungal activity against F. oxysporum which causes wilt disease in tomato plants. (Culebro-Ricaldi et al. 2017). Therefore, entomopathogenic fungi that are antagonistic to plant pathogens can be used as an alternative for biological control of pathogenic fungi (Vega et al. 2009).

The aim of this study was to obtain endophytic *B. bassiana* isolates that are effective in inhibiting the growth of *C. acutatum* fungus *in vitro*.

METHODS

Isolation and identification of the pathogenic fungus *Colletotrichum acutatum*

Samples of chili fruits showing symptoms of anthracnose were collected from Nagari Paninjauan, Sepuluh Koto District, Tanah Datar Regency. Fungal isolation was performed using the direct planting method on *Potato Dextrose Agar* (PDA) media. Chili fruits showing symptoms of anthracnose were cut into 1 × 1 cm size. The surface was sterilized with sterile distilled water (for 60 seconds); 70% alcohol (for 30 seconds); sterile distilled water again (for 60 seconds) and dried. The cut chili fruit pieces were placed in Petri dishes containing PDA media three pieces each and incubated at room temperature for three days. The growing fungus suspected to be *C. acutatum* was isolated again until pure culture was obtained and propagated. Identification was by observing the morphology of *C. acutatum* macroscopically to obtain its characteristics based on the book Genera of Imperfect Fungi by Barnet and Hunter (1972).

Propagation of the endophytic fungus *Beauveria bassiana*

The *B. bassiana* isolates used were the result of isolation from parts (stems, leaves, roots) of chili plants and wheat plant stems. Five *B. bassiana* WS, PD114, TD312, BbKo, and KT2B22, were used All *B. bassiana* isolates were propagated using *Sabouraud Dextrose Agar with Extract* (SDAY) media and incubated for 21 days.

Antagonistic activity test using the dual culture method

Tests were performed to determine the antagonistic activity of each B. bassiana fungal isolate against the pathogenic fungus C. acutatum. Antagonistic and pathogenic fungi that were seven days old were taken at 0.7 cm intervals apart and then placed on SDAY media in the same Petri dishes containing only pathogenic fungi were placed in the media. The fungi were incubated at room temperature for 21 days. The inhibitory ability of B. bassiana to suppress the development of C. acutatum was determined based on the percentage of inhibit. Observations were made from 1 day after incubation to 21 days after incubation. Observations were made by measuring the area of the C. acutatum fungal colony using millimetre chart by plotting the area of the colony on glass plastic. The percentage of inhibit can be calculated using the formula :

$$\mathrm{DH} = \frac{\mathrm{lk} - \mathrm{lp}}{\mathrm{lk}} \times 100\%$$

where

DH= percentage of inhibition

lk= Area of pathogenic fungal colony in the control

lp= Area of pathogenic fungal colony in the treatment

Antagonistic activity efficacy test using the dual culture method

The test was conducted to determine the antagonistic ability of each isolate of *B. bassiana* against the pathogenic fungus *C. acutatum*. Antagonistic fungi and pathogenic fungi that reached seven days of age were taken 0.7 cm and then placed on SDAY media in the same petri dish, with a distance of 3 cm on the center line of the petri dish. For the control, petri dishes were placed with media containing only pathogenic fungi. The fungi were at room temperature for 21 days. The inhibitory ability of *B. bassiana* in suppressing the development of *C. acutatum* was determined based on the percentage of inhibition. Observations were started from 1 day after incubation to 21 days after incubation. Observations were made by measuring the colony area of *C. acutatum* using millimeter chart paper by drawing the colony area on glass plastic.

Inhibitory activity of *B. bassiana* against *C. acutatum* using the dual culture method

The results of the analysis of variance showed that the treatment of the five isolates of endophytic fungi *B. bassiana* had a significant effect on the colony area of fungi *C. acutatum* at the age of 11 days after inoculation (dai) compared to the control group. The size of *C. acutatum* fungal colonies with the treatments of *B. bassiana* was not significantly different. The treatment that resulted in the smallest *C. acutatum* fungal colony area was the *B. bassiana* KT2B21 isolate with an average colony area of 29.8 cm^2. The average colony area and percentage of inhibition of *B. bassiana* isolates in Table 1.

Table 1. Inhibitory activity of *B. bassiana* isolates against *C. acutatum* at 11 days after inoculation.

Treatment	Colony size (cm^2) ± SD		Inhibition(%)
B. bassiana TD 312	42,0 ± 7.56	a	0
B. bassiana WS	40,0 ± 8,49	a	23.29
B. bassiana PD114	35,2 ± 10.3	a	51.57
B. bassiana BbKo	33,0 ± 11.5	a	52.61
B. bassiana KT2B21	29,8 ± 16.4	a	54.97

Numbers in the same column followed by the same lowercase letter are not significantly different according to the LSD at the 5% level

Table 1 shows that the colony area of *C. acutatum* with different treatments showed significantly different results. The treatment that resulted in the smallest *C. acutatum* fungal colony area was the *B. bassiana* KT2B21 isolate with an average colony area of 29.8 cm^2.The inhibition of C. acutatum fungal colony growth B. bassiana treatment is thought to be due to the response to secondary metabolites produced by the B. bassiana fungus that have antifungal properties. This is the opinion of Ownley et al. (2010) who stated that B. bassiana produces many secondary metabolite compounds that are toxic and can interfere with the growth of pathogenic fungal colonies, including beauvericin, bassianin, beauverolides, bassianolides, oosporein, and bassianolone. Halwiyah et al. (2019) reported that B. bassiana was able to inhibit the growth of Fusarium solani with an inhibition percentage of 29.19%.

The results of observations by the dual culture method at the age of 21 days showed that the colonies of each B. bassiana isolate were able to grow on the surface of the C. acutatum fungal colony. The B. bassiana fungal colony that growing on the C. acutatum fungal colony did not mix, so the hyphae or mycelia of the two fungi could be separated. Slide culture observations showed that the hyphae of the endophytic fungus B. bassiana isolate were not hyperparasitic on the hyphae of C. acutatum.

The colony area of *C. acutatum*

The results of the analysis of variance of the colony area of *C. acutatum* showed that the treatment gave a significantly different effect. The results of the LSD follow-up test at the 5% level of each treatment are shown in Table 2.

Table 2. The colony size of *C. acutatum* after treatment with endophytic fungus *B. bassiana* isolate at 14 days after inoculation.

Treatment	Colony size cm^2 ± SD		Efficacy (%)
Control	38.2 ± 7.01	a	0
B. bassiana WS	29.3 ± 10.3	b	23.29
B. bassiana BbKo	18.5 ± 2.54	c	51.57
B. bassiana PD114	18.1 ± 2.64	c	52.61
B. bassiana TD 312	17.2 ± 5.10	c	54.97
B. bassiana KT2B21	11.6 ± 0.96	c	69.63

Numbers in the same column followed by the same lowercase letter are not significantly different according to the LSD at the 5% level

Table 2 shows that the colony size of *C. acutatum* inthe control group was significantly different from those in the treatment groups of the five isolates of the endophytic fungi *B. bassiana*. The colony size of *C. acutatum* in the control group was 38.20 cm^2, which showed a significantly different result from the colony size in all treatments of endophytic *B. bassiana* fungal isolates. The treatment with the highest efficacy was isolate *B. bassiana* KT2B21 isolate with an average colony area of 11.6 cm^2, and an efficacy of 69.63%.

The results of the antagonistic test of the five *B. bassiana* isolates against *C. acutatum* using the culture vapor method showed that the isolates inhibited the growth of *C. acutatum* fungal colonies when compared to the control group. A study by Moloinyane and Felix (2019), stated that *B. bassiana* produces volatile volatile compounds, namely naphthalene, polyphenols, alkaloids, and avonoids which are antifungal and contain toxins.

Fresh weight and dry weight of C. acutatum fungal colonies

The fresh weight and dry weight of the *C. acutatum* fungal colonies were not significantly affected by the treatment of five isolates of the endophytic fungus *B. bassiana*, according to the results (Table 3). Several isolation treatments failed to inhibit the growth of *C. acutatum* when dry weight was monitored. It is believed that this is due to the effect of the area of the *C. acutatum* fungal colony, whereby the fungus colony fresh weight and dry weight were produced in proportion to its size; in other words, the smaller that the area of the colony, the smaller the fresh and dry weight results, produced by the dried *C. acutatum*.

Table 3. Fresh weight of C. acutatum fungal colonies after treatment with endophytic *B. bassiana* fungal isolates at 14 days of age.

Treatment	Fresh weight g		Dry weight g
Control	1.888	a	0.064
B. bassiana BbKo	1.650	ab	0.048
B. bassiana WS	1.322	abc	0.038
B. bassiana PD114	1.180	bc	0.030
B. bassiana KT2B21	1.168	bc	0.032
B. bassiana TD 312	0.928	c	0.028

Numbers in the same column followed by the same lowercase letter are not significantly different according to the LSD at the 5% level

CONCLUSIONS

The test results of all isolates of the endophytic fungus *B. bassiana* used showed that they were able to stop the growth of fungal colonies of *C. acutatum*. With an inhibition percentage of 67.26-72.36% at 11 days of age, all isolates of the endophytic fungus *B. bassiana* were able to stop the growth of *C. acutatum* in the dual culture method. Using the steam culture method, the endophytic *B. bassiana* fungal isolate was able to suppress the colony size of *C. acutatum*, but it had no effect on the fresh weight and dry weight of the colony. Of the five *B. bassiana* isolates that were studied, *B. bassiana* TD312 was the most successful in preventing the growth of *C. acutatum*.

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