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PREFACE

This edition of Kultivasi Journal Volume 22 No. 3 (2023) contains articles from various scientific fields in the agricultural field. These articles are related to plant production and are taken from various sectors, such as plant breeding, agronomy, plant pests and diseases, weed science, and soil science. This knowledge increases plant production, both commercial and still at the initial stage.

This publication still consists of 14 articles from academicians and researchers edited and reviewed by professional editors and reviewers from Indonesia and abroad, which are expected to increase academic knowledge for academic scientists and agricultural practitioners. The contribution of researchers and academics is an essential factor in the future development of the farming industry. Kultivasi Journal has already consistently published an English version this year (2023), hoping to spread our information more widely domestically and overseas to readers and authors. For the next, we encourage it to be indexed in International journal indexing. We hope that sharing knowledge through cultivation journals can always be useful and become the core of future agricultural progress.

Warm greetings from the Kultivasi Journal Team. Happy New Year with new enthusiasm.

December 2023

Editorial Team

AUTHOR'S INSTRUCTIONS

Manuscript that met scientific requirements can be published. The original manuscript is sent to the editor in accordance with the writing requirements as listed below. Editors have the right to change and suggest improvements in accordance with the norms of science and scientific communication. Editors cannot accept papers that have been published in other publications.

The manuscript is typed on Microsoft Word software, on A4 size paper with a writing length ranging from 6-15 pages and followed the template. The manuscript in the Jurnal Kultivasi can be written in English with an effective and academic language style.

The full manuscript is sent to the editors accompanied by a cover letter from the author. The sent manuscript is a group of original paper, soft file of images and other suplementary materials. The editor issues the letter of manuscript acceptance to author once the paper is considered to be going to publish.

Special Requirements

Review Articles:

Articles should discuss critically and comprehensively the development of a topic that is actual public concern based on new findings supported by sufficient and up-to-date literature. Before writing an article, it is recommended that the author contact the Chairman of the Editorial Board for clarification of the selected topic.

The systematics of writing peel articles consists of: Title, author's name and correspondence address; Abstract with keywords; The Introduction contains justifications for the importance of the topic being discussed; Subject matter; Conclusion; Acknowledgment; and References.

Research Articles:

The original manuscript is compiled on the basis of the following sections:

Title

- The title must be brief and indicate the identity of the subject, the purpose of the study and contain keywords and be written in Bahasa Indonesia and English. Titles range from 6-20 words, created with capital letters except for latin names written in italics.

Author's name

- The authors must list the name without the title, profession, agency and address of the place of work and the author's email clearly in accordance with applicable ethics. If it is written by more than one author, the writing of the order of names should be adjusted according to the contribution level of each author. The writing of the name of the first author is written the last syllable first (although not the surname), while the subsequent author the initial syllable is abbreviated and the next syllable is written in full. For example: Tati Nurmala and Yudithia Maxiselly then written as Nurmala, T. and Y. Maxiselly

Abstract

- Abstract is an informative writing that is a brief description about the background, objectives, methods, results and conclusions. Abstract is written in English with a maximum of 250 words and equipped with keywords.

Introduction

- Introduction presents the background on the importance of research, underlying hypotheses, general approaches and research objectives as well as related literature reviews.

Materials and Method

- Materials and Methods contains an explanation of the time, place, technique, design, plant material and other materials of experiment as well as statistical data analysis. It should be writen in detail so that it is repeatable and reproduceable. If the method used is known in advance then the reference should be listed.

Results and Discussions

- Results and discussions are briefly outlined assisted by informative tables, graphs and photographs. The discussion is a brief and clear review of research results and refers to previous related literatures. Table or Figure Captions are written in English.

Conclusion

- Conclusion is the final decision of the conducted research and the follow-up advice for further studies.

Acknowledgment

- Acknowledgment to sponsors or parties who support the research briefly.

Reference

There are at least 20 references from the last 10 years. The references list all related libraries along with the aim of making it easier to search for readers who need it. Only list libraries that have been published either in the form of textbooks or scientific articles. Using an internationally applicable article author's name writing system. Inside the text, the reference should be written as follows:

- Two authors: Tati Nurmala and Yudithia Maxiselly *then written* Nurmala and Maxiselly (2014) or (Nurmala and Maxiselly, 2014).
- Three or more authors: Nurmala et al. (2014) or (Nurmala et al., 2014).
- Book writing format: Author's Last Name. Initials of the year it was published. Book title (each initial letter of a word is written in capital letters, except for conjunctions/prepositions; Edition if the edition is more than one). Name Publisher. Place published.
  Example: Solaimalai A, Anantharaju P, Irulandi S, Theradimani M. 2021. Maize Crop Improvement, Production, and Post Harvest Technology. CRC Press. Oxon.
- Article/Journal writing format: Author's last name. Publication Year initials. Article title (only letters at the beginning of the title are capitalized, except for place names, varieties, and people). Journal name, Volume(Issue): Page number.
  Example: Zakry FAA, Shamsuddin ZH, Rahim KA, Zakaria ZZ, Rahim AA. 2012. Inoculation of Bacillus sphaericus UPMB-10 to young oil palm and measurement of its uptake of fixed nitrogen using the 15N isotope dilution technique. Microbes Environ., 27: 257–262.

CONTENTS

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Kadapi M · Salim PO · Sumadi

Evaluation of physiological quality of seed on yield of yellow and black soybean treated with biological seed coating

Abstract. The demand for soybeans as one of cereal commodities increases every year, however, to meet the production and demand level is still challenging in Indonesia. One of the causes of low soybean production is stress during cultivation, lack of nutrients, or poor quality of soybean seeds. One solution is to increase seed protection by coating the seeds with an environmentally friendly biological seed coating. This study aims to obtain the best biological seed coating for increasing soybean seed viability, vigor, and yield. The research was conducted at the Faculty of Agriculture Experimental Station of Universitas Padjadjaran, Jatinangor from August to November 2021. Two sets of experimental design were employed in this study, a Completely Randomized Design for the viability and vigor parameters in laboratory, and a Randomized Block Design with four replications for evaluation of the yield components in the field. The experiment was carried out with a combination of soybean cultivar and biological seed coating. The cultivars used in this study were Anjasmoro cv. (yellow) and Detam-4 cv. (black) and the biological seed coatings were *B. subtilis*, *Trichoderma* sp., and *Rhizobium* sp. Post-hoc test after F-test used Least Significance Different (LSD) with a significant level of 5%. The results showed that the application of the three biological seed coatings was not significantly affect seed physiological traits. However, the seed coating treatments increased the number of seeds per plant and seed weight per plant in yellow soybeans. Meanwhile, the application of *B. subtilis* and *Rhizobium* sp. in black soybeans increased the number of seeds per plant and the weight of seeds per plant. The best biological seed coating in this experiment was *B. subtilis*.

Keywords: *B. subtilis* • Biological Seed Coating • *Rhizobium* sp • Soybean • *Trichoderma* sp.

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Introduction

In Indonesia, soybean is one of important food crops which is indicated by the high demand year by year. There are two types of soybean according to the color of the seed coat, namely yellow and black. Each type of soybean has different industrial purpose, in which the yellow soybean is needed as raw materials for milk, "tempe" and tofu "tahu", while the black soybean is the main ingredient for soy sauce (STATISTICS INDONESIA, 2018). Indonesia still needs to import about 2.5 million tons per year to meet its soybean needs from several countries such as the United States, Canada, China, France, and Malaysia (STATISTICS INDONESIA, 2018), while soybean production reaches 0.9 million tons per year.

Several factors contributed to low soybean production in Indonesia such as limited arable land and less precise cultivation practices leading to low productivity. Soybean productivity is only around 1.56 tons which potential yield of soybean is up to 3 tons per hectare (STATISTICS INDONESIA, 2021; Balitkabi, 2015; Susanto & Nugrahaeni, 2017). As mentioned above, the lack of productivity may be caused by two factors, environmental and cultivation practices factors. The environmental factors may be modified in the field by cultivation practices to improve or adjust biological, chemical, and physical quality, while the others need more effort to modify such as temperature, relative humidity, rain, and light intensity. One of the efforts that can be applied to improve soybean productivity to avoid environmental stress is seed coating. Using seed coatings can increase seed vigor and viability, protect from environmental stress, maintain moisture content, and extend seed storability (Marwan & Handayani, 2019). Even, seed coating may improve seed performance by using substances such as pesticides to avoid biotic stress, nutrition, and microbes to boost growth in the early stage (Copeland & McDonald, 2004).

Seed coating with biological seed coatings or commonly known as PGPM (Plant Growth Promoting Microorganism) has several advantages such as environmentally friendly, protection from stress, increasing nutrient absorption, and stimulating plant growth (Ma, 2019). Some of microorganism that can use as seed coating substances are Rhizobium sp, Trichoderma sp. and *Bacillus subtilis*. As reported by Sutariati et al. (2006) that *B. subtilis* is an antagonistic bacterium that can induce plant growth and resistance. Tavanti et al. (2020) suggested that the application of *B. subtilis* can increase vigor, viability, and seed yield up to 15%. Also, Rhizobium sp. can be symbiotic with legume plants and form root nodules that help nitrogen fixation (Sari & Prayudyaningsih, 2015).

Inoculation of Rhizobium sp. as a biological seed coating can increase seed yield (Purwaningsih et al., 2012). Sumadi (2015) proposed that Trichoderma sp. is a seed coating substance due to its role as a decomposing organism, biological agent, and plant growth stimulator. In addition, the application of microorganism as a seed coating can increase the number of seeds per plant, seed weight per plant, and 100 seed weight (Winara et al., 2018). Based on these reports, the evaluation of some of microorganism species on physiological quality of seeds and yield of soybean is required to obtain which microorganisms can be used as biological seed coatings that are effective in increasing viability, vigor, and yield in soybean.

Materials and Methods

The experiment was conducted at the Experimental Farm of the Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency, West Java with an altitude of ±750 meters above sea level in August-November 2021. The materials used in this experiment were yellow soybean cv. Anjasmoro and black soybean cv. Detam 4 obtained from the Research Center for Miscellaneous Bean and Tuber Crops (BALITKABI) Malang, East Java. Biological seed coatings, Trichoderma sp. (Tricho-G), Rhizobium sp. (Rhizobium), *Bacillus subtilis* was isolated by Microbiology Laboratory of the Department of Soil Science, Faculty of Agriculture, Universitas Padjadjaran. Polybags 30x30 cm was filled with a well-mixed of Inceptisols soil and manure (volume ratio of 3:1) as planting media. The chemical fertilizer used in present experiment were urea (0.4 g/plant) as a nitrogen source, KCl (0.8 g/plant) as potassium source, and TSP (0.6 g/plant) as phosphor source. Crop maintenance consisted of watering, weeding, and mechanical pest control based on need.

Two sets of experiment was employed in this study, a randomized group design was used as the experimental design in the field with 8 treatments including control and three replications. The treatments were a combination of two soybean cultivars coated by *B. subtilis*, Rhizobium sp., and Trichoderma sp. Each treatment consisted of 2 plants per polybag. The dose for biological coating was prepared as follows: *B. subtilis* 3 ml/100 seeds (Tavanti et al., 2020), Rhizobium sp. (Rhizobium) 5g/100 seeds (Sari et al., 2015), Trichoderma sp. (Tricho-G) 3 g/100 seeds (Sumadi et al., 2015). In the laboratory, a completely randomized design was used to analyze physiological seed traits. Analysis of variance (ANOVA) by the F (Fisher) test at a real level of 5% was used for both experimental designs. In which, the Least Significance Difference (LSD) as post-hoc test at 5% significance level was applied for comparing each treatment with its respective control (Gomez & Gomez, 1976). Moreover, normality, transformation the data and the data analysis were calculated using SPSS ver. 21.

Plant growth indicated by plant height was measured at the end of vegetative stage from the soil surface to the tip of crop. Yield components of soybean such as the number of pods per plant, the number of filled pods per plant, the number of seeds per plant, 100-grain weight, and seed weight per plant measured after harvesting and drying the seed for 3 days.

Physiological quality evaluation was conducted by observing the seed viability (germination and vigor traits) using the rolled paper with plastic test method after being coated with biological seed coatings. The paper used in this study was “merang paper” as same as towel paper in retaining moisture. The normal seed germination was observed at 5 days for FDC (First Day Count) and at 8 days for LDC (Last Day Count) in germinator. To determine the normal dry weight of seedlings, the seedlings were dried in an oven for 3 days at 80^oC before weighing.

Results and Discussion

Climate, Plant Height, and Physiological of Seed Quality. Watering during cultivation is required due to the low rainfall intensity during the cultivation period, i.e., 0.3 mm in August, 0.8 mm in September, 2.9 mm in October, and 20.2 mm in November. The rainfall required by soybean plants during cultivation ranges from 120-135 mm/month (Sumarno & Manshuri, 2013). Soybean require enough water in the vegetative to early generative stage, particularly at pod filling. However, in the maturation stage, the soybean requires lower than the vegetative stage. Temperature data during the study from August to November were 23^0C, 23.6^0C, 23.6^0C, and 23.5^0C respectively. The ideal temperature for soybean growth and development is 22-27^0C (Sumarno & Manshuri, 2013). The temperature during the implementation of the study was in the rage optimum for the growth and development of soybean. Also, the temperature was optimum for the growth of *B. subtilis* and Rhizobium sp. The average humidity during the study ranged from 84 to 93% and indicated that the relative humidity was increased in November due to rainy season. In the growth and development phase, soybean requires optimal relative humidity ranging from 75-90%, while in the pre-harvest phase soybean require lower humidity of 60- 75% (Sumarno & Manshuri, 2013).

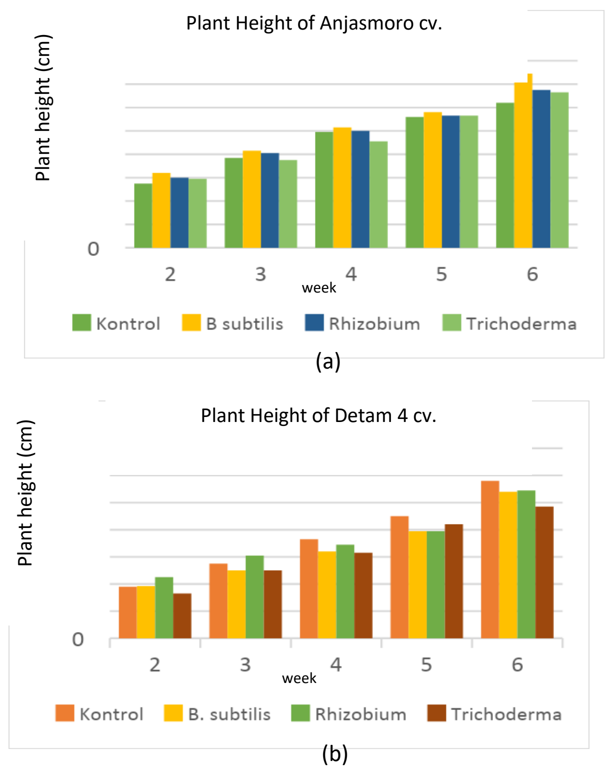

Figure 1. Plant height of yellow (a) and black (b) soybean at 2-6 weeks after planting.

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Plant height was measured at 2-6 weeks after planting in yellow soybean. Even though, these data were not calculated by statistical analysis, according to the descriptive presented in Figure 1, the application of microorganisms as bio-seed coating substances can enhance the plant height of Anjasmoro cultivars and *B. subtilis* treatment shows the highest plant height. This phenomenon is in accordance with previous research as reported by Bavaresco et al. (2020). *B. subtilis* produces phytohormones that increase plant growth. While, in Detam cultivar, the application of biological seed coatings has no direct effect on the increase in plant height.

Table 1. Effect of biological seed coatings on yellow and black soybean on seed viability and vigor.

Treatment	GP	VI	DWS (g)
Anjasmoro			
Control	90	8.55	0.14
B. subtilis	90.5	9.13	0.14
Rhizobium sp.	90.5	8.74	0.12
Trichoderma sp.	92	9.2	0.14
Detam 4			
Control	90	8.55	0.09
B. subtilis	83.5	8.26	0.10
Rhizobium sp.	84.5	8.08	0.09
Trichoderma sp.	92	8.95	0.09

note: GP = Germination Percentage, VI = Vigor Index, DWS = Dry Weight of Seedling (g)

Seed viability and vigor. The results of statistical analysis show that the physiological seed quality of two cultivars are in good condition, hence the effect of seed coating was not significantly noticed in these variables (Table 1).

Number of pods. The results of statistical analysis showed that the biological seed coating treatment did not affect the number of pods and filled pods per plant. However, there was an increase in the number of pods and the number of filled pods in yellow and black soybean due to the application of biological seed coatings. Li et al. (2021) reported that the application of *B. subtilis* can increase the availability of phosphate elements that are useful for pod formation and seed filling in soybean (Table 3).

The application of Rhizobium sp. can increase fixed nitrogen and indirectly can increase the formation of chlorophyll so that photosynthesis increases (Purwaningsih et al., 2012). Increased photosynthesis along with the production of photosynthates used for the formation and filling of pods. Harman (2006) informed that Trichoderma sp. fungus increases photosynthesis and solubility of phosphorus elements that are useful for the formation and filling of seeds.

Table 2. Effect of biological seed coatings on yellow and black soybean on number of seeds per plant and 100-grain weight.

Treatment	Number of seed	Weight of 100 seed (g)
Anjasmoro		
Control	66.25	15.65
B. subtilis	97.75*	15.33
Rhizobium sp.	81.5*	15.41
Trichoderma sp.	86.75*	15.60
Detam 4		
Control	114.75	10.38
B. subtilis	133.25**	10.41
Rhizobium sp.	127.75**	10.52
Trichoderma sp.	112	10.17

Note: The sign (*) on yellow soybean and (**) on black soybean shows that the treatment results are significantly different according to the 5% LSD test when compared to the control

Table 3. Effect of biological seed coatings on yellow and black soybean on number of pods and number of filled pods.

Treatment	Number of pod	Number of filled pod	%Filled pod
Anjasmoro			
Control	61	47.75	78.28
B. subtilis	82	60.5	73.78
Rhizobium sp.	69.25	57.5	75.81
Trichoderma sp.	69	58	84.06
Detam 4			
Control	75.5	62.5	82.78
B. subtilis	92	69.5	75.54
Rhizobium sp.	96.75	73	75.45
Trichoderma sp.	70.5	59.25	84.04

Number of Seed. The results of statistical analysis showed that the application of biological seed coatings influenced the number of seeds per plant (Table 2). This is indicated by significant differences in the application of the three seed coatings in yellow soybean, while Trichoderma sp. biological coating treatment indicated no effect in number of seed of black soybean. This is in line with several previous studies conducted by Tavanti et al. (2020), Purwaningsih et al. (2012),

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and Winara et al. (2018). *B. subtilis* may stimulate plant growth by producing amino acids, vitamins, and growth-inducing substances (Djaenuddin & Muis, 2015). Rhizobium sp. application increases nitrogen content and the number of seeds per plant (Purwaningsih et al., 2012). Hence, the increasing of nitrogen advantageous in the photosynthesis of plants and increase the solubility of phosphorus, that in the end support in seed formation (Lakitan, 2007; Jamilli et al., 2017).

Table 4: effect of biological seed coatings on yellow and black soybean on seed weight per plant.

Perlakuan	Seed weight (g)	Yield per ha (ton)
Anjasmoro		
Control	8.61	1.1
B. subtilis	13.17*	1.69
Rhizobium sp.	11.18*	1.43
Trichoderma sp.	11.57*	1.48
Detam 4		
Control	11.57	1.48
B. subtilis	13.62**	1.74
Rhizobium sp.	13.25**	1.7
Trichoderma sp.	10.89	1.39

Note: The sign (*) on yellow soybean and (**) on black soybean shows that the treatment results are significantly different according to the 5% LSD test when compared to the control

Seed weight. The results of statistical analysis showed that the application of biological seed coatings can increase seed weight per plant (Table 4). This is indicated by significant differences in the three treatments of biological seed coating for yellow soybean and *B. subtilis* and Rhizobium sp for black soybean. This increase in seed weight occurs along with the increase in the number of seeds. *B. subtilis* can increase seed weight per plant due to *B. subtilis* can increase the growth of soybean plant roots (Hungria et al., 2013). The increase in nutrient content along with the production of photosynthates that will be support for seed formation. The nitrogen fixation with the presence of Rhizobium sp. Bacteria, also may increase seed weight (Meirina et al., 2007). Sumadi et al. (2015) reported that the application of Trichoderma sp. can increase seed weight up to 10% when compared to the control. This is because the Trichoderma sp. can stimulate plant growth by increasing the absorption of nutrients, especially phosphorus and nitrogen, resulting in an increase in seed weight that improve the yield (Marra et al., 2019).

Table 4: effect of biological seed coatings on yellow and black soybean on seed weight per plant.

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Note: The sign (*) on yellow soybean and (**) on black soybean shows that the treatment results are significantly different according to the 5% LSD test when compared to the control

Weight of 100 grains. The results of further tests showed no effect due to the application of biological seed coatings on the weight of 100 grains. The difference in 100-grain weight in yellow and black soybean is due to genetic.

Conclusion

The biological seed coating application, particularly *B. subtilis,* can be used for enhancing soybean yield as indicated by the increase of seed number and seed weight per plant in yellow soybean cv. Anjasmoro and black soybean cv. Detam. Although, the effect of biological seed coating was not showed in physiological seed traits due to high quality of seed use in this study.

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Ruminta · Sabilla Y · Wicaksono FY · Wahyudin A

Analysis of vulnerability and risk of maize (*Zea mays* L.) production decrease on rainfed land in Garut Regency due to climate change and its strategic adaptation options

Abstract. Climate change, especially air temperature and rainfall, impacts the agricultural sector, one of which is the reduction of maize production. As an anticipatory effort to reduce maize production due to climate change, a study is needed to identify the possible hazard, vulnerability, and risk of maize yield reduction at the sub-district level in the largest maize-producing center in West Java, Garut Regency. After identifying areas with high or very high levels of potential yield reduction risk, a strategic adaptation that can be applied to deal with climate change can be identified. The method used in this research is descriptive quantitative. The data used include temperature, rainfall, planting area, harvest area, production, productivity, and socio-economic data of farmers obtained from LAPAN, BPS, Garut Regency Agriculture Office, and other related sources. The results of the study stated that the areas with a potential risk of production decrease at a very high level (IR >0.81) are in Wanaraja and Malangbong sub-districts; high level (IR: 0.61-0.80) are in Cisewu, Pakenjeng, Banyuresmi, and Limbangan. Meanwhile, the potential risk level of maize productivity decrease is very high (IR >0.81) in Cisewu, Pamulihan, Banyuresmi, Malangbong, and Limbangan; high (0.61-0.80) in Bungbulang, Singajaya, Cilawu, Bayongbong, Leles, Leuwigoong, Cibiuk, Cibatu, and Selaawi. Adaptation strategy to minimize the potential risk of reduced maize yields can be done by using superior hybrid varieties, managing planting time, water management, minimum tillage, and mixed cropping.

Keywords: Rainfall · Risk · Strategic adaptation · Temperature

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Introduction

Maize (*Zea mays* L.) is one of the agricultural commodities for human consumption but also for livestock feed and industrial raw material, so has quite a lot of benefits. However, the increasing demand for maize is not matched by sufficient availability or production of maize, as happened in 2012-2016 where one of the important components in the calculation of production, namely the maize harvested area in Indonesia, decreased by an average of 2.78% each year (Nuryati et al., 2016). The decrease in maize harvest area is caused by the conversion of agricultural land into other interests such as industry and housing. The impact of climate change on agricultural production is the decrease in maize crop harvested area (Herlina & Prasetyorini, 2020).

Climate change is a condition in which the magnitude of some climate elements tends to change or deviate from average conditions and existing dynamics towards a certain direction (decrease or increase). Global climate change in Indonesia seems to be a reality and has been felt (Ruminta, 2011). This is indicated by disasters such as floods, droughts (long dry season), and shifts in the rainy season which can certainly threaten the resilience of the agricultural sector, especially food, because food crops generally include annual crops that are relatively sensitive to stress, especially excess and lack of water.

Maize production in Garut Regency, which is one of the largest maize-producing centers in West Java, still fluctuates. This can be seen from the data from BPS Garut Regency (2019) where from 2014 to 2019 the production of maize decreased from 567,876 tons to 489,301 tons. This is suspected due to climate change, especially in West Java, including Garut Regency, where maize is predominantly grown on dry or rainfed land. If there is a shift in the rainy or dry season due to climate change, it is feared that there will be land degradation due to soil erosion by water, or drought, which will certainly have an impact on the productivity of maize plants (Estiyaningsih & Syakir, 2017). Likewise, a prolonged rainy season has the potential to result in an increase in the volume of water on the soil surface or inundation in maize crops, which will create anaerobic conditions, resulting in unstable nutrient and water transport to leaf tissues and resulting in closed stomata that will ultimately reduce plant yields.

Therefore, it is necessary to conduct research to find out how much climate change has occurred in Garut Regency from 1982-2018, as well as the need for prediction and anticipation as an effort to minimize losses that can occur by making a study of the potential level of hazard, vulnerability, and risk of reducing maize crop yields.

The purpose of this study is to determine the magnitude of climate change in Garut Regency and analyze which areas have the potential for high to very high levels of risk of decreased maize production so that later it is expected to find a recommendation or strategic adaptation options that are appropriate as an effort to adjust and reduce the risk of agricultural production failure.

Materials and Methods

The experiment was conducted in March-August 2022. This research used a quantitative descriptive method, with data collected from 1982-2018 which was then interpreted using ArcGIS software. The data used in the research include rainfall and temperature. data on land area, harvest area, production, productivity of maize, altitude, and socio-economic of farmers obtained from LAPAN Garut, Garut Regency Agriculture Office, and BPS.

The stages of analysis used include the following

(1). Hazard Analysis

a.) Effect of Temperature Increase on Maize Yield

Ruminta & Handoko (2012) revealed that an increase in air temperature can lead to an increase in plant respiration which has the potential to reduce crop yields. The relationship is written with the following *Temperaturweretient* formula.

$$\mathbf{Q_{10} = 2^{(T-20)/10}}$$

An increase in temperature can result in a decrease in yield, written in the following formula.

$$\mathbf{\Delta Yp_1 = Y_0\,(Q_{10}-Q_{10o})}$$

Where: T = temperature (°C); $\Delta Yp1$ = potential yield reduction due to crop respiration (ton/ha); Y_0 = crop production before air temperature increase (ton/ha); Q_{10} = temperature quotient after temperature increase; Q_{10o} = initial temperature quotient.

Relationship between yield reduction due to an increase in air temperature.

$$\mathbf{Yp_2 = Y_o\ (T_o - T_b)/(T - T_b)}$$
$$\mathbf{\Delta Yp_2 = Y_o - Yp_2}$$

Where: ΔYp2 = potential yield reduction due to decreased crop age (ton/ha); Yo = crop production before air temperature increase (°C); T_o = initial air temperature (°C); T = air temperature after temperature increase (°C); Tb = plant base temperature (°C).

b.) Effect of Rainfall on Crop Yields

$$\mathbf{\Delta Yp_3 = k\ .\ \Delta P}$$

Where: ΔYp3 = potential reduction in maize yield (ton/ha) due to drought; P = change in rainfall (mm/season).

$$\mathbf{\Delta Y_a = max\ (\Delta Yp_1, \Delta Yp_2, \Delta Yp_3)}$$

Where: ΔY_a = reduction in crop yield due to increased air temperature (ton/ha); ΔYp1 = potential reduction in yield due to plant respiration (ton/ha); ΔYp2 = potential reduction in yield due to decreased crop age (ton/ha); ΔYp3 = potential reduction in maize yield (ton/ha) due to drought.

(2). Vulnerability Analysis

$$\mathbf{V = E \times S / AC}$$

Where: V = vulnerability; E = exposure; S = sensitivity; AC = adaptive capacity.

(3). Risk Analysis

$$\mathbf{R = H\ .\ V}$$

Where: R = Risk; H = Hazard.

In this study, a survey was also conducted with maize farmers and officers of the Agriculture Office to find out the adaptation options maize farmers in Garut Regency have.

Results and Discussion

Analysis of Climate Change in Garut Regency. Based on the analysis of air temperature and rainfall data from 1982-2018, Garut Regency has experienced climate change as shown in Table 1.

Table 1. Climate Changes

Climate Indicator	Climate Changes	
	Period of 1982-1999	Period of 2000-2018
Average Air Temperature (°C)	26.64	26.84
Average Rainfall Amount (mm)	1872.71	2392.49
Consecutive Wet Months (BB)	3	4
Consecutive Wet Months (BK)	2	1
Oldeman Classification	D2	D1

Table 1 shows that Garut Regency in the period 1982-1999 and 2000-2018 experienced an increase in air temperature of 0.2°C. The analysis results also show that rainfall in Garut Regency during the period 1982-1999 and 2000-2018 increased by 519.78 mm. The increase in rainfall is an impact of the increase in temperature in Garut Regency, and this is in line with the statement of Prasetyo et al. (2021), which states that in tropical areas, the increase in air temperature is followed by an increase in rainfall intensity as a result of high evaporation.

Besides the increase in rainfall, the climate type of Garut Regency has also changed, which is characterized by an increase in the average wet month in the 2000-2018 period. The climate type grouping used in the study is the Oldeman climate type. In 1982-1999 Garut Regency was included in the D2 agroclimatic zone area, then in the next period, namely 2000-2018 Garut Regency experienced an increase in wet months consecutively to 4 months (D1). The addition of 1 wet month in the 2000-2018 period is allegedly related to the increase in rainfall in the same year. Concerning agriculture, especially food, this D1 agro-climatic zone type means that it can be planted by short-aged rice once, and the time for planting secondary crops (including maize) is sufficient (Harahap et al., 2021; Maylay, 2019).

Climogram Changes in Garut Regency. A climogram is a graph that describes the climate conditions in a location. Based on the results of the climogram analysis listed in Figure 1, it can be concluded that in the 1982-1999 and 2000-2018 periods, there has been an increase in air temperature, which is characterized by a pattern of shifting temperature numbers towards the Y axis. Rainfall in certain months is also seen to have undergone significant changes which is also evidenced by the pattern of shifting rainfall numbers towards the X axis. Climate change described by climogram has also occurred in Malang, East Java, where the area generally experienced an increase in average air temperature and rainfall characterized by a shift in the climogram to the right (Ruminta, 2015).

Hazard of Maize Production Decrease. The potential hazard of maize production decrease in Garut Regency is obtained from the analysis results assuming that changes in air temperature and rainfall are related to the potential decrease of food crops. The result of the analysis of the magnitude of the potential hazard of maize production decrease in Garut

Regency is shown in Figure 2. The potential hazard of decreased maize production due to climate change in each sub-district averaged 3%. The area with the highest potential hazard of maize production decline is Wanaraja Subdistrict, and the highest level of potential maize production decline is in Pakenjeng Subdistrict.

The potential decrease in production can occur due to climate change in Garut Regency because climate change, such as an increase in temperature, impacts crop yields. The amount of air temperature is directly related to metabolic processes such as respiration. When the air temperature increases, the respiration rate also increases. High respiration causes the decomposition of photosynthesis products, thereby reducing plant yields. Likewise with rainfall, according to the analysis, Garut Regency experienced an increase in rainfall in several months when the average rainfall reached 300 mm/month. In contrast, the rainfall needed by maize plants grown on non-irrigated land is around 85-200 mm/month (Kemendag, 2016). This could lead to a decrease in maize yields, as maize is intolerant of inundation (anaerobic conditions) (Tian et al., 2020; Chen et al., 2014; Mangani et al., 2018).

Hazard of Decreasing Maize Productivity. Productivity is a value that shows the average production yield/unit area of food crop commodities. The magnitude of the hazard of decreasing productivity of maize crops is calculated to determine the potential decrease in maize productivity/unit of land in each sub-district in Garut Regency. The amount of potential productivity decrease is calculated in the same way as the production hazard analysis, which in this analysis requires data on maize productivity from 1982 to 2018.

The results of the analysis of the magnitude of the potential hazard of decreased maize productivity in Garut Regency are shown in Figure 3. The potential hazard of decreased maize productivity in Garut Regency is moderate to very high. The high level of potential decrease dominates in almost every region in Garut Regency. Meanwhile, the region with the highest potential decrease is Pamulihan Subdistrict. Similar to production, the potential hazard of decreasing maize productivity in each sub-district in Garut Regency averages at 3%

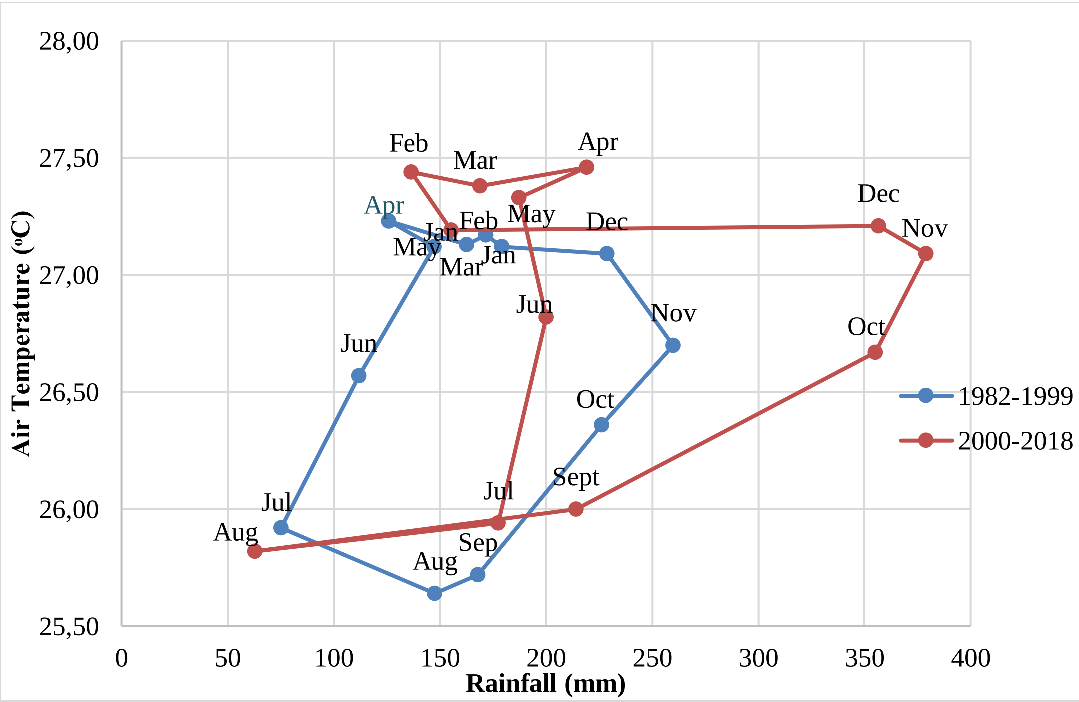

Figure 1. Climogram of Garut Regency

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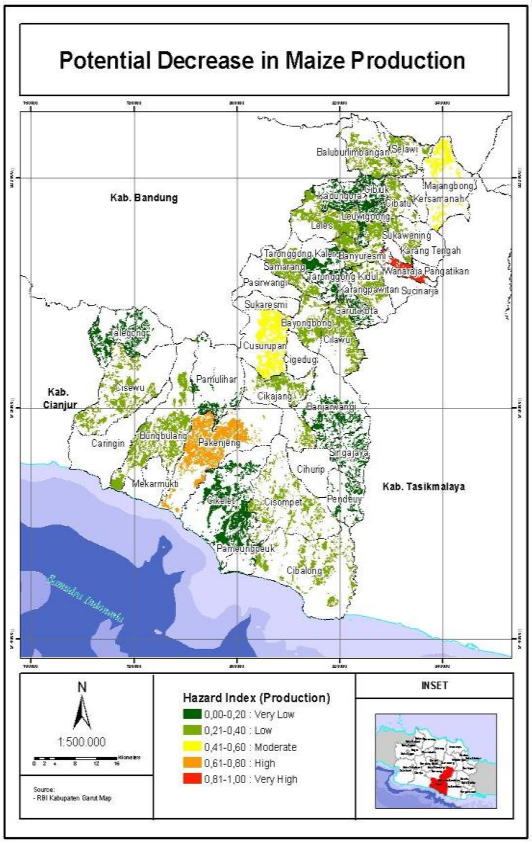

Figure 2. Map of potential decrease of maize production

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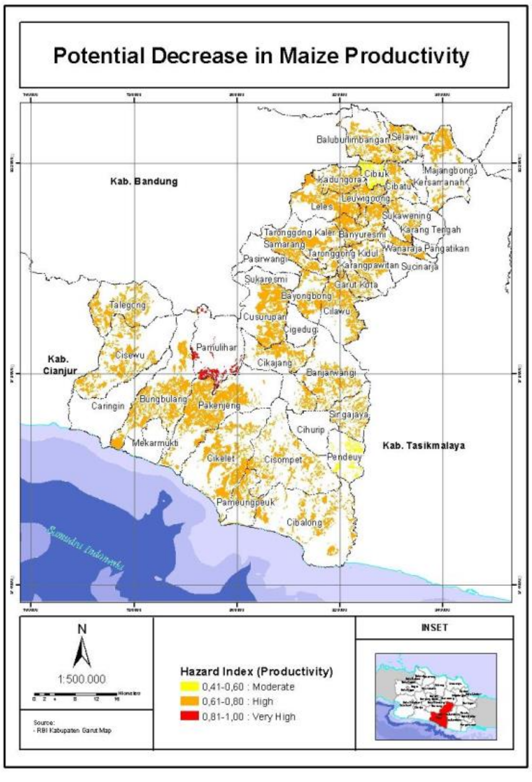

Figure 3. Map of potential decrease of maize productivity

Vulnerability of Agriculture Sector in Garut Regency. The potential vulnerability of reduced maize production was analyzed using a combination of three components: exposure, sensitivity, and adaptive capacity. The indicators that makeup exposure, the magnitude of potential exposure due to climate change, are the number of maize farmers and the area of land planted with maize. The sensitivity indicators, which are the dimensions of agriculture easily affected by climate change, are rainfed land area and altitude. While the indicators used in analyzing the adaptive capacity that shows the ability of farmers to deal with climate change are education and income.

High levels of exposure and sensitivity can increase the level of vulnerability. At the same time, adaptive capacity is inversely proportional to vulnerability, meaning that the greater the level of adaptive capacity in an area, the lower the level of vulnerability. The results of the vulnerability analysis in Garut Regency are shown in Figure 4.

From the results of this analysis, it can be seen that the areas with the highest vulnerability index are only in Malangbong and Limbangan, with a value of. In contrast, areas that fall into the high vulnerability category are Cisewu, Banyuresmi, and Selaawi.

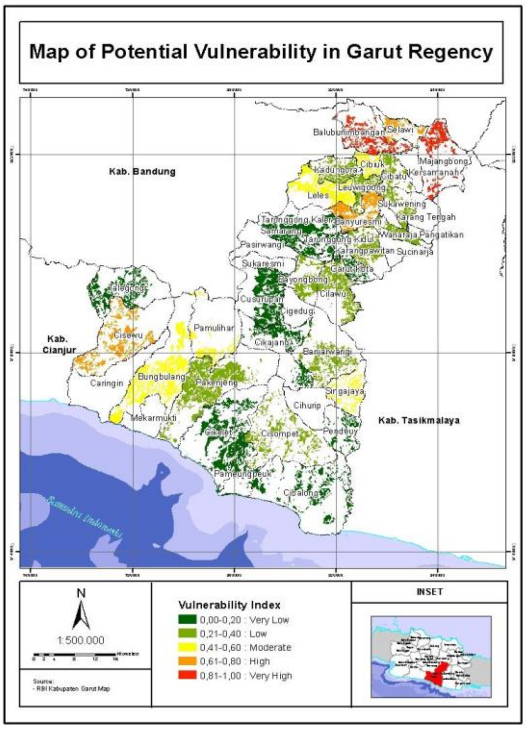

Figure 4. Map of Potential Vulnerabilities

Risk of Maize Production Decrease. Based on the results of the analysis of the potential risk of decreased maize crop production obtained from the product of hazard and vulnerability, it can be seen that two sub-districts are included in the area that has a very high level of risk of decreased production, namely Wanaraja and Malangbong. This shows that each of these areas has the highest level of hazard and vulnerability to maize production decrease among the other areas, while Cisewu, Pakenjeng, Banyuresmi, and Limbangan sub-districts are included in the high-risk areas (Figure 5).

Risk of Maize Productivity Decrease. The analysis of the potential risk of decreased productivity is calculated per unit area (ha^{-1}) planted with maize. Based on the results, the areas with the highest level of risk are Cisewu, Pamulihan, Banyuresmi, Malangbong, and Limbangan sub-districts. Areas with potentially high-risk levels are found in nine sub-districts, including Bungbulang, Singajaya, Cilawu, Bayongbong, Leles, Leuwigoong, Cibiuk, Cibatu, and Selaawi (Figure 6).

From the areas with the potential risk of decreasing maize yields in both production and productivity with high and very high levels, strategic adaptation efforts to climate change are needed so that maize yields can increase or maintain at least. If strategic adaptation efforts are not made, it is feared that maize in Garut Regency will decrease and disrupt the supply of food needs.

Strategic Adaptation Options. The adaptation is especially prioritized in areas with high or very high levels of risks from the impacts of climate change. Most maize farmers in Garut Regency have recognized the impact of climate change on agriculture. Farmers in Garut Regency have made some efforts to anticipate climate change, including the use of hybrid maize seeds of Bisi 16 and Bisi 18 varieties, which are considered to have an important role in suppressing the decrease in maize production due to climate change. This is because, in addition to having high average yields (9.2 and 9.1 ton/ha), both varieties can be planted during the dry/rainy season, which is also in accordance with the climatic conditions of Garut Regency, which has been predicted to experience increased rainfall. In addition to the use of these maize varieties, Litbang Pertanian in its Katam system also recommends using hybrid maize seeds of Pioneer 15, Bisi 9, Bisi 12, Bisi 13, and DK 3 in the Garut Regency area (Litbang Pertanian, 2020). The recommended varieties have high yield potential, can be planted in two seasons, and are early maturing. Early-maturing hybrid varieties are considered an effort to minimize crop failure due to climate change, such as short rainy periods or prolonged rains that will disrupt the growth of maize plants (Carena, 2013; Major et al., 2021).

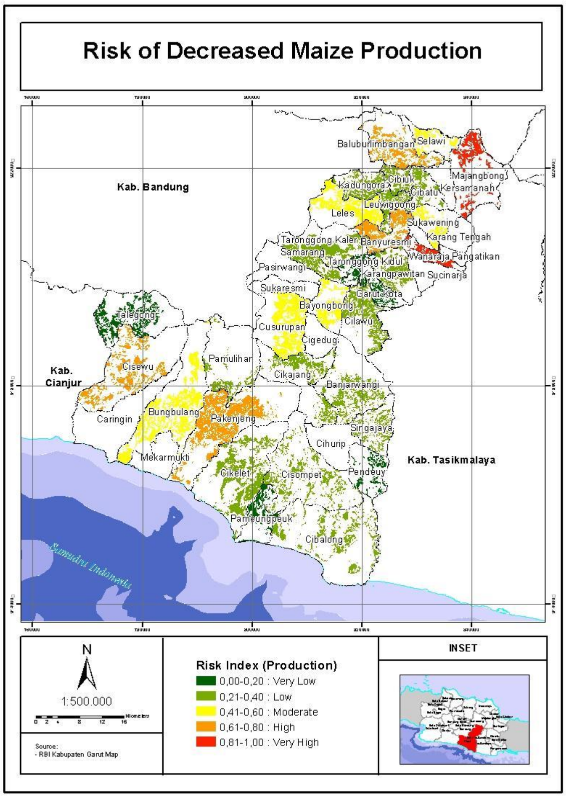

Figure 5. Maize Production Decrease Risk Map

Efforts to manage planting time also need to be made to reduce losses due to floods or droughts due to climate change. In addition, to reduce the occurrence of inundation around maize crops due to high rainfall, a good drainage system is needed so that maize growth is not disturbed, or an alternative can be made by making a bed system (Fahong et al., 2004).

To anticipate the occurrence of drought due to insufficient rainwater supply, especially when maize planting is done on rainfed or dry land, some farmers in Garut Regency have made efforts by collecting rainwater and making boreholes which the local agricultural agency also facilitates. The borehole wells have a big contribution in the effort to prevent a water crisis that is feared to lead to crop failure.

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Minimum tillage is also important to avoid soil saturation and minimize soil aggregates from damage, and minimum tillage increases the activity of microorganisms in the soil (Wahyuningtyas, 2015). The mixed cropping system that most farmers have also applied has the advantage of increasing crop yields, the diversity of plant species can also limit the spread of pests (Thornton & Herrero, 2014; Thamo et al., 2017; Ghahramani et al., 2020).

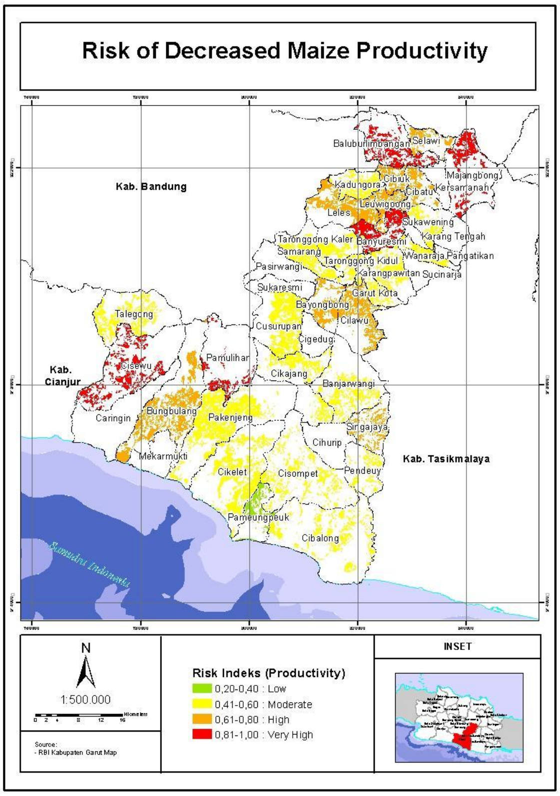

Figure 6. Maize Productivity Decrease Risk Map

Conclusion

1. Garut Regency experienced climate change characterized by an increase in average air temperature of 0.2°C and an increase in rainfall of 519.78 mm, and there was a climogram shift to the right and upward in the 2000-2018 period accompanied by a change in climate type from D2 to D1.
2. An increase in average air temperature by 0.2°C and rainfall by 519.78 mm in Garut Regency can decrease maize production and productivity by 3% on average.
3. Areas with a very high risk of maize production decrease are located in Wanaraja and Malangbong sub-districts; high level is located in Cisewu, Pakenjeng, Banyuresmi, and Limbangan sub-districts, while areas with a very high risk of maize productivity decrease are located in Cisewu, Pamulihan, Banyuresmi, Malangbong, and Limbangan sub-districts; high-risk level is located in Bungbulang, Singajaya, Cilawu, Bayongbong, Leles, Leuwigoong, Cibiuk, Cibatu, and Selaawi sub-districts.
4. Adaptation strategies that can be recommended to deal with climate change, some of which have also been implemented by local farmers, including the use of high-yielding seeds that can be planted during droughts or prolonged rains, such as the hybrid varieties BISI 16 and BISI 18. Litbang Pertanian also recommends using early-maturing and high-yielding varieties such as Pioneer 15, BISI 9, BISI 12, BISI 13, and DK 3. Other adaptation strategies that can be carried out are proper planting time management, rainwater harvesting or drilling wells, minimum tillage, and mixed cropping.

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Algina A · Yulianti SY · Syamsyiah R · Yasminingrum V · Vendi BFN · Dewi VK

Determining the potential of sonic bloom in inducing rice resistance (*Oryza sativa*) against the attack of bacterial leaf blight disease caused by *Xanthomonas oryzae*

Abstract. *Xanthomonas oryzae* which causes bacterial leaf blight disease is one of the main pathogens that attack rice crops. The threat of losing rice yields due to *X. oryzae* needs to be avoided by implementing appropriate control strategies. Sonic bloom has the potential to induce plant immunity against diseases. Hence, this study aimed to examine the potential of sonic bloom in inducing rice resistance to bacterial leaf blight. The experiment was arranged in a Randomized Block Design (RBD) with five treatments and three replications. The treatments consisted of several frequencies, namely PR (0.5 - 1 kHz and inoculated with *X. oryzae*), PS (3 - 5 kHz and inoculated with *X. oryzae*), PT (7 - 10 kHz and inoculated with *X. oryzae*), KP (inoculated with *X. oryzae* without sonic bloom treatment), KN (no bacterial inoculation and sonic bloom treatment). The results showed that all sonic bloom treatments (LF, MF, HF) had a significant effect on increasing the intensity of BLB disease in rice plants. This showed that sonic bloom in this range does not have the potential to induce rice plant resistance to BLB. Further research to find out the causes of this is needed.

Keywords: Bacterial leaf blight • Cicadas • Disease intensity • *Xanthomonas oryzae*

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Introduction

Bacterial leaf blight (BLB) is one of the crucial diseases in rice cultivation. BLB disease caused by *Xanthomonas oryzae* pv. oryzae is one of the causes of rice yield loss with a percentage of 80-90% in rice-producing countries, especially in Asia (Vikal & Bhatia, 2017). According to the Badan Peramalan Organisme Pengganggu Tumbuhan (Center for Forecasting Plant Pest Organisms) Indonesia (2021), the distribution of BLB disease in Indonesia during the 2021 rice planting season was estimated to be 28,743 ha with the highest attack in West Java Province covering 6,381 ha.

The threat of loss of rice yields due to BLB needs to be avoided by implementing appropriate control strategies. In general, control can be carried out in various practices, including mechanical, physical, chemical, cultural and biological techniques (Suganda, 2020). Synthetic chemical pesticides or bactericides, such as nickel dimethyl dithiocarbamate, dithianon, and phenazine, are frequently used to manage BLB at the farm level (Kurniawati, 2021). However, utilizing chemical pesticides as the only form of control will have numerous detrimental implications on human health and the environment (Nicolopoulou-Stamati et al., 2016). Employing the resistant varieties is one of the practices in controlling BLB, it must be balanced with the application of other cultivation elements. Spacing, proper fertilization, and land sanitation are essential elements of healthy farming (Kurniawati, 2021). In light of this, integration of these practices should be promoted to get a great result, this concept is well-known as integrated pest management (IPM) (Deguine et al., 2021). A development of various control practices is important for supporting IPM.

Sonic bloom is a new control practice that can be developed for controlling BLB disease in rice. It is presumed that plant resistance can be increased by using sonic bloom by generating energy or vibration around the plant through the use of sound waves so that it can suppress attacks by pests and diseases. The research of Hassanien et al. (2014) shows that sonic bloom treatment could reduce spider mites, aphids, gray mold, leaf blight and viral diseases by 6%, 8%, 9%, 11%, and 8% respectively on tomatoes in the greenhouse. Furthermore, the use of sonic bloom can reduce the attack of *Rhizoctonia solani* which causes rice sheath blight by up to 50%. Hormones that can increase plant resistance to pests are produced by plant gene expression which is influenced by mechanical stimuli in the form of sonic bloom (Joshi et al., 2019). Sonic bloom has not been widely used by farmers in Indonesia. The use of sonic bloom technology in rice is expected to be able to induce plant resistance to BLB disease.

In addition, sonic bloom is a technology that can trigger the opening of stomata (Ai et al., 2021; Prasetyo & Wicaksono, 2019). The high sound frequency used through sonic bloom on plants can cause the stomata opening to become wider. This has implications in increasing the uptake of water, nutrients, and CO_2 through the stomata on the leaves thereby helping the optimization of the photosynthesis process. In addition, mustard plants that were treated with sonic bloom with a frequency of 3,000 Hz had a 20% higher weight yield compared to the control treatment (Putri et al., 2021).

The sound of cicadas is often considered a dominant and iconic feature of nature in many regions around the world. This characteristic buzzing or droning noise, produced by male cicadas to attract females, is particularly prominent during the hot summer months (Haskell, 2018). Anas & Kadarisman (2018) used cicadas sound as a sonic bloom technology for enhancing rice growth. Study on the effect of cicadas sound on rice resistance would be interesting.

The purpose of this study was to determine the potential of sonic bloom and its appropriate frequency level in inducing rice resistance to BLB disease. The novelty in this study is the utilization of sonic bloom with the sound of cicadas in inducing rice resistance to BLB disease.

Materials and Methods

Time and Location. This experiment was conducted for four months from June - September 2022 at the Sari Kedele Farm Greenhouse, Jatinangor and the Entomology and Biotechnology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Padjadjaran.

Materials. The equipment used in this study were Robot speakers "RB100" as a sound source with specifications of frequency response range 100 Hz - 18 kHz, ability to work for 8 hours, and can be used with Bluetooth, USB, or TF Card, flash drives, saws, scissors, rulers, knives, UV transparent plastic, wood, hammers, nails, chlorophyll meters, microscopes, digital scales, laboratory equipment (Bunsen burner, object glass and covers, reaction tubes, petri dish, spatula), Microsoft Excel and SmartstatXL Excel Add In, Adobe Photoshop CC 2022 software, ImageJ software, Audacity software, frequency meter application, sound meter application. The materials used were Mapan 05 variety rice seeds, buckets, topsoil of a paddy field, compost, manure, NPK 15-15-15 fertilizer, water, *X. oryzae* isolate, distilled water, and clear nail polish.

Experimental Design. The experiment was arranged in a Randomized Block Design (RBD) with five treatments and three replications. Sonic bloom was applied for 3 hours per day (07.00 - 10.00 WIB) with three different frequencies taken from the sound of the cicadas or in Indonesia it's called "tonggeret". The length of sonic bloom exposure time refers to the research of Hendrawan et al (2020), which stated that the 3-hour exposure time showed the best results on several variables of growth and physiology of kailan plants.

LF : 0.5 - 1 kHz and inoculated with *X. oryzae*
MF : 3 - 5 kHz and inoculated with *X. oryzae*
HF : 7 - 10 kHz and inoculated with *X. oryzae*
PC : inoculated with *X. oryzae* without sonic bloom treatment
NC : no bacterial inoculation and sonic bloom treatment

Notes: LF, Low Frequency Treatment; MF, Moderate Frequency Treatment; HF, High Frequency Treatment; PC, Positive Control; NC, Negative Control.

Sonic Bloom Chamber Construction. A wooden frame was constructed and coated with transparent UV plastic to form a chamber for rice growth. After that, the speakers were placed in it. The speaker was placed at the top of the device by hanging using a rope. This device was made to keep each treatment under the same conditions and facilitate observation. The chamber is presented in Figure 1.

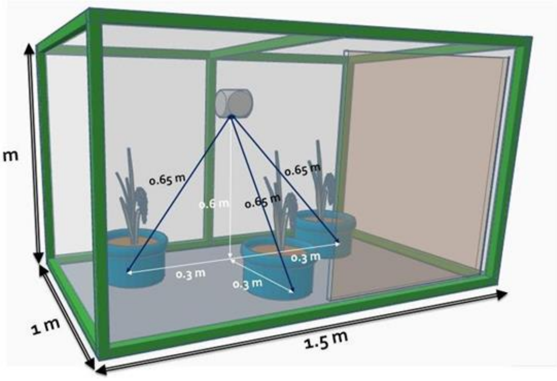

Figure 1. Design of sonic bloom chamber

The sound used was a high quality sound of cicadas obtained from the freesound.org website. The sound was adjusted and altered for frequency and intensity according to the desired range for this research using the Audacity software. The accuracy of the frequency was examined using a frequency meter application that had been tested for functionality (calibration) beforehand. Sound intensity was measured using the sound meter application.

Planting Media Preparation. Planting media was prepared by adding topsoil of paddy field and manure that had been mixed into a bucket with a ratio of 1 : 1. The mixture of planting media was loosened first and soaked before the rice was planted.

Rice Planting. Mapan 05 variety rice seeds were first sown in trays containing planting media for 15 days. Seedling that had been sown was transplanted into a bucket that had been prepared beforehand. The buckets were put into the sonic bloom chamber according to their respective treatments then stored in the greenhouse. Routine maintenance was carried out such as watering, weeding, and fertilization.

***X. oryzae* Inoculation.** *X. oryzae* was inoculated when the rice was 16 days after sowing (DAS). The inoculation technique used was spraying a suspension of *X. oryzae* with a density of 10^{10} CFU/mL as much as 5 mL by using a spray bottle on each rice plant in a bucket directly without being injured.

Observation. Observations were conducted on several variables included:

a. Disease parameters (disease intensity and development rate of the disease);
b. Physiological parameters (stomatal opening, chlorophyll index, and stomatal conductance);

c. Growth parameters (plant height, fresh weight, root length, leaf area, number of tillers, and number of leaves).

Observations of disease intensity were made daily for 14 days by scoring each treatment pot, then calculated using a formula:

$$DI\ (\%) = \sum (n \times z)/(N \times Z) \times 100\%$$

With n = number of samples that have the same score value; z = score value; N = total number of samples observed; and Z = highest score used. Observations of the development rate of disease progression were seen from the graph of intensity development, infection rate (r) values, Area Under Disease Progressive Curve (AUDPC) values, and the percentage of disease inhibition.

For growth parameters and stomatal opening, observations were made on day 14 shortly after the plants were harvested. Then for physiological parameters except stomatal opening, observations were made every 3 days for 14 days.

Data analysis. Data analysis was performed using Excel Software and SmartstatXL Excel Add-In. Analysis data was conducted using Analysis of Variance (Anova) for all observation variables. If Anova showed a significant effect, then Duncan's multiple range test (DMRT) was conducted at the 5% significant level.

Result and Discussion

Disease Intensity. Based on Table 1, the intensity of leaf blight in LF, MF, and HF treatments is significantly different from NC and PC. The sonic bloom treatment has a higher disease intensity when compared to both controls. In addition, NC and PC had the lowest AUDPC values, which amounted to 30.21 and 58.92 and were significant to the sonic bloom treatment. LF had an AUDPC value of 138.41 and was significant against MF and HF which had AUDPC values of 189.03 and 180.14. The higher AUDPC value in the sonic bloom treatment indicates that the development of disease severity in rice plants treated with sonic bloom is higher than both controls.

Disease progression from the first day to 14th day after inoculation showed an increase in all treatments (Figure 2). On day 3, HF showed a significant change in the graph of disease intensity. LF and MF showed significant changes on day 4, while PC showed significant changes on day 12. This is thought to be because *Xoo* has passed the lag phase faster in the sonic bloom treatment compared to control.

Table 1. Disease intensity and AUDPC

Treatment	Disease Intensity (%)	AUDPC
NC	2.12 a	30.21 a
PC	4.99 b	58.92 a
LF	9.18 c	138.41 b
MF	10.10 c	189.03 c
HF	9.24 c	180.14 c

Note: *Numbers followed by the same letter in the same column are not significantly different based on Duncan's test at 5% significance level. NC, Negative Control; PC, Positive Control; LF, Low Frequency Treatment; MF, Moderate Frequency Treatment; HF, High Frequency Treatment; DI, Disease Intensity; AUDPC, *Area Under the Disease Progress Curve*.

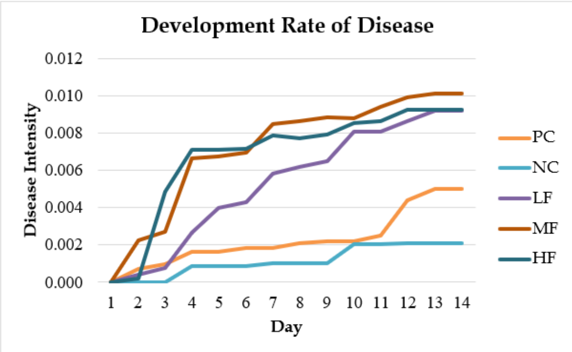

Figure 2. Developmental rate of BLB disease with several sonic bloom treatments.

The high values of disease intensity and AUDPC in LF, MF, and HF are thought to be due to sound exposure that not only affects plants, but can also affect bacteria. Juergensmeyer (2004) stated that the lag phase of bacteria can be shortened and the growth rate of bacterial cells can increase due to the influence of sound frequency. In addition, sound vibration can also provide optimum conditions for bacterial cell membranes to increase metabolic activity and bacterial growth (Shaobin et al., 2010; Ying, 2009).

Shah et al. (2016) stated that the treatment of raag ahir bhairav music exposure with a frequency range of 150 - 7811 Hz can increase the growth and production of exopolysaccharide (EPS) in *Xanthomonas campestris* by 6.66% and 32.06%, respectively. Bianco et al. (2016), stated that Xanthomonas spp. produces the main EPS in the form of xanthan which has a function as a bacterial defense from stress and helps penetration on the plant surface with the formation of biofilms.

Sonic bloom treatment in this study was able to significantly increase stomatal opening against the control. It is also thought to cause BLB disease intensity in the sonic bloom treatment to be higher when compared to the control. Sawinski et al. (2013), mentioned that bacteria cannot penetrate directly into the leaf epidermis so that endophyte colonization occurs through natural holes, such as stomata and hydathodes or through wounds. Stomatal pores are limited by two guard cells that regulate gas exchange and transpiration through changes in their openings in response to the environment, such as effective photosynthesis lighting, CO2 levels, water availability, and the stress hormone abscisic acid (ABA) (Sirichandra et al., 2009). Stomatal closure is one of the plant defense responses in the face of pathogen attack (Nejat & Mantri, 2017).

Effect of Sonic Bloom Treatment with Different Frequency on Physiological Characteristic. Based on statistical analysis, sonic bloom treatment showed a significant effect on stomatal opening, but not significant on chlorophyll index and stomatal conductance. Figure 3a shows that LF, MF, and HF are significantly different from NC and PC in the variable of stomatal opening. LF, MF, and HF were not significantly different and had mean values of stomatal opening of 6.55 µm, 7.18 µm, and 6.35 µm, respectively. This is in accordance with the principle of the ability of sound waves in sonic bloom to trigger stomatal opening by generating energy or vibration around the plant (Ai et al., 2021; Prasetyo & Wicaksono, 2019).

Chlorophyll functions as a catcher and converter of sunlight energy into chemical energy used by plants for photosynthesis (Melkozernov & Blankenship, 2006). Based on Figure 3b, sonic bloom treatment did not show a significantly different effect on chlorophyll index. This is contrary to the research of Hendrawan et al. (2020), which states that sonic bloom treatment can increase the photosynthesis process optimally, which also has an impact on increasing the amount of leaf chlorophyll.

Sonic bloom treatment did not show a significant effect on stomatal conductance (Figure 3c). Stomatal conductance is a representation of the number of stomata that open in response to the environment. The higher the stomatal conductance, the greater the number of open stomata. The greater number of open stomata implies an increase in CO_2 fixation so that the photosynthetic rate of plants will increase and growth will be higher (Nuraisah et al., 2019).

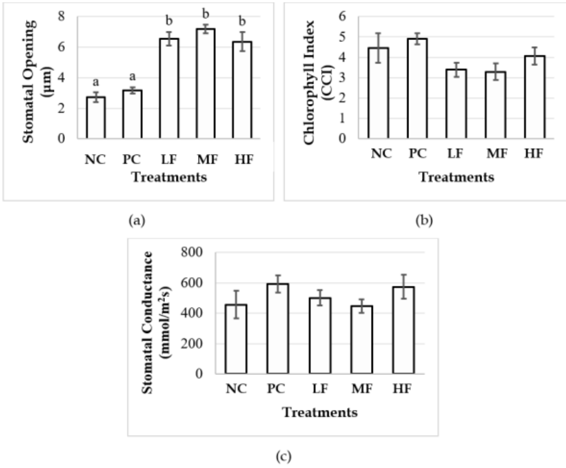

Figure 3. Effect of Sonic Bloom Treatment with Different Frequencies on the Physiological Characteristic (a) stomatal opening; (b) chlorophyll index; (c) stomatal conductance; NC, Negative Control; PC, Positive Control; LF, Low Frequency; MF, Medium Frequency; HF, High Frequency

Effect of Sonic Bloom Treatment with Different Frequency on Plant Growth. Based on statistical analysis, sonic bloom treatment showed a significant effect on plant height, number of leaves, and fresh weight. However, it did not show a significant effect on root length, leaf area, and number of tillers. Based on Figure 4a, further test analysis shows that MF and HF have lower mean values and are significant to both controls in the plant height variable, but LF does not show a significant value to both controls.

Based on Figure 4b, sonic bloom treatment does not show a significant effect on PC on the number of leaves variable, but it is significant for NC. NC has the highest mean value, which is 42.61. Similar to the fresh weight variable in Figure 4c, NC has the highest mean value, which is 16.46 g and significant with MF and HF. Han et al. (2008), stated that Xoo infects plants through natural openings such as hydathodes and/or injured plant parts, then colonizes the xylem. This causes blockage of the xylem and disruption of nutrient and water transport from the roots, resulting in suboptimal plant growth.

Roots are one of the important components in supporting the growth of rice plants that have a role in the absorption of water and nutrients (Sumadji & Purbasari, 2018). Based on Figure 4d, the analysis results show that the sonic bloom treatment does not show a significant effect on the root length variable. Similarly, the variables of leaf area and number of tillers can be seen in Figure 4e and 4f. Bhandawat & Jayaswall (2022), stated that plants are naturally sensitive to sound perception, but the response shown by plants is slow and much more subtle, unlike animals or humans who can express their response quickly.

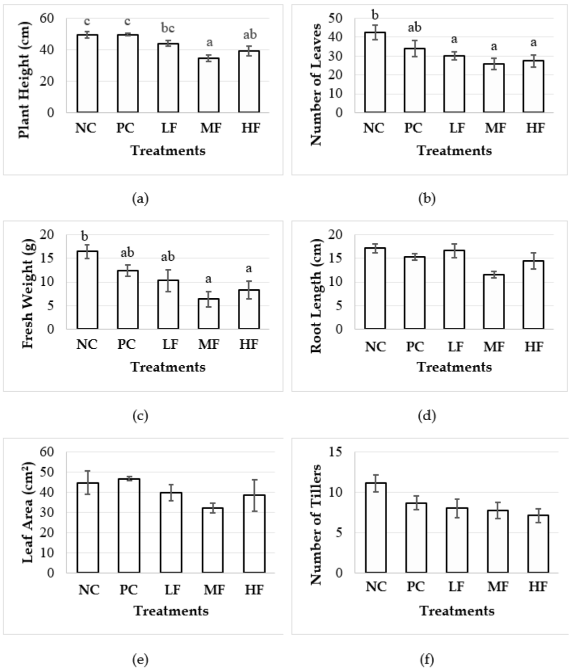

Figure 4. Effect of Sonic Bloom Treatment with Different Frequencies on Plant Growth (a) plant height; (b) number of leaves; (c) fresh weight; (d) root length; (e) leaf area; (f) number of tillers; NC, Negative Control; PC, Positive Control; LF, Low Frequency; MF, Medium Frequency; HF, High Frequency

Conclusion

Sonic bloom with frequency ranges of 0.5 - 1 kHz (LF), 3 - 5 kHz (MF), and 7 - 10 kHz (HF) has not shown potential in inducing rice resistance to BLB disease. Further experiments are needed to further examine the reasons for the inability of sonic bloom to induce rice resistance to BLB disease and explore the frequency range that has the potential to induce rice resistance to BLB disease.

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The application of Florpyrauxifen-benzyl 25 g/L, a new auxin synthetic herbicide, to control and inhibit the growth of water hyacinth weed (*Eichhornia crassipes* (Mart). Solms)

Abstract. Water hyacinth is an invasive species that spreads rapidly and causes several issues in aquatic habitats; therefore, efforts are required to eradicate weeds in aquatic ecosystems. Aquatic weed control in Indonesia using herbicide is very limited, so it can be an alternative for aquatic weed control management. This research goal was to examine the effectiveness of the herbicide with active agent Florpyrauxifen-benzyl 25 g/L in controlling and inhibiting the rapid growth of (*E. crassipes*). This research was carried out at the Ciparanje Greenhouse and Weed Science Laboratory, Faculty of Agriculture Universitas Padjadjaran, West Java, Indonesia, from August to October 2022. The experiment utilized a randomized block design (RBD) with eight treatments and four replications. The treatments consisted of herbicides with active ingredients Florpyrauxifen-benzyl 25 g/L doses of 5, 15, 25, 35, 45, herbicide 2,4-D DMA 825 g/L (1200), Penoxsulam 25 g/L (12.5) (g a.i/ha), and Control (Without Herbicide). According to the experiments, *E. crassipes* was effectively inhibited and controlled by the herbicide Florpyrauxifen-benzyl 25 g/L at a dose of 5 g a.i./ha. Florpyrauxifen-benzyl 25 g/L herbicide can inhibit relative growth rate, doubling time, number of leaves and clumps of *E. crassipes* up to 6 WAA.

Keywords: *Eichhornia crassipes* (Mart). Solms • Florpyrauxifen-benzyl 25g/L • Herbicide •Weeds

Aplikasi herbisida sintetik auksin baru, Florpyrauxifen-benzyl 25 g/L untuk mengendalikan dan menghambat pertumbuhan gulma air eceng gondok (*Eichhornia crassipes* (Mart). Solms)

Sari. Eceng gondok merupakan spesies invasif yang penyebarannya sangat cepat dan menimbulkan berbagai masalah di badan air, sehingga diperlukan usaha untuk mengendalikan gulma di ekosistem perairan. Pengendalian gulma air di Indonesia menggunakan herbisida sangat terbatas sehingga dapat menjadi alternatif untuk manajemen pengendalian gulma air. Penelitian ini memiliki tujuan untuk mengetahui efektivitas herbisida Florpyrauxifen-benzyl 25 g/L dalam mengendalikan dan menghambat pertumbuhan gulma air eceng gondok (*E. crassipes*). Percobaan ini dilakukan pada bulan Agustus 2022 hingga Oktober 2022 di Rumah Kaca Ciparanje dan Laboratorium Ilmu Gulma Fakultas Pertanian, Jawa Barat, Indonesia. Percobaan terdiri dari 8 perlakuan dan 4 ulangan menggunakan rancangan acak kelompok (RAK). Perlakuan terdiri dari herbisida berbahan aktif Florpyrauxifen-benzyl 25 g/L dosis 5, 15, 25, 35, 45, herbisida 2,4-D Dimetil Amina 825 g/L (dosis 1200), Penoxsulam 25 g/L (dosis 12,5) (g b.a/ha), dan Kontrol (Tanpa Herbisida). Hasil penelitian memperlihatkan bahwa herbisida sintetik auksin baru Florpyrauxifen-benzyl 25 g/L diawali dari dosis 5 g b.a/ha efektif mengendalikan gulma *Eichhornia crassipes* (Mart). Solm hingga 6 MSA. Herbisida Florpyrauxifen-benzyl 25 g/L dapat menghambat laju pertumbuhan relatif, doubling time, jumlah daun, dan jumlah rumpun gulma hingga 6 MSA.

Kata Kunci: *Eichhornia crassipes* (Mart). Solms) • Florpyrauxifen-benzyl 25 g/L • Gulma air • Herbisida

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Introduction

Water hyacinth (*Eichhornia crassipes* (Mart). Solms), is one species of aquatic weed which spreads widely, grows quickly, and is considered as an invasive species worldwide (Kurniadie et al., 2023). The rapid spread and ecological adaptability of the water hyacinth have detrimental effects on the environment, economy, and society (Sharma et al., 2016). Invasions of water hyacinth can result in water loss that is three times greater than in areas where water hyacinth is not covered (Osmond & Petroeschhevsky, 2013).

An overpopulation of water hyacinth in aquatic environments causes a variety of issues. Water hyacinth increases water loss in lakes and rivers, obstructs water transportation facilities, diminishes aesthetic value, causes blockage of waterways, prevents sunlight from reaching the water's body (Sasaqi et al., 2019; Ayanda et al., 2020).Water hyacinth can grow and develop in waters depending on environmental conditions such temperature, nutrients, light, pH, water salinity, waves, turbidity, and seasons (Wilson et al., 2005; Zarkami et al., 2021). In India, a single water hyacinth plant can double in size in just 14 days and cover a square meter in just 52 days (Gutiérrez et al., 2001). According to Sasaqi et al. (2019), In Rawapening Lake Indonesia, the water hyacinth's relative growth rate varied from 6.40 to 7.26% per day, and its doubling time (DT) ranged from 9.6 to 10.8 days.

Due to their negative effects on the ecosystem, invasive species water hyacinth must be controlled. There have been numerous attempts to control water hyacinth weeds, including mechanical control through manual weeding, biological control, and chemical control (Gettys et al., 2014). Chemical control using herbicide can be less affordable than mechanical control, but it must be suitable for humans and the environment (Mirzajani et al., 2022).

Aquatic weed control using herbicides has been widely used in numerous continents such as America and Australia. Glyphosate, 2,4-D, Diquat, Endothal, Fluridone, Penoxsulam, Imazamox, and Imazapyr are the most often used herbicides to control aquatic weeds (Villamagna and Murphy, 2010; Madsen and Kyser, 2020). Florpyrauxifen-benzyl is a new synthetic auxin herbicide that belongs to the arylicolinate family and works as a systemic post-emergence herbicide. This herbicide, which has a wide spectrum and quick absorption, is used to manage weeds in rice cultivation and aquatic ecosystems (Maienfisch and Mangelinckx, 2021).

Synthetic auxin herbicides imitate the natural plant hormone auxin, causing stems and petioles to curl and inhibiting plants growth (Grossmann, 2007). Synthetic auxin herbicides deregulate plant growth processes. Herbicide Flopyrauxifen-benzyl stimulated the abscisic acid (ABA) and ethylene precursor (ACC) (Gao et al., 2022). An increase in ABA concentration induces the stomata to close, which speeds up the death of cells by limiting the absorption of CO_2 and releasing reactive oxygen species (Grossmann, 2010).

Auxin synthetic herbicides attach to specific plant receptors, activating multiple deadly processes. Many auxin receptors in plants are referred to be the TIR1 and AFB protein (Lee et al., 2014). Florpyrauxifen-benzyl (FPB) binds to the nucleus of the cell with weak affinity to the TIR1 receptor and greater affinity to the AFB5 receptor, which makes it different from another auxin synthetic (2,4-D) (Maienfisch and Mangelinckx, 2021). The former auxin synthetic herbicide 2,4-D is selective against broadleaf weeds, and Florpyrauxifen-benzyl as a broad-spectrum herbicide can control weeds (grasses, broadleaves, and sedges) (Costa and Aschner, 2014; Maienfisch and Mangelinckx, 2021). Although many different molecules are classified as auxin herbicides, each molecule has unique herbicidal properties that are determined by many factors such as group family herbicide, efficacy, crop tolerance, dosage, persistence, and herbicide selectivity (Herrera et al., 2021).

Research on aquatic weed management in Indonesia is very limited. This research is needed to determine the optimum dosage of Florpyrauxifen-benzyl 25 g/L herbicide for controlling and decreasing the rapid growth of the invasive species *Eichhornia crassipes*.

Materials and Methods

Location, Materials, and Tools. The study was carried out at the Ciparanje Greenhouse and Weed Science Lab, Faculty of Agriculture, Universitas Padjadjaran. The research was conducted between August to October of 2022. The temperature and humidity ranged from 25.4 to 29^{0}C and 71 to 86% during the experiment.

The tools used in this experiment were a knapsack boom sprayer, flat fan nozzle, a bucket with a diameter of 72 cm x 24 cm high, an analytical balance, a measuring cup, thermometer and hygrometer, gauges, stationery, filters, plastic trays, and oven. The materials used in this study were water hyacinth propagules, water, herbicide Florpyrauxifen-benzyl 25 g/L, 2,4-D Dimethyl Amine 825 g/L, Penoxsulam 25 g/L, and foliar fertilizer (7.5% N, 2% P_2O_5, and 3% K_2O).

This study used a randomized block design (RBD) consisting of one factor, herbicide dosages with eight treatments and four replications. The treatments consisted of herbicides: Florpyrauxifen-benzyl (FPB) 25 g/L doses of 5, 15, 25, 35, 45 g.a.i/ha, herbicide 2.4-D DMA 825 g/L dose of 1200 g a.i/ha, Penoxsulam 25 g/L dose of 12.5 g a.i/ha, and control (without herbicide).

The weed propagules used originated from a holding pond located in Sukarapih Village, Sumedang District, West Java. Water hyacinth that used in this research has eight to ten leaves that each weighed between 25 and 35 grams. Weeds were transplanted into a plastic bucket with a diameter (72 cm) and height (24 cm) and filled with 55 liters of water. Before herbicide application, weeds were planted in plastic bucket tubs for three weeks as part of the adaptation process. Foliar fertilizer was equally distributed throughout the whole surface of the weed leaves before herbicide application.

Each plastic bucket contains 15 samples of the weed *E. crassipes*. Weeds were stored in a bucket of water for a total of eight treatments, which were repeated four times. Therefore, 480 weed propagules were utilized in the greenhouse experiment. A knapsack sprayer equipped with flat fan nozzles was used to apply herbicide three weeks after planting. The volume of water used is 400 liters per hectare at a pressure of 1 kilogram per square centimeter (15-20 p.s.i).

Weed observations included fresh weight, relative growth rate, doubling time, number of leaves, number of clumps, dried weight, and growth reduction of weed. According to Mitchell and Tur. (1975), the relative growth rate (RGR) is determined using the fresh weight value using the following formula:

$$RGR = \frac{(\ln MT_2 - \ln MT_1)}{T_2 - T_1}$$

Information:
RGR = Relative growth rate
MT_1= Biomass of weed at the first observation
MT_2= Biomass of weed at the end observation
T= Time observation (days)

When the fresh weight value of weeds doubles in comparison to the initial observation, it is known as the doubling time (DT). According to Mitchell and Tur. (1975), the formula for calculating doubling time using the formula below:

$$DT = \ln_2/RGR$$

Information:
$\ln_2$ = Natural logarithm
DT = Doubling time
RGR=Relative growth rate

The quantity of water hyacinth clumps is measured by counting the number of vegetative buds that sprout into new plants. The number of leaves on a weed hyacinth is measured by counting all the leaves that are still upright and above the water. Weed dry weight is achieved by destroying it and then drying it for 48 hours at 80°C to a constant dry weight. By comparing the dry weight value of the herbicide treatment with the control, it is possible to convert the dry weight value of weeds into the growth reduction percentage. Hilton (1957) calculated the growth reduction % using the formula below:

$$\%GR=1-(T/C) \times 100\%$$

Information:
%GR = Proportion of treatment inhibition.
T = Dry weight value of the weeds in herbicide treatments.
C = Dry weight of the weeds in control treatments.

This study's data processing was conducted using the ANOVA test and SASM Agri 8.1 software. If the treatment has a significant effect, the Scottt-Knott Advanced test at a significance level of α= 5% is used to examine the difference in mean values between treatments.

Results and Disccusion

Fresh Weight of *Eichhornia crassipes.* Weed fresh weight significantly decreased during the observation period from 0 WAA to 6 week after application (WAA). In contrast to the control treatment, there was an increase in weed biomass during the period of observation (Table 1). According to the results from statistical analysis, observations of the fresh weight of water hyacinth weeds at 6 WAA indicated that the application of the herbicide Florpyrauxifen-benzyl 25 g/L dose of 5 to 45 g a.i/ha, herbicide 2,4-D DMA 825 g/L, and penoxsulam 25 g/L gave significantly different values from the control treatment.

Table 1. Fresh weight of the weed *E. crassipes.*

Treatment (Herbicide)	Rate (g a.i/ha)	Fresh Weight (g)		
		0 WAA	4 WAA	6 WAA
FPB 25 g/L	5	33.31 a	7.13 c	0.00 d
FPB 25 g/L	15	32.90 b	5.53 d	0.00 d
FPB 25 g/L	25	33.66 a	57.00 e	0.00 d
FPB 25 g/L	35	33.98 a	4.13 f	0.00 d
FPB 25 g/L	45	33.75 a	4.09 f	0.00 d
2,4-D DMA 825 g/L	1200	33.59 a	5.44 d	6.74 c
Penoxsulam 25 g/L	12.5	32.24 b	23.72 b	15.88 b
Control	-	34.29 a	84.60 a	111.94a

Note: The average value following the identical letter is not significantly different, according to the Scott-Knott test, at the 5% significance level. FPB= Florpyrauxifen-benzyl

Herbicide Florpyrauxifen-benzyl 25 g/L dose of 5 – 45 g a.i./ha is effective in controlling water hyacinth weeds up to 6 WAA. This is defined by the absence of weed development or renewal, becaused the vegetative propagation through stolons process to stop. Genetic variability caused by rapid clonal reproduction and predominance of vegetative propagation characterize the spread of invasive water hyacinth species (Zhang et al., 2010).

The weed biomass increased as the number of leaves gradually increased in the control treatment, suggesting a rise in vegetative growth. The reduced plant fresh weight that follows herbicide application is caused by several things, including the weakening of the leaf stalks and the separation of the leaves from the weeds' bodies. Synthetic auxin herbicide that mimics the growth-regulating hormone indole-3-acetic acid. Auxin excess in sensitive plants shows as leaf epinasty, bending of the stem and petiole, curling of the leaf and stem leaf blades, and general mortality (Grossmann, 2010).

Relative Growth Rate and Doubling Time. In addition to determining plant biomass, relative growth rate can also be used to describe an aquatic plant's capacity to absorb nutrients. Table 2 shows observational data on the effect of herbicide application on the RGR and DT of *Eichhornia crassipes* from 0 to 6 WAA. RGR and DT values are determined from measurements on the fresh weight of weeds.

Table 2. RGR and DT of the weed *E. crassipes.*

Treatment (Herbicide)	Rate (g a.i/ha)	RGR (%/Day)	DT (Day)
FPB 25 g/L	5	~	~
FPB 25 g/L	15	~	~
FPB 25 g/L	25	~	~
FPB 25 g/L	35	~	~
FPB 25 g/L	45	~	~
2,4-D DMA 825 g/L	1200	~	~
Penoxsulam 25 g/L	12.5	~	~
Control	-	0.0282	24.60

Note ~ = There is no value of RGR and DT.
FPB= Florpyrauxifen-benzyl

The use of the herbicides Florpyrauxifen-benzyl 25 g/L at dose of 5 to 45 g a.i/ha, Penoxsulam 25 g/L, and 2,4-D DMA 825 g/L can reduce the RGR and DT of weed by up to 6 WAA. Due to a decrease in weed fresh weight values, which was shown by weed death at the end of the observation, weed RGR and doubling time values were not obtained in all herbicide treatments (Table 2). Water hyacinths have a high or low relative growth rate, depending on the season, the availability of nutrients, the density of the plants, sunlight, and environmental factors (Astuti and Indriatmoko, 2018).

The RGR value for water hyacinth in the control treatment was 0.02825%/day. The result for the doubling time in the control treatment (without herbicides) was 24.60 days. Comparing the *Eichhornia crassipes* plant to other varieties of aquatic weeds like *Salvinia* sp., *Lemma* sp., and *Spirodela* sp., it tends to have a low RGR value and a relatively long doubling time (Astuti and Indriatmoko, 2018). Rich nutrient supplies for plants can speed up relative growth and reduce the length of time between doublings. Water hyacinth weeds can multiply at a rate of 6.40 to 7.26% per day in conditions of high nutrient availability, which allows them to rapidly cover the entire water's surface (Prasetyo et al., 2021).

Number of *E. crassipes* Leaves. The results showed that the application of herbicide Florpyrauxifen-benzyl 25 g/L doses of 5 to 45 g a.i/ha could significantly affect the control treatment up to 6 WAA and could reduce the number of leaves of the weed *Eichhornia crassipes* (Table 3). The herbicide Florpyrauxifen-benzyl 25 g/L dose of 5 to 45 g a.i/ha showed significantly different values from the herbicides 2,4-D DMA 825 g/L dose of 1200 g a.i/ha and penoxsulam 25 g/L dose of 12.5 g a.i/ha at 6 WAA.

Table 3. Number of leaves of the weed *E. crassipes.*

Treatment (Herbicide)	Rate (g a.i/ha)	Number of Leaves		
		0 WAA	4 WAA	6 WAA
FPB 25 g/L	5	8.95 a	3.20 c	0.00 d
FPB 25 g/L	15	9.00 a	2.75 d	0.00 d
FPB 25 g/L	25	8.85 a	2.00 e	0.00 d
FPB 25 g/L	35	8.95 a	1.60 f	0.00 d
FPB 25 g/L	45	9.05 a	1.45 f	0.00 d
2,4-D DMA 825 g/L	1200	8.85 a	2.95 d	3.30 c
Penoxsulam 25 g/L	12.5	9.40 a	7.55 b	4.10 b
Control	-	9.20 a	20.15 a	23.00 a

Note: The average value following the identical letter is not significantly different, according to the Scott-Knott test, at the 5% significance level. FPB= Florpyrauxifen-benzyl.

After the application of the herbicides 2,4-D DMA 825 g/L and Penoxsulam 25 g/L, at 6 WAA observations showed that each weed clump was still producing leaves. The weed biomass increased as the number of leaves gradually increased in the control treatment, indicating an increase in vegetative growth. At high doses, the weed separates from the body, the petiole rots, and the leaf stalk collapses. The weed's body balance is thrown off by its uncontrolled growth. According to Chinnusamy et al. (2012), uncontrolled cell division and proliferation as well as turgidity changes are to blame.

Number of *E. crassipes* Clumps. The results showed that the use of the herbicide Florpyrauxifen-benzyl 25 g/L had a significant effect on the untreated treatment up to 6 WAA and could prevent the growth of *Eichhornia crassipes weeds* (Table 4). The mother plant's new plantlets (daughter plants) were unable to be spread by the herbicide. The herbicide Florpyrauxifen-benzyl 25 g/L dose of 5 to 45 g a.i/ha showed significantly different values from the herbicides 2,4-D DMA 825 g/L dose of 1200 g a.i/ha and penoxsulam 25 g/L dose of 12.5 g a.i/ha at 6 WAA. Compared to the control treatment, all herbicide treatments showed values that were significantly different.

The total number of weed clumps at 6 WAA increased in the control treatment. The mother plant's new plantlets generated more daughter plants, and this was accompanied by an increase in the rate of relative growth, fresh and dry weight, and leaf number.

Table 4. Number of clumps of the weed *E. crassipes.*

Treatment (Herbicide)	Rate (g a.i/ha)	Number of Clumps		
		2 WAA	4 WAA	6 WAA
FPB 25 g/L	5	1.00 b	1.00 c	0.00 d
FPB 25 g/L	15	1.00 b	1.00 c	0.00 d
FPB 25 g/L	25	1.00 b	1.00 c	0.00 d
FPB 25 g/L	35	1.00 b	1.00 c	0.00 d
FPB 25 g/L	45	1.00 b	1.00 c	0.00 d
2,4-D DMA 825 g/L	1200	1.00 b	1.50 b	1.75 b
Penoxsulam 25 g/L	12.5	1.00 b	1.00 c	1.00 c
Control	-	2.13 a	2.93 a	3.17 a

Note: The average value following the identical letter is not significantly different, according to the Scott-Knott test, at the 5% significance level. FPB= Florpyrauxifen-benzyl.

Weeds will maintain continually photosynthesis to sustain their lives in a steady environment. Environmental factors have a big impact on how water hyacinth weeds grow and develop in a body of water. Sunlight, nutrients, pH, salinity, manner of reproduction and dissemination, as well as other biotic variables, are significant elements influencing the growth of *Eichhornia crassipes* weed (Soedarsono et al., 2013). The optimum pH range for *Eichhornia crassipes* from 6.5 to 8.5 (Gaikwad and Gavande, 2017). If the pH is either above or below this range, water hyacinth growth will be inhibited. During the research, the pH of the water ranged from 6.92 to 7.52, which favoured the growth of water hyacinth weeds.

Weed Dry Weight of *Eichhornia crassipes.* Table 5 shows observational data and statistical analysis of the impact of herbicide application on the weed *Eichhornia crassipes*' average dry weight at 2 to 6 WAA. Water hyacinth weeds were successfully controlled by the herbicide Florpyrauxifen-benzyl (FPB) 25 g/L at a dose level of 5 to 45 g a.i/ha, according to data obtained at 2 to 6 WAA (Week After Application), as indicated by a gradual decrease in the average value of dry weight and significantly different values compared to the control treatment.

Table 5. Weed dry weight of *E. crassipes.*

Treatment (Herbicide)	Rate (g a.i/ha)	Weed Dry Weight (g)		
		2 WAA	4 WAA	6 WAA
FPB 25 g/L	5	2.21 c	0.43 c	0.00 d
FPB 25 g/L	15	1.90 d	0.28 c	0.00 d
FPB 25 g/L	25	1.83 d	0.24 c	0.00 d
FPB 25 g/L	35	1.72 e	0.19 c	0.00 d
FPB 25 g/L	45	1.59 e	0.15 c	0.00 d
2,4-D DMA 825 g/L	1200	1.91 d	0.29 c	0.35 c
Penoxsulam 25 g/L	12.5	2.68 b	2.47 b	1.79 b
Control	-	4.69 a	6.78 a	8.57 a

Note: The average value following the identical letter is not significantly different, according to the Scott-Knott test, at the 5% significance level. FPB= Florpyrauxifen-benzyl.

The herbicide 2,4-D DMA 825 g/L and herbicide Florpyrauxifen-benzyl 25 g/L at a dose of 15 g a.i/ha at 2 to 4 WAA had comparable dry weight values and no significant differences. The herbicide Florpyrauxifen-benzyl 25 g/L dose of 5 to 45 g a.i/ha showed significantly different values from the herbicides 2,4-D DMA 825 g/L dose of 1200 g a.i/ha and penoxsulam 25 g/L dose of 12.5 g a.i/ha at 6 WAA. The reduction in dry weight of *Eichhornia crassipes* was induced by the herbicide Florpyrauxifen-benzyl (FPB) ability to act as an IAA hormone imitator that functioned rapidly in association with an increased in weed metabolism. Uncontrolled gene expression is started by proteins that are involved in plant regulation (Parry et al., 2009; McCauley et al., 2020).

Susceptible weeds began to show leaf curling and rolling three days after the application of auxin synthetic herbicides. Chlorosis and necrosis of the leaf blade up to the petiole then occurred as a result. Rolling leaves can reduce the amount of leaf surface sunlight absorbed, and limiting total photosynthesis (Nio and Lenak, 2014). The growth of weeds not treated to herbicides will not be inhibited, and they will continue to actively perform photosynthesis. The control treatment revealed a gradual increase in weed biomass, followed by vegetative growth, an increase in leaf numbers, and the number clumps.

Leaf stalks from the weed *Eichhornia crassipes* become brittle and float on the surface of the water in response to herbicides, while other sections that have decayed down below the surface of the water deteriorate more quickly. Only in the control treatment did weeds remain standing and float above the water's surface (Figure 1).

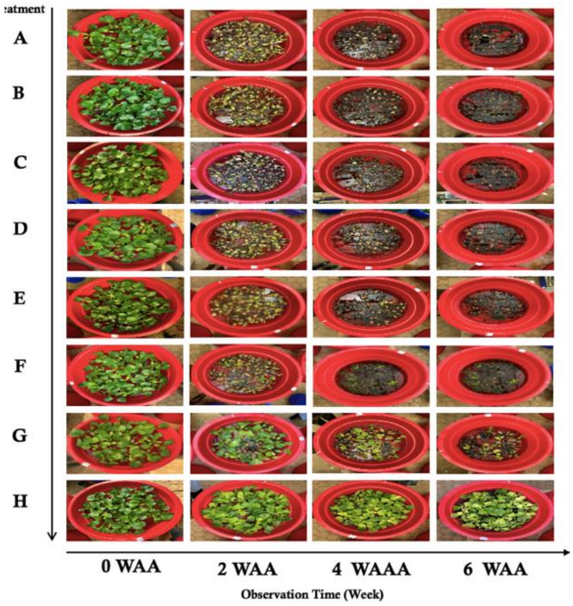

Fig 1. Effect of herbicides on *E. crassipes* weed damage symptoms: Herbicide treatments (g a.i/ha): A. FPB 5 g, B. FPB 15 g, C. FPB 25 g, D. FPB 35 g, E. FPB 45 g, F. 2,4-D DMA 1200 g, G. Penoxsulam 12.5 g, H. Control (without herbicide).

Growth Reduction Percentage (%). The herbicide Florpyrauxifen-benzyl 25 g/L is effective for controlling *Eichhornia crassipes* up to 6 WAA. This is shown by the dry weight value of 0.00 g (Table 5) at doses of 5 to 45 g a.i./ha, with a growth reduction of up to 100% of total weed mortality (Table 6).

Table 6. Growth reduction percentage of the weed *E. crassipes*

Treatment (Herbicide)	Rate (g a.i/ha)	Growth Reduction (%)		
		2 WAA	4 WAA	6 WAA
FPB 25 g/L	5	52.87 b	93.65 a	100.00 a
FPB 25 g/L	15	59.43 a	95.86 a	100.00 a
FPB 25 g/L	25	60.92 a	96.48 a	100.00 a
FPB 25 g/L	35	63.27 a	97.21 a	100.00 a
FPB 25 g/L	45	66.15 a	97.78 a	100.00 a
2,4-D DMA 825 g/L	1200	59.32 a	95.75 a	95.83 b
Penoxsulam 25 g/L	12.5	42.68 c	63.60 b	79.00 c
Control	-	0.00 d	0.00 c	0.00 d

Note: The average value following the identical letter is not significantly different, according to the Scott-Knott test, at the 5% significance level. FPB= Florpyrauxifen-benzyl.

The herbicide Florpyrauxifen-benzyl 25 g/L dose of 5 to 45 g a.i/ha showed significantly different values from the herbicides 2,4-D DMA 825 g/L dose of 1200 g a.i/ha and penoxsulam 25 g/L dose of 12.5 g a.i/ha at 6 WAA. All herbicide treatments showed significantly different values from the control treatment. The herbicide Florpyrauxifen benzyl 25 g/L at the dosage level of 5 to 45 g a.i/ha had the highest growth reduction percentage value up to 100% when compared to the herbicides 2,4-D DMA 825 g/L dose 1200 g a.i/ha up to 95.83% and Penoxsulam 25 g/L dose 12.5 g a.i/ha up to 79.00%.

At 6 WAA, all herbicide treatments resulted in growth reduction percentage ranging from 79.00% to 100%. According to Mudge et al. (2021), the herbicide Florpyrauxifen-benzyl at a dose level of 14.8 – 58.9 g a.i/ha can reduce the total biomass of *Eichhornia crassipes* weeds by 90 – 100% when compared to uncontrolled treatments. The effectiveness of the new synthetic auxin herbicide Florpyrauxifen-benzyl at a low dose is comparable to the previous herbicide at the maximum dose. So, this new active agent herbicide can be used at a lower dose for aquatic weed control, thereby reducing the environmental risk it poses.

Conclusion

Herbicide Florpyrauxifen-benzyl 25 g/L, start with a dose of 5 g a.i./ha, effectively controls *Eichhornia crassipes* with a growth reduction rate of 100 % up to 6 WAA. Water hyacinth can grow at a slower rate by decreasing their relative growth rate, doubling time, number of leaves and clumps when treated with the herbicide Florpyrauxifen-benzyl 25 g/L. The efficient use of herbicide Florpyrauxifen-benzyl 25 g/L can be an alternative method for controlling aquatic weeds in Indonesia.

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Liquid organic matter from banana peel improves morpho-physiological traits of coffee seedlings

Abstract. Due to its economic advantage, the Robusta coffee clones BP 308 and BP 939 are widely grown. Many factors affect coffee growth during the cultivation practice, especially in the availability of adequate nutrients at the nursery stages. Apart from inorganic fertilizer application, organic matter needs to be applied in the nursery stages to support plant growth, such as applying liquid organic matter (LOM) derived from banana peel waste. This study was conducted to find out how the LOM of banana peels affected the morphological and physiological responses of BP 308 and BP 939 clone Robusta coffee seedlings and what proper dosages of LOM were needed. The experiment was conducted at the Ciparanje Experimental Station, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor from January to April 2022. This experiment used a randomized block design method consisting of 10 treatments and 3 repetitions. The treatments tested included 1.5 g of NPK inorganic fertilizer; 10 $mL.L^{-1}.plant^{-1}$ LOM ; 20 $mL.L^{-1}.plant^{-1}$ LOM; 30 $mL. L^{-1}.plant^{-1}$ LOM and 40 $mL. L^{-1} .plant^{-1}$ LOM that was given to both clones, namely BP 308 and BP 939. The results of this experiment showed that there were differences in the effect of LOM between BP308 and BP939 on the morphological response such as an increase in plant height and leaf number, on the physiological response such as chlorophyll index and stomatal conductance at the 3 months after treatment (MAT). The BP939 was partly better in response to LOM of 10 $mL.L^{-1}.plant^{-1}$ on plant height, the BP308 was partly better in stomatal conductance.

Keywords: Banana peel waste · Clone BP 308 · Clone BP 939 · Robusta

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Introduction

One of Indonesia's top plantation commodity crops is coffee plants (*Coffea* sp.). It can significantly increase national economic income by providing income for farmers, producing industrial raw materials, and creating jobs (Simaremare, 2022). According to information from the Directorate General of Plantations (Ditjenbun, 2019), Indonesia produces about 700,000 tons of coffee annually, or about 9% of the world's total production. Indonesia is now the world's fourth-largest coffee producer, behind Brazil, Vietnam, and Colombia (Martauli, 2018). Raising domestic coffee's production and quality will make it more competitive in the global market (Akbar, 2019).

Arabica, Robusta, and Liberica are the three coffee varieties popular in Indonesia, according to Danarti (2007), Robusta and Arabica coffee are well-known for having a high economic worth (Wihartanto, 2017) with a production value of 70.14%. Robusta coffee predominates on Indonesian coffee plantations due to its advantages with environmental conditions such as resistance to disease, leaf rust, and high production (Martauli, 2018; Ditjenbun, 2019). According to the Coffee and Cocoa Research Center, some Robusta clones are popular to be cultivated by farmers due to their proper traits of well cultivated namely clones BP 42, BP 409, BP 939, BP 308, BP 534, and SA 23 (Hendro, 2012). Clones BP 939 and BP 308 has been suggested as superior clone.

The Robusta coffee, clone BP 308 reportedly has a growth potential of up to 10% better than the Robusta coffee clone BP 939 (Muliasari, 2019). While clone BP 939 has the lowest stomatal density and the highest yield or production potential of 1.4–1.9 tons. ha^{-1} and is vulnerable to parasitic nematodes (Kepmentan, 2017). However, both clones are valuable to grow in small-scale coffee plantations.

In the nursery stage, coffee seedlings are vulnerable to environmental conditions such as nutrient deficiency and drought. The application of organic matter at the nursery must be done to minimize the negative impact in such conditions.

Organic matter, such as waste of banana peel, can be used as liquid organic fertilizer. According to data from BPS (2013), total national banana production in 2012 reached 34.35% of total national fruit production, so the waste of banana peel will be abundant and properly utilized as an organic matter for plant growth. Banana peel contains potassium elements that are useful for improving physiological activities in plants, such as photosynthesis by modulating opening and closing stomata (Masdar, 2003; Amrutha et al., 2007; Hussein et al., 2019), and involvement in enzymatic systems, plant resistance, protein synthesis, and pH regulation (Amrutha et al., 2007).

The method how to use banana peel waste as a useful organic matter for plants is by producing LOM. Several studies showed the application of 40 mL of LOM increased the height of Arabica coffee seedlings 60 days after transplanting (Irawati 2019). Fadhlan's (2015) suggestion that 20 ml of LOM significantly increases plant height, root volume, root dry weight, and shoot dry weight among Robusta coffee seedlings clone BP 939. A significant effect of 50 mL LOM had also been shown by increasing in height, diameter, shoot fresh weight, root fresh weight, and root dry weight of oil palm seedlings (Anhar, 2021).

According to the previous studies above mentioned, the study on the development and physiological responses of Robusta coffee seedlings among various clones and various doses of LOM derived from banana peel waste is required.

Materials and Methods

Plant materials used were three-month-old seedlings of the Robusta coffee clones BP 308 and BP 939, Inceptisol, LOM derived from kepok banana peel waste, EM-4-brown sugar, and NPK fertilizer (16-16-16). Instrument used in present experiment were LOM-making container, analytical scales, 35 x 35 cm polybag, thermal imaging camera (Flir Inc. US), hygrometer, 50% net shade, and chlorophyll meter (Apoogee, UK).

Randomized Block Design was utilized as the experimental design. There were a total of 30 experimental units, with each group consisting of 10 treatments performed three times, so there were 60 research experimental units with 2 plants each. Significantly difference among the data were alalyzed by Duncan Multiple Range Test (DMRT). The 10 treatments in detail as follows:

A = Clone BP 308 + 1,5 g NPK
B = Clone BP 939 + 1,5 g NPK
C = Clone BP 308 + 10 $mL.L^{-1}.plant^{-1}$ LOM
D = Clone BP 939 +10 $mL.L^{-1}.plant^{-1}$ LOM
E = Clone BP 308 + 20 $mL.L^{-1}.plant^{-1}$ LOM
F = Clone BP 939 + 20 $mL.L^{-1}.plant^{-1}$ LOM
G= Clone BP 308 + 30 $mL.L^{-1}.plant^{-1}$ LOM
H= Clone BP 939 + 30 $mL.L^{-1}.plant^{-1}$ LOM
I = Clone BP 308 + 40 $mL.L^{-1}. plant^{-1}$ LOM
J = Clone BP 939 + 40 $mL.L^{-1}. plant^{-1}$ LOM

Measurements parameters: This study has two parameters: morphological parameters such as plant height, leaf number, and chlorophyll index, and physiological parameters such as leaf temperature and stomatal conductance. All parameters were measured three times at 1, 2, and 3 months after transplanting.

Plant height and leaf number were measured by calculating the increase in plant height and leaf number per month. The chlorophyll index was measured by inserting 2nd leaf from above into the cuvette of the chlorophyll meter then the value of the index was recorded. Stomatal conductance was measured by using a porometer (Decagon Device, US Inc.) at the 2nd leaf from above.

All data collected were subjected to analysis of variance and the continue with Duncan multiple range test (DMRT) in SPSS statistical software (IBM Inc.).

Results and Discussion

Generally, LOM banana peel treatment significantly affected plant height increase, leaf number increase, chlorophyll index, and stomatal conductance responses.

The response of plant height increment at the 1st and 2nd MAT was no significant difference among the treatment of doses and clones. At the 3 MAT, the application of 10 $mL.L^{-1}.plant^{-1}$ LOM was better in the plant height increase of D, compared to the G treatment of 30 $mL.L^{-1}.plant^{-1}$ LOM (Table 1). The LOM application tended no significant difference to inorganic fertilizer application i.e., NPK, which means the application of LOM potentially complementary or substitute for inorganic fertilizer at the seedling stage. It is well known that the nutrients of inorganic fertilizers are higher than those of organic fertilizers. The effect of LOM is to improve plant growth due to its micro and macronutrients (Mappanganro, 2018).

Table 1. Response of plant height increment at 1, 2, and 3 MAT among clones and LOA doses

Treatments	Plant Height Increase (cm)		
	1st MAT	2nd MAT	3rd MAT
A	3.3 a	5.7 a	10.1 ab
B	3.4 a	6.6 a	15.7 c
C	2.1 a	4.2 a	8.7 ab
D	3.4 a	4.8 a	10.6 b
E	2.2 a	4.4 a	7.8 ab
F	2.2 a	4.3 a	8.7 ab
G	4.7 a	3.1 a	5.4 a
H	2.8 a	10.6a	7.2 ab
I	3.2 a	5.5 a	9 ab
J	4.6 a	3.6 a	6.2 ab

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

A similar effect was well as in another growth parameter i.e., leaf number increase (Table 2.). At the 3 MAT clone, BP939 showed a significant difference in leaf number increase between two doses of LOM namely 10 and 20 $mL.L^{-1}.plant^{-1}$ or D and F treatment, others showed no significant difference except in B. Leaf number of plants is correlated to photosynthetic capacity where more increase leaf number has the possible increase in photosynthesis (Permatasari, 2014; Hu et al., 2021).

Table 2. Response of leaf number increment at 1, 2, and 3 MAT among clones and LOA doses

Treatments	Leaf Number Increase (sheet)		
	1st MAT	2nd MAT	3rd MAT
A	2.3 a	4.7 abc	6.7 ab
B	4.0 a	8.3 c	21 c
C	2.7 a	4.3 ab	9.3 b
D	1.7 a	1.3 a	2.3 a
E	1.7 a	3.3 ab	5.3 ab
F	4.3 a	5.3 bc	11 b
G	2 a	3.7 ab	6.3 ab
H	5.3 a	6.3 bc	11.7 b
I	2.7 a	4.3 ab	6.7 ab
J	2.3 a	4.7 abc	8.3 ab

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

The statistical analysis showed that treating LOM banana peel waste at 1 MAT significantly affected the chlorophyll index of clone BP 939 and clone BP 308. Treatment I was higher than C, D, and H treatments, but it was not significantly different from the others (Table 3). This result indicates that the application of LOM of banana peel waste has a positive effect on the chlorophyll index as well as inorganic fertilizers application result. According to Sakiroh (2020), clone BP 308 has a relatively high chlorophyll content. A high chlorophyll index indicates a higher photo-synthetic rate, which will positively affect shoot growth and development (Firdaus et al., 2021).

There are significant effects of LOA among the doses at 1 MAT, where J is higher in chlorophyll index compared to C, D, and H. However it does not differ with the application of inorganic fertilizer. These results indicate fast release of LOM at the first application. Chlorophyll index response among the LOM application at 2 and 3 MAT was no significant difference indicating all doses have a similar effect, however, it was significantly lower compared to inorganic fertilizer application except at 2 MAT of A and J treatment, LOM had a similar effect with A. These indicate that inorganic fertilizer was absorbed by plants slower than LOM i.e. up to 2-3 MAT. The Clone BP 939 had a higher response in absorption of inorganic fertilizer compared to BP 308 (Table 3.) Moreover, inorganic fertilizer is well known to contain higher nutrients e.g., NPK than that LOM. According to Permana (2015), applying N fertilizer affects the chlorophyll index. Marvelia et al. (2006) stated that N nutrients positively affect leaf chlorophyll. Leaves will be better able to absorb sunlight, this helps the process of photosynthesis. Chlorophyll can be formed through N nutrients that are available in plants.

Table 3. Response of chlorophyll index at 1, 2, and 3 MAT among clones and LOA doses

Treatments	Chlorophyll Index		
	1st MAT	2nd MAT	3rd MAT
A	23.1 bcd	32.1 b	58.7 b
B	23.8 bcd	49.9 c	71.4 b
C	13.9 ab	18.3 ab	26.9 a
D	18.4 abc	13.4 a	12.6 a
E	20.1 abcd	16.7 ab	17.7 a
F	25.9 cd	22.7 ab	15.2 a
G	21.8 abcd	19.4 ab	26.2 a
H	11.6 a	15.4 ab	18.7 a
I	30.5 d	21.5 ab	22.8 a
J	20.2 abcd	12.8 a	14.7 a

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

The results of statistical tests at 1 MAT and 2 MAT showed that all treatments did not significantly affect the value of stomatal conductance of Robusta coffee seedlings in both BP 939 and BP 308 clones (Table 4.). This is a positive response to the application of LOM due to it gives the same response as the application of inorganic fertilizers. According to Arista (2015), a stomatal opening will affect the value of stomatal conductance, meaning that the more open stomata, the higher the conductance value. This opening is influenced by several things, including carbon dioxide, humidity, temperature, wind, light, and leaf water potential (Lestari, 2006; Soleh et al., 2017, 2018).

Table 4. Response of Stomatal Conductance at 1, 2, and 3 MAT among Clones and LOM doses

Treatments	Stomatal Conductance (mmol H_2O $m^{-2}s^{-1}$)		
	1st MAT	2nd MAT	3rd MAT
A	12.1 a	18.6 a	109.6 ab
B	7.6 a	21.6 a	185.7 bcd
C	9.5 a	10.5 a	238.9 d
D	10.4 a	98.8 a	205.7 bcd
E	12.7 a	24.2 a	194.9 bcd
F	8.4 a	141.2 a	282.73 d
G	11.5 a	159.4 a	133 abc
H	11.9 a	57.5 a	233.1 cd
I	9.7 a	98.5 a	73.7 a
J	8.3 a	21.7 a	222.7 cd

*Values followed by the same letter within each row are not different at the 0.05 level of significance according to DMRT test.

At 3 MAT, the treatment of LOM had a significant effect on the stomatal conductance of clone BP 939 and clone BP 308. Treatments C and F were significantly different from treatments A, G, and I but not significantly different from the other treatments. At 3 MAT, the best results were obtained from the treatment of LOM with a dose of 10 mL.L-1.plant-1 (treatment C) for clone BP 308 and a dose of 20 mL.L- 1.plant-1 (treatment F) for clone BP 939 (Table 4.). This shows that applying LOM can positively affect the value of leaf stomatal conductance so that the magnitude is the same as applying inorganic fertilizers. This is due to the effect of LOM application that can modulate opening and closing stomata (Soleh et al., 2018; Hu et al., 2021). According to Jones (1991) & Wijaya (2008), potassium (K) is an essential macro element that plays a role in maintaining water availability in plants and cell turgor pressure as well as in opening and closing leaf stomata. Plants with sufficient potassium will find it easier to close the stomata and reduce transpiration than plants that lack K (Hu et al., 2013; Nugroho, 2015). Plants with sufficient K elements will increase the transcription of genes related to ethylene synthesis so that the ethylene formed will inhibit abscisic acid activity in stimulating stomatal closure so that the stomata close slowly (Benlloch-Gonzalez et al., 2010)

Conclusion

The application of LOM derived from banana peel has a positive effect on increasing morphological responses of Robusta coffee seedlings of clone BP 308 and clone BP 939 such as in plant height and leaf number, physiological responses, represented by chlorophyll index and stomatal conductance at the 3 months after treatment (MAT). The BP939 was partly better in response to LOM of 10 $mL.L^{-1}.plant^{-1}$ on plant height, the BP308 was partly better in stomatal conductance.

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Morphophysiological characteristics of upland rice plants with organic approach through reduced NPK fertilizer and wood vinegar application

Abstract. Unefficient use of synthetic fertilizer in upland rice production leads to the low productivity and tends to harm the environtment. An organic approach by using wood vinegar is promising to improve the fertilizer efficiency. The objective of this study was to determine the response of upland rice with the application of different wood vinegar and synthetic fertilizer N-P-K rates on morpho-physiological characters. A split plot design with the main plot of N-P-K fertilizer and a subplot of wood vinegar was applied with three replications. Growth and physiological character were observed. The data were analyzed by the F test, then proceed with the Duncan Multiple Range Test at p≤0.05. The results showed that a half and full recommended synthetic fertilizer rate of N-P-K had a similar result to gaining optimum morpho-physiological character of upland rice. Wood vinegar with a rate of 75 L ha^{-1} obtained the highest performance on morpho-physiological character of upland rice. An increasing application rate of wood vinegar improved the morpho-physiological character of upland rice at different rates of N-P-K synthetic fertilizers.

Keywords: Morpho-physiological characters · N-P-K fertilizers · Upland rice · Wood vinegar

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Introduction

Rice is one of the most important crops in the world, especially in Asia countries including Indonesia. Nutrient management is a key entry point to maintain physiological mechanisms in contributing to optimum plant growth and development. Three major essential plant nutrients, N-P-K as the primary macronutrients because of the large quantities taken up by plants from the soil relative to other essential nutrients (Nurmala et al., 2015). Deficiency in these nutrients inhibits plant growth and development. The elements of N-P-K play an important role in plant growth and physiological processes and yield as well (Liu et al., 2014).

Fertilization must be applied as the plant needs to maintain the ability of soil to provide nutrients and survival of microorganisms (Sabry, 2015). Meanwhile, the application of synthetic fertilizer of N-P-K inadequate crop demand (Wahyudin et al., 2017). Consequently, the supply of nutrients is often insufficient to meet crop demands and over rates. This condition hampers plant physiological processes to gain optimum growth. Therefore, there is a need to explore the efficient utilization of the available nutrient resources that lead to improved plant growth by a combination of synthetic fertilizers with potential organic matter.

Farmyard manure, crop residues, and composts for a short-term supply of nutrients and long-term build-up of soil organic matter are commonly used. But, the application of these organic matter does not affect making balancing with the application of synthetic fertilizer. Wang et al., (2016) mentioned that the application of organic materials can be used as an alternative to reducing the use of synthetic fertilizers and able to maintain environmental balance. Therefore, finding the potential organic matter to reduce the application of synthetic fertilizer and improve plant growth must be explored.

The environment friendliness and renewability resource by using biomass is considered through converted to liquid fuels such as wood vinegar by the thermochemical approaches to obtain high value-added products (Lu et al., 2019). Wood vinegar as a source of organic matter needs to explore. Wood vinegar increases the activity of antioxidant enzymes, guaiacol peroxidase, and ascorbate peroxidase accelerated amylase activity (Dissatian et al., 2018).

Therefore, it increases root activity, which promoted the seed germination and root growth (Lu et al., 2019; Robb & Joseph, 2019), and reduce insects attack and bacterial diseases (Rogelio, 2018), fungal diseases and improve both plant health and crop quality (Robb & Joseph, 2019). Rogelio (2018) mentioned that 1% dilution of wood vinegar improves the growth and yield of rice. Anotherr study revealed that using wood vinegar about 2 mL L^{-1} by foliar application improves crop yield, but as fungicide at a rate of equal parts vinegar to water is required (Robb & Joseph, 2019).

Wood vinegar application achieves rapid and uniform seed germination in upland rice (Dissatian et al., 2018) and generally improves seed germination (Robb and Joseph, 2019). Few studies were done to explore the capacity of wood vinegar on upland rice. Contribution of this study could be a benefit to improve the performance of upland rice in dryland areas especially in tropical countries by using natural resources and environmentally friendly and reduce the application of synthetic fertilizers. Wood vinegar has benefit to further utilization as a sustainable alternative to chemicals for plant growth regulation in agriculture (Lu et al., 2019) and no harm to any beneficial insects and reduce chemical pesticide (Robb & Joseph, 2019).

Therefore, this study needs to be conducted to find out the influence of wood vinegar and N-P-K fertilizer on plant growth and physiological characters of upland rice in dry land area and to investigate the low dosage application of synthetic fertilizers to support physiological process and plant growth.

Materials and Methods

Field site. The study was conducted during one planting season during the dry season in April-July 2017 at Experimental Farm, Klampok District, Banjarnegara Regency, Central Java, Indonesia, with a coordinate of latitude of 7°27′ N, longitude of 109° 28′ E and altitude of 85 m above sea levels). The rainfall intensity, relative humidity, and temperature were 80 mm, 75%, and 30 ^{0}C, respectively, on average during the study. The soil of the experimental site at 0-30 cm depth had a soil texture of sandy loam, pH (Potentiometry) of 6, organic matter content (Walkley and Black) of 5.17%, total nitrogen (N) (Kjeldahl) of 0.17%, available phosphorous (P) (Bray I) of 5.36 mg kg^{-1}, extractable potassium (K) (Bray I) of 145.41 mg kg^{-1} and Cation Exchange Capacity (*N* NH_4OAc pH 7.0) of 15.42 $cmol^{(+)}$ kg^{-1}.

Experimental materials and treatment. Upland rice seeds of Inpago Unsoed 1 variety, fertilizers i.e. urea, SP-36, KCl, and wood vinegar were applied. Split plot design with the main plot of rate of N-P-K fertilizer according to the recommended rate of 100 N, 100 P205 and 50 K2O kg ha-1 i.e. a half and full recommended rates and subplot of the rate of wood vinegar (WV) i.e. 0, 4.686, 9.375, 18.75, 37.50 and 75.00 L ha-1 were applied with three replication. At sowing time, the full rate of P2O5 and K2O and one-third rate of N were applied according to treatment. Two-third rate of N was applied at tillering and panicle initiation stages. Each plot size of 2.0 m x 4.0 m and distances 0.5 m between plots with 1.0 m between blocks were arranged.

Observed Variables. Observed variables viz. growth character, i.e. number of leaves, leaf area (cm^2), plant height (cm), number of tillers, shoot dry weight (g) and root dry weight (g), and physiological characters viz. proline content (µmol g^{-1}) (Bates et al., 1973), chlorophyll a and b (mg g^{-1}) (Yoshida et al., 1976) were observed at the end of the vegetative stage.

Statistical Analysis. The observed data were analyzed by the F test to find out the significance level of each treatment and its interaction on observed variables. If there were significant differences, then proceed with the Duncan Multiple Range Test (DMRT) at $p \leq 0.05$. Both analyses were applied using the statistical program CropStat 7.2 (IRRI, 2007).

Results and Discussion

Generally, applications of N-P-K fertilizer and wood vinegar in different rates have been shown the various effect on upland rice performance. A half rate of N-P-K fertilizers resulted in an equal to the full recommended rate on all morphological and physiological characters. But, the application of wood vinegar resulted mostly to improve the performance of upland rice.

Morphological Character. Rate of different N-P-K fertilizers gave no significant effect on all morphological characters of upland rice. Application N-P-K fertilizers of a half and full recommended rates was not significantly different on plant height, leaf area, the total number of tillers and, shoot and root dry weights in the range of 69.11-69.94 cm, 39.23-41.52 cm^2, 29.41-31.09 g, 22.40-22.56, and 3.79-6.06 g, respectively (Table 01.). The similar results indicated with an increase in the N-P-K fertilizer rate was not affect significantly to improve growth performance.

Wood vinegar with a rate of 75 L ha^{-1} with the highest value found in all growth characters of plant height, leaf area, the total number of tillers and, shoot and root dry weights. The increases of all components of growth were affected by the application of wood vinegar, with an increase on plant height with rate from 68 cm for no application (0 L ha^{-1}) to approximately 72 cm for the maximum application (75 L ha^{-1}). The similar results no application (0 L ha^{-1}) and a high rate (75 L ha^{-1}) of wood vinegar obtained on leaf area, the total number of tillers and, shoot and root dry weights i.e. 39 and 43 cm^2, 20 and 25, 25 and 38 g and, 3 and 4 g, respectively (Table 1).

Table 1. Plant growth characters of upland rice with application of N-P-K fertilizers and wood vinegar.

	Plant height (cm)	Number of leaf	Leaf area (cm^2)	Number of Tiller	Dry shoot weight (g)	Dry root weight (g)
N-P-K recommended (kg ha^{-1})						
50% rate	69.94	24.38	41.52	22.40	29.41	3.79
100% rate	69.11	24.31	39.23	22.56	31.09	4.06
WV (L ha^{-1})						
0	68.16 d	25.43	39.06 d	20.67 e	25.90 e	3.43 e
4.686	67.33 d	26.50	39.51 cd	20.67 e	27.27 d	3.62 d
9.375	69.03 c	23.97	39.60 c	21.60 d	28.47 c	3.80 c
18.75	69.40 c	23.60	39.74 c	22.73 c	30.13 b	3.88 c
37.50	70.42 b	22.20	40.88 b	23.70 b	30.77 b	4.20 b
75.00	72.80 a	24.37	43.46 a	25.50 a	38.96 a	4.63 a
CV (%)	3.18	13.03	2.91	5.76	8.29	5.91

Note: recommended rate of N-P-K was 100 N, 100 $P_2 0_5$ and 50 K_2O kg ha^{-1}, respectively, WV=wood vinegar, CV=coefficient variance. In the same column, the number followed by the same letter indicates no significant difference according to the DMRT at $p \leq 0.05$.

Table 2. Physiological characters of upland rice with application of N-P-K fertilizers and wood vinegar.

	Proline content (µMol g^{-1})	Chlorophyll content (mg g^{-1})	
		Ch a	Ch b
N-P-K recommended (kg ha^{-1})			
50%rate	14.05	3.65	1.53
100% rate	14.58	4.01	1.73
WV rate (L ha^{-1})			
0	12.41	3.65	1.39 c
4.686	14.78	3.94	1.48 c
9.375	12.97	3.35	1.34 c
18.75	10.07	3.76	1.52 c
37.50	10.53	3.88	1.87 b
75.00	13.43	4.40	2.25 a
CV (%)	23.00	10.90	11.44

Note: recommended rate of N-P-K was 100 N, 100 P_20_5 and 50 K_2O kg ha^{-1}, respectively, WV=wood vinegar, CV=coefficient variance. In the same column, the number followed by the same letter indicates no significant difference according to the DMRT at $p \leq 0.05$.

Generally, there were significant differences in all morphological characters between no application and application of wood vinegar. Thus, an increase in the rate of wood vinegar up to 75 L ha^{-1} rate gained the high performance of upland rice growth.

Physiological Character. The application of different N-P-K fertilizer rates gave no significant effect on all physiological components of upland rice. The results obtained in the treatment of a half and full recommended rates on proline content of 14.05-14.58 µMol g^{-1}, Meanwhile, chlorophyll a and chlorophyll b about 3.65-4.01 mg g^{-1} and 1.53-1.73 mg g^{-1}, respectively (Table 2). Addition rate of N-P-K fertilizer could not improve proline content, chlorophyll a and chlorophyll b. Therefore, the low rate of a half N-P-K fertilizer affected to obtain the optimal physiological performance.

The results indicated a strong relationship between wood vinegar and chlorophyll b content. The maximum rate (75.00 L ha^{-1}) showed the highest chlorophyll b content of 2.25 mg g^{-1}. The application of wood vinegar in rate 9.375-18.75 L ha^{-1} produced no significant effect on chlorophyll b content in the range 1.34-1.52 mg g^{-1} and no significantly different with no application (0 L ha^{-1}) about 1.39 mg g^{-1} (Table 2). Chlorophyll b content tended to increase with an increase in the wood vinegar rate. The contents of proline and chlorophyll-a were not significant due to the application of wood vinegar with a range of 10.07-14.78 µMol g^{-1} and 3.35-4.40 mg g^{-1}, respectively (Table 2).

Discussion

The application of a half N-P-K rate indicated similar to the full N-P-K rate on all morpho-physiological characters (Table 1, 2). This provides information that the soil condition used as a planting medium in this study was able to support plant growth performance due to the application of 50% and 100% recommended dose of N-P-K fertilizers were able to produce equal growth and physiological characters (Table 1, 2). The availability of nutrients for plants is important and it can be fulfilled by the application of synthetic fertilizer (N-P-K) and it will affect the physiology process of plants. The major element of N-P-K plays an important role to support the metabolism process in plants (Ebrahimi et al., 2012; Pavlovic et al., 2014; Haque & Haque, 2016). The results of this study were matched with the expectation that N-P-K fertilizer applications can be reduced to 50% of the recommended rate to support a more environmentally-friendly agricultural system. Excessive application of fertilizers causes soil degradation physically, chemically, and biologically so that it will adversely plant growth and development. Yousaf et al., (2017) mentioned that over-fertilization can create salt concentration by which directly impact on beneficial soil microorganism and insufficient root system to supply adequate water and nutrients to the plant.

In the present study, the high rate of N-P-K fertilizers (recommended rate) could not improve plant height, leaf area, number of tillers, dry shoot, and root weights (Table 1). Moreover, proline content as plant stress indicator unaffected by high (full N-P-K) and low (a half N-P-K) rates and contents of chlorophyll a and b as well (Table 2). Therefore, the application of a half N-P-K rate did not give an adverse effect on plant growth but the plant could absorb the low availability of nutrients to generate chlorophyll in supporting optimum plant growth. Tardieu (2013) mentioned that sufficient absorption of nutrients increases the rates of photosynthesis and carbohydrate formation by which support the growth of plant organs especially shoots, roots, and leaves so directly increase biomass fresh weight. Therefore, the efficiency of synthetic fertilizer of N-P-K rose to support plant growth and physiological process in upland rice. Thus, soil conditions with high C organic (5.17%) and pH at 6.0 gave a positive effect on plant performance due to improvements sufficient of nutrient uptake by plants. Soil pH and organic matter strongly affect soil functions and plant nutrient availability. Moreover, pH influences the solubility and availability of plant nutrients and organic matter decomposition (Adak et al., 2014).

Different response happened to physiological characters. Proline and chlorophyll a content had similar responses due to the application of wood vinegar. The proper response was gained on chlorophyll b content only at a different rate of wood vinegar (Table 2). Increased rate of wood vinegar improved the content of chlorophyll b. The wood vinegar showed an overall higher chlorophyll content compared to the no application of wood vinegar. The function of photosynthetic activity is monitored based on fluorescence and absorption of light re-emitted or released by plant leaves such as quantification of chlorophyll (Pavlovic et al., 2014). In this case revealed that chlorophyll b had higher response than chlorophyll a due to the higher content in plant leaves.

Wood vinegar had a strong relationship with plant growth characters. The maximum rate (75.00 L ha^{-1}) of wood vinegar exhibited the highest plant performance compared to other rates. An increasing rate of wood vinegar obtained greater plant height, leaf area, number of tillers, dry shoot, and root weights (Table 1). The increase in vegetative growth is followed by an increase in chlorophyll levels. Negi et al. (2017) stated that the formation and acceleration of plant growth in stimulating plant vegetative organs such as root and leaf growths due to the high content of chlorophyll.

An increase in the rate of wood vinegar and the rate of N-P-K fertilizers did not increase the number of leaves. This indicated the availability of wood vinegar improved N-P-K fertilizer efficiency. Increased efficiency in the use of N-P-K fertilizer is influenced by the presence of acetic acid in the wood vinegar. Wood vinegar contains some organic acids such as acetic acid (Mela et al., 2013). Acetic acid is a precursor from the auxin hormone and as well-known that auxin has some functions such as apical dominance and differentiation and root branching.

Currently, awareness of environmental safety is enhanced, which is globally acknowledged for reduced levels of chemical residues. The agricultural system through organic farming is a method to avoid or largely exclude the use of synthetic input such as fertilizers and instead relies on crop residue. Thus, accelerate to develop organic rice farming is important over and done with applying organic cultivation techniques. This study was revealed that the application of wood vinegar could improve morpho-physiological characters of upland rice. Therefore, the low rate of N-P-K fertilizers with the availability of wood vinegar had a chance to produce a suitable performance of upland rice and it could improve growth performance in other crops. However, the further exploration of both treatments still needs to carry out for resulting the deeply scientific information.

Conclusion

The applications of N-P-K fertilizers a half and full recommended rates had the same impact on morpho-physiological characters but it improved due to the application of wood vinegar at a rate of 5%. Reduction of 50% N-P-K fertilizers along with the increasing rate of wood vinegar improved morpho-physiological characters of upland rice. Due to different dose of N-P-K fertilizer was no effect on morpho-physiological characters. Therefore, the application of wood vinegar could reduce the synthetic fertilizer dose to improve upland rice in environmental friendly production.

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Response differences of two maize hybrid varieties to the application of bioagent-ameliorant and chicken manure in fertile soil

Abstract. To ensure adequate nutrition for the growth of maize (*Zea mays* L.) in sustainable agriculture, it is necessary to apply bio-agent soil conditioner and manure. This study aims to determine the effect of doses of bioagent-ameliorant and chicken manure on growth and yield components. The research was conducted in highland with an altitude 800 m above sea level. This study used an experimental method with two sets of experiments, namely experiments using one and two-cobs maize cultivars. The experiment used a randomized block design (RBD) with two treatment factors and three replications. The first treatment factor was the dose of bioagent ameliorant, which consisted of 3 levels, namely 0, 7.5, and 15 kg/ha, while the second factor was the dose of chicken manure, which consisted of 3 levels, namely 0.5 and 10 tons/ha. The observed growth components were plant height and number of leaves, while the yield components observed were cob length, cob diameter, cob weight per plant, and cob weight per plot. In research on two-cob maize experiment, there was no interaction effect between doses of soil conditioner and chicken manure, while the interaction effect on plant height occurred in one-cob maize experiment. The single effect of ameliorant doses could not increase all components of growth and yield, both in one and two-cob maize cultivars. The single effect of doses of chicken manure increased number of leaves, cob length, cob weight per plant, and cob weight per plot in one-cob maize cultivar, while increased plant height in two-cob maize cultivar.

Keywords: Fertilizer efficiency · Maize · Soil quality · Sustainable agriculture

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Introduction

Maize or corn (*Zea mays* L.) is one of the staple food crop in Indonesia. Consumption of corn kernels in Indonesia was 14.37 million tons in 2021, most of which are used for the food and feed industry, while production was 15.79 million tons (Catriana, 2021) to supply this corn consumption. However, sustainable corn production must be carried to supply further consumption (Suwarto & Prihantoro, 2020).

To guarantee sustainable maize production, plants must absorb sufficient nutrients from the soil through the application of fertilizers. Synthetic fertilizers are often used by farmers which decrease soil quality (Tale & Ingole, 2015). A way to restore soil quality is to provide ameliorant with biological agents, including compost, biochar, dolomite, and humic acid, which are added with the biological agent *Bacillus* sp. and *Pseudomonas* sp. (Li et al., 2020; Chaudhary et al., 2022; Wei et al., 2020).

Compost has been known through previous studies to improve soil structure and increase the availability of nutrients in the soil (Scotti et al., 2016). Biochar can increase cation exchange capacity (CEC) and soil moisture, thereby increasing fertilization efficiency (Agegnehu et al., 2017). Dolomite is a soil enhancer to increases soil pH, while humic acid can increase CEC and stimulate the activity of microorganisms that produce plant growth hormones (Shaaban et al., 2015; Ampong et al., 2022). Biological agent *Bacillus* sp. make nitrogen fixation from the air to other forms of nitrogen so it can be absorbed by plants (Yousuf et al., 2017). On the other hand, *Pseudomonas* sp. can convert phosphorus into an available form that can be absorbed by plants (Liu et al., 2019).

The effectiveness of existing biological agents in soil ameliorant can be increased through the application of manure, such as chicken manure. Manure is known to increase the organic matter content needed for the growth and development of beneficial microbes in ameliorant (Liu et al., 2013; Singh et al., 2020). In addition, manure can also increase soil fertility, increase CEC and improve soil structure (Singh et al., 2020).

Research on the application of bioagent-ameliorant and chicken manure needs to be carried out to maintain or increase maize production in a sustainable agriculture. Research needs to be conducted on two hybrid corn cultivars that are widely cultivated in Indonesia, namely one and two-cob corn cultivars (Subagio & Aqil, 2013).

Materials and Methods

The research was conducted in Margahurip Village, Banjaran District, Bandung Regency, West Java Province. The altitude of the study site is ±800 m above sea level, the average rainfall is 2,598.4 mm/year and it is included in the C3 agro-climatological zone based on the Oldeman climate classification. The research site has soil with a pH of 6.8 (neutral), 2.07% C-organic content (moderate), 0.18% N (moderate), C/N ratio 11 (low), available P_2O_5 53.2 ppm (very high), Ca 11.23 me/100 g (high), Mg 2.59 me/100 g (high), K 0.33 me/100 g (moderate), Na 0.23 me/100 g (low), CEC 18.02 me/100 g (moderate) and base saturation (BS) 80% (high). The experiment was carried out from August to November 2022.

The materials used in this study were one-cob maize cultivar (cv. NK 7328 Sumo), two-cob maize cultivar (cv. Bisi-2), ameliorant (consisted of 40% compost, 20% biochar, 20% dolomite, 5% humic acid, 3% bacteria *Bacillus* sp. and *Pseudomonas* sp. and 12% other ingredients), chicken manure (contains C-organic 17.56%, C/N ratio 13.6, N 1.29%, P_2O_5 1 .27%, K2O 3.99% and moisture 6.41%), urea fertilizer, NPK 15:15:15 fertilizer, emamectin benzoate and Iufenuron insecticides, Dimetomorphic fungicides, Difenoconazole fungicides, and atrazine and mesotrion herbicides. The tools used are tape measure, calipers, digital scales, and cultivation equipment.

This study used experimental method with two sets of experiments, namely experiments using one and two-cobs maize cultivars. The experiment used a randomized block design (RBD) with two treatment factors and three replications. The first treatment factor was the dose of bioagent-ameliorant, which consisted of 3 levels, namely 0, 7.5, and 15 kg/ha, while the second factor was the dose of chicken manure, which consisted of 3 levels, namely 0, 5, and 10 tons/ha.

The plot size was 160 cm x 500 cm and the number of plots was 27. Plants were planted with a spacing of 20 cm x 80 cm, so that there is a population of 50 plants for each plot. Samples used 8 plants for each plot. The distance between plots was 30 cm and the distance between replications was 50 cm.

Observations were made on the growth and yield components. Growth components were plant height and number of leaves, while the yield components observed were cob length, cob diameter, cob weight per plant and cob weight per plot. Plant height was measured from the base of the stem to the tip of the leaf using a tape measure at 49 days after sowing (DAS). The number of leaves was counted at the age of 49 DAS. Cob length, cob diameter, cob weight per plant and cob weight per plot were measured after the cobs were dried. The length of the cob was measured using a tape measure, while the diameter of the cob was measured using a caliper. Cob weight per plant and cob weight per plot were measured using digital scale.

Statistical analysis was performed using ANOVA at 5% significance level to determine whether there were factors that made a difference. Furthermore, data analysis was performed using Duncan's multiple range test at 5% significance level to determine the difference between treatment levels (Gaspersz, 1995).

Land preparation begins with clearing the land using herbicides, then plowing. Chicken manure was given a week before planting, while bioagent-ameliorant was given 3 days before planting. Ameliorant was given according to the treatment dose, previously dissolved in 1 liter of water and stirred until it looks homogeneous. A maize seed was planted in a planting hole with a depth of 3-5 cm. Watering was done when there was no rain. Weeding and hilling were carried out at 15, 29, and 43 DAS. Urea fertilizer 200 kg/ha and NPK fertilizer 300 kg/ha were applied at 21 hst and 40 hst. Control of pests and diseases used insecticides and fungicides. Corn harvest was done at 105 DAS by hand picking, then removing the corn husks and silk and drying to 14% seed moisture content.

Results and Discussion

Results. In the study of two-cob maize cultivars, there was no interaction effect between the dose of soil conditioner and the dose of chicken manure, both on the growth and yield components of the plant. The single effect of soil ameliorant doses could not increase all growth and yield components, while the single effect of chicken manure doses increased plant height at doses of 5 and 10 tons/ha, but could not increase the number of leaves and all yield components (Table 1 and 2).

Table 1. The single effect of ameliorant and chicken manure doses on the growth components of two-cobs corn

Treatment	Plant Height (cm)	Number of Leaves
Ameliorant dose		
0 kg/Ha	155.58 a	12.06 a
7.5 kgs/Ha	154.53 a	12.08 a
15 kgs/Ha	156.75 a	12.22 a
Chicken manure dose		
0 Ton/Ha	150.81 a	12.31 a
5 Tons/Ha	155.78 b	12.06 a
10 Tons/Ha	160.28 c	12.00 a

Note: The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

Table 2. The single effect of ameliorant and chicken manure doses on the yield components of two-cobs corn

Treatment	L (cm)	D (cm)	W/p (g)	W/u (g)
Ameliorant dose				
0 kg/Ha	18.00 a	3.84 a	279.97 a	13.42 a
7.5 kgs/Ha	18.11 a	3.82 a	282.25 a	13.72 a
15 kgs/Ha	18.22 a	3.85 a	283.39 a	13.83 a
Chicken manure dose				
0 Ton/Ha	17.88 a	3.85 ab	290.42 a	13.37 a
5 Tons/Ha	18.13 a	3.77 a	277.31 a	13.56 a
10 Tons/Ha	18.33 a	3.88 b	277.89 a	14.06 a

Note: L was cob length, D was cob diameter, W/p was cob weight per plant, W/u was cob weight per plot. The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

In a study of one-cob maize cultivars, an interaction effect was found between the dose of ameliorant and the dose of chicken manure on plant height (Table 3). Increasing the dose of ameliorant up to 15 kg/ha without manure increased plant height, but increasing the dose of ameliorant on plots with manure of 5 and 10 tons/ha gave the same height. The single effect of ameliorant did not improve the number of leaves or all yield components. The single effect of chicken manure increased the number of leaves, cob length, cob weight per plant and cob

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weight per plot (Table 4 and 5). The best dose of chicken manure for number of leaves was 10 tons/ha, but not different from 5 tons/ha, while the best dose of chicken manure for cob length, cob weight per plant and cob weight per plot was 10 tons/ha.

Table 3. The single effect of ameliorant and chicken manure doses on the plant height of one-cob corn

Chicken manure dose	Ameliorant dose		
	0 kg/ha	7.5 kgs/ha	15 kgs/ha
0 ton/ha	106.67 a A	122.92 a B	122.08 a B
5 tons/ha	125.83 b A	122.50 a A	124.17 a A
10 tons/ha	128.75 b A	127.92 a A	129.58 a A

Note: The average number marked with the same capital letter (horizontal direction) or lowercase letter (vertical direction) was not different according to Duncan's Multiple Range Test at 5% significance level.

Table 4. The single effect of ameliorant and chicken manure doses on number of leaves of one-cob corn

Treatment	Number of Leaves
Ameliorant dose	
0 kg/Ha	12.83 a
7.5 kgs/Ha	13.03 a
15 kgs/Ha	13.22 a
Chicken manure dose	
0 Ton/Ha	12.53 a
5 Tons/Ha	13.11 b
10 Tons/Ha	13.44 b

Note: The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

Discussion. There was no interaction effect between bioagent-ameliorant and manure on most of the observations because the ameliorant could not increase growth or yield. This can also be seen in the single effect of ameliorant which did not make a difference in plant growth or yield. This situation was due to the fertile soil at the research site, where the criteria were neutral pH, moderate CEC, high BS, moderate organic-C content, moderate N content, very high available P content, moderate K content and high Ca and Mg content (Soil Research Institute, 2009).

Table 5. The single effect of ameliorant and chicken manure doses on the yield components of one-cob corn

Treatment	L (cm)	D (cm)	W/p (g)	W/u (g)
Ameliorant dose				
0 kg/Ha	19.36 a	5.01 a	285.78 a	13.94 a
7.5 kgs/Ha	19.22 a	5.08 a	291.53 a	14.12 a
15 kgs/Ha	19.53 a	5.05 a	286.31 a	14.28 a
Chicken manure dose				
0 Ton/Ha	19.11 a	4.98 a	278.67 a	13.79 a
5 Tons/Ha	19.22 a	5.05 a	285.19 ab	14.17 ab
10 Tons/Ha	19.69 b	5.11 a	299.75 b	14.39 b

Note: L was cob length, D was cob diameter, W/p was cob weight per plant, W/u was cob weight per plot. The average number marked with the same letter in the same column was not different according to Duncan's Multiple Range Test at 5% significance level.

Dolomite in ameliorant could not significantly increase soil pH which has neutral criteria (Rastija et al., 2014). Dolomite containing Ca and Mg also had no effect, because the soil contains high Ca and Mg, so it cannot play a role as it does where the content of Ca and Mg is low (Higgins et al., 2012; Soratto & Crusciol, 2008). Compost and biochar which function to increase CEC also have no effect on good soil CEC (Mautuka et al., 2022). Nitrogenase on *Bacillus* sp. did not make nitrogen fixation in quite high soil N content (Ayuni et al., 2015). Bacteria *Pseudomonas* sp. which functions to provide the available form of P did not work in very high available P content (Zabihi et al., 2011).

In contrast to most of the observations, there was an interaction effect that occurs between ameliorant and manure on plant height. Manure only enhanced plant growth when there was no application of ameliorant. This can happened because manure has same effects as bioagent-ameliorant, such as improving soil structure, increasing soil CEC, increasing soil fertility, and improving the environment for the growth of microorganisms (Singh et al., 2020).

Chicken manure could significantly increase several components of growth and yield of maize. This could occur due to improvements in soil structure, addition of soil CEC, increasing soil fertility, and additional nutrients for microorganism due to manure application (Bayu et al., 2005). On the other hand, the increase in growth and yield of maize due to the application of chicken manure occurred more in one-cob maize than with two-cobs. This situation is interesting, but further studies are needed to discuss it. Unfortunately, the interaction that occurs between two treatments on plant height of one-cob maize may be revealed if it supported by data on nutrient uptake. Besides, this experiment proved that fertile soils does not need any treatment to maintain its quality.

Conclusion

In the two-cobs maize cultivar, there was no interaction effect between the dose of ameliorant and chicken manure on growth and yield components, while the interaction effect between the dose of ameliorant and chicken manure on plant height occurred in the one-cobs maize cultivar. The single effect of soil conditioner doses could not increase all growth components and yield components, both in research on two and one cob maize cultivars, except number of leaves in one-cob cultivar. The single effect of chicken manure dose increased plant height in two-cobs maize cultivar, while increasing the number of leaves, cob length, cob weight per plant and cob weight per plot in one-cob cultivar.

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Interactive effects of NPK fertilizer and paclobutrazol concentration on growth and yield of hanjeli (*Coix lacryma*-jobi L.)

Abstract The balance between growth and crop yield can be manipulated by exploiting nutrient and retardant interactions. This study is aiming to assess the effects of various combinations of NPK 16-16-16 fertilizer in different doses, along with the application of multiple concentrations of paclobutrazol on the growth and yield of hanjeli. This experiment was carried out in the experimental field of Ciparanje, Faculty of Agriculture Universitas Padjadjaran, Jatinangor, Sumedang from February 2021 to August 2021. This research was conducted in a split-plot design with three replications. The main plot consisted of 200 kg/ha (n_1), 250 kg/ha (n_2), and 300 kg/ha (n_3). The subplot consisted of 2000 ppm (p1), 3000 (p2), and 4000 ppm (p3). The results show that there were interaction effects between different doses of NPK fertilizer and paclobutrazol concentrations on plant height and 100-grain weight. The best combination came from the application of 200 kg/ha NPK fertilizer with 3000 ppm of paclobutrazol, which gave higher results in plant height and 200 kg/ha NPK fertilizer with 2000 ppm of paclobutrazol on 100-grain weight.

Keywords: Doses · Hanjeli · Nutrients · Paclobutrazol · Retardant

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Introduction

Hanjeli is a food crop that has potential to support the food diversification program. According to previous study by Qosim & Nurmala (2011) the chemical component of hanjeli is comprised of 71.81% carbs, 10.89% protein, 1.38% ash, and 5.18% lipid. This shows hanjeli may be used as a substitute food crop. However, the yield potential of hanjeli needs to improve. One of the constraints is the harvest time for hanjeli is classified as long, due to it being a perennial plant.

Fertilization is one of many important ways for improving growth and yield of hanjeli crop. Ramadhan et al. (2022) stated that NPK Mutiara 16-16-16 fertilizer contains optimal and balanced amounts of nitrogen (N), phosphorus (P) and Potassium (K) nutrients and contains additional nutrients in the form of Ca and Mg for increasing the growth of the plant. N is known for its effectiveness in helping plants grow quickly, it also accelerates the seed as well as fruit production (Gojon, 2017). Phosphorus is a major player when it comes to photosynthesis and has great significance helping plant grow (Lovio-Fragoso et al., 2021). K helps greatly in photosynthesis, improving the quality of fruits, protein building, and disease reduction (Hasanuzzaman et al., 2018).

In contrast to fertilization, paclobutrazol may reduce shoot growth while increasing root-shoot ratios. The application of Paclobutrazol improved stem diameter, modified root architecture, decreased plant height, and contributed to enhanced yield (Syahputra et al., 2016; Pal et al., 2016). Application of paclobutrazol on crops modifies hormonal balance and growth, leading to increased yield. Paclobutrazol can inhibit cell elongation and stem internode elongation by inhibiting gibberellin biosynthesis, causing a decrease in the rate of cell division (Desta & Amare, 2021). In addition to providing an inhibitory effect on stems, application of paclobutrazol can also shorten harvest time and increase grain yields. This is because paclobutrazol can decrease the rate of cell release which results in the plant resting the growing point and diverting photosynthetic results in the generative phase to fill the pods and seeds so that the harvest time is shortened (Zulfaniah et al., 2020).

The combination of NPK fertilizer with paclobutrazol is expected to be a cultivation technique that can increase yield of hanjeli. Aldini et al., (2022) showed that different NPK fertilizer doses and paclobutrazol could increase growth and yield in tomato plants. However, there is no information regarding the interaction of the application of NPK fertilizer and concentration of paclobutrazol in hanjeli plants. In this research, we employed NPK fertilizer (16-16-16) in different doses and concentrations of paclobutrazol (*Coix lacryma-jobi* L.) thus providing a theoretical basis for efficient fertilizer and retardant application.

Materials and Methods

This research was conducted from February to August 2021 at the Experimental Field of the Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency, West Java. The altitude of the research location was 737 m above sea level. The soil order in growing location was Inceptisols with the climate type of C3 according to Oldeman's classification. Rainfall intensity during the study period was 118 mm (February), 490 mm (March), 44.5 mm (April), 120.5 mm (Mei), 85.5 mm (June), 16 mm (July) and 10 mm (August). The characteristic of soil media used in present experiment was pH 5.96 (slightly acidic soil), C-organic 01.7% (very low), N total 0.12% (low), C/N 7.08 (moderate), P_2O_5 total 60.65 mg/100 g (very high), available P_2O_5 10.70 ppm (moderate), K_2O 11.60 mg/100 g (low), and cation exchange capacity 22.51 me 100 g^{-1} (moderate).

The tools that were used for this research included a meter gauge, analytical scale with 0.01 gram accuracy, and a camera. The materials that were used included the seeds of hanjeli var. ma-yuen, NPK 16–16–16 fertilizer, plant growth regulator of paclobutrazol, and Profenofos insecticide.

This research was done using an experimental method, i.e., Split Plot Design, with doses of NPK fertilizer as the first factor and paclobutrazol as the second ones. The first factor consisted of 3 levels, 200 kg/ha (n_1), 250 kg/ha (n_2), and 300 kg/ha (n_3), while the second factor consisted of 3 levels, 2000 ppm (p_1), 3000 (p_2), and 4000 ppm (p_3). All treatments were repeated three times, so there were 27 plots. Each plot was 5.1 m^2 that consisted of 18 plants.

Land preparation involved of weed removal, plowing, and plots making. The plots were 3 m width and 1.7 m length. The distance between plots was 0.3 m, while replication distance was 1 m. Plant spacing was 60 cm x 50 cm. Experimental plots were fertilized with manure at a dose of 2 tons/ha a week before planting. Healthy and well sprouted hanjeli were planted in a hole with 3 cm depth and covered by soil. The application of NPK according to treatment was given gradually over three times at 3 week after sowing (WAS), 8 WAS and 13 WAS by side dressing. Paclobutrazol treatment was applied to the plant gradually over two times at 13 WAS (early flowering stage) and 15 WAS (14 days after the flowers appeared). Plant cultivation included watering, weeding, pest and disease control. Plants received water via surface irrigation. Weeds was removed by mechanical weeding. Pest was controlled by spraying insecticide, while black mildew was managed by fungicide. Hanjeli are harvested 165 days after sowing (DAS), or when the seed reaches physiological maturity. Dry and yellowish leaves on the plant physically suggested that seeds were ready to be harvested.

Four hanjeli plants were selected to measure growth and yield attributes consisting of plant height, leaf area, number of productive tillers, root-shoot ratio, 100-grain weight, and grain weight per plot. Plant height was measured from the level of ground surface to the tip of the main stem using roll meter at 90% flowering before harvest and the mean values were computed for further analysis. Leaf area was calculated using the regression equation method for hanjeli y = 0.277 +0.683 (widht x length), (R2 = 94.5%) at vegetative stage. Similarly, number of productive tillers was recorded by counting the tillers that produce flowers at 18 WAS (reproductive stage). Root-shoot ratio obtained by comparing the dry weight of shoot with the dry weight of root plant after harvest. 100-grain weight and grain weight per plot were measured after harvest using an analytical scale at 14% moisture content.

Data collected were subjected to analysis of variance (ANOVA) procedure for a Split Plot design and where treatment means were significant, they were separated using Duncan's test at 5% level of probability using SmartstatXL statistical software.

Results and Discussion

Plant height. The ANOVA result in Figure 1 showed that the NPK fertilizer and paclobutrazol concentration interaction is significant for plant height. The combination of NPK fertilizer doses of 200 kg ha^{-1} and concentration of paclobutrazol 3000 ppm was considered as the lowest plant height, 202.08 cm, but is not the best combination because it produced a low yield component (Figure 4). The combination of NPK fertilizer doses of 200 kg ha^{-1} with concentration of paclobutrazol 2000 ppm is considered to be the best treatment on the character of plant height, which classified as a desirable low height and produced a fairly high yield of 100-grain weight.

This is due to the role of NPK fertilizer on plant height. An increased nitrogen dose may have delayed the crop's reproductive phase by lengthening the vegetative phase (Gul et al., 2015). Then, phosphorus and potassium application promote the formation of new cells, increases plant vigor and accelerates leaf development (Sankadiya & Sanodiya, 2021). Therefore, in this study, the function of paclobutrazol in terms of inhibiting plant growth is thought to be limited by the role of these nutrients, so that the decrease in plant height growth is also very dependent on the number of doses of NPK fertilizer given.

Leaf area Leaf area is an important indicator reflecting the growth status of plant. Based on the result of the statistical data analysis in Table 1, showed that there was no interaction between the doses of NPK fertilizer and the concentrations of paclobutrazol on leaf area. Single effect of NPK fertilizer and paclobutrazol concentration did not affect the leaf area of hanjeli. The range of total leaf area from the single effect of NPK doses was 145.28-148.87 cm^2, while the range of total leaf area from the single effect of paclobutrazol application was 145.78-148.39 cm^2.

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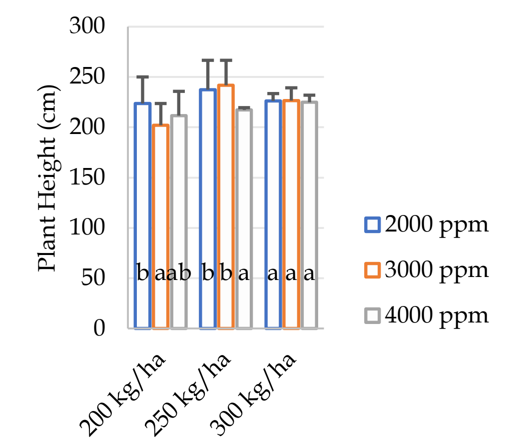
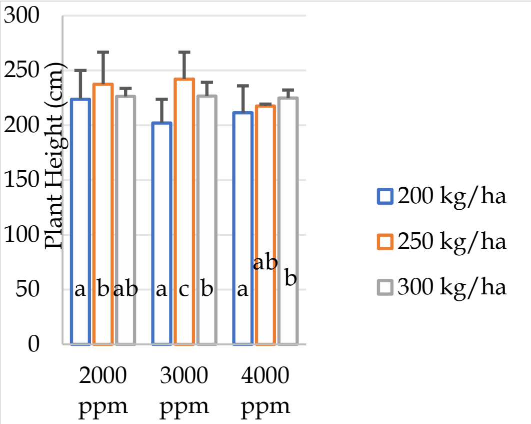
Table 1. Effects of NPK fertilizer doses and paclobutrazol concentrations on the leaf area and number of productive tillers of Hanjeli

Treatment	Leaf area (cm^2)	Number of productive tillers
n_1: NPK 200 kg/ha	148.87	6.47
n_2: NPK 250 kg/ha	145.28	7.50
n_3: NPK 300 kg/ha	146.21	7.81
p_1: Paclobutrazol 2000 ppm	145.78	7.11
p_2: Paclobutrazol 3000 ppm	148.39	7.44
p_3: Paclobutrazol 4000 ppm	146.18	7.22

Note: The mean value is not significantly different according to ANOVA test.



a. NPK fertilizer dose x paclobutrazol concentrations



b. Paclobutrazol concentration x NPK fertilizer dose

Figure 1. Interaction effect of NPK fertilizer dose and paclobutrazol concentration on plant height

Note: Plant height affected by NPK fertilizer dose and paclobutrazol concentration (a) A similar letter inside the bar chart indicates no significant difference between paclobutrazol concentration treatments per NPK dose. (b) A similar letter inside the bar chart indicates no significant difference between NPK dose treatments per paclobutrazol.

There was no significant difference in the leaf area after application of NPK fertilizer doses and paclobutrazol concentration, apparently it was due to the needs of leaf nutrients have been met while the concentration of paclobutrazol used was not appropriate. As reported by Mustofa (2022) there was no real effect on leave area from different concentration of liquid organic fertilizers. Nitrogen promote leaf area during vegetative development and help to maintain functional leaf area during the growth period. Nitrogen plays a large role in the production of nucleotides and phosphatides, which increases the concentration of phosphorus in the plants. Phosphorus are related to carbon assimilation metabolism and influence leaf photosynthesis (Xing & Wu, 2014). Potassium is in charge of preserving the right water potential, turgid pressure, and encouraging cell elongation in the leaves. Potassium also influences the uptake and transport of nitrate within the plant (Xu et al., 2020). Along with NPK fertilizer, the action of paclobutrazol in promoting plant growth may be connected to how it affects leaf. Roseli et al., (2012) stated that paclobutrazol's inhibitory effects reduce the leaf area *S. myrtifolium* but no abnormal leaf formation.

Number of productive tillers Table 1 showed that there was no interaction between the dose of NPK fertilizer and the concentration of paclobutrazol on number of productive tillers. Single effect of NPK fertilizer and paclobutrazol concentration also did not affect number of productive tillers of hanjeli**.** The range of number of productive tillers from single effect of NPK doses was 6.47-7.81, while the range of number productive tillers from the single effect of paclobutrazol application was 7.11-7.44.

We theorize that water, hormone balance, and nutrient were sufficient at the beginning of the growth phase, thus the number of productive tillers were relatively same. NPK fertilizer affects the increase in photosynthetic yield which is then directed to the formation of plant vegetative organs such as initiation of tillers and roots so that the final yield increases (Firmansyah et al., 2017). Similar result was reported by Nagar et al., (2021) that the application of paclobutrazol did not have a significant effect on the number of tillers in wheat plants.

Root-shoot ratio Table 2 showed that there was no interaction between the doses of NPK fertilizer and the concentration of paclobutrazol on root-shoot ratio. Single effect of NPK fertilizer and paclobutrazol concentration also did not affect root-shoot ratio of hanjeli. The range of root-shoot ratio from the single effect of NPK doses was 5.3-6.7, while the range of NPK doses from the single effect of paclobutrazol application was 5.2-6.4.

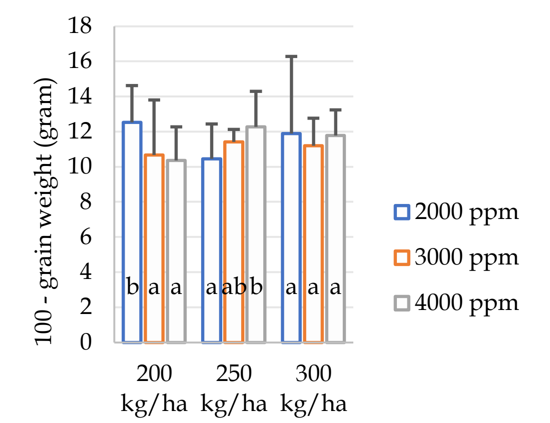
Based on the result of the statistical data analysis in the Table 2, it shows that the NPK fertilizer application and paclobutrazol concentration did not have a significant effect on the root-shoot ratio of hanjeli plants. According to Irwan et al., 2017 the ideal root-shoot ratio for cereal crop is 3. In this research, the root-shoot ratio that is higher than 3 is thought to be due to NPK fertilizer application and genetic response. The optimum N and P availability positively affects the above-ground part of the plant, including the leaf area and the photosynthetic capacity per unit of leaf area (Luo et al., 2016). Besides nitrogen and phosphorus, the potassium function is to production of ATP by regulating the rate of photosynthesis (Sardans & Peñuelas, 2021). In addition to NPK fertilizer, paclobutrazol had no impact on root-shoot ratio. We assumed that genetic factors influence the result.

Table 2. Effect of NPK fertilizer dose and paclobutrazol concentration on root-shoot ratio

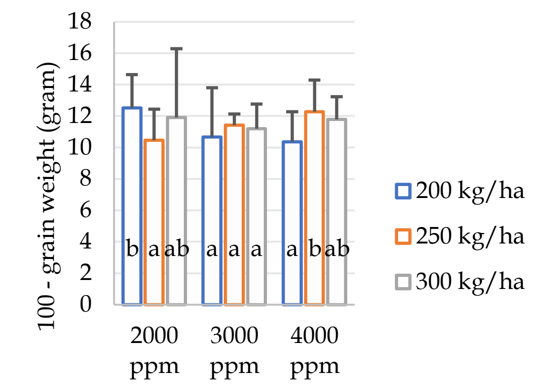
Treatment	**Root-shoot ratio**
n_1: NPK 200 kg/ha	6.72
n_2: NPK 250 kg/ha	5.80
n_3: NPK 300 kg/ha	5.36
p_1: Paclobutrazol 2000 ppm	6.14
p_2: Paclobutrazol 3000 ppm	5.28
p_3: Paclobutrazol 4000 ppm	6.44

Note: The mean value is not significantly different according to ANOVA test.

100-grain weight Figure 2 showed that there was an interaction between the doses of NPK fertilizer and the concentration of paclobutrazol on 100-grain weight. In the two-way table shown in Table 4, the application of paclobutrazol with a concentration of 2000 ppm was significantly different compared to other treatments at the same NPK dose (200 kg ha^{-1}). Meanwhile, the increasing dose of NPK fertilizer at each level of paclobutrazol application did not show an increase in the 100-grain weight of hanjeli var. Ma-yuen.



a. NPK fertilizer dose x paclobutrazol concentration



b. Paclobutrazol concentration X NPK fertilizer dose

Figure 2. Interaction effect of NPK fertilizer dose and paclobutrazol concentration on 100-grain weight

Note: 100-grain weight affected by NPK fertilizers and paclobutrazol concentrations (a) A similar letter inside the bar chart indicates no significant difference between paclobutrazol concentration treatments per NPK dose. (b) A similar letter inside the bar chart indicates no significant difference between NPK dose treatments per paclobutrazol.

The 100-grain weight of hanjeli is affected by genetics and environment. In this study, the addition of the NPK dose did not necessarily increase 100-grain weight of hanjeli at each level of paclobutrazol application, this indicates hat the paclobutrazol treatment is affected by the NPK dose and vice versa. paclobutrazol has the ability to uniform seed weight, seed formation and ripening by deactivating the hormone gibberellin (Xiang et al., 2017), while NPK fertilizer plays role in optimizing photosynthates and their distribution. Hardiyanti & Andriani (2022) reported that the application of NPK fertilizer in the right dose had an impact on the increase of plant height, number of leaves, shoot dry weight, root dry weight, root shoot ratio and total dry weight. Later, paclobutrazol application served to increase the dry matter partition into grain yield (Kamran et al., 2018).

Grain weight per plot Statistical analysis showed that there was no interaction between NPK fertilizer doses and paclobutrazol concentrations on grain weight per plot. The single effect of the NPK fertilization doses and paclobutrazol application is presented in Table 3. The dose of NPK treatment showed that the grain weight per plot ranged from 1025 g to 1339 g and the paclobutrazol application treatment ranged from 1146 g to 1235 g.

Table 3. The grain weight per plot of hanjeli plants under different NPK fertilization doses and paclobutrazol concentrations

Treatment	**Grain weight (g)**
n_1: NPK 200 kg/ha	1025
n_2: NPK 250 kg/ha	1339
n_3: NPK 300 kg/ha	1177
p_1: Paclobutrazol 2000 ppm	1159
p_2: Paclobutrazol 3000 ppm	1235
p_3: Paclobutrazol 4000 ppm	1146

Note: The mean value is not significantly different according to ANOVA test.

The addition of nutrients in this study did not show any significant differences in the character of grain weight per plot. We suspected that the presence of phosphorus is very crucial and it required in large quantities to support grain formation. Phosphorus is one of the macro elements needed by plants in the process of energy transfer, signal transduction, and enzyme activation (Wang et al., 2017). In cereal crops such as wheat, limited phosphorus supply can reduce grain yields by limiting the number of productive tillers (El Mazlouzi et al., 2020). Beside fertilization, paclobutrazol didn't give a significant effect on grain weight per plot. We predicted that abscisic acid and ethylene plays a more important role than gibberellin in grain production, hence why paclobutrazol has no discernible impact.

Conclusion

Hanjeli productivity can be regulated by NPK fertilizer and paclobutrazol concentration. There were interactions between doses of NPK fertilizer and the concentrations of paclobutrazol on the character of plant height and the 100-grain weight. The combination of 200 kg/ha of NPK and 3000 ppm paclobutrazol resulted in the best character of plant height which is 202.08 cm. Alternatively, 200 kg/ha of NPK and 2000 ppm paclobutrazol gave the best combination for grain weight, while the other characters did not show any interactions.

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Shallot cultivation originated from True Shallot Seed (TSS) on Andisols enriched with various ameliorants

Abstract. Application of soil ameliorants is important to improve Andisols properties and increase shallot productivity. The research objective is to determine the kind of ameliorant which the best effect on the growth and productivity of shallots originating from TSS in Andisols Lembang, West Java. The experiment was conducted in Margahayu Research Station, Lembang, West Java from January to May 2021. A randomized block design (RBD) with 6 treatments and 5 replications was set up in the field. Treatments include control (no ameliorant), 20 tons/ha of horse manure, 10 tons/ha of rice straw compost, 10 tons/ha of bamboo leaf compost, 10 tons/ha of husk biochar, and 5 kg/ha humic acid. The results showed that vegetative performance and yield of true shallot seed-based shallot variety of Trisula in Andisols enriched with rice straw compost was higher than in other ameliorant treatments. Additionally, nutrient uptake in rice straw compost treatment was also higher than in other ameliorant treatments.

Keywords: Andisols · Bamboo leaf compost · Humic acid · Husk biochar · Rice straw compost

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Introduction

In the last 10 years, shallot production in Indonesia has continually increased and reached twice from 964,221 tons in 2012 to 1,982,360 tons in 2022. The area of shallot production has also continued to increase in the last 10 years, from 99,519 ha in 2012 to 184,386 ha in 2022, meanwhile, the productivity slightly increased from 9,7 tons per ha in 2012 to 10,7 tons per ha in 2022 (Ministry of Agriculture, 2022). The increase in shallot production and productivity could be attributed to the highly intensive level of shallot cultivation. For instance, farmers commonly use exceeded dosages of N and P fertilizers that is higher than recommended doses (Basuki, 2014). Excessive use of chemical fertilizers and without regard to conservation principles could cause land degradation.

Since the 1990s, the Indonesian Vegetable Research Institute (IVEGRI) (since 2022 it transformed into the Indonesian Institute for Testing Instrument Standard of Vegetable Crop) has conducted various studies related to the use of botanical shallot seeds (TSS, True Shallot Seed) as an alternative planting material. The research mainly focused on the use of TSS as planting material, developing cultivation techniques to produce consumable bulbs and TSS production (Sumarni et al., 2012), and producing bulb planting materials from TSS (Sopha et al., 2015). There was significant difference of the cultivation techniques and varieties used in producing shallots from bulbs and TSS. However, botanical shallot seeds were considered technically and economically feasible to be used as alternative planting materials. TSS gives several advantages such as less seed needed, easy storage, long-term storage, and relatively virus-free seeds (Prahardini & Sudaryono, 2018).

Shallot production in the highlands is commonly cultivated on Andisols. The characteristics of Andic soil are highly related to the presence of non-crystalline minerals such as allophane, imogolite, ferrihiphrit, or humus allophane complex in the soil (Rachim & Arifin, 2011). Andisols has several unique properties that can affect the productivity of agricultural commodity, includes high P fixation, organic matter content, bulk density, porosity and mesopores, and has a pH-dependent charge. In addition, high P retention (>85%) in Andisolss can lessen agricultural productivity because it could limit the availability of P in the soil (Anda & Dahlgren, 2020). With such limitations of Andisols, specific improvement should be implemented to increase the productivity of shallot cultivation on that certain soil type.

Ameliorant is a soil enhancer that can be used to improve soil properties. It is suggested that the use of various ameliorants could improve soil properties (Avifah et al., 2022). Application of ameliorants can improve soil physical properties, such as its water holding capacity, pore aeration, and infiltration rate. In addition, the provision of ameliorants can increase nutrients, soil pH and CEC, and reduce Al-dd (Dariah et al., 2015). Ameliorants can also be a source of energy and food for soil microbes, as well as provide a conducive environment for soil organisms that play significant roles in increasing nutrient availability in the soil (Rusdi et al., 2019).

Organic materials could be used to increase the availability of P in the soil (Sari et al., 2017). Organic acids from organic material decomposition could trigger the release of P that is commonly bound by the amorphous fraction in Andisols. This process increases the availability P and reduce P retention in Andisols (Irawan et al., 2016). In addition, the provision of organic matter could also add the P nutrients and consequently could increase the amount of P in the soil.

Bamboo leaf and rice straw-based compost that contains high silica contents i.e. 58.3% and 4-20%, respectively could be used to improve Andisols properties (Nugraha et al., 2017). Silicate is one of the anions that could release P from the huge affinity of adsorption complex and push the adsorbed phosphate anion. The addition of Si into the soil can reduce the activity of Al, Fe and Mn. Silicate anions could replace P anions at adsorption sites, and make them available for plants (Mariana et al., 2015).

Biochar is an active charcoal that can be used as a soil ameliorant. Biochar could improve soil chemical properties, increase soil pH and CEC (Zhu et al., 2014), increase nutrient ion absorption and reduce P retention in Andisols (Yuliana, 2018). Biochar application can increase nutrient availability through three mechanisms i.e., provision of nutrient supply, retaining nutrients, and triggering the dynamics of microorganisms in the soil (Yu et al., 2019). A combination of biochar and dolomite could increase shallot production in the highland areas (Haryati & Erfandi, 2019), while combination of biochar and Trichoderma could reduce the application of chemical fertilizers by 50%, increase the diameter and height of shallot bulbs (Adnyana & Rahayu, 2016).

Humic acid could be used as a soil ameliorant since it can reduce P retention and increase available P in the Andisols. Phosphor retention decreased through a chelating mechanism or the formation of complexes with Al and Fe (Sandrawati et al., 2018). The release of phosphate retention occurs due to negative charge of soil colloid because of the addition of huge quantities of negatively charged ameliorants to the soil that block the positive charge on the soil colloid and fill the exchange sites (Devnita, 2010).

Numerous studies have been conducted to determine the effect of various ameliorants on shallot productivity, however limited studies have been conducted on true shallot seeds-based shallot cultivations in Andisols. Therefore, this study was conducted to determine the effect of ameliorants includes manure, rice straw compost, bamboo leaf compost, husk charcoal, and commercial humic acid on the productivity of shallots from TSS in Andisols Lembang, West Java.

Materials and Methods

The experiment was conducted from January to May 2021 at Margahayu Research Station of IVEGRI, Lembang, West Java, Indonesia. The soil in this experiment site was categorized as Andisols order with class texture of loamy clay (28% sand, 41% dust and 32% clay). Additionally, soil analysis was performed in the Integrated Laboratory of IVEGRI. A shallot variety of Trisula was used in this study.

The study was arranged using a randomized block design (RBD) with 6 treatments and 5 replications, i.e., control (without ameliorant, A), 20 tons/ha of horse manure (B), 10 tons/ha of rice straw compost (C), 10 tons/ha of bamboo leaf compost (D), 10 tons/ha of husk charcoal (E), and 5 kg/ha humic acid (F). Ameliorants were applied 2 weeks prior to transplanting. TSS seedlings aged three weeks were moved to experimental plots size 5m x 1m. The plant spacing used was 20 x 20 cm, so there were 125 plants in each experimental plot.

Observations of vegetative growth parameters, i.e., plant height and number of tillers were carried out to the 15 randomly selected sample plants on the 2, 4, 6 and 8 weeks after transplanting. The plant P uptake analysis was carried out at the maximum vegetative growth phase (on 45 days after transplanting). One plant sample in each treatment plot was collected for this laboratory analysis. On the harvesting day, the number of bulbs per plant and the weight of fresh bulbs was recorded. Additionally, dry weight and askip dry weight per plot were recorded after drying process. Chemical properties of the experiment site soil before planting and each experiment plot after harvesting time were analyzed in the laboratory. The effect of ameliorant on plant growth and yield productivity was analyzed using the ANOVA test at the 5% level and was tested further with the DMRT advanced test at the 5% level.

Results and Discussion

Andisols in Lembang made from Andesite, has an acidic pH, and has a high to very high (but less than 25%) organic C content in the topsoil layer (Devnita, 2010). Chemical analysis of the experimental site' soil (Table 1) shows that the soil had a slightly acidic H_2O pH of 5.8 and a KCl pH of 4.9. The pH KCl suggested the low exchangeable Al content, thus it cannot be measured by the titration method (Rosalina & Maipuw, 2019). C Organic and Total N content in the soil was high i.e., 5.72 and 0.59% respectively. The available P and K content was high i.e., 122.7 and 302.4 ppm respectively. The content of potential P and K was also considered high i.e., 503.04 and 42.43 mg/100g, respectively.

Table 1. Characteristics of experimental site' soil prior to transplanting and after harvesting

Parameters	Unit	Prior to Transplant	After harvesting					
			A	B	C	D	E	F
pH H_2O		5.8	5.5	5.5	5.6	5.5	5.5	5.5
pH KCl		4.9	4.8	4.8	4.8	4.8	4.8	4.8
C Organic	%	5.72	5.42	5.71	5.49	5.87	5.79	5.80
N Total		0.59	0.61	0.65	0.61	0.65	0.66	0.61
P Olsen (P_2O_5)	ppm	122.7	205.0	204.8	201.6	194.4	208.8	200.6
K MV		302.4	334.1	376.4	489.5	370.9	351.0	402.0
P HCl (P_2O_5)	mg/100g	503.04	462.15	477.14	463.86	467.28	494.94	472.08
K HCl (K_2O)		42.43	48.15	60.45	66.96	51.13	47.83	60.72
Ca-dd	mol /kg	7.82	7.80	7.64	8.05	8.36	7.46	8.53
Mg-dd		1.88	1.83	1.82	2.02	1.92	1.74	2.03
K-dd		1.01	1.30	1.36	1.71	1.33	1.26	1.47
Na-dd		0.05	0.07	0.08	0.09	0.05	0.09	0.08
CEC		24.23	30.23	29.80	29.87	29.13	29.22	28.64

The results of soil chemical analysis after harvest showed a decrease in pH, both in non-ameliorant and with ameliorant soils (Table 1). The decrease in pH that occurred was still quite acidic (5.5 – 6.5). High rainfall during field activities triggers acid dilution followed by an increase in H+ ions in the topsoil, so that the pH drops (Olojugba, 2018). Organic C content in treatments A (non-ameliorant) and C (rice straw compost) decreased, while in other treatments it increased slightly. The nutrients N and K have increased, which probably comes from other than ameliorant also comes from N and K fertilization given during plant growth. Treatment C (rice straw compost) caused the highest increase in K element, this was due to the high K content in rice straw compost (Kadengkang et al., 2015). While the available P content increased in all treatments, and vice versa, potential P decreased. The results of the decomposition of organic matter in the form of organic acids bind Al and Fe allophan in Andisolss in the form of chelation causing available P to increase (Sari et al., 2017).

Table 2. Precipitation, temperature, and relative humidity during experiment period

Month	Precipitation (mm)	Minimum temperature (°C)	Maximum temperature (°C)	Relative humidity (%)
1	190	16.3	24.9	86.5
2	188	17.7	25.4	88.6
3	235.5	16.2	24.4	80.2
4	181.5	16.7	25.1	88.6
5	128.5	17.1	24.9	77.3

Source: IVEGRI' meteorological station

The ameliorant treatments caused significant differences in plant height measured at 2, 4, 6, 8 weeks after planting (Table 3). At the beginning of growth, bamboo leaf compost ameliorant (D) produced plants with the highest size, which differed significantly from humic acid treatment (F). In the following weeks, the humic acid treatment still produced plants with the shortest size. Until the end of the observation, the ameliorant of rice straw compost seemed to consistently produce the highest shallot plants. Aside from being an ameliorant, organic matter can also function as a source of nutrition for plants. Organic materials, such as manure and compost (bamboo leaves and rice straw) have higher N, P, and K content than biochar, husk charcoal and humic acid, so they have a positive effect on plant growth.

Table 3. Shallot heights in ameliorants treatments

Treatments	Plant (cm) Plant ages (weeks after transplanting)			
	2	4	6	8
A	14.5 ab	16.3 a	27.9 a	39.9 ab
B	14.5 ab	15.9 a	26.5 ab	37.7 ab
C	14.3 ab	16.1 a	28.6 a	41.7 a
D	15.2 a	15.7 ab	25.7 ab	36.9 ab
E	14.7 ab	15.0 b	24.8 b	36.2 b
F	13.4 b	14.5 b	24.7 b	35.9 b

Note: control (without ameliorant, A), 20 tons/ha of horse manure (B), 10 tons/ha of rice straw compost (C), 10 tons/ha of bamboo leaf compost (D), 10 tons/ha of husk charcoal (E), and 5 kg/ha humic acid (F). Mean followed by similar letter was not significantly different based on DMRT advanced test at 0.05.

Table 4. Number of shallot leaves in ameliorants treatments

Treatments	Number of shallot leaves							
	Crop ages (weeks after transplanting)							
	2		4		6		8	
A	2	a	3.2	a	5.8	a	6.2	a
B	2	a	3.2	a	5.5	a	5.9	a
C	2	a	3.5	a	6.5	a	7.0	a
D	2	a	3.4	a	5.4	a	5.7	a
E	2	a	3.1	a	4.9	a	5.1	a
F	2	a	3.4	a	6.0	a	6.3	a

Note: control (without ameliorant, A), 20 tons/ha of horse manure (B), 10 tons/ha of rice straw compost (C), 10 tons/ha of bamboo leaf compost (D), 10 tons/ha of husk charcoal (E), and 5 kg/ha humic acid (F). Mean followed by similar letter was not significantly different based on DMRT advanced test at 0.05.

Table 5. Number of shallot tillers cultivated in various ameliorant treatments.

Treatments	Number of tillers				
	Crop ages (weeks after transplanting)				
	2	4	6	8	10
A	1.0 a	1.0 a	1.0 a	1.8 a	1.9 a
B	1.0 a	1.0 a	1.0 a	1.6 a	1.7 a
C	1.0 a	1.0 a	1.0 a	1.8 a	2.0 a
D	1.0 a	1.0 a	1.0 a	1.5 a	1.6 a
E	1.0 a	1.0 a	1.0 a	1.5 a	1.6 a
F	1.0 a	1.0 a	1.0 a	1.7 a	1.8 a

The number of leaves and tillers were not affected by the different types of ameliorants treatments (Table 4 and Table 5). However, there was a tendency for plants treated with rice straw compost to have the highest number of leaves and tillers. Previous study has shown that the genotypic factor greatly influences the variable number of leaves and number of tillers (Waluyo et al., 2021). The number of tillers in this case was very low, ranging from 1.6 to 2. Shallots grown from TSS seedlings commonly grow differently from plants whose seeds were bulbs.

Nutrients uptake in various ameliorant treatments (Table 6) shows that Nitrogen, Phosphor and Potassium in compost rice straw treatment was relatively high compared to other treatments. This high nutrient uptake contributed to relatively high shallot growth and production in this treatment compared to other treatments. The post-harvest parameters include fresh weight, dry weight, and askip dry weight were not affected by the different types of ameliorants used in the experiment (Table 7). High incidence of crops diseases (data is not presented) due to high rainfall and relative humidity during the experiment (Table 2) might contribute to the quite low shallot yield and insignificantly different yields among treatments. However, shallots treated with manure and composts (treatment B, C and D) tended to have higher yield compared to other treatments. While charcoal husk and humate acid functioned only as soil ameliorant, manure and compost could be used as soil ameliorant and nutrient sources for crops. A previous study found that compost had a significant effect on the number of leaves, number of tubers harvested, and fresh weight of bulbs since it provides nutrients needed for shallot growth (Susanti, 2015) and the use of 15 tons/ha rice straw compost could reduce 50% NPK fertilizer (Tarigan et al., 2017).

Table 6. Nitrogen (N), Phosphor (P), and Potassium (K) uptake in various ameliorant treatments

Treatment	Content (%)			Absorption (mg/plant)		
	N	P	K	N	P	K
A	3.48	0.28	3.92	56.46	4.46	63.66
B	2.87	0.26	3.47	66.31	5.99	80.26
C	3.07	0.26	3.41	68.21	5.79	75.59
D	2.73	0.24	2.67	60.13	5.28	58.89
E	2.84	0.24	3.08	60.82	5.04	65.92
F	3.17	0.27	3.61	51.80	4.38	58.93

Note: control (without ameliorant, A), 20 tons/ha of horse manure (B), 10 tons/ha of rice straw compost (C), 10 tons/ha of bamboo leaf compost (D), 10 tons/ha of husk charcoal (E), and 5 kg/ha humic acid (F).

Table 7. Fresh weight (g), dry weight (g), and askip dry weight (g) in various ameliorant treatments

Treatment	Fresh weight (g)		Dry weight (g)		Askip Dry weight (g)	
A	4691.0	a	3355.0	a	1913.0	a
B	6729.6	a	4755.0	a	1635.0	a
C	7028.0	a	5092.6	a	1987.0	a
D	5958.6	a	4176.8	a	1750.0	a
E	5423.0	a	3935.6	a	1636.0	a
F	5083.6	a	3709.8	a	1995.0	a

Note: control (without ameliorant, A), 20 tons/ha of horse manure (B), 10 tons/ha of rice straw compost (C), 10 tons/ha of bamboo leaf compost (D), 10 tons/ha of husk charcoal (E), and 5 kg/ha humic acid (F). Mean followed by similar letter was not significantly different based on DMRT advanced test at 0.05.

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Conclusion

1. Vegetative performance and yield of true shallot seed-based shallot variety of Trisula in Andisols enriched with rice straw compost was slightly higher than in other ameliorant treatments.
2. Nutrient uptake in rice straw compost treatment was also higher than in other ameliorant treatments.

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Adaptation of several hybrid maize in West Nusa Tenggara drylands using modified plant spacing for optimal seed and biomass productions

Abstract. Maize is a crucial multipurpose strategic food crop in Indonesia. Land expansion employing dry land, row-space technology, and suitable varieties, is emerging as the solution to fulfill the rising need for seeds and biomass. The study was carried out from August to December using a factorial randomized block design consisting of two treatment factors, namely the treatment factor of 6 varieties and 2 row-spacings, to verify the new superior hybrid maize, which is adaptable in dry land Senayan village, Poto Tano sub-district, West Sumbawa district, and West Nusa Tenggara (NTB). The results showed that JH 37 and JH 29 varieties were adaptive to be developed in dry climate dryland areas for seed and biomass production using various narrow and wide planting space system. Jakarin, Bisi 18 and HJ 21 varieties could be planted in drylands by considering the planting space system for seed or biomass production, while the Nasa 29 variety was not recommended to be planted in drylands area for seed production, but could be used for biomass production by considering a wide planting space system such as Legowo system.

Keywords: Adaptive variety · Dry land · Hybrid · Planting space system

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Introduction

The demand for maize (Zea mays L.), a multipurpose strategic food crop that is significant for Indonesia's food, feed, and alternative bio sector, rises along with the country's population and number of farmers. With an increase of 2.24% per year, national maize productivity in 2019–2021 will remain low (16.85 t/ha), demonstrating the use of poor maize production technology (Wahyudin et al., 2015; PUSDATIN Ministry of Agriculture, 2020).

Maize is directed to develop on dry land with limited water sources in dry climates with proper water management so that the water needs for growth and seed filling of maize plants are sufficient. The development of maize on fertile land and readily available water sources is less competitive with other food crops like rice. According to Ritung et al. (2015), West Nusa Tenggara makes up about 1.72 million hectares of Indonesia's overall 144.47 million ha dry land area.

Limited water supplies, adaptable varieties, and inefficient farming techniques all have a significant impact on maize output in desert drylands. Water management, soil fertility, the use of new superior varieties (VUB), and the simplicity or convenience of a cultivation system are all important factors to consider when trying to increase maize output in arid climate drylands (Desyanto & Herman, 2014; Mulyani & Sarwani, 2013; Helviani et al., 2021). In order to increase land productivity and cropping index from one planting to two or three planting times, agricultural development in dryland climates utilizes the potential of available water resources with simple and affordable technology combined with the use of VUB and in situ organic matter management (Mulyani et al., 2014; Stewart, 2016; Sardiana et al., 2017). Hybrid maize productivity in dryland and dry climate is still low and constrained by suboptimal cultivation technology and inappropriate use of hybrid maize varieties, resulting in productivity far below potential yields (<10 t/ha). The average productivity of hybrid maize in West Nusa Tenggara is 6.7 t/ha (Statistics Indonesia, 2018). Test results for several hybrid maize varieties on dry land, namely Bima 20 URI around 8.72 t/ha, Nasa-29 around 8.51 t/ha, JH-37 around 9.32 t/ha, and Bima-14 around 8. 61 t/ha (Pratama et al., 2019; Triguna et al., 2021). According to Hipi (2008), the test results of several hybrid maize varieties were the production of Bima-2 Bantimurung 9.45 t/ha, Bima-3 Bantimurung 9.40 t/ha of dry shells. Hybrid maize production on rainfed paddy fields in NTB varieties Nasa 29 (10.07 t/ha), HJ 21 (11.1 t/ha), JH 37 (10.6 t/ha), and JH 45 (10.6 t/ha) (Erawati, 2020). Composite and hybrid maize production in North Lombok NTB varieties P4IS (3.59 t/ha), Gumarang (3.38 t/ha), Lamuru (4.60 t/ha) and NK 212 (4.30 t/ha) (Wahyudin et al., 2018).

The steps taken to overcome the problems of hybrid maize production in dry climate drylands from the aspect of variety types are adaptive quickly by verifying the production testing of several types of varieties in dry climate drylands. Varieties that have high production in dryland dry climate indicate that they are adaptive to this environment. Genotypes that have different limiting factors of tolerance to drought stress and plant potential are determined by how many seeds are formed in the growing environment (Suwardi & Azrai, 2013). Therefore, these types of varieties are very likely to be developed in dryland dry climate. To meet the increasing national demand for maize, it is necessary to increase production using new superior varieties and land expansion by utilizing dry climate drylands.

The objective of this research is to verify the suitability of new high-yielding varieties on dry climate drylands to serve as a basis for the selection and development of hybrid maize in West Sumbawa District, NTB using modification of plant space represented by planting space system.

Materials and Methods

The study was carried out from August to December 2021 in dry land of Senayan village, Poto Tano sub-district, West Sumbawa district, West Nusa Tenggara (NTB). The study employed two factors randomized completely block design, with the first factor was variety consist of six varieties: (Nasa 29), (JH 29), (JH 37), (Jakarin), (HJ 21), and (JH 29) and the second factor was cropping system comprises two cropping systems, i.e., the conventional system (population: 71,428 tan/ha, 70 x 20 cm spacing) and the Legowo system (population: 71,428 plant/ha, 90-50 x 20 cm spacing), were used in Bisi 18 and the treatment factor.

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Planting used a Tugal system, 5 cm deep, with a spacing determined by the treatment, and covered with 2-5 t/ha of organic fertilizer. Maize plants were fertilized twice with inorganic fertilizer, the first with NPK (300 kg/ha) at 7 days after planting (DAP) and the second with urea (250 kg/ha) at 30-35 DAP. To prevent plant friability, each row of plants was hilled before weeding with a specific herbicide for maize plants at a concentration of 2 l/ha.

The initial weeding was done using selective post-emergence herbicides (Calaris) at dose of 2 l/ha when the maize plants were 7–10 DAP or before the first fertilization. When the soil is moist and the weeds have two to three leaves, the herbicide is administered. At 21 to 25 DAP, use a machine or a hoe to weed while hilling the plants to strengthen them to make irrigation easier.

Data observed were plant height (30 DAP, 110 DAP), cob height (110 DAP), leaf area index (ILD), biomass weight, harvest index (IP), rainfall, correlation between plant spacing and varieties, relationship between production and biomass, yield and yield components and soil analysis before the experiment.

Yield (t/ha) of each variety according to Firdaus et al. (2002) using the formula:

$$\text{Yield}\left(\frac{t}{ha}\right) = \frac{10000}{HA} \times \frac{100\text{-}MCS}{100\text{-}15} \times W \times 0.80$$

Description:
MCS = Moisture content of seeds at harvest
HA = Harvest area (m2)
15 = 15% seed moisture content
W = Weight of harvested peeled cob (kg)
0.80 = Mean of shelling percentage (yield)"

Data results were analyzed statistically using analysis of variance, then if significantly and very significantly different followed by Duncan's Multi Range Test (DMRT) at the 5% level.

Results and Discussion

Data from observations of climatic parameters made daily during the 5 months of research on Sumbawa Island showed that rainfall during the experiment was below 20 mm/day. At the beginning of planting in August, the rain was very scarce, but the humidity was still 70% might be caused by wind blow from Australia (Figure 1) Water need during the maize growing period is around 400-600 ml (Farhad et al. 2011) and that's a pretty much amount of water. Water for plant needs can be obtained from dew that forms in the morning. Some plants can utilize this dew for their water needs and it really depends on the genetic ability of each plant.

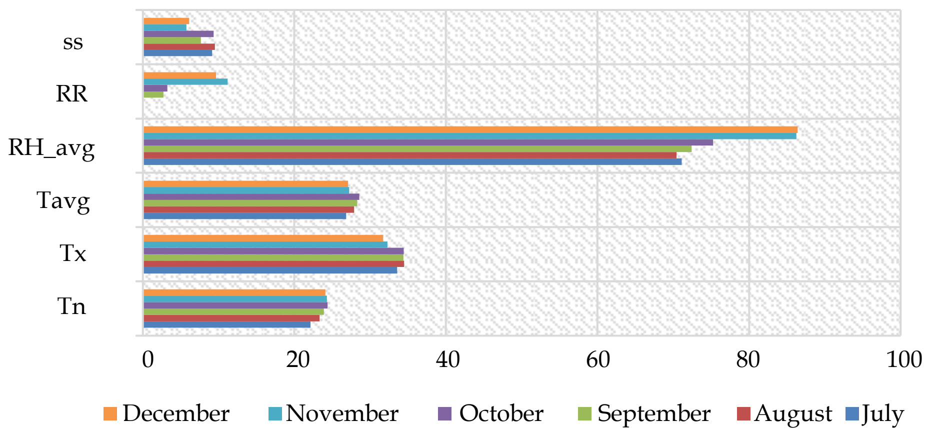

Figure 1. Sumbawa Island Average Monthly Climate Parameter Data

Description: Tn: Minimum temperature (°C); Tx: Maximum temperature (°C); Tavg: Average temperature (°C); RH_avg: Average humidity (%); RR: Rainfall (mm); ss: Length of sunshine (hours)

Getting varieties that can adapt to dry land is very beneficial because it will reduce production costs by eliminating the cost of too much watering. From the climatic parameter data diagram, it can also be seen that the Sumbawa region has high humidity which allows maize to utilize the vapor formed by utilizing its adventitious roots. Adventitious maize root function to support and defense against various biotic and abiotic stresses (Steffens et al., 2016).

Based on the results of soil analysis, it shows that the soil where the experiment was conducted belongs to the dust class with a pH of 7.61 so that the soil is neutral. Nitrogen, C-organic and P Bray-1 (ppm) contents were low, C/N ratio was medium and K2O content was very high. Exchangeable cations (me/100 g) of K was low, Ca and Mg were high, and Na was low. Base saturation was very high and CEC (me/100 g) was very low (Table 1).

The results showed that the plant height at 30 DAP in conventional system was not significantly different between varieties, while in Legowo system Jakarin variety was significantly different from Nasa 29 and JH 29 (Table 2). Conventional system at 30 DAP did not cause competition between plants to obtain nutrients, water and sunlight in various varieties, so they still showed the same performance at plant height. Legowo system for plant height of Jakarin variety was significantly different from Nasa 29 and JH 29, but not significantly different from the JH 37, HJ 21 and Bisi 18 varieties. This indicated that Legowo system caused competition between plants at 30 DAP so that plant height lower than the conventional system. The greater the plant spacing the lower the plant height, this indicated that any increase in plant spacing will reduce plant height (Yulisma, 2011). The competition of sunlight will make plant produce more auxin in their meristem tissue.

Table 1. Soil analysis before experiment, Poto Tano sub-district, West Sumbawa district, NTB.

Type of assignment	Assign-ment value	Valence
Texture		
Clay (%)	5	Dust
Dust (%)	64	
Sand (%)	31	
pH: Water (1:2:5)	7.61	Neutral
C-Organic (%)	0.92	Low
N Total (%)	0.10	Low
C/N	9	Medium
P Bray-1 (ppm)	9	Low
K2 O (ppm)	162	Very high
Exchangeable cations (me/100 g)		
K	0.35	Medium
Ca	15.85	High
Mg	2.37	High
Na	0.38	Low
CEC (me/100 g)	6.57	Very low
Base saturation (%)	100	Very high

Source: Soil, plant, fertilizer and water laboratory of BPTP South Sulawesi, 2021

Table 2. Mean agronomic variables at two planting systems and six hybrid maize varieties in Poto Tano district, West Sumbawa NTB.

Planting Space systems	Varieties	Plant height 30 DAP (cm)	Plant height 110 DAP (cm)	Cob Position Height110 DAP (cm)	Leaf area index 110 DAP (ILD)	Biomass(%) 110 DAP	Harvest index (HI)
	Nasa 29	61.00ab	175.33a-d	109.33ab	5.43a	66.81a	0.66a
70 x 20 cm	JH 29	61.93ab	195.40a	124.00a	4.99a	64.19ab	0.62ab
(Conventional)	JH 37	64.00a	184.73a-d	113.33ab	5.93a	61.57ab	0.61 ab
	Jakarin	61.00ab	178.66a-d	104.00ab	5.24a	62.97ab	0.63 ab
	HJ 21	56.60ab	177.66a-d	106.33ab	8.79a	63.93ab	0.64 ab
	Bisi 18	64.33a	190.33ab	106.67ab	5.91a	60.91ab	0.64 ab
	Nasa 29	45.40b	193.33ab	102.33ab	5.19a	60.14ab	0.60 ab
	JH 29	46.40b	134.13d	96.33b	5.47a	57.67bc	0.57bc
(90-50) x 20 cm	JH 37	55.46ab	167.73cd	98.67ab	5.41a	59.15abc	0.59abc
(Legowo)	Jakarin	66.60a	172bcd	99.00ab	5.15a	60.84ab	0.60 ab
	HJ 21	53.00ab	188.33abc	116.33ab	5.87a	52.71c	0.52c
	Bisi 18	61.87ab	185.66a-d	106.67ab	5.15a	60.91ab	0.60 ab
CV (%)		15.84	6.24	12.56	15.50	6.64	6.76

Description: Numbers followed by the same letter in the same column indicate not significantly different basedon Duncan's test at 5% level.

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Table 3. Average yield variables and yield components in two planting space systems using six new hybrid maize varieties in, Poto Tano district, West Sumbawa NTB.

Planting Space System	Varieties	Production (t/ha)	Cob length (cm)	Cob diameter (cm)	Number of kernel row/cob	Number of seed in row	100 seeds weight (g)
70 x 20 cm	Nasa 29	8.10d	17.27ab	4.39c	13.00d	35.93	33.33a-d
	JH 29	9.92ab	18.31a	4.90a	16.86a	30.03	30.33cd
	JH 37	10.37a	16.27b	4.70ab	15.13bc	33.83	26.66d
	Jakarin	9.28abc	17.23ab	4.85a	14.75bc	33.86	35.33a
	HJ 21	8.81bcd	16.91ab	4.91a	14.80bc	3496	35.33a
	Bisi 18	8.65cd	17.57ab	4.76a	15.46bc	35.9	30.33cd
(90-50) x 20 cm	Nasa 29	8.1d	17.01ab	4.39c	13.20d	37.7	33.00a-d
	JH 29	9.68abc	17.43ab	4.91a	16.06ab	36.33	31.00bcd
	JH 37	9.97ab	17.03ab	4.73a	15.06bc	34.96	33.33a-d
	Jakarin	9.52abc	17.46ab	4.78a	15.55bc	33.7	34.66ab
	HJ 21	9.39abc	17.10ab	4.89a	14.46c	33.8	34.33abc
	Bisi 18	9.46abc	17.33ab	4.65abc	16.00ab	36.13	31.33a-d
CV (%)		6.8	4.68	3.46	4.63	4.96	6.7

Description: Numbers followed by the same letter in the same column indicate not significantly different basedon Duncan's test at 5% level.

Plant height and cob height at 110 DAP showed that in conventional system was not significantly different between various varieties, while in Legowo system for the JH 29 variety was significantly different from the Nasa 29 and HJ 21 varieties, the cob height in conventional system and Legowo system were not significantly different between various varieties, but the JH 29 variety was significantly different in both of planting systems. This showed that inLegowo system there was a plant gap so that the level of water evaporation is higher than the conventional system which affected Nasa 29 and JH 29 varieties.

High water evaporation affects the availability of water in the soil that can affect plant growth. Plant height is strongly influenced by the level of competition between plants, especially competition for water, sunlight and growing space. The narrower spacing, the higher compe-tition between plants (Aisah & Herlina, 2018).

Biomass weight and harvest index are interrelated in determining the ability of plants to yield. Harvest index is the ratio of seed dry weight yield to total plant dry weight yield (Wahyudin et al., 2015). Table 2 showed biomass weight and harvest index (HI) of all varieties in conventional system were not significantly different, but when using Legowo system the biomass weight of HJ 21 varieties was significantly different from Nasa 29 and Bisi 18 varieties, while the harvest index (HI) of HJ 21 variety was significantly different from Nasa 29, Jakarin and Bisi 18 varieties. This showed that plant growth of each variety was influenced by the growing environment (planting system) due to competition between plants for water, nutrients, and sunlight in addition to plant genetic factors. The competition for sunlight and water causes synergistic and antagonistic additive plant responses (Zhang et al., 2011). However, this is influenced by the type of plant, especially the type of leaves. The upright type leaves will get more sunlight than the flat type leaves at various population levels. Upright type leaves maize will utilize more sunlight for photosynthesis even at high populations. High production per unit area in certain populations can utilize the use of sunlight in the photosynthesis process optimally (Kartika, 2018).

Table 3 showed that the production of the JH 37 variety was significantly different from Nasa 29, HJ 21 and Bisi 18 varieties, but was not significantly different from the JH 29 and Jakarin varieties using conventional system, while using Logowo system JH 37 variety was significantly different from Nasa 29 variety and was not significantly different from other varieties. The highest production at both of spacing system was achieved by JH 37 variety (10.37 t/ha and 9.97 t/ha) at 15% moisture content. This indicated that JH 37 variety in both spacing systems was superior to other varieties tested in dry climate dryland. JH 37 variety in dry climate dryland has high production and was able to adapt to drought stress morphologically and physiologically by optimally utilizing limited water and sunlight energy. Plants that can adapt to changes in irradiation by modifying morphology and physiology, will use available sunlight energy efficiently (Koike, 2013), so it has high yield potential even at high populations.

The cob length of JH 37 variety in conventional system was significantly different from JH 29 variety, but not significantly different from other varieties. The cob diameter of the Nasa 29 variety was significantly different from other varieties in conventional system, while the Legowo system was not significantly different from Bisi 18 variety. The cob length of various varieties in different spacing varies greatly, it is influenced by the environment (water, nutrients, sunlight) and genetics. Maize growth and production are strongly influenced by many factors such as variety type and spacing/population level (Yulisma, 2011). Cob length is closely related to the utilization of sunlight in the photosynthesis process, which are transmitted to the cob formation of various population levels that cause different cob sizes.

The number of row seeds per cob of Nasa 29 variety was significantly different from other varieties in both spacing systems, while the number of seeds per row was not significantly different. The number of rows per cob of Nasa 29 variety has fewer than other varieties and this is influenced by genetic factors. The number of seeds in addition to being influenced by genetic factors is also influenced by plant condition during the pollination phase.

Plants under drought stress during the pollination phase cause wilt, so that pollen is reduced and as a result decreasing in seed formation. The number of seed row per cob and the number of seeds in a row are strongly influenced in addition to the type of variety/genetic and environmental factors also influenced by the plant condition during the pollination phase. The optimal pollination phase will produce the maximum number of seed rows per cob and the number of seeds in a row according to the type of variety (Suwardi et al., 2020).

The 100 seed weight of the JH 37 variety was significantly different from the Jakarin and HJ 21 varieties but was not significantly different from the Nasa 29 and JH 29 varieties in conventional system. The weight of 100 seeds of all varieties was not significantly different using Logowo System. This showed that the planting space system, genetic factors and the availability of water for plant metabolic processes during photosynthesis also affect the weight of 100 seeds. Plants that occur drought will experience leaf rolling which results in inhibition of the photosynthesis process. Seed weights apart from genetic factors is also influenced by the ability of leaves during the photosynthesis process if there is a disturbance in the absorption of sunlight, the process is disrupted so that the results of photosynthesis transmitted to the seeds are reduced (Suwardi et al., 2020).

The correlation value between two characters in a certain spacing allows us to choose the best spacing for the best increase in maize production in drylands such as in NTB. The results of the correlation analysis between characters in the two planting space system conditions showed that in the dry environment using conventional system, production characters were negatively and significantly correlated to biomass characters, harvest index and plant height at 100 DAP and positively and significantly correlated to cob length, cob diameter, number of rows per cob and plant height at 30 DAP, while in Legowo system, production characters were negatively and significantly correlated to biomass characters, harvest index and 100 seeds weight and significantly positively correlated to the number of row seed per cob (Table 4).

Biomass characters were significantly positively correlated to harvest index under both planting space system conditions, significantly negatively correlated to cob diameter at Legowo system, and significantly negatively correlated to 100 seeds weight at conventional system. The two important characters of production and biomass were found to be negatively correlated to each other, but highly significant in Legowo system, which means that the greater the spacing, the higher the seed production, but the lower the biomass yield. Positive and significant character correlation were between cob length to cob diameter and number of seeds per row, cob diameter to number of seed row per cob, plant height at 30 DAP and leaf area index, number of rows of seeds to plant height at 100 DAP and cob position height at 100 DAP, plant height at 30 DAP to leaf area index and plant height at 100 DAP to cob position height at 100 DAP.

Table 4. Correlation between parameters under two planting space systems of new hybrid maize varieties

		BIO	HI	W100	CL	CD	NRC	NSR	PH30	PH100	CPH100	LAI
PROD	70	-0.242	-0.2485	0.0999	0.4597*	0.7712**	0.5957**	0.1141	0.5581**	-0.2498	0.2091	0.2861
	90	-0.5849**	-0.5497**	-0.4851*	0.07	0.3194	0.5375*	-0.1124	0.254	0.345	0.3428	0.1518
BIO	70		0.9987**	-0.4765*	-0.2825	-0.3011	0.2445	-0.2674	-0.0979	-0.2778	-0.3283	-0.141
	90		0.9967**	0.1449	-0.0802	-0.5691**	-0.3407	0.1824	-0.1386	0.016	0.0644	-0.1793
HI	70			-0.4781*	-0.2857	-0.3082	0.226	-0.259	-0.1054	-0.2691	-0.3314	-0.1566
	90			0.1579	-0.0829	-0.541*	-0.3192	0.1606	-0.1286	0.0279	0.0767	-0.1928
B100	70				-0.0622	-0.027	-0.3186	-0.2549	0.3609	0.1617	0.1934	0.2895
	90				-0.0701	0.099	-0.4512	-0.1327	0.0244	-0.479*	-0.462*	-0.0642
CL	70					0.5061*	0.088	0.5015*	0.1339	-0.117	-0.121	0.3056
	90					0.3682	0.411	0.7961**	0.2686	0.3804	0.3177	0.1762
CD	70						0.5003*	-0.009	0.4758*	-0.2348	0.2293	0.4665*
	90						0.4767*	0.0968	0.1291	0.2587	0.0728	-0.0249
NRC	70							-0.1659	0.3598	-0.4203	-0.0114	0.0761
	90							0.2855	0.1866	0.7484**	0.5439**	0.0555
NSR	70								-0.1919	0.2827	0.2192	-0.2576
	90								0.2322	0.3476	0.222	0.2008
PH30	70									0.1082	0.4131	0.5291*
	90									0.3197	-0.0298	0.4127
PH100	70										0.7624**	-0.1356
	90										0.8398**	-0.0246
CPH100	70											0.036
	90											-0.0584

Description: PROD : production, BIO : Biomass, HI : Harvest Index, W100: weight of 100 seeds, CL: Cob Length, CD : Cob Diameter, NRC : Number of Row per Cob, NSR: Number of Seed Row, PH30: Plant Height at 30 DAP, PH100: Plant Height at 100 DAP, CPH: Cob Position Height at 100DAP; LAI : Leaf Area Index

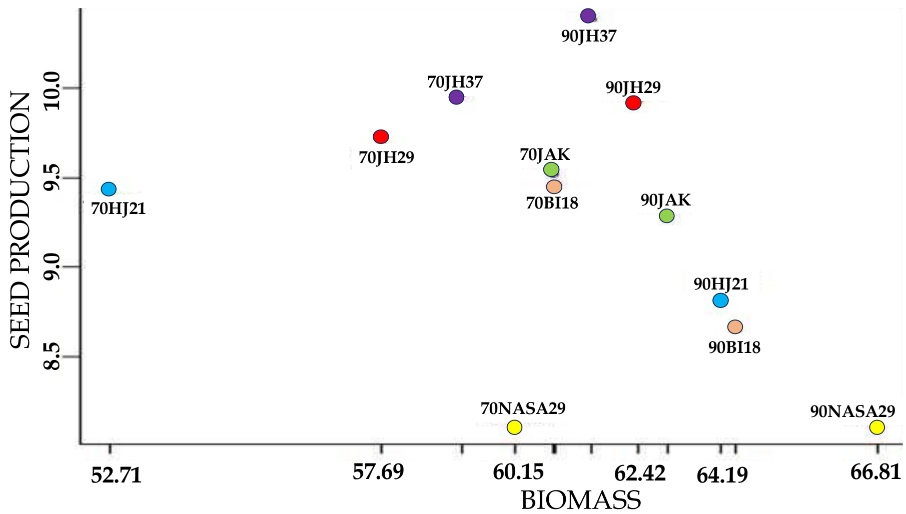

Figure 1. Correlation between seed production and biomass in two planting space systems using new improved maize varieties.

A negative correlation value between two characters indicates that the two characters have opposite activities. A high correlation value indicates how many varieties have characters whose action is opposite. The correlation of important characters between biomass and production showed that the correlation value was 58%, indicating that mostly tested varieties had opposite character actions (Table 4).

The two-way picture of the relationship between production and biomass characters with 2 planting space systems, showed that the JH 37 and JH 29 varieties experienced an increase in seed production and biomass simultaneously with the expansion of planting distances. In contrast, the Jakarin, Bisi and HJ 21 varieties experienced an increase in biomass and a decrease in production simultaneously with the increase in spacing, while Nasa 29 variety increased spacing only caused an increase in biomass with a fixed seed production (Figure 1).

Plant responsiveness to environmental changes is needed to determine the level of plant adaptability, so that plants that are responsive to changes in treatment that are adaptive to the environment. The results of this observation show that the JH 37 and JH 29 varieties are adaptive varieties in drylands that can produce seed optimally with wider plant spacing. The response of both varieties is positive to the increase in plant spacing where the increase in plant spacing increases biomass and production which is the goal in maize production in dry climate drylands such as in West Sumbawa District, NTB. Wide spacing was represented by Legowo system, while narrow spacing was represented by conventional system.

Conclusion

JH 37 and JH 29 varieties were adaptive to be developed in dry climates and dryland areas for seed and biomass production either in narrow or wide planting space systems. Jakarin, Bisi 18 and HJ 21 varieties could be planted in drylands by considering the planting space system for seed or biomass production, while the Nasa 29 variety was not recommended to be planted in drylands area for seed production but could be used for biomass production by considering a wide planting space system such as Legowo system.

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Review : The harvesting process and recent advances on health benefits of white tea

Abstract. The meticulous harvesting process and appropriate post-harvest techniques play pivotal roles in preserving the quality and health benefits of white tea. This careful approach maintains the bioactive compounds such as polyphenols, caffeine, gallic acid, Epigallocationchin (EGC), Epigallocationchin gallate (EGCG), and Epicatechin gallate (ECG), integral to white tea's health benefits. The stability of catechin content in tea plants is greatly influenced by the environment (clone, plant age, leaf age, altitude, temperature, humidity, processing, and pH when storing dry tea). In Indonesia, the raw materials used to produce white tea are mostly pecco from the superior GMB clone Assamica variety which has high polyphenol content (14.83 – 15.43% dry weight). To increase polyphenol levels, the treatment that needs to be considered is the provision of optimum and appropriate fertilizer. The highest catechin content comes from plucking in summer and spring season. Subsequently, controlled post-harvest processes, including controlled withering and drying, safeguard the integrity of active compounds like catechins as antioxidants in white tea, mitigating free radicals and cellular damage. The highest antioxidant showed from 23 hours whithered. The storage time for white tea also has an impact on quality. The content of catechins and amino acids showed a tendency to decrease with storage time. On the other hand, gallic acid increases with the length of storage. The combined effect of these phases, from harvesting through post-harvesting, contributes significantly to white tea's health benefits, encompassing cardioprotective effects, anti-diabetic potential, prevention of anticarcinogenic and antimutagenic activity, neuroprotective properties, and antimicrobial attributes.

Keywords: Antioxidant · Bioprospecting · *Camellia sinensis* · Health · White Tea

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Introduction

Tea is one of the beverages with sensory properties, stimulant effects, and a health impact. Those benefits make tea the second largest beverage after mineral water (Dias et al., 2013). A large amount of tea consumption can be reflected in its production and consumption value, which reaches three billion kilograms annually, where most of the production supply is produced from Southeast Asia (Hayat et al., 2015). Not only the taste and aroma, the antioxidant content of tea which has many benefits for the body is a consideration for people when consuming it (Hajiboland, 2017). Tea has potential as a source of antioxidants and contains more than 700 chemical compounds, such as flavonoids, amino acids, theanine, vitamins (B, C, E, and K), caffeine, polysaccharides, and catechins. The most widely studied positive role of tea for human health includes normalizing blood pressure, lowering blood cholesterol levels, fighting cardiovascular disease, cancer, diabetes mellitus, obesity, central nervous system and microorganism-based diseases (Sanlier et al., 2018; Shao et al., 2019; Sharma et al., 2013).

The raw material for shoots greatly influences the quality of the tea produced. Quality tea comes from 2-3 young leaves and a bud. This part of the plant is rich in polyphenolic compounds, caffeine, and amino acids that affect the quality of the taste, aroma, and color of the tea produced. Today's popular tea types are green, oolong, black, and white (Ajisaka & Sandiantoro, 2012).

There are two groups of well-known tea varieties: the first one is the Assamica variety from Assam (India) with large leaves, and the second one is the sinensis variety originating from China with small leaves (Wachira et al., 2013). Most tea plants cultivated in Indonesia are hybrids of natural crosses between Assam tea and Sinensis tea with an Assam-type tendency. Considering that the most significant tea production in Indonesia is black tea and planters require high plant productivity, the tea clones recommended by the Indonesia Research Institute for Tea and Cinchona (RITC) are Assam-type clones (Sriyadi, 2011).

The simplest processing method is applied to white tea, consisting solely of extended drying and withering operations without any fermentation or enzyme deactivation stages. (Dai et al., 2017, Tan et al., 2016). White tea is processed naturally through withering and drying with the help of wind and sunlight immediately after the plucking process is carried out, without undergoing any oxidation fermentation processes or grinding so as not to damage the actual shape of the tea (Tohawa, 2013). The raw material for making white tea consists of 2 types, namely shoots (*Camellia sinensis*) that are still curled, called pecco, and shoots with one or two young leaves, called peony. White tea comes from tea shoots that are still buds, small in size, and have white hairs commonly called silver needle (Hajiaghaalipour et al., 2015). Dried tea leaves can contain around 30-42% polyphenolic compounds in the form of catechins (Bag et al., 2022; Rabbani et al., 2019). The stability of catechin content in tea plants is greatly influenced by the environment, such as clone, plant age, leaf age, altitude, temperature, humidity, processing, and pH when storing dry tea (Zeng et al., 2018). White tea has a variety of content that is beneficial to health, including polyphenols, caffeine, theogallin, gallic acid, theaflavins, flavonol glycosides, epigallocatechin (EGC), epigallocatechinalatine (EGCG), and epicatechinalatine (ECG) (Islam, 2011). The strong antioxidant activity of white tea is largely due to its high content of EGCG, ECG, and EGC as these catechins represent approximately 80-90% of the total catechins in tea leaves (Lee et al., 2014).

The chemical compounds in tea leaves consist of three major groups with many health benefits: polyphenols, caffeine, and essential oils. The substances contained in tea are very easily oxidized. The oxidation process occurs when tea leaves are exposed to sunlight (Ajisaka & Sandiantoro, 2012).

This review describes white tea's production process, chemical content, and health benefits. Thus, it is expected to provide information about white tea and its potential as antioxidant bioprospecting.

Subject Matter

White Tea Benefits for Health. Tea contains several bioactive compounds which are believed to have various physiological properties, including stimulant and antidepressant, anti-inflammatory, antioxidant, antiatherosclerotic, antihypertensive, anti-infective, antimutagenic, anticarcinogenic and anticancer promoting antimicrobial, hypolipidemic, hypocholesterolemic, neuroprotective, and antidiabetic agents. Tea also enhances the immune. This physiological mechanism is attributed to the chemical properties of polyphenols and their healthful antioxidant effects, even though it's still controversial. Despite the abundance of data on the phenolic constituents, antioxidant activity, and ameliorative effects of green and black teas on health, the information on white tea is still less discoverable, which is the rarest and least processed tea (Dias et al., 2013).

Tea leaves contain 30-40% polyphenols, most of which are known as catechins. Pecco shoots produce highest catechin content varying between 8.36%-18.22% between other parts of the leaf. The catechin content in other parts of the leaves are first leaf between 5.78%-13.48%, second leaf between 4.43%-15.81%, and internodes + stalk leaves between 1.78%-12.15% (Martono & Setiyono, 2014). The catechin content in white tea makes white tea a functional drink that has benefits for the body compared to other types of tea.

Catechin is a component that determines the quality of tea leaves which is colorless, soluble in water, and can influence the taste, color and aroma of tea (Anjarsari, 2016). Catechin is a bioactive compound with a flavan-3-ol framework which is a strong antioxidant, stronger than glutathione, vitamin E, vitamin C, and β-carotene (Grzesik et al., 2018, Sutarna et al., 2013). Tea-derived catechins exhibit remarkable antioxidant activity due to their ability to neutralize free radicals and increase the activity of detoxifying enzymes, including glutathione peroxidase, catalase and glutathione reductase (Kochman et al., 2020). In the body, catechins help the performance of the superoxide dismutase (SOD) enzyme which functions to get rid of free radicals (Martono, 2015). The main catechin group compounds consist of 8 types, including: catechin (C), epicatechin (EC), gallocatechin (GC), epigalocatechin (EGC), catechin gallate (CG), epicatechin gallate (ECG), gallocatechin gallate (GCG), and epigalocatechin gallate (EGCG) (Sang et al., 2011). Among this group of catechins, EGCG is present in the largest number and has been carried out in many health studies (Xing et al., 2019). One of the characters that indicates catechin content can be seen in the astringent and bitter taste of drinks with significant correlation values (Xu et al. 2018). Meanwhile, morphological characters also indicate the compound content in tea. Morphological characters that are significantly correlated with catechin content are stomata density and leaf angle (Khomaeni, 2015).

White tea contains more catechins and their derivatives than any other tea. The epigallocatechin gallate (EGCG) component of white tea positively affects health. White tea protects against cardiovascular disease, cancer, diabetes mellitus, obesity, central nervous system, and microorganism-based diseases (Sanlier et al., 2018).

a. Cardioprotective Effect. Natural antioxidants, such as polyphenolic compounds from food, can inhibit lipid oxidation and weaken the rate of atherosclerosis and thrombosis. An epidemiological study showed that populations in Europe with higher concentrations of natural antioxidants, L-ascorbic acid, and -tocopherol in plasma had lower cases of coronary heart disease. Several epidemiological studies have shown that flavonoid intake is inversely related to coronary heart disease mortality. Tea catechins effectively reduce cholesterol absorption from the intestine, lower cholesterol solubility, and increase fecal excretion of cholesterol and total lipids. Other components of tea, especially quercetin and L-theanine, reduce blood pressure in animals and humans and lower the risk of disease development (Kobayashi & Ikeda, 2017; Yoo et al., 2020; Chen et al., 2020).

b. Antidiabetic. There is some evidence that tea is a hypoglycemic agent. In-vitro studies of mice show that EGCC of other catechins and theaflavins helps prevent hyperglycemia by increasing insulin activity and possibly by preventing cell damage. All studies show that polyphenols do not increase insulin secretion but reduce insulin resistance and improve insulin sensitivity (Liu et al., 2021, Manhas & Khan, 2022).

c. Anticarcinogenic and Antimutagenic.The polyphenols in tea play an essential role in cancer prevention by reducing DNA damage in cells and reducing cancer activation leading to malignancy (Majidinia et al., 2019). Many studies have shown that tea and its constituents, particularly EGCG, are antimutagenic and anti-inflammatory by intercepting carcinogenic agents and reducing oxidant species before damaging DNA (Shariare et al., 2020).

d. Neuroprotection Activities. Isolated tea constituents have previously been shown to

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exert a protective effect on nerve cells. For example, EGCG has been shown to have neuroprotective activity in experiments using mice, and an epidemiological study showed that the risk of Parkinson's disease was reduced when tea consumption was 2 cups/day (Pervin et al., 2018; Luo et al., 2021).

e. Antimicrobial Properties. Tea also exhibits antimicrobial properties, mainly due to its polyphenols. The level of this activity depends on the bacterial species and the polyphenol structure. Due to differences in the outer membrane, gram-negative bacteria are more resistant to polyphenols than gram-positive bacteria. The antimicrobial activity of non-fermented teas is higher than that of semi-fermented or fermented teas. In addition, the most increased antimicrobial activity occurred in samples with the highest total polyphenol concentration and antioxidant activity. Thus, white tea is expected to have higher antimicrobial activity than other teas. The main components responsible for antimicrobial activity are EGCG and EGC, which also have more antioxidant activity. EGCG at 10–100 M has been shown to reduce the growth of Escherichia coli by about 50% (Dias et al., 2013).

World Tea Production. Based on annual bulletin data (International tea committee, 2022) Indonesia is the 6th tea producing country in the world, namely 127.00 M.Kg. The largest tea producing country is still occupied by China 3063.15 M.Kg, then second by India 1343.06 M.Kg and respectively Kenya 537.83 M.Kg, Sri Lanka 299.34 M.Kg and Vietnam 180.00 M.Kg. In Indonesia, the largest production is black tea, followed by green tea production. White tea production in Indonesia is still small, there is no clear data that shows the amount because white tea production is limited in each tea plantation so white tea consumers are still quite limited.

White Tea Production. White tea comes from the tea plant (Camellia sinensis), like green and black tea. White tea is made from very young and un-bloomed Camellia sinensis leaf buds, commonly called pecco. The pecco was still covered with fine silver-white hairs, giving the impression of a velvety white color, with a needle-like shape commonly called silver needle. Apart from that, white tea can also be made from shoots with one or two young leaves, called peony. The ideal time and weather for plucking white tea is early morning when the sun is high enough to dry out any remaining moisture on the buds. Plucking is not done on rainy days or during the snow season (Zhao et al., 2019). The highest catechin content comes from plucking in summer and spring season (Paiva et al., 2021; Ma et al., 2022).

White tea is often plucked in the morning when the humidity is still high (Maulana et al., 2019). To avoid the tea leaves breaking, this process is carried out very carefully. To retain the flavor and aroma of white tea, the leaves should be selected which not fully opened yet (Braber et al., 2011). In addition, plucking white tea at the right time, especially at certain growth phases, can affect the number of bioactive substances contained in tea (Kaur et al., 2019). Tea farmers play a very important role in this situation.

Based on the data of tea plantation division of Research Institute for Tea and Cinchona (IRITC), white tea production in Indonesia is usually made from pecco which produces silver needle. A case study conducted at IRITC as the biggest white tea producer in Indonesia, shows that the raw material for white tea production is taken from Pecco, which is then sorted into several variants when the raw material arrives at the factory. Not all of the pecco raw materials plucked from the garden will become silver needle. For pecco that is still a complete needle and has not been opened, it will be a silver needle grade. Meanwhile, for pecco that has opened it is called white leafy and the sorting results for pecco that are plucked and then open into shoots that have one to two young leaves are classified as white peony. Another type of white tea is when silver needles are combined and pressed into a round pearl shape, it is called white pearl tea. Based on data taken from white tea production at IRITC during September 2018-August 2023, pecco production as a raw material for white tea ranges from 7-10 kg per hectare depending on the season. White tea processing has an average processing yield of 25% so it will produce 1.75 - 2.5 kg of dry tea/ha. Pecco plucking is done manually and the pluckers is required to be skilled and have expertise in plucking.

In China, the withering process of white tea varies depending on region. Sometimes, the plant must be shaded a month or more before the shoots are plucked to produce white tea, so it has lower levels of chlorophyll and higher polyphenol antioxidants but is very low in caffeine. The lack of processing in white tea makes white tea a premium health tea with the highest polyphenol antioxidant content of all tea types (Tohawa, 2013). In Indonesia, the raw materials used to produce white tea are mostly pecco from the superior GMB clone Assamica variety which has high polyphenol content, namely (14.83 - 15.43% dry weight). Polyphenols in tea are responsible for the formation of tea color, taste strength, and partly for flavor in the beverages and further benefits health. In an effort to increase polyphenol levels, the treatment that needs to be considered is the provision of optimum and appropriate fertilizer (Maulana et al., 2020; Rezamela et al., 2020).

Tohawa (2013) said that in producing quality white tea, the processing is a stage that needs to be considered. Not only does it produce a delicious taste, aroma and brew, but good processing can also maintain the antioxidant compounds in the raw materials of white tea so that it can produce white tea that brings optimum benefits to the body. White tea processing does not go through a fermentation step, the same as oolong or black tea. The process is without deactivating enzymes like green tea. White tea only goes through decolorization and drying. To prevent oxidation, the tea` leaves were immediately evaporated and dried after collection (Sanlier et al., 2018).

White tea processing usually only goes through two stages: withering and drying. Sometimes, the same processing methods as sun drying can be considered as withering and drying. The earliest processing method was sun drying (Maulana et al, 2020). Sun withering increasing the concentration of flavone glycosides and astringent flavonoids in white tea (Zou et al., 2022). Modern white tea can be produced through sun drying, airing, and basket frying. Although the modified withering is better than natural withering (Chen et al., 2012). White tea can be produced in spring, summer, and fall but not in winter. Usually, spring white tea is of premium quality, followed by autumn white tea. The ideal time and season for plucking is in the morning when it is summer, and the sun is high enough to dry out and reduce moisture in the tea shoots (Dias et al., 2019; Jenny & Mao, 2013).

The Silver needle white tea processing process includes the plucked tea shoots being immediately brought to the white tea processing plant and placed on an aluminum tray for the withering process (Maulana et al., 2020). Withering tea shoots in the sun from 11 a.m. to 3 p.m. and continues overnight indoors. The processing step was repeated for four days. In the last step, it is dried in an oven at 60°C until the moisture content obtained by the product is 3-4%. The tea samples were packed in aluminum foil and stored in a room with a relative humidity (RH) of 60%.

White peony tea is processed in two simple steps: withering and drying (Jiang, 2009). Withering is the key that determines the final quality of white tea. There are usually three withering methods for white peonies: sun withering, drying, and low-temperature withering. Drying is the most widely used method for White Peony. The spring drying requirements are 18-25°C, and the relative humidity (RH) is 67-80%. Typically, temperatures of 30–32°C and RH of 60–75% are more acceptable for drying in summer and autumn. Drying time is usually 52-60 hours (Jenny & Mao, 2013).

The white peony tea processing processes include plucking 1-2 leaves and a bud, sorting, withering at a temperature of 27°C for 20 hours on a winnowing tray and arranging on a withering rack, aerated with a fan to make air circulation smoother and temperature regulation with Air Conditioner (Ulandari et al., 2019). Furthermore, it withers back with indirect sunlight for approximately one hour until a distinctive aroma appears on the tea leaves. The tea leaves are steamed at 90°C for 2 minutes, then re-aired until cold. Rolling with the Top Roller (TR) machine for 5 minutes until the tea leaves roll perfectly. They were dried in an oven at 90°C. This drying process causes white peony tea to have a moisture content of 4-5%. The drying process was carried out for 60 minutes at a temperature of 90°C.

Long-time withering is the key process for the manufacturing of white tea and the dynamic changes of the characteristic metabolites. The white tea that produced from withering a bud in 96 hours observation indicated the oxidation reaction still running after plucked. Despite the minimum processing step of white tea manufacturing, total polyphenols of the leaves are decreasing, whereas a small amount of theaflavin detected and reducing but thearubigin detected in the experiment are increasing (Maulana et al., 2020).

During withering, the content of tryptophan, histidine, isoleucine, lysine,

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phenylalanine, proline, leucine, valine, and tyrosine significantly increased. The level of glutamic acid and aspartic acid also decreased significantly, especially during the first 20 hours of withering. The highest antioxidant showed from 23 hours whithered (Paiva et al., 2021). After 36 hours of withering, almost half of their content was lost. During the withering process, the levels of the metabolites, which included theaflavins, theaflavins 3-gallate, theaflavins digallate, theasinensin A, and theasinensin B, significantly increased. The dimeric catechin metabolites included flavonol-O-glycosides and flavone-C-glycosides, and their fold changes reached up to 15. The levels of the methylated catechins of EGC 3-methylgallate and EC 3-O-(3-O-methylgallate) catechins. The predominant metabolites in the group were flavonol-O-glycosides and flavone-C-glycosides, and they remained quite stable. Over the course of the first 28 hours, the levels of methylated catechins of EGC 3-methylgallate and EC 3-O-(3-O-methylgallate) increased, and between 28 and 36 hours, they slightly declined. Procyanidins, benzyl primeveroside, linalool primeveroside, and linalool oxide primeveroside, as well as metabolites such as catechins of GC, GCG, C, EGC, and EC, all saw a considerable drop during the withering process. Compared to the original composition in fresh leaves, less than 50% of the GC, GCG, and C content was retained in the finished white tea product. After the 36-hour withering process, the tea leaves contained between 59 and 90% of the fragrance primeverosides (Dai et al., 2017).

The storage time for white tea also has an impact on quality. The content of catechins and amino acids showed a tendency to decrease with storage time. On the other hand, gallic acid increases with the length of storage (Ning et al., 2016).

Conclusion

White tea is a functional drink that has benefits for the body compared to other types of tea. The meticulous harvesting and precise post-harvesting practices profoundly influence the quality and health-enhancing properties of white tea. The careful selection of leaves pecco and one or two young leaves, called peony, harvested during optimal atmospheric conditions and specific growth phases, ensures the retention of vital bioactive compounds like polyphenols and catechins, Epigallocationchin (EGC), Epigallocationchin gallate (EGCG), and Epicatechin gallate (ECG). The stability of catechin content in tea plants is greatly influenced by the environment, such as clone, plant age, leaf age, altitude, temperature, humidity, processing, and pH when storing dry tea. In Indonesia, the raw materials used to produce white tea are mostly pecco from the superior GMB clone Assamica variety which has high polyphenol content, namely (14.83 – 15.43% dry weight). To increase polyphenol levels, the treatment that needs to be considered is the provision of optimum and appropriate fertilizer. The highest catechin content comes from plucking in summer and spring season. Moreover, the controlled post-harvest processes, such as withering and drying, preserve these compounds, notably catechins, known for their antioxidant properties among 8.36% -18.22%, shielding the body from free radical damage. The highest antioxidant showed from 23 hours whithered. The storage time for white tea also has an impact on quality. The content of catechins and amino acids showed a tendency to decrease with storage time. On the other hand, gallic acid increases with the length of storage. The cumulative effect of these practices underscores white tea's multifaceted health benefits, including its potential in cardioprotection, diabetes prevention, anti-carcinogenic and antimicrobial activities, neuroprotection, and more.

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The effectiveness of garlic extract against *Spodoptera litura* on chili

Abstract. *Spodoptera litura* is a polyphagous pest and attack many families of cultivated plants, such as chili plants. Application of synthetic pesticides is still the mainstay for controlling this pest in the field. To support eco-friendly plant protection management, it is important to explore potential natural materials such as garlic extract. This research aims to determine the potential of garlic extract in controlling *S. litura* on chili plants, and to see its indirect effect on chili yield. The research was carried out in two sites, in the laboratory and the field. The experiment used a completely randomized design with 6 treatments and 4 replications. The concentrations of garlic extract, i.e., control (0%), 24%, 26%, 28%, 30%, and 32%. The results showed the application of garlic extract had a significant effect on the mortality of *S. litura*, the frequency of attacks, and the intensity of pest attacks in the field, and had an effect on the variable number of fruit and fruit weight of chili plants. The LC_{50} and LC_{90} values reached 19.66% and 29.97% in the laboratory, and 28.30% and 34.3%% in the field, respectively. The LT_{50} and LT_{90} values from the 32% garlic extract in the laboratory were respectively 3.37 and 7.23 days. The application of garlic extraction affected growth and yield, i.e. healthy leaves, number of fruits, and weight of fruits in chili. The garlic extract is potentially used as an organic pesticide to suppress the *S.litura* attacks while keeping the plant's growth and yield.

Keywords: Eco-friendly · Garlic · Organic pesticide · Pest · *Spodoptera litura*

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Introduction

Spodoptera litura, commonly named armyworm, is one of the main pest on several crops in Indonesia. This is a polyphagous insect, which attacks many types of plants from various family. Spodoptera's life cycle ranges from 29-32 days; 5-6 days of imago, the egg hatches on 3-4 days, the growth period of larva from instars 1st to 6th are around 12-15 days, then the pupa stage lasts about 7 days before hatching into an imago. A mated female imago produces thousands of eggs during her life (Fattah & Ilyas, 2016; Lestari et al., 2013). The difference of Spodoptera's life cycle affected by the types of host plants (Xue et al., 2010). Narvekar et al., (2018) reported that imago longevity maximum of 8 days in castor and sweet potato, while the total development period was significantly high in tapioca for 37 days. In chili, the population of Spodoptera (3.67 larvae/plant) appeared after 13 weeks after transplanting seed and the peak reached on 17 weeks after transplanting (Saini et al., 2017). The early and massive attacks of *S. litura* on chili plant affect the chili productivity.

Chili (*Capsicum annum*) has the highest productivity after shallots, potatoes and cabbage in Indonesia. In 2022, the national chili production was recorded at 1.5 million of tons with productivity reaching 8.36 tons per hectare. The consumption of chili reaches 636,560 tons on a household scale, out of food industry and processing (Statistics Indonesia, 2022). However, the low productivity of chili has a much greater effect caused by *S. litura* on chili cultivation because it attacks leaves and obstructs the growth and development of chili (Cahyono et al., 2017). In 2017, Technology Assessment and Application Agency stated that *S. litura* plays the main cause of many chili plants dying and crop failure (Cahyamurti & Purwanto, 2021). *S. litura* larval decrease the productivity of chili up to 35% (de Freitas Bueno et al., 2011) thus, pest management is needed to control the *S. litura* attacks.

S. litura becomes a major pest for chili plant. For controlling this pest, farmers of Jamalpur region are frequently spraying insecticides without any pre-harvest interval causing pest resistance, resurgence and environmental health hazard. Resistance to different insecticides of *S. litura* caused sporadic out breaks of the pest and serious crop damage (Mannan & Rahman, 2020). However, the use of synthetic pesticides is still the main control measure, it is necessary to look for alternative materials for control to better support a better and more sustainable cultivation system by implementing an integrated plant protection pattern as stated in the Republic of Indonesia Law No. 22 of 2019.

Garlic extract has the potential to use as an organic pesticide. The extract prevent the negative effects of abiotic stress on plants, as well as playing a role in controlling biotic stress, both from pest groups and microorganisms cause plant diseases (Rinaldi et al., 2019; Golubkina et al., 2022). Several research proved the potential of garlic extract as an organic pesticide for controlling plant pest organisms include research results from Moniharapon and Nindatu (2015) which show the ability of garlic extract to control the pest *Crocidolomia binoltalis*. The results of other research conducted by Irfan (2010) showed the ability of garlic extract to control plant rot caused by bacterial attacks. Another potential of garlic extract, except being able to control insect pests as well as repellent to birds that attack rice (Hardiansyah et al., 2020). This research aims to find out how effective garlic extract is in controlling the *S. litura* pest, which is one of the pests that often attack chili plants.

Materials and Methods

The research was conducted from June to September 2022 at Plantation Seed Production and Development, Bandung, and Integrated Laboratory, UIN Sunan Gunung Djati, Bandung. The materials used were chili seeds, *S. litura* larva, garlic, planting media (soil and husk charcoal), organic fertilizer, and NPK fertilizer.

The research design used a Randomized Complete Block Design with various garlic extract concentrations as the treatments and 4 replications:

P0 : 0 % garlic extract
P1 : 24% garlic extract
P2 : 26% garlic extract
P3 : 28% garlic extract
P4 : 30% garlic extract
P5 : 32% garlic extract

The observed variables divided into field and laboratory works. Mortality worked for field and laboratory; accelerated death rate, attack frequency and intensity of leaf damage worked in field, and yield parameters (numbers of fruit per plant and weight per fruit).

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Mortality of *S. litura* observed in 24 hours after application for 7 days in laboratory and for 4 days in the field. The death larva calculated:

$$M = \frac{a}{N} x100\%$$

M = Mortality percentage
a = Numbers of death larva
N = Numbers of observed larva

Accelerate Death Rate

$$V = \frac{T1N1 + T2N2 + T3N3 + \cdots + TnNn}{n}$$

V = Accelerate of death rate
T = Time of observation
N = Numbers of death larva
n = Numbers of observed larva

Attack Frequency in the field observed for 4 days every 24 hours and calculated:

$$FS = \frac{X}{Y}\, x\; 100\%$$

FS : Attack frequency
X : Numbers of affected plant leaves
Y : Numbers of observed plant leaves

Classification of pest attack according to percentage of attack frequency:
<10% : Very low
10-50% : Low
51-75% : Moderate
>75% : High

Intensity of damaged leaves was the level of damage to leaves caused by *S. litura*. The observation worked for 4 days after application. The calculation of intensity of damaged leaves using:

$$IK = \sum [\![((ni \times vi))/(z \times n) \times 100\%]\!]$$

IK = Intensity of damage
Ni = Number of sample plants –i with certain score
Vi = Score of each sample plant -i
n = Numbers of all sample unit
z = Highest score used

The score of IK leaves:
0 : No attack
1 : Intensity of damage 1-25 %
2 : Intensity of damage >25-50 %
3 : Intensity of damage >50-75 %
4 : Intensity of damage >75 %

Intensity of damage category according to Directorate of Food Crop Protection (2018)
<= 25% = Light
>25<=50% = Moderate
>50<=85% = Heavy
>85% = Puso

Larval Rearing of *S. litura*. Larva used in the research was instar 3 larva from the second stage of rearing in laboratory. The larva-fed chili leaves are pesticide-free during the rearing. The larva fed in boxes, during the pupa stage, the larva provided sterile sawdust to grow as a pupa. The hatched pupa grew into imago, and was fed by honey solution 10% (v/v) and provide fresh leaves as the media to lay the eggs. The egg hatched inside the plastic box until reaching instar III and the larva was ready to be invested.

Garlic Extraction . Garlic extraction was made by grinding the garlic using a blender machine and adding water to reach the concentration of each treatment. The extract was left for 48 hours and got strained. The strain product was the final extraction to be applied.

Application of Garlic Extract. The garlic extract was applied by physical method for laboratory works. The larva was invested in as many as 10, sprayed by the extract, and fed by chili leaves for each treatment and replication in a petri dish (ø 9cm). First, the leaves were weighed to get the initial weight of feed then be replaced every 24 hours, and were weighed for final feeding to get the eating reduction calculation.

Garlic extract application in the field was applied 67 days after planting. Pesticide was applied in each treatment and replication. Each treatment x replication consisted of three plants. As many as 5 larva instar III was invested in the leaves and sprayed by each treatment. The plants were covered using a covering cloth sized 30 x 20 x 60 cm^3).

Data Analysis. The collected data tested homogeneity using DSSTAAT software. The post-hoc test used Duncan Multiple Range Test (DMRT) on 95%. The mortality data calculated on lethal concentration LC_{50} and LC_{90} from each treatment using regression from http://14.139.232.166/Probit/probitanalysis.html.

Results and Discussion

Mortality. Laboratory works for 7 days showed the significant effect of the garlic extraction to the *S. litura* mortality. The garlic extract concentration of 32% produced a mortality response of up to 100%. However, other results show that giving 28% extract can be a more efficient treatment to apply because the results of data analysis and post-hoc tests show that the 28, 30, and 32% treatments provided a mortality response that is not significantly different. Meanwhile, the highest mortality observed in the field was in the 30 and 32% treatments with mortality that was not significantly different between the two (Table 1). The garlic extract has a high mortality of *S. litura* compared to papaya leaves extract for 47-63% (Rahayu et al., 2023) and betel nut extract for 83.30% (Eri et al., 2014).

The differences in mortality rates that occur in the laboratory and the field were affected by other different environmental factors, which also influence the mortality rate after treatment in the laboratory and field.

Based on the mortality data in Table 1, lethal concentration (LC) values were obtained consisting of LC_{50} and LC_{90}. These values indicate the ability or toxic level of garlic extract applied to *S. litura* larva and killed 50% (LC_{50}) and 90% (LC_{90}) of the total larval population tested. Based on the research results, the LC values obtained for both LC_{50} and LC_{90} in the field were higher than the laboratory test results (Figure 1). This proved that garlic extract applied in the laboratory shows higher toxic levels compared to the field. In addition, Jelita et al. (2020) stated the smaller LC value indicates the more toxic of the extract applied to the object being tested. Another cause that affected the difference in toxic levels between research results in the laboratory and in the field is exposure to sunlight, which most likely accelerates the rate of evaporation of extracts applied in the field. Because in this study the extract was made using water as a solvent, which evaporates relatively quickly compared to other solvents.

Table 1. Mortality of *S. litura* larva after applying garlic extract in laboratory and field.

Treatments	*Laboratory*		*Field*	
	Σ Larva	% Mortality*	Σ Larva	%Mortality*
Control	40	20.0 a	20	5.0 a
24% garlic extract	40	82.5 b	20	20.0 ab
26% garlic extract	40	80.0 b	20	35.0 b
28% garlic extract	40	87.5 bc	20	40.0 b
30% garlic extract	40	90.0 bc	20	65.0 c
32% garlic extract	40	100.0 c	20	85.0 c

Note: (*) Significantly effect of treatments in analysis of variance (5%). Numbers followed by the same alphabet gave non-significant differences at DMRT 5%.

Table 2. Effect of garlic extract application to the death rate of *S. litura* larva

Treatments	Σ Larva	Death Acceleration (head/day)	LT_{50}	LT_{90}
Control	40	0.65	19.01	101.2
24% garlic extraction	40	2.75	3.59	8.44
26% garlic extraction	40	2.825	3.93	9.30
28% garlic extraction	40	3.05	3.40	8.09
30% garlic extraction	40	3.725	3.89	7.17
32% garlic extraction	40	3.725	3.37	7.23

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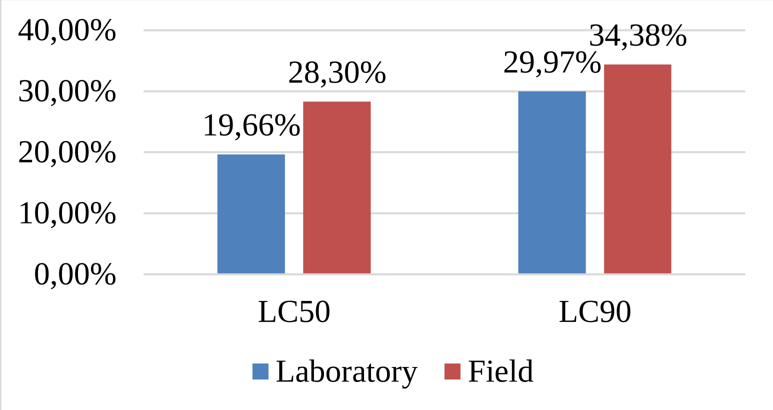

Figure 1. Lethal concentration of garlic extract in *S. litura* larva

Death Rate Acceleration. The results of the rate of death showed that garlic extract had a significant effect on the rate of death of *S. litura* larva in the laboratory. The higher concentration of garlic extract applied, the faster the death rate. The Lethal Time (LT) value consisting of LT_{50} and LT_{90} showed the time required for the treatment to produce a death rate of 50% and 90% of the population. The results of this study showed that treatment in the laboratory with garlic extract with a concentration of 32% resulted in the death of 50% and 90% of the population respectively within 3.37 and 7.23 days (Table 2). the similar toxic level to the fungal culture filtrate, which had the mortality of 96% and 85.33% (LT_{50}) on 7.36 days and 8.09 days, respectively (Gustianingtyas et al., 2020). However, different times of death between treatments given were possible due to the chemical compounds contained in the extract applied. Several compounds in garlic extract were possible to be the active compounds that cause death in the insect larva are allicin and several flavonoid compounds (Sasmilati et al., 2017)

Attack Frequency of *S. litura* in Chili. The application of garlic extract to chili plants significantly had a real effect in reducing the frequency of *S. litura* attacks. The observations made on the fourth day after application of garlic extract to chili plants. Based on the data in Table 3, from the initial observation to the 4th observation after the application of garlic extract, the results showed that increasing the concentration of garlic extract to 32% on chili plants decrease the frequency of attacks by *S. litura* larva. While the highest attack classification in the control was relatively low (< 50%), by a little amount spray of garlic extract could significantly reduce the frequency of attacks to less than 20% for the 30-32% extraction on the fourth day. The results of other research showed similar effect regarding the ability of garlic extract to reduce the frequency of aphid attacks, the higher concentration of the extract decrease the frequency of mealy-bug pests on chili plants (Azizah et al., 2020). Thus, the application of garlic extract is one of the potential organic pesticides to control the *S. litura* larva pest on chili plants.

Table 3. Frequency of *S. litura* attack after application of numerous garlic extract concentration.

Treatments	Percentage of Attacks Frequency*							
	Day 1		Day 2		Day 3		Day 4	
Control	46.99	a	44.58	a	43.24	A	40.37	a
24% garlic extract	35.40	b	36.76	b	37.64	B	30.24	b
26% garlic extract	26.59	cd	33.17	bc	31.87	C	27.63	bc
28% garlic extract	28.16	c	29.01	cd	27.30	D	23.97	c
30% garlic extract	22.09	d	23.83	d	21.84	E	14.23	d
32% garlic extract	15.84	e	13.42	e	14.23	E	13.22	d

Note: (*) Significantly effect of treatments in analysis of variance (5%). Numbers followed by the same alphabet gave non-significant differences at DMRT 5%.

Table 4. Intensity of *S. litura* attacks on chili plant after garlic extract application

Treatments	Intensity of Attacks (%)*			
	1 DAA	2 DAA	3 DAA	4 DAA
Control	30.00 c	33.42 d	33.80 e	38.78 e
24% garlic extract	20.16 b	23.93 c	19.47 d	25.88 d
26% garlic extract	12.20 ab	6.32 a	15.01 c	16.72 c
28% garlic extract	11.91 ab	6.32 a	13.10 bc	13.88 bc
30% garlic extract	12.21 ab	9.72 ab	11.37 b	9.13 ab
32% garlic extract	5,.6 a	6.32 a	6.03 a	6.63 a

Note: (*) Significantly effect of treatments in analysis of variance (5%). Numbers followed by the same alphabet gave non-significant differences at DMRT 5%.

Intensity of S. litura attacks in Chili Plants. The intensity of S. litura attacks on chili plants after application of garlic extract with various concentrations showed that the higher the concentration of garlic extract, up to 32%, resulted in decreasing the intensity of S. litura attacks. The application of garlic extract significantly affect the intensity of S. litura attacks on chili plants. In 4 days after application, garlic extraction of 30 and 32% showed the lowest attack intensity compared to other treatments (Table 4). Table 4 qualitatively showed the effect of applying garlic extract significantly reduce the level of attack intensity from the moderate category (38.78%) in control, to the light category (≤ 25%) in the treatment of 24-32% garlic extraction.

The intensity of plant damage can be effected by several things, including the ability of the pest to cause the damage, the availability of host plants for the pest, the age of the plant or the physiological condition of the plant and the effect of pesticide application in the field (Sudewi et al., 2020). The direct effect of organic pesticide application was on larva mortality, while the indirect effect was the intensity of pest attacks or the intensity of damage to cultivated plants. Cahyamurti and Purwanto (2021) stated the bio-control agent againts S. litura should have a significant effect in leaf damage to the control. Thus, the garlic extraction potentially become the organic pesticide to control S. litura attacks.

Growth and Yield of Chili. Despite of direct effect of garlic extract to S. litura insects, the indirect effect observed to the growth and yield of chili plant. In general, the application of garlic extract had no significant effect on chili plant height. Plant height in each treatment, including the control, showed the similar plant height (Figure 2). Plant height was not affected by the application of garlic extract. It is assumed that the invested larva did not attack the growing point of the chili plant, but attacked only the leaves of the plant, so the garlic extract acted as a fertilizer for the growth of the chili plant.

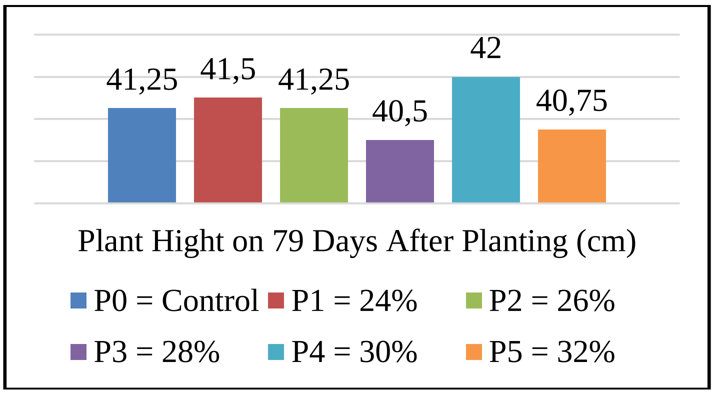

Figure 2. Plant height on 79 days after planting

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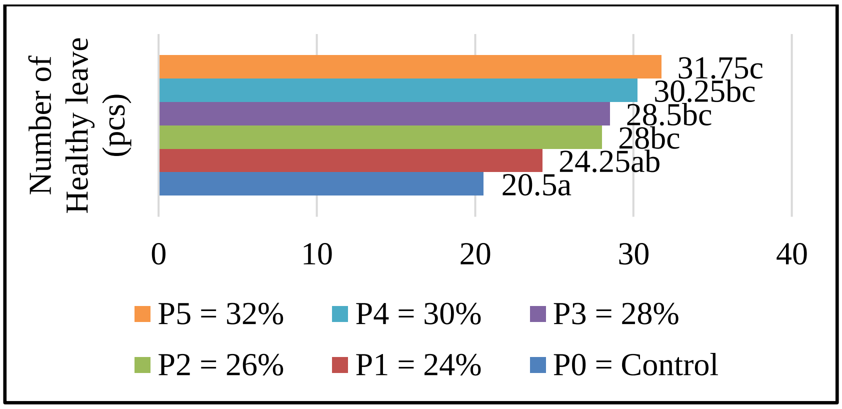

Figure 3. The number of healthy leave (non-attacked) on 79 days after planting

The observation conducted into number of healthy leave (no infection). The application of garlic extract had a significant effect on the number of leave on 79 days after planting. This effect showed in each treatment (26%-32%) while the 24% garlic extract had no significantly different from control (Figure 3). This indirect effect indicates to be related to the intensity of pest attacks on plants. The higher concentration applied, the more decrease intensity of pest attacks, and plant will be able to stand the number of healthy leaves. However, the 36% garlic extract had the number of healthy leaves for 31.75 pcs, while in the control treatment only produced 20.5 pcs.

The results showed that there was a significant effect of garlic extract application to the number of fruit and fruit weight of chili plants. Increasing the concentration of garlic extract had an effect on increasing the number of fruit and average fruit weight. In control treatment, the average number of fruits were only 3.5 pcs, while by 32% garlic extract application produce an average of 16.5 pcs fruits. Nevertheless, the average fruit weight variable, the control only produced 12.96 g, while the 32% of garlic extract application could reach 23.36 g per fruit, twice as high (Figure 4). This might be affected by several observed variables such as mortality, frequency and intensity of pest attacks, which ultimately leads to the growth and development of cultivated plants. Sabaruddin (2021) stated the organic pesticides against *S.litura* attacks and reached the plant height and number of leaves in chili. In addition, the percentage concentration of Neem leaf extract effect on growth of chili plants (Tobing and Mulyaningsih, 2020). It can be concluded that the application of organic pesticides, apart from being able to control pest attacks, can also increase plant growth and yield.

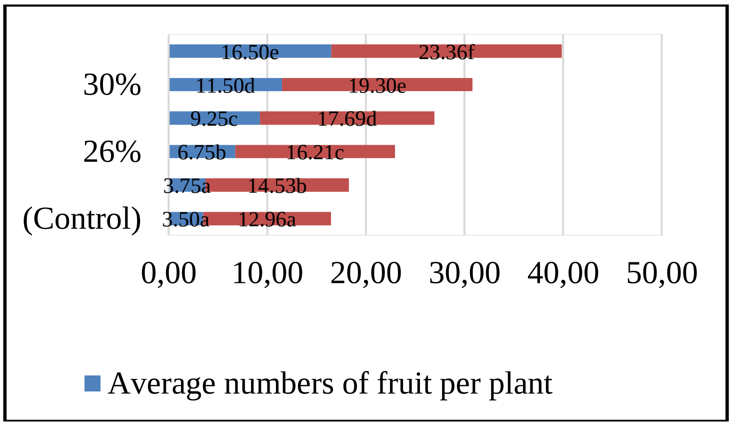

Figure 2. Effect of garlic extract application to the yield of chili.

Conclusion

Garlic extraction controlled *S. litura* in chili cultivation. Increasing the concentration up to 32% increased the mortality and accelerated the rate of death of *S. litura* in both field and laboratory. LC_{50} and LC_{90} reached into 19.66% and 29.97% in laboratory while 28.30 % and 34.3% in the field, respectively. LT_{50} and LT_{90} of 32% garlic extraction in laboratory was 3.37 and 7.23 days. Besides having an effect on *S. litura*, the application of garlic extraction affected growth and yield, such as number of healthy leave, number of fruits and weight of fruits in chili.

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Rahayu S · Saptadi D · Azmi C · Kusumanegara K · Handayani T · Tambunan IR · Bermawie N · Maulana H

Callus induction and proliferation of *Centella asiatica* L. generated from leaves and petioles in the presence of Dicamba and BAP

Abstract. Centella's need for industrial raw materials is high as a medicinal plant. These needs can be met through rapid multiplication using tissue culture techniques. In this study, induction and proliferation for a callus of centella cv. Castina 3 was conducted in the MS basal medium plus 4 mgL^{-1} Dicamba withand enriched with 7 concentrations of BAP (0, 0.1, 0.3, 0.5, 0.7, 0.9, and 1.1 mgL^{-1}). Two kinds of explant were used, i.e., leaf and petiole. The results revealed that the addition of BAP in MS plus Dicamba medim stimulated better and produced a higher callus growth rate, both from leaf and petiole explants, than that media with Dicamba alone. Furthermore, 4 mgL^{-1} Dicamba + 1.1 mgL^{-1} BAP had a friable callus in the induction phase and a friable-compact callus in the proliferation phase. From this finding, it can be considered to use a combination of 4 mgL^{-1} Dicamba with 1.1 mgL^{-1} BAP in callus induction and proliferation for Centella rapid multiplication.

Keywords: BAP · Callus induction · Centella · Dicamba · Proliferation

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Introduction

Centella (*Centella asiatica* L.) is commonly used for medicinal purposes, as this plant is rich in bioactive compounds, which are included in the triterpenoid, such as asiacotide, madecassoside, asiatic acid, and madecassic acid (Prasad et al., 2019; Anam et al., 2023; Diniz et al., 2023). Centella is one of the most important raw materials in the industry of jamu or herbal tonic (Elfahmi et al., 2014; Prasad et al., 2014), medicine (Thuraisingam et al., 2023; Vijayakumar et al., 2023), health-care supplement (Sardrood et al., 2019; Ogunka-Nnoka et al., 2020), and cosmetisc (Subha & Ranjit, 2014; Karlina et al., 2022; Liu et al., 2022; Sari et al., 2022). This leads to the increasing demand for centella from time to time. Unfortunately, few efforts are carried out to cultivate this plant, and to meet industrial needs, as people tend to have this product directly from nature. Continuous harvesting, tends to overexploitation without restoration, that leads to decline this plant in the near future (Kor et al., 2021).

Centella could be propagated *in-vitro* using an indirect regeneration strategy via the callus phase (Rahayu et al., 2016; Gururajan et al., 2021; Luthra et al., 2022). Callus is frequently used in basic research and industrial applications (Kruglova et al., 2023). Apart from producing a large number of seedlings using a piece of original plant (Mohapatra et al., 2021), this technique can be employed as well in culture of calluas and cell suspension to produce secondary metabolites, particularly asiacotide, the principal pharma-cological active component in centella (Ncube et al., 2017; Luthra et al., 2022; Kruglova et al., 2023).

Adding Dicamba to growth media helps the formaction of centella callus, with 4 mgL^{-1} being the optimum dose (Rahayu et al., 2016), even though both the amount and the quality of calli generated remained inadequate. It is assumed that adding cytokinin, such as BAP, will be more effective in creating more calli because this hor-mone is an essential regulator for cell architecture and proliferation (Schaller et al., 2015). The utilization of BAP is predicted to boost the number and quality of calluses. This study evaluated the effect of combining Dicamba with BAP on centella callus production.

Materials and Methods

This activity was carried out in the Center for Standard Testing of Biotechnology Instruments and Agricultural Genetic Resources, Bogor's tissue culture laboratory from August to October 2021. Prior to tissue culture works, stolons were collected from centella plants cv. Castina 3 in the greenhouse and utilized as explants for *in vitro* culture. Stolon surface sterilization was performed with 0.5 gL^{-1} benomyl and 20 gL^{-1} streptomycin sulfate, each for one hour. Continuing sterilization with 70% alcohol, 15.75% sodium hypochlorite, and 10.5% sodium hypochlorite for 5, 7, and 9 minutes, respectively. Afterward, rinse using sterilized distilled water three times. The stolon apical shoots were then isolated and cultured for 5 weeks on MS medium (Murashige & Skoog, 1962) without growth regulators to develop plantlets.

Once the plantlets were fully developed, leaves and petioles were isolated in 0.5 x 0.5 cm and 1 x 0.15 cm, respectively. In the induction of callus, explants in the form of leaves and petioles were then placed on MS media with 3% sugar and pH 5.8, treated with Dicamba (3,6-dichloro-2-methoxybenzoic acid) and BAP then solidified with 0.3% agar. The culture was then incubated at 22°C, 300 lux light intensity, and a photoperiod of 16 hours. The present tratment was a combination of Dicamba and BAP, as follow A : Dicamba 4 mgL^{-1}; B : Dicamba 4 mgL^{-1} + BAP 0.1 mgL^{-1}; C : Dicamba 4 mgL^{-1} + BAP 0.3 mgL^{-1}; D : Dicamba 4 mgL^{-1} + BAP 0.5 mgL^{-1}; E : Dicamba 4 mgL^{-1} + BAP 0.7 mgL^{-1}; F : Dicamba 4 mgL^{-1} + BAP 0.9 mgL^{-1}; G : Dicamba 4 mgL^{-1} + BAP 1.1 mgL^{-1}. A randomized complete design with ten replications was utilized. Observations were made on the percentage of callus induction, fresh weight of callus, rate of callus growth, and color and texture of callus. The rate of callus growth is measured using the following scoring:

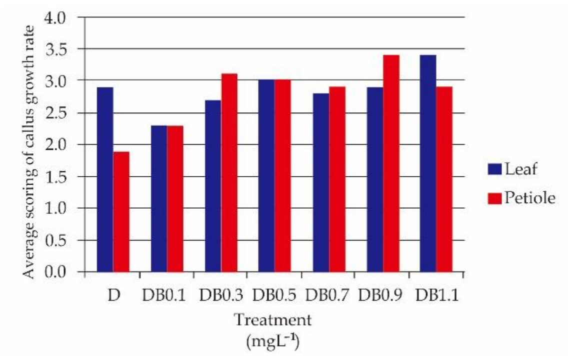
0 = no growth of callus
1 = growth of callus on 1 - 25% of explant
2 = growth of callus on 26 – 50% of explant
3 = growth of callus on 51 – 75% of explant
4 = growth of callus on 76 – 100% of explant

The callus induction was observed four weeks after transplanting, followed by observation in the proliferation phase for the next 4 weeks. Analysis of Variance (ANOVA) was used to examine the acquired data, followed by Least Significant Difference (LSD) at 5% to distinguish between treatments.

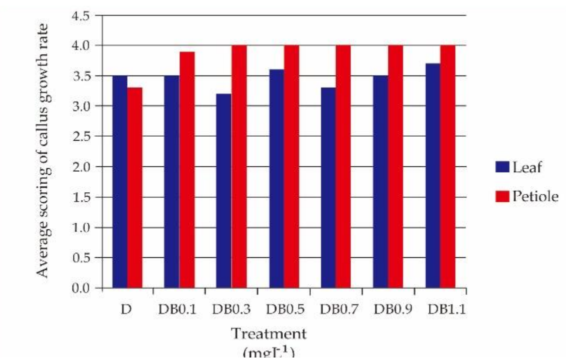
Results and Discussion

In the present study, callus occurred in all treatments after 4 weeks of culture incubation. All treatments affected each parameter observed in both leaf and petioles explants. The addition of 4 mgL^{-1} Dicamba together with BAP to the medium enhanced callus formation and callus fresh weight during the induction and proliferation phases. The callus growth rate, determined by the percentage of callus formation, varied between treatments (Figure 1). In the induction and proliferation phases, callus from petiole explants grown on a medium containing a combination of Dicamba and BAP at all concentrations grew faster than control media (treatment A or only Dicamba). Furthermore, callus originating from petioles grew faster than from leaves during the induction phase in several treatments.

The finding of this study, which indicated that callus originating from petioles grew faster than callus originating from leaves, contradicted the finding of previous research. Usha et al. (2015) discovered that leaf explants were the best for callus induction compared to other plant parts (Usha et al., 2015). The petioles used as explants in this study were obtained from *in vitro* plants, so the cell tissue may still be in a juvenile state. Combining Dicamba, a type of auxin, with BAP, a type of cytokinin, promoted callus growth more effectively than Dicamba alone. This is consistent with previous findings that auxin and cytokinin in the form of BAP encourage callus formation (Anwar & Isda, 2020; Gururajan et al., 2021).



A



B

Figure. 1. The rate of callus growth at induction (A) and proliferation phase (B)

(Treatment: D= Dicamba 4 mgL^{-1}; DB0.1= Dicamba 4 mgL^{-1} + BAP 0.1 mgL^{-1}; DB0.3= Dicamba 4 mgL^{-1} + BAP 0.3 mgL^{-1}; DB0.5= Dicamba 4 mgL^{-1} + BAP 0.5 mgL^{-1}; DB0.7= Dicamba 4 mgL^{-1} + BAP 0.7 mgL^{-1}; DB0.9= Dicamba 4 mgL^{-1} + BAP 0.9 mgL^{-1}; DB1.1= Dicamba 4 mgL^{-1} + BAP 1.1 mgL^{-1})

Table 1. Effect of combination of Dicamba dan BAP treatment on the fresh weight of callus generated from leaf and petiole explant in the induction and proliferation phase

Treatment	Induction phase		Proliferation phase	
	Leaf explant	Petiole Explant	Leaf Explant	Petiole Explant
A	0.252 e	0.130 c	0.578 c	0.380 c
B	0.358 cde	0.208 c	0.791 bc	0.620 c
C	0.294 de	0.301 abc	0.609 c	0.946 b
D	0.521 bc	0.291 bc	0.995 b	0.974 b
E	0.465 cd	0.386 ab	0.963 b	1.045 b
F	0.545 b	0.483 a	1.215 a	1.585 a
G	0.752 a	0.370 ab	1.379 a	1.230 b

Means in the same column followed by the same letter are not significantly different at a 5% level of probability. A combination of Dicamba and BAP, as follow A : Dicamba 4 mgL^{-1}; B : Dicamba 4 mgL^{-1} + BAP 0.1 mgL^{-1}; C : Dicamba 4 mgL^{-1} + BAP 0.3 mgL^{-1}; D : Dicamba 4 mgL^{-1} + BAP 0.5 mgL^{-1}; E : Dicamba 4 mgL^{-1} + BAP 0.7 mgL^{-1}; F : Dicamba 4 mgL^{-1} + BAP 0.9 mgL^{-1}; G : Dicamba 4 mgL^{-1} + BAP 1.1 mgL^{-1}.

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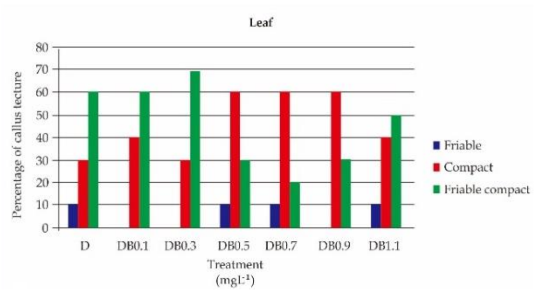
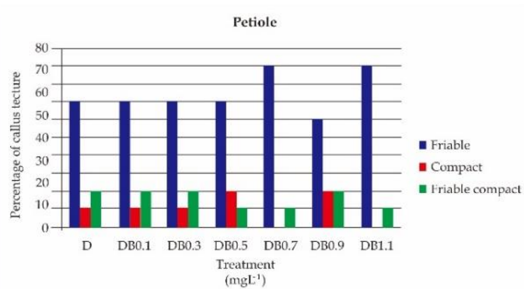
Similarly, there were variations in the fresh weight of the callus between treatments, and the treatment combining Dicamba and BAP (treatments B - G) was significantly different from the control (treatment A) (Table 1). There was even a tendency for increasing the concentration of BAP to increase the fresh weight of the callus. This happened throughout the induction and proliferation phases with all types of explants. Treatment G (Dicamba 4 mgL^{-1} + BAP 1.1 mgL^{-1}) provided callus with the most significant fresh weight for callus formed from leaf explants at both the induction and proliferation stages. Meanwhile, treatment F (Dicamba 4 mgL^{-1} + BAP 0.9 mgL^{-1}) produced the highest fresh weight of callus developed from petioles.

These findings suggest that cytokinin, in this case BAP, significantly affects the induction and proliferation of centella callus. Callus initiation requires the addition of cytokinin and auxin to the growth media, as with other dicotyledonous plants (Schaller et al., 2015; Fehér, 2019). Cytokinin, along with auxin, is known to regulate cell division and morphogenesis (Fehér, 2019). The fresh weight of the callus is particularly essential when it comes to centella as a medicinal plant. Secondary metabolites are abundant in calluses with considerable fresh weight. Apart from that, it facilitates regeneration into plantlets for additional propagation material. However, when large amounts of secondary metabolites are desired, it is necessary to pay attention to the density level of the callus culture, where it is often necessary to subculture to maintain the freshness of the culture as well as to increase the number of cultures (Varshney & Anis, 2016).

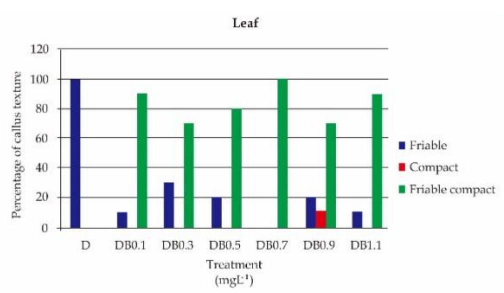
Apart from callus growth, observations were also made on callus morphology, in this case, the texture and color of the callus. The observations' findings revealed variations in texture and callus color among the treatments applied, both throughout the induction and proliferation phases. During the induction phase, the texture of the callus originating from the leaves was friable and friable - compact. However the callus originating from the petiole was dominated by friable texture (Figure 2). Raising the BAP concentration in calluses originating from leaves tended to increase the number of calluses with a compact texture. Meanwhile, during the proliferation phase, the most friable texture was discovered in callus that got only Dicamba treatment (Figure 2).



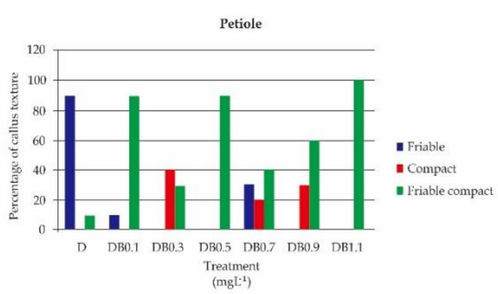
(A)



(B)



(C)



(D)

Figure. 2. The texture of callus generated from leaf and petiole explant in the induction phase (A and B) and proliferation phase (C and D)

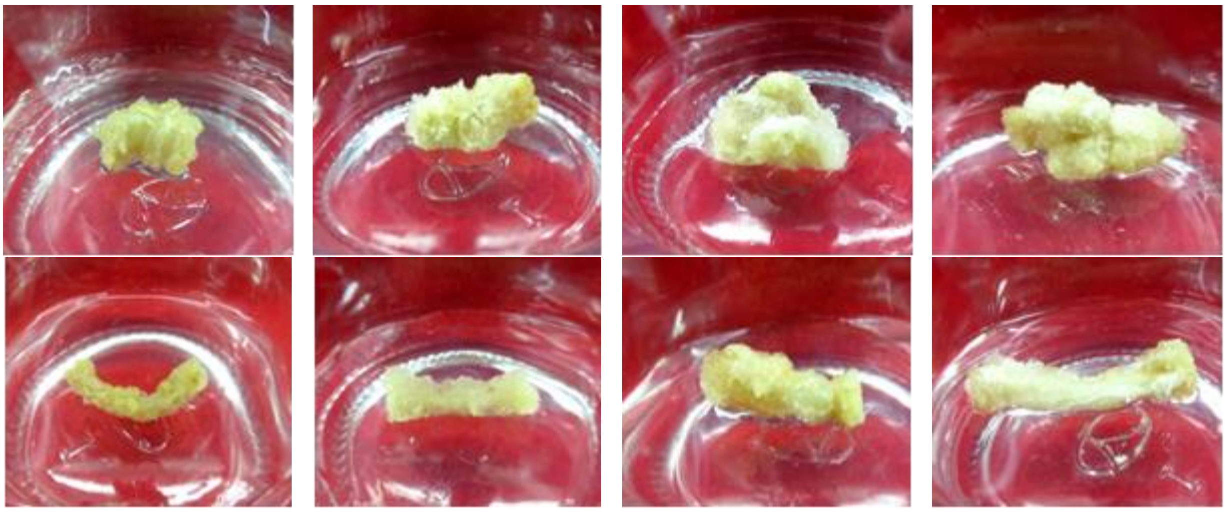
(Treatment: D= Dicamba 4 mgL^{-1}; DB0.1= Dicamba 4 mgL^{-1} + BAP 0.1 mgL^{-1}; DB0.3= Dicamba 4 mgL^{-1} + BAP 0.3 mgL^{-1}; DB0.5= Dicamba 4 mgL^{-1} + BAP 0.5 mgL^{-1}; DB0.7= Dicamba 4 mgL^{-1} + BAP 0.7 mgL^{-1}; DB0.9= Dicamba 4 mgL^{-1} + BAP 0.9 mgL^{-1}; DB1.1= Dicamba 4 mgL^{-1} + BAP 1.1 mgL^{-1})

The combination of Dicamba and BAP treatment produced calluses with a friable - compact texture. This applies equally to calluses resulting from both leaves and petioles. From this study, it was indicated that BAP added to the media increased callus compactness. The advantage of the compact callus texture is that it is good for regenerating into plantlets. However, this compact texture is unsuitable for cell suspensions to produce secondary metabolites. For cell suspensions, a friable callus texture is preferred.

Table 2 shows variations in callus color due to treatment and changes in callus color from the induction phase to the proliferation phase. The callus color variations observed varied from cream to brownish cream. Different callus color changes due to hormone treatment occur between explant types (leaves and petioles) during the induction phase, where the callus appears, as shown in Figure 3. Extending the culture period over the proliferation phase caused alterations in callus color. In previous studies, using auxin stimulates callus browning over long periods of culture (Usha et al., 2015; Rahayu et al., 2016). To prevent browning of the callus, it is necessary to sub-culture regularly after the culture reaches 4 weeks of age. Apart from that, adding cytokinin in the form of BAP is also expected to reduce the browning or darkening of the callus color. In this study, the callus in the proliferation stage changed color to brownish cream and brownish yellow cream compared to the preceding one in the induction phase, which was still brighter (cream, white cream, and greenish cream). The synthesis and accumulation of harmful compounds, such as phenol, that cause browning, as well as the reduction in nutrient content in the media due to prolonged use in closed jars, are thought to contribute to the change in callus color in the proliferation phase to become darker (Schaller et al., 2015; Anwar & Isda, 2020). Particularly in Centella, the concentration of methyl jasmonate, which induces browning, is known to increase as Centella grows (Ganie et al., 2022).

Table 2. The color of the callus generated from leaf and petiole explant in the induction phase and proliferation phase

Treatment	Induction Phase		Proliferation Phase	
	Leaf explant	Petiole explant	Leaf explant	Petiole explant
A	Cream	Cream	Brownish-cream	Brownish-cream
B	Brownish-cream	Whitish-cream	Brownish-cream	Brownish-cream
C	Brownish-cream	Whitish-cream	Brownish-cream	Brownish yellow-cream
D	Greenish-cream	Brownish-cream	Brownish-cream	Brownish yellow-cream
E	Greenish-cream	Brownish-cream	Brownish yellow-cream	Brownish yellow-cream
F	Whitish-cream	Brownish-cream	Brownish yellow-cream	Brownish yellow-cream
G	Whitish-cream	Whitish-cream	Brownish yellow-cream	Brownish yellow-cream



4 mgL^{-1} Dicamba | 4 mgL^{-1} Dicamba + 0.3 mgL^{-1} BAP | 4 mgL^{-1} Dicamba + 0.7 mgL^{-1} BAP | 4 mgL^{-1} Dicamba + 1.1 mgL^{-1} BAP

Figure 3. The appearance of callus generated from leaf explants (top) and petioles (bottom) in the induction phase

The color of the callus can indicate the quality of the callus. Callus, which is embryonic and quickly regenerates to form shoots, is generally green, while yellow callus tends to turn brown and stop growing because it is non-embryonic (Ganie et al., 2022). Several centella investigations found that media enriched with 1 mgL^{-1} BAP and 0.3 mgL^{-1} NAA, as well as 2 mgL^{-1} BAP and 2 mg/L Kn, produced green callus (Anwar and Isda, 2020; Gururajan et al., 2021). Callus cultured on media with NAA and BA is also bright green (Mikhovich & Teteryuk, 2020; Wante and Leung, 2022).

The findings of this study can be used in future research to determine the best media composition for centella callus growth while preventing centella callus browning. This is essential since centella is used as a source of traditional medicine, but this plant has not been widely cultivated intensively. Therefore, efforts to preserve genetic material through *in vitro* culture are required to anticipate the extinction of centella genetic material in nature and provide an alternate method for producing secondary metabolites from cell suspensions.

Conclusion

According to the results of the studies, the media containing a combination of 4 mgL^{-1} Dicamba and 1.1 mgL^{-1} BAP developed the most remarkable Centella callus growth, both in the induction and proliferation phases, as demonstrated by the high callus growth rate and callus fresh weight. In addition, the treatment of the Dicamba and BAP combination generated variation in the callus texture and color of the callus, with the addition of BAP tending to enhance the compactness of the callus texture.

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Correlation analysis between agronomic character and yield of Padjadjaran maize hybrids at medium- and high-population densities

Abstract. Maize is a prospective food commodity that developed in Indonesia. The use of hybrid corn gives better yield than open-pollinated varieties. Spacing management in hybrid maize production can reduce competition between plants, so that the plant canopy and roots can grow optimally. This research aimed to compare the differences in the phenotypic performance of the agronomic characters of Padjadjaran maize hybrid, determine the dominant agronomic characteristics, and determine the correlation between the growth and yield characteristics at medium- and high-population densities. The experiment was carried out from December 2021 until May 2022 at Sanggar Penelitian, Latihan dan Pengembangan Pertanian (SPLPP) Universitas Padjadjaran, Arjasari, Bandung Regency. This experiment used Randomized Completely Block Design analysis with 20 treatments of Padjadjaran maize hybrids and 4 check varieties, all treatments were replicated 3 times in both population densities. Statistical analysis used multiple regression linear analysis and correlation test. The experimental results showed that the yield of 20 genotypes of Padjadjaran maize hybrids at medium population density was influenced by the ear length, number of seeds per row, and number of seed rows, while in the high population density, it was influenced by number of seed rows. Correlation analysis revealed a positive and significant relationship between the growth and yield components in medium population density. Meanwhile, the correlation at high population density between the components of growth and yield was not consistent.

Keywords: Agronomic character · High population density · Maize hybrid · Moderate population density

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Introduction

Maize (*Zea mays* L.) is a prospective commodity food developed in Indonesia. It has four purposes or functions, called 4F: animal feed (feed), food, fiber, and fuel (Panikkai et al., 2017). Estimatedly, 58% of people need maize for feed, while for food only about 30%, and the rest for industry, seeds and others (Ministry of Agriculture, 2013). Future challenges include how to fulfill the need for maize as a material standard for feed, food, and energy (Zakaria, 2011). In 2020, production of maize reached 21.53 million tons, or growed 5% compared to production of maize feed in 2019 (20.5 million metric tons). Factory feed needed 8.5 million tons and for breeders to 3.48 million tons (Directorate General of PKH, 2020). According to data from the Ministry of Agriculture (2021), maize productivity fluctuated, namely 5.52 ton ha^{-1} in 2019, 5.58 ton ha^{-1} in 2020, and 5.55 ton ha^{-1} in 2021.

Possible efforts to increase production of maize include extensification (area expansion) and intensification (increase productivity) (Bakhri, 2007). Extensification was not effective in limiting agriculture areas. Thus, intensification is conducted to increase production by using superior or hybrid varieties that produce high yield (Winarso, 2014; Yuwariah et al., 2017) and regulating population plants (Yusri, 2013).

Agronomic and yield evaluation is one of the stages carried out by plant breeders to determine the best genotype in terms of agronomics, morphology, and yield (Soeranto, 2018). Yield potency from a plant is determined by growth and yield components (Putra et al., 2015). A total of 20 genotypes of hybrid Padjadjaran maize were selected for the study. This will be seen in appearance character agronomy based on component future growth and results compared to commercial varieties. Each genotype with different parents will be evaluated based on agronomic performance to produce the best genotype.

Genetics can influence the plant appearance (Wardiana, 2015). In addition, Numba et al. (2018) stated that plant height and leaf number on maize are influenced by genotypic factor. Testing of plant agronomic characters has become important issue in order to determine the genotype superiority (Siswati et al., 2015). Correlation test can be performed between agronomic characteristics, in order to provide important key information in plant breeding program. Additionally, Amas et al. (2021) reported that those information can be important step in shortening wheat selection. For example, Pennita et al. (2020) has showed the strong and positive correlation between agronomic character of diameter of the maize ears with another agronomic character of plant height.

Padjadjaran hybrid maizes require an optimal growing environment, one of them is plant population setting. The plant population setting is part of the intensification program to increase plant yield (Wahyudin et al., 2015). According to Gardner et al. (1996), setting plant density aims to minimize intrapopulation competition in order to give optimal environment for plant canopy and roots. However, there are still limited studies regarding plant population density on corn agronomic characteristics. Therefore, present study aimed to determine the correlation between the growth and yield characteristics at medium- and high-population densities.

Materials and Methods

Present research was carried out in the Sanggar Penelitian, Latihan, dan Pengembangan Pertanian (SPLPP), Faculty of Agriculture, Universitas Padjadjaran in Arjasari District, Bandung Regency, with an altitude of ± 950 meters above sea level. The research was held from December 2021 – May 2022, on agriculture area that has slopes >15%, soil pH 4.5–5.5, and clay soil texture. The average monthly rainfall from December 2021 to May 2022 was 182.9 mm per month. The average temperature at SPLPP Arjasari ranges between 23.3-24.1^{o}C.

The materials used in the study were 20 Padjadjaran hybrid genotypes, 4 commercial seed varieties (Table 1), NPK fertilizer (16:16:16), urea fertilizer, Dithane 80 WP, Antracol 70 WP, Sidamethrin 50 EC. The tools used in the study were ruler (measurement of height, width, and length of leaves), analytical scales (for measuring heavy corn maize), a luxmeter (for measuring intensity of light), and cultivation tools.

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Table 1. Maize genotypes used in present study comprised of Padjadjaran hybrids and commercial varieties

Treatment			Information
No	Code	Genotipe	
1	H1	DR 4 X MDR 7.2.3	Padjadjaran Hybrids
2	H2	DR 4 X MDR 16.6.14	
3	H3	DR 5 X MDR 18.8.1	
4	H4	DR 6 X DR 7	
5	H5	DR 7 X DR 8	
6	H6	DR 8 X MDR 18.8.1	
7	H7	DR 8 X R 9	
8	H8	DR 8 X MDR 1.1.3	
9	H9	DR10 X MDR 9.1.3	
10	H10	DR 11 X DR 16	
11	H11	DR 14 X DR 18	
12	H12	DR 19 X DR 20	
13	H13	MDR 3.1.4 X MDR 18.5.1.	
14	H14	MDR 3.1.2 X MDR 153.14.1	
15	H15	MDR 7.4.3 X DR 18	
16	H16	MDR 7.4.3 X 18.8.1	
17	H17	MDR 7.4.3 X MDR 1.1.3	
18	H18	MDR 9.1.3 X MDR 1.1.3	
19	H19	MDR 18.8.1 X MDR 7.1.9	
20	H20	MDR 153.3.2 X MDR 8.5.3	
21	C1	BISI 2	Commercial Varieties
22	C2	BISI 77	
23	C4	PERTIWI 3	
24	C5	NK 212	

The experimental design was Randomized Completely Block Design (RCBD), consisted of 20 treatments of Padjadjaran hybrid maize and 4 commercial varieties (BISI 2, BISI 77, Pertiwi 3, NK 212) with three replications and planted in two planting densities, namely medium and high densities. Obtained data was analyzed using multiple linear regression and analysis correlation at 5% significance level. Observation were made on several variables, namely ear diameter, ear length, number of seed rows, number of seeds per row, number of seeds per ear, and weight of seeds per ear (yield).

Medium planting density used a spacing of 70x15 cm, while high density used a spacing of 70x10 cm. Each plot was made 3x3 m. Each planting hole is filled by 1 seed. First fertilizer application was carried out in 30 days after sowing (DAS) using NPK with a dose 150 kg/ha, while second fertilizer was applied in 45 DAS using 150 kg/ha NPK and 300 kg/ha urea. Fertilizer was immersed between planting holes in rows. Harvesting was done at physiological maturity of seeds and husks already yellowish colored, as well as ear hairs colored brown and dry. It was carried out at 117 DAS. Ears drying was carried out for one week under the sun.

Results and Discussion

Analysis of multiple linear regressions on twenty genotypes of maize under different planting density was modelled by regression equation as depicted in Table 2. At medium population density, there were currently 15 genotypes of Padjadjaran hybrid maize and their yield was influenced by agronomic character with determinations coefficient above 80%.

In general, Padjadjaran maize gave a coefficient of determination of 65% and an estimation yield of 8.2 tons/ha, which was influenced by agronomy characteristics such ear length, number of seeds per row, and number of seed rows (Table 4). From the 15 genotypes of Padjadjaran maize, only 3 best genotypes were obtained. They were really influenced by agronomy characteristics, namely number of seeds per row, ear length, weight of 1000 seeds, and number of seeds per ear with coefficient of determination 97%–100% (Table 3).

Ear length character was related to the number of seeds per ear, so it can give more yield. Aligns with the statement of Noviana & Ishaq (2011), the varieties with long ear showed higher yield. The weight of seeds per ear influenced the production of maize (Noviana & Ishaq, 2011). Enhancement weight seed has a close relationship with high-directed photosynthetic activity to ear (Hartanti et al., 2014). The bigger partitioned photosynthate is allocated to ear, so that the higher seeds weight, vice versa (Hidayati & Armaini, 2015).

On high density, there were 17 genotypes of Padjadjaran hybrid maize that were influenced by agronomic characters with coefficient determinations above 80% (Table 4). In general, Padjadjaran hybrid maize were affected by the number of seeds rows per ear with a coefficient determination of 88% and estimation yield of 4.0 tons/ha (Table 5). From the 17 genotypes of Padjadjaran maize, there were five best genotypes. The yield of those five maize genotypes were strongly influenced by agronomic characteristics, namely ear length, ear diameter, number of seeds per ear, number of seed rows per ear and weight of 1000 seeds with coefficient of determination ranged from 97% to99% (Table 5).

Table 2. Regression equation model of padjadjaran hybrid and check varieties at medium density

Code	Regression Equation	Coefficient of Determination (R^2)
H	Y = -115.503+2.166X1*-3.547X2+0.735X3*+2.491X4*+0.453X5+62.199X6	65%
H1	Y = -9.318+0.095X1-10.763X2-0.989X3+3.396X4+0.356X5+78.373X6	92%
H2	Y = -13.8889 + 3.5371X1 -11.7747X2+0.0685X3-5.2891X4+0.5721X5+98.7871X6	94%
H3	Y = -4.513+1.509X1-1.266X2+1.273X3-5.973X4+0.357X5+66.719X6	97%
H4	Y = -203.303+0.122X1+27.106X2+2.538X3+7.224X4-0.351X5+72.865X6	85%
H5	Y = 9.1961+6.5685X1-0.5037X2+0.4739X3-0.9699X4+0.0374X5-7.1526X6	76%
H6	Y = 42.123+1.458X1+23.672X2+2.988X3-3.072X4+0.215X5-329.272X6	96%
H7	Y = 369.335-7.648X1-63.915X2-0.605X3+13.873X4-0.370X5+28.541X6	57%
H8	Y = -4.082+4.739X1+30.249X2-2.633X3+7.087X4-0.622X5-10.938X6	31%
H9	Y = -119.1281-12.544X1-78.7096X2+4.6357X3+11.3568X4+1.9473X5+130.4652X6	94%
H10	Y = 169.948-2.868X1+31.413X2+0.106X3-7.004X4-0.498X5+75.374X6	93%
H11	Y = -344.373*+4.228X1+33.183X2+4.694X3*+0.319X4+0.226X5+29.001X6	97%
H12	Y = -173.887-15.915X1*+18.824X2+1.0509X3+6.411X4+1.155X5*+100.334X6	99%
H13	Y = -591.892-6.498X1+69.022X2+4.402X3+5.515X4+0.692X5+164.874X6*	97%
H14	Y = -1110.513+9.205X1+163.394X2+7.350X3+25.256X4-1.487X5+172.147X6	79%
H15	Y = -9.838+3.152X1-8.393X2-0.536X3-2.694X4+0.619X5*+40.844X6	100%
H16	Y = -214.787+0.980X1+7.262X2+3.123X3+2.825X4+0.305X5+77.794X6	97%
H17	Y = -263.120+2.128X1-0.276X2+1.353X3+10.423X4+0.468X5+69.280X6	52%
H18	Y = -98.705-12.056X1+42.688X2-0.276X3-0.413X4+0.257X5+282.376X6	94%
H19	Y = -458.580+0.088X1+86.941X2+0.724X3+1.149X4+0.087X5+159.261X6*	98%
H20	Y = -356.573+5.257X1+20.993X2-0.330X3+10.276X4+0.278X5+126.120X6	96%
C1	Y = 43.7721-2.7644X1-19.2941X2+0.9644X3+0.8307X4+0.4176X5+10.1736X6	93%
C2	Y = 359.805+2.108X1-92.205X2-4.071X3-3.563X4+1.074X5+89.481X6	97%
C4	Y = -320.157-1.052X1+44.137X2+5.302X3+0.821X4+0.143X5+9.695X6	94%
C5	Y = 120.312+3.758X1-57.690X2*+0.265X3+6.654X4+0.524X5*-63.050	98%

Notes: H was Padjadjaran hybrid maize, C was check variety, X1 ear length, X2 was ear diameter, X3 was number of seeds per row, X4 was number of seeds rows per ear, X5 was weight of 1000 seeds , X6 was number of seeds per ear , Y was weight of seeds per ear (yield), * was significant affected yield

Table 3. Relationship of yield components with yield at medium density

No.	Treatment	Yield components that significantly affected yield	Coefficient of Determination (R^2) (%)	Yield (tons/ha)
A	H (H1 – H20)	Ear length, number of seeds per row, and number of seed rows	65%	8.2
1.	H11	Number of seeds per row	97%	8.2
2.	H12	Ear length, weight 1000 seeds	99%	8.7
3.	H13	Number of seeds per ear	97%	8.8
4.	H15	Weight of 1000 Seeds	100%	7.4
5.	H19	Number of seeds per ear	98%	6.8
6.	C1			5.3
7.	C2			11.5
8.	C4			8.2
9.	C5			8.9

Table 4. Regression equation model of padjadjaran maize hybrid and check varieties at high density

Code	Equality Regression	Coefficient of Determination (R^2)
H	Y= -12.378+1.927X1+1.245X2+0.406X3-4.597X4*+0.283X5+1.068X6	88%
H1	Y= -318.085+5.378X1-6.401X2+1.276X3+10.853X4+0.224X5+1.739X6	98%
H2	Y= 70.887+0.967X1-8.750X2+0.563X3-0.291X4+0.068X5+0.003X6	99%
H3	Y= 35.694-2.046X1+15.888X2-0.088X3-0X4-0.104X5+0.432X6	99%
H4	Y= 49.374-9.020X1+26.172X2-2.229X3-1.614X4+0.771X5-0.334X6	70%
H5	Y= -52.047+5.659X1-34.118X2*-0.691X3+4.116X4+0.209X5*+1.348X6*	99%
H6	Y=-77.536 +10.801X1-15.494X2-5.324X3+5.896X4+0.397X5+1.075X6	97%
H7	Y= -1.487-0.436X1-7.119X2+0.322X3+2.419X4-0.113X5+1.612X6	91%
H8	Y= 3.051-4.278X1-5.035X2+1.001X3-3.302X4+0.349X5*+0.682X6*	99%
H9	Y= -107.703+11.250X1*+8.580X2*-1.931X3*-1.622X4-0.097X5+1.992X6*	99%
H10	Y= -299.637+11.566X1+15.673X2-3.0695X3+12.439X4-0.038X5+1.413X6	98%
H11	Y= -329.055+27.112X1*-21.153X2*-4.479X3*+10.171X4*+0.217X5*+0.566X6*	99%
H12	Y= -20.193+4.116X1-11.638X2+0.300X3-1.887X4+0.210X5+0.577X6	96%
H13	Y= -37.766+2.302X1+1.834X2+0.285X3+2.516X4+0.005X5+0.470X6	78%
H14	Y= -144.015+3.255X1-46.054X2+0.687X3+21.629X4+0.112X5+0.150X6	94%
H15	Y= 50.199-0.573X1+5.798X2+0.980X3-1.152X4+0.002X5-0.096X6	91%
H16	Y= -66.919+2.394X1-10.693X2+0.125X3+1.7132X4+0.259X5*+1.189X6*	97%
H17	Y= -45.420+2.501X1-10.474X2+2.042X3+1.876X4+0.200X5-0.139X6	45%
H18	Y= -11.929-2.0281X1+70.702X2-2.289X3-4.221X4-0.052X5+1.110X6	95%
H19	Y= 1.126-14.978X1-21.695X2+1.807X3-16.831X4-0.213X5+2.224X6	94%
H20	Y= -56.108+1.403X1+1.194X2+1.316X3-0.732X4+0.066X5+0.952X6	90%
C1	Y= -103.831+2.682X1+32.689X2-0.178X3-3.303X4+0.684X5-1.119X6	94%
C2	Y= -278.258-8.163X1+12.516X2+7.672X3+7.181X4+0.068X5+2.119X6	77%
C4	Y= -36.614+4.414X1+33.696X2-2.217X3-1.860X4-0.142X5+1.092X6	38%
C5	Y= 158.770-5.711X1-22.385X2+0.817X3-6.345X4+0.306X5+1.647X6	97%

Notes: H was Padjadjaran hybrid, C was maize check variety, X1 ear length, X2 was ear diameter, X3 was number of seeds per row, X4 was number of seeds rows per ear, X5 was weight of 1000 seeds , X6 was number of seeds per ear , Y was weight of seeds per ear (yield), * was significant affected yield

Table 5. Relationship of yield components with yield at high population density

No.	Treatment	Yield components that significantly affected yield	Coefficient of Determination (R^2) (%)	Yield (tons/ha)
B	H (H1 – H20)	Number of Seed Rows	88%	4.0
1.	H5	Ear Diameter, Weight of 1000 Seeds, Yield Seed	99%	3.4
2.	H8	Weight of 1000 Seeds, Yield Seed	99%	5.5
3.	H9	Ear Length, Ear Diameter, Quantity Seeds per Ear, Yield Seed	99%	6.5
4.	H11	Ear Length, Ear Diameter, Quantity Seeds per Ear, Number of Rows of Seeds per Cob, Weight of 1000 Seeds, Number of Seeds per Ear	99%	4.8
5.	H16	Weight of 1000 Seeds, Weight of Seeds per Ear	97%	3.5
6.	C1			3.9
7.	C2			4.4
8.	C4			5
9.	C5			5.9

The yield was dominant influenced by number of seed rows. The average number of seed rows per ear in the study between 12.00 and 14.89. Overall, average Padjadjaran hybrid has the potential to have the same yield as other plant maize hybrids, namely 12–14 rows per ear (Balitsereal, 2012). The yield of H11 hybrid genotype was most influenced by agronomic characters on high density. It was affected by ear length, ear diameter, number of seeds per row, number of seed rows, weight of 1000 seeds, and number of seeds per ear with coefficient of determination 99% and estimation yield of 4.8 tons/ha. This was in agreement with the results of previous studies. Bahoush & Abbasdokht (2008), Selvaraj et al. (2011), El-Badawy & Mehasen (2011), and Zarei et al. (2012) stated that maize yield was directly affected by ear length, ear diameter, number of seeds per row, number of seed rows and weight of 1000 seeds.

Thus, both on medium and high density, the yield of Padjadjaran hybrid genotypes were effectively identified by observation on agronomic characters, such as ear length, ear diameter, number seeds per row, number of seed rows per ear, weight of 1000 seeds, and number of seeds per ear.

Based on the analysis correlation from 20 genotypes of Padjadjaran hybrid, there was a closeness and positive correlation between gagronomic characters and yield. The correlation between maize agronomic characters and yield component from 20 Padjadjaran hybrids on density medium and high density were displayed in Table 6 and Table 7. According to Ramadhan (2014), if two characters have a positive correlation, the increasing value of one character will followed by another correlated character, vice versa.

On medium density, plant height had a significant correlation with yield components. Tall plants can intercept more solar radiation that increase photosynthesis rate then maximize yield (Rahni, 2012; Surtinah, 2018). The LAI had significant correlation with yield components, except the number of seed rows and number of seeds per ear. Leaf Area Index (LAI) is a parameter that directly influences the growth and development of plants (Wahyudin et al., 2017). According to Surtinah (2018), the photosynthesis process in active leaves gave optimum yield due to the accumulation of dry material.

On high density, plant height correlated positively with ear diameter (r = 0.23*), while with number of seeds per ear had negative correlation. This is caused by competition between plants. High populations of plant can increase etiolation, and the tall plant had more competition with solar radiation, which caused the decreasing photosynthesis rate and supply of photosynthate to be reduced (Aisah & Herlina, 2018).

Table 6. Correlation between growth components and yield components at medium population density

Growth components	Yield Components						
	EL	ED	NSR	NR	W1000	NSE	WSE
PH	0.449**	0.420**	0.307**	0.213	0.435**	0.050	0.523**
LAI	0.408**	0.315**	0.304**	0.093	0.404**	0.162	0.426**

Notes: PH was plant height, LAI was leaf area index , EL was ear length, ED was ear diameter , NSR was Number of seeds per row, NR was number of seed rows, W1000 was weight of 1000 seeds, NSE was number of seeds per ear, WSE was weight seeds per ear, * was significant correlation, ** was very significant correlation.

Table 7. Correlation between growth components characters and yield components at high population density

Growth components	Yield Components						
	EL	ED	NSR	NR	W1000	NSE	WSE
PH	0.21	0.23*	0.16	0.19	0.01	-0.24*	-0.04
LAI	0.26*	0.37*	0.23*	0.29*	0.24*	-0.17	0.10

Notes: PH was plant height, LAI was leaf area index , EL was ear length, ED was ear diameter , NSR was Number of seeds per row, NR was number of seed rows, W1000 was weight of 1000 seeds, NSE was number of seeds per ear, WSE was weight seeds per ear, * was significant correlation, ** was very significant correlation.

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Conclusion

Correlation analysis revealed a positive and significant relationship between the agronomic characters and yield components at medium population density. Meanwhile, the correlation between the components of agronomic characters and yield in the high population density was not consistent.

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