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Phenological Study of Flowering and Fruiting in Banana "Rejang" (*Musa acuminata Colla*)

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Abstract

Banana "Rejang" originates from Rejang Lebong Regency in Bengkulu Province, Sumatra, at elevations ranging from 600 to 700 meters above sea level. Banana "Rejang" is known for its sweet taste, high fibre in the pseudo stems, resistance to *Fusarium* spp., with slender and long fruits, and tapering fruit tips. This study aims to examine the phenological patterns of Rejang bananas and establish appropriate harvest criteria using the heat unit method. A descriptive research design was employed to illustrate the phenological development during the generative phase without external treatments. A total of 25 Rejang banana plants were observed and measured, spanning the developmental stages from flag leaf emergence to flowering and fruiting. Data were collected daily at 7:00 a.m., 10:00 a.m., 1:00 p.m., and 4:00 p.m. The average daily temperature was recorded to calculate heat units in degrees Celsius (°C). Phenological development begins with the emergence of the flag leaf at 102 days after planting, corresponding to an accumulated heat unit of 1,800-degree days. Flower initiation occurs at 134 days after planting, with 2,330-degree days accumulated as heat units. The period from flower initiation to anthesis lasts approximately 4 days, followed by a period of 4 days after anthesis (DAA). Bract opening occurs 3 DAA, followed by bract rolling at 7 DAA and banana heart emergence at 10 DAA. The bunch stalk forms 7 days after anthesis, after the banana heart emerges. Fertilization occurs 165 days after planting (DAP), with a total heat unit accumulation of 2,833 degree-days. This stage involves the formation of the bunch stalk and the emergence of the fruit cluster, which occurs 5 DAA. The rachis appears at 5 days after anthesis, and fruit development is reached at 12 DAA after rachis emergence. The optimal harvest time for Rejang bananas is 90 days after anthesis with a heat unit of 1700-degree days.

Keywords: anthesis, generative, harvest criteria, heat unit, vegetative

Introduction

Banana "Rejang" is one of Indonesia's local banana species with great potential as a genetic resource for breeding. One of the main objectives of banana breeding is to produce triploid bananas that exhibit agronomic advantages and superior fruit quality. Crossbreeding between mixoploid and diploid Rejang bananas has successfully produced superior triploid hybrids with the potential to be developed into high-quality banana cultivars (Poerba et al., 2017). According to BPS (2024), Indonesia's banana production in 2023 reached approximately 9.335 million tonnes. The advantages and high production of bananas present a significant opportunity for the development of Indonesia's agricultural economy.

Banana "Rejang" is one of the local banana varieties not widely known in Indonesia. This results in the description of the variety not being available in full, including the determination of harvest criteria and harvest age, which are still not supported by scientific data. To collect information about the development of Rejang bananas, observations were made on their phenology to study the stages of plant development, including the emergence of shoots, flowering, fruiting, and harvest time. Phenology studies also examine how each stage of development is influenced by various environmental factors, such as temperature, rainfall, and light intensity (Cahyani et al., 2023).

The determination of harvest criteria and harvest age in bananas can be carried out through several approaches, including observing changes in peel color, the presence of fruit ridges or angles (Esguerra and Rolle, 2018), and calculating the number of days from flower anthesis to harvest (Hailu et al., 2013; Amin et al., 2015; Dzomeku et al., 2016). A research experiment conducted by Febri et al. (2023) on Rejang bananas planted at an altitude of 187 meters above sea level (masl) reported a harvest age of 90 days after anthesis (DAA). However, further studies are needed to establish the harvest age of Rejang

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bananas more comprehensively. In addition, to ensure a consistent and measurable harvest time across various growing locations, a more universal method is required. One such method is calculating heat units from anthesis to the point of optimal fruit maturity. The heat unit concept describes the relationship between air temperature and the phenological phases of plant growth and development (Neild, 1967; McMaster and Wilhelm, 1997; Brown, 2013; Fraisse and Paula-Moraes, 2018; Widodo et al., 2021). The results from all six experiments confirmed that 650 degree days can be used as a reliable and measurable harvest criterion for Mas Kirana bananas. Based on these findings, an exploratory study was initiated on the flowering and fruiting phenology of Rejang bananas at a higher altitude than the previous study that was conducted by Febri (2023) at lower elevations. This new study is grounded in the hypothesis that altitude significantly affects the accumulation of heat units and, consequently, the determination of harvest time for Rejang bananas.

Materials and Methods

The research was conducted from November 2023 to July 2024 at the Sukamantri Experimental Station (532 m above sea level), while fruit analysis was carried out at the Post-harvest Laboratory, IPB University. A descriptive method was used to objectively record the generative phase of Rejang bananas without treatment, using 25 five-month-old Rejang banana shoots. The land used was free from *Fusarium* wilt disease; the soil was loosened for 2 weeks. The soil pH ranged from 5.5 to 6.0, and the total land area measured 16 m × 17 m, with planting holes of 50 cm × 50 cm × 50 cm and a planting distance of 3 m × 3 m. Fertilization was carried out twice, at the vegetative and generative phases. Fertilization at the vegetative phase was applied twice, 300 g NPK per plant at planting and 250 g NPK per plant. During the generative phase, 150 g of NPK fertilizer was applied per plant.

Banana tree maintenance involved shoot thinning, weeding, pruning of old leaves, watering, and pest control. Harvesting was conducted when the fruit skin appeared shiny and the fruit shape was perfectly round, with only healthy and pest-free fruit being selected.

Vegetative and Generative Growth of Banana Rejang

The vegetative phase refers to the period of growth preceding flowering, during which the stem and leaves develop. Vegetative observations began two weeks after planting (WAP). They were conducted every two weeks until the end of the vegetative phase, marked by the appearance of the flag leaf, in 25 Rejang banana trees. The generative phase was measured from the emergence of the flag leaf to the formation of fruit, tracking the reproductive development of the tree.

Flowering and Fruiting Phenology

Observations and measurements were conducted throughout the plant's life cycle, starting from the development of flower buds at the base of the plant to the flowering and fruiting phases, using 25 Rejang banana trees. Data collection was conducted daily at 7:00 a.m., 10:00 a.m., 1:00 p.m., and 4:00 p.m.

Accumulation of Heat Units

Heat units are measured by calculating the daily average temperature from anthesis to harvest, using maximum and minimum thermometers. The thermometer is installed at a height of 1.5 meters above the ground. The formula used to calculate heat units was based on Umber et al. (2011) as follows:

$$HU=\Sigma\left(\frac{T\,max + Tmin}{2}\right)-b$$

Note:
HU = Heat units (degree days)
T_{max} = Average maximum temperature (˚C)
T_{min} = Average minimum temperature (˚C)
b = Base temperature (10˚C)

Production Components

Measurements of banana "Rejang" production include the number of combs per bunch, the number of fruits per comb, comb weight, fruit length, and fruit weight. The number of combs per bunch is determined by counting the combs in each bunch used as experimental material. The number of fruits per comb is calculated from the second comb. Comb weight is measured by weighing the second banana comb. Fruit weight is obtained by calculating the average weight of the fruits in one comb. Fruit length is measured from the base to the tip of the fruit. All measurements follow the methodology of Abdurrohim et al. (2018).

Respiration Rates

The respiration rate is measured based on the rate of CO_2 gas production in banana fruits. Observations are conducted daily from the time of harvest until the fruit reaches a yellow color scale. The respiration rate is determined by measuring the CO_2 emissions produced by the fruit each day using a cosmotector

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(Cosmos XP-316A gas detector) (Figure 2). Measurements are taken after the fruit has been incubated in a closed container for three hours. This respiration rate measurement method follows the research of Widodo et al. (2021). Bananas used for respiration rate measurements were taken from the third comb. The recording of the respiration rate is conducted using the following formula:

$$L = \frac{V \times K \times 1.76}{W \times B}$$

Notes:
L = CO_2 emission rate (mL CO_2.kg^{-1}.h^{-1})
V = Volume of free air in the jar (ml)
K = CO_2 concentration
W = Incubation time (hours)
B = Sample weight (kg)
Constant value = 1.76

Data Analysis

Data analysis was conducted using descriptive statistics, focusing on the vegetative and generative (flower) morphological characteristics of the plants. The results were presented in a phenology graph for the observation period, created using Excel software. Rainfall, temperature, and humidity data for the observation period were obtained from the Meteorology, Climatology, and Geophysics Agency (MCGA) observation station in Bogor Regency.

Results and Discussion

Vegetative and Generative Phases

Banana "Rejang" trees exhibit good vegetative growth (Table 1). The average height is 145.5 cm, with a range from 115.7 cm to 200.4 cm, indicating variability in plant size. The average leaf length is 60.9 cm, with a maximum value of 72.7 cm and a minimum of 54.9 cm. Leaf width ranges from 20.9 cm to 28.5 cm, with an average of 22.7 cm. The average number of leaves per plant is 5.6, with a range from 5.0 to 6.3, demonstrating a high degree of uniformity in the number of leaves. A similar consistency is observed in the number of shoots, with an average of 3 shoots per plant. The average diameter of the pseudo-stem is 11.72 cm, with a variation between 10.23 cm and 15.49 cm. The diversity of the pseudo-stem falls within the moderate category, indicating minimal variation in stem strength or thickness between plants.

The generative phase showed considerable variation in the results (Table 2). The average size of the bunch stalk was 52.79 cm, with a maximum value of 72 cm and a minimum of 38 cm, indicating significant variation in the size of the bunch stalk between plants. The diameter of the bunch stalk averaged 11.09 cm, with a range from 8 cm to 15 cm, showing noticeable variation but still within normal limits. The average length of the banana heart was 28.25 cm, with a maximum length of 37 cm and a minimum of 18 cm, reflecting variation in size and potential differences in flower and fruit production. The average diameter of the heart was 9.30 cm, with a range from 7 to 12 cm. The length of the rachis (the stem part of the bunch) averaged 60.96 cm, with a maximum of 80 cm and a minimum of 50 cm. The flower length averaged 6.05 cm, with a range from 4 cm to 8.5 cm, indicating significant variability. This variable exhibited the greatest level of diversity among all the observed generative characteristics.

Production Components

Banana "Rejang" demonstrates good production potential, although there is considerable diversity in the components of the harvest (Table 3). The average initial weight per comb is 443.7 g, with a maximum of 738.6 g and a minimum of 229.8 g. After the ripening or shrinking process, the final weight per comb decreases to an average of 328.7 g, with a maximum value of 542.7 g and a minimum of 151.2 g. The average weight per fruit is 27.2 g, ranging from 12.7 g to 45.5 g, indicating substantial variation in fruit size, both between plants and among combs within a bunch. The average fruit length is 11.5 cm, with a minimum of 9.7 cm and a maximum of 14.6 cm, indicating relatively uniform length compared to weight. The average number of fruits per comb is 11.9, with a range from 8 to 17, reflecting moderate

Table 1. Vegetative growth performance of banana "Rejang"

Variable	Mean	Max	Min	Standard deviation	Coefficient of variation
Plant height (cm)	145.5	200.4	115.7	19.54	13.43
Leaf length (cm)	60.9	72.7	54.9	4.48	7.36
Leaf width (cm)	22.7	28.5	20.9	1.71	7.53
Number of leaves	5.6	6.3	5.0	0.33	5.82
Number of offspring	3.0	3.0	2.0	0.21	8.28
Pseudostem diameter (cm)	11.72	15.49	10.23	1.33	11.36

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diversity in the number of fruits formed on each comb. On average, there are 6.8 combs per bunch, with a maximum of 8 combs and a minimum of 5 combs.

Biratu et al. (2022) evaluated several cultivars of dessert banana (*Musa* spp.) in the Tigray region, Ethiopia, and found that Ducase Hybrid gave the highest yield but was susceptible to wind, while Williams-I was recommended as a cultivar that balanced productivity and resistance. This study highlights the importance of cultivar selection based on environmental adaptation and yield potential. Dahang et al. (2022) compared traditional and modern Barangan banana cultivation in Sukadame (Deli Serdang) and found that modern methods increased productivity and profits, although marketing costs remained a significant challenge.

Flowering Phenology

The process of fruit formation begins with the emergence of flowers (flag leaves) (Figure 1). The emergence of flowers occurs between February and March. The average time for the emergence of flag leaves in banana "Rejang" is observed in February, approximately 102 days after planting (DAP). The average time for flower emergence is around 134 DAP, and the average time for anthesis in Rejang bananas is 138 DAP.

The flower development phase in banana "Rejang" initiates with the opening of bracts, typically observed between February and March. Floral emergence from the bract sheath is recorded approximately 141 days after pollination (DAP), corresponding to an average of 4 days after anthesis (DAA). Subsequent bract opening occurs at around 145 DAP, with the interval from bract opening to bract rolling averaging 3 DAA. The bracts then undergo a rolling process, typically observed at 148 days after planting (DAP). The duration from bract rolling to the emergence of the banana inflorescence (banana heart) spans an average of 7 DAA (Figure 2).

The development of flowers into fruits begins with the emergence of the banana heart at approximately 158 days after pollination (DAP), followed by the appearance of the bunch stalk around 165 DAP. Fruit combs typically appear around 170 days after pollination (DAP) (Figure 3).

Fruit development begins with the emergence of the rachis and the subsequent filling of starch in the fruit approximately three months after the banana reaches maturity (Figure 4). The average rachis emerges at 175 days after planting (DAP), followed by fruit emergence at 187 DAP.

Heat Unit

Heat unit accumulation is calculated throughout the growth cycle, beginning from planting and continuing through flowering, fruiting, and harvest. The development of flowers and fruit on "Rejang" bananas requires a specific amount of thermal energy. Based on the accumulated heat unit data (Table 4), Rejang banana plants require approximately 102 days after pollination (DAP) with an accumulated heat unit of

Table 2. Generative growth performance of banana "Rejang"

Variable	Mean	Max	Min	Standard deviation	Coefficient of variation
Size of bunch stalk (cm)	52.79	72	38	8.48	16.06
Diameter of bunch stalk (cm)	11.09	15	8	1.78	16.01
Heart length (cm)	28.25	37	18	4.62	16.34
Heart diameter (cm)	9.30	12	7	1.27	13.69
Rachis length (cm)	60.96	80	50	7.38	12.11
Flower length (cm)	6.05	8.5	4	1.27	21.02

Table 3. Yield components of banana "Rejang"

Variable	Mean	Max	Min	Standard deviation	Coefficient of variation
Initial weight per comb (g)	443.7	738.6	229.8	123.04	27.73
Final weight per comb (g)	328.7	542.7	151.2	101.57	30.90
Individual fruit weight (g)	27.2	45.5	12.7	6.9	25.40
Individual fruit length (cm)	11.5	14.6	9.7	1.16	10.10
Number of fruits per comb	11.9	17.0	8.0	2.27	19.12
Number of combs per bunch	6.8	8.0	5.0	0.88	12.95

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Figure 1. Development of banana “Rejang” shoots into flowers: (1) emergence of flag leaf at 102 DAP, (2) emergence of flowers at 134 DAP, and (3) anthesis at 138 DAP.

Figure 2. Banana “Rejang” phases of flower development: (1) opening of the flower from the bract sheath at 141 DAP, (2) opening of the bracts at 145 DAP, and (3) rolling of the bracts at 148 DAP.

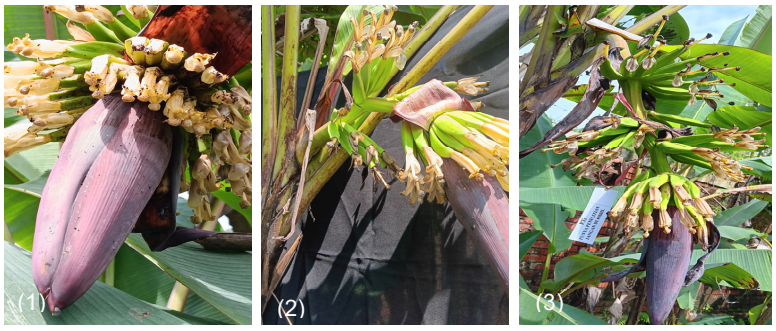

Figure 3. Banana “Rejang” phases of flower development into fruits: (1) emergence of banana heart at 158 DAP, (2) emergence of bunch stalk at 165 DAP, and (3) emergence of fruit comb at 170 DAP.

Figure 4. Phases of fruit development: (1) emergence of rachis 175 DAP, and (2) fruit 187 DAP.

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1800 degree days to reach the flag leaf emergence phase, which marks the beginning of the transition from the vegetative phase to the generative phase. The flowering phase occurs at 134 DAP with a heat unit of 2330 degree days, so the plant requires an additional approximately 530 degree days since the emergence of the flag leaf to enter the flower formation stage.

The overall generative phase occurred at 165 DAP with a total heat unit of 2833 degree days, indicating that this phase is an advanced stage of generative development. The fruit formation process occurs in stages, beginning with the development of the bunch stalk and culminating in the emergence of fruit within 22 days after pollination (DAP). After anthesis, bananas require 90 days with a temperature accumulation heat unit of around 1700 degree days to reach maturity and are ready for harvest. The flag leaf emergence phase, until the harvest of Rejang banana plants, takes 277 days after planting (DAP) with an accumulation of heat units of 5,163 degree days. This information suggests that heat units play a crucial role in regulating the duration of banana phenology development and can serve as a reference for determining optimal planting and harvesting times under specific agroclimatic conditions.

Fruit Respiration Rates

The respiration rates, measured from harvest until the fruit reaches a peel color scale of 6, is a key physiological indicator for assessing the ripening progression of bananas. Variations in respiration activity can be indirectly monitored through observable changes in peel coloration. In Rejang bananas, the skin color advances consistently during storage, as illustrated in Figure 5, which depicts a transition from scale 2 to scale 6. This change in peel color reflects the ripening level and guides optimal storage duration before consumption. On a scale of 1, the peel is entirely green. A faint yellow hue appears at scale 2. On a scale of 3, green and yellow are evenly balanced. Scale 4 marks the dominance of yellow, while scale 5 indicates a nearly entirely yellow peel with minimal green. On a scale of 6, the banana peel is uniformly yellow, indicating full ripeness and readiness for consumption. Fruit peel color should be used as one of the criteria of banana maturity. Lobo and Rojas (2020) explained that bananas are climacteric fruits. After being harvested when physiologically mature, the fruit undergoes increased respiration and ethylene production, leading to ripening and subsequent biochemical changes. Post-harvest management is crucial for maintaining green life, preventing diseases such as crown rot and anthracnose, and employing a physical or biological approach to reduce the use of fungicides.

Figure 6 shows the graph of respiration rate (mL CO_2.kg^{-1}.h^{-1}) on the color scale of banana fruit skin during storage. Overall, CO_2 production will continue to increase on the color scale 5 on the skin of the Rejang banana fruit and decrease on the color scale 6. At the first color scale stage, the respiration rate is about 400 mL CO_2.kg^{-1}.h^{-1}. As the fruit progresses to stages 2 and 3 on the color scale, the respiration rate increases significantly, exceeding 600 mL CO_2.kg^{-1}.h^{-1} CO_2 production increases until the color scale 4 and 5, where CO_2 production peaks above

Table 4. Heat unit accumulation at different phenological stages of banana “Rejang”

Phenological stage	Duration (DAP)	Duration (DAA)	Heat units (degree days)
Planting to flag leaf emergence	102	–	1800
Planting to flowering	134	–	2330
Flowering to anthesis	–	4	–
Anthesis to bract opening	–	7	–
Bract opening to bract rolling	–	3	–
Bract rolling to banana heart emergence	–	10	–
Banana heart emergence to bunch stalk formation	–	7	–
Planting to fertilization	165	–	2833
Bunch stalk formation to fruit comb emergence	–	5	–
Fruit comb emergence to rachis emergence	–	5	–
Rachis emergence to fruit emergence	–	12	–
Anthesis to harvest	–	90	1700
Flag leaf emergence to harvest	277	–	5163

Notes: DAP = days after planting; DAA = days after anthesis.

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800 mL CO_2.kg^{-1}.h^{-1}. However, after the peak of color scale 5, the respiration rate drops sharply on color scale 6 to approximately 600 mL CO_2.kg^{-1}.h^{-1}. This decrease indicates that the respiration process slows down as the fruit reaches full maturity and develops its color.

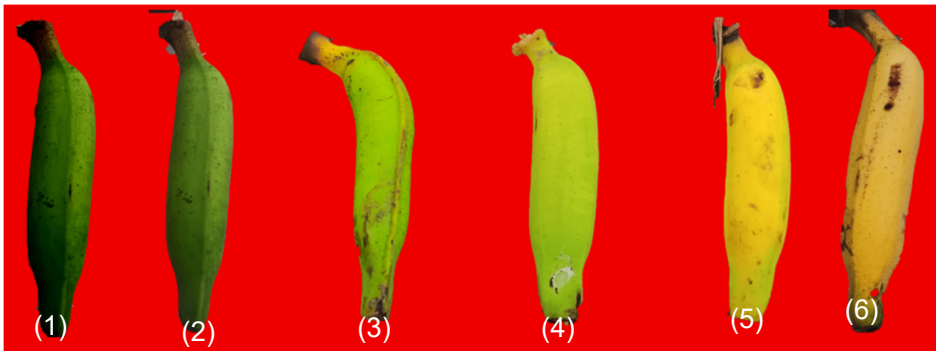

Figure 5. The color scale of banana "Rejang" skin: (1) green at 1 day after storage, (2) green with a little yellow at 3 days after storage, (3) yellowish green at 6 days after storage, (4) yellow dominated green at 8 days after storage, (5) yellow with a little green tip at 10 days after storage (6) full yellow at 11 days after storage.

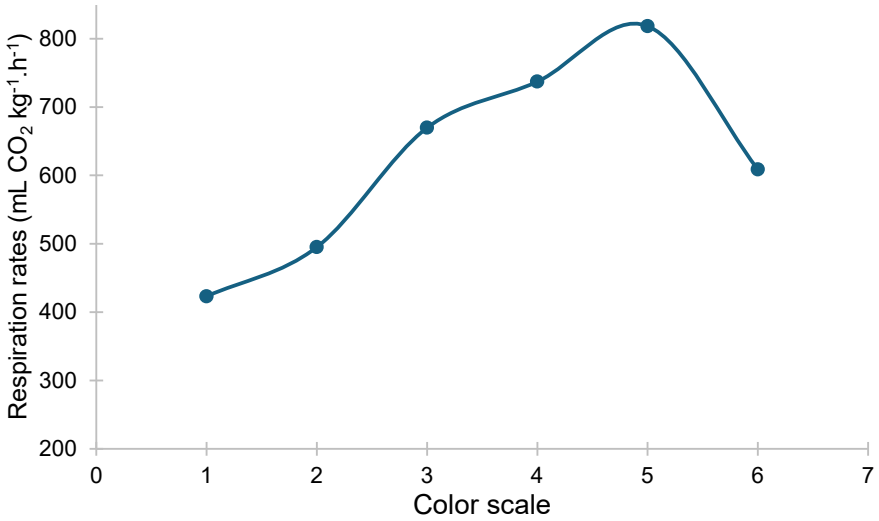

Figure 6. Respiration rates (mL CO_2.kg^{-1}.h^{-1}) of banana "Rejang" at each peel color scale as described in Figure 5.

Discussion

This research is exploratory and aims to gather information on the phenological patterns of flowering and fruiting in Rejang bananas, as well as to identify the harvest criteria for Rejang bananas using the heat unit accumulation method and the quantitative morphological characteristics of Rejang bananas, including flower traits, pollen viability, and pollen size, are influenced by their ploidy levels, as in the study by Riandini et al. (2021) who identified 14 types of bananas growing in Curup Tengah District, Rejang Lebong, including one from the genus Ensete. This study employs an exploratory method to compile morphological identification keys, supporting the preservation and development of local banana resources with high diversity. One of the findings of this study is the Rejang banana. According to Martanti et al. (2022), the qualitative morphological characteristics of the flowers remain unchanged. A comprehensive understanding of these floral morphological traits, particularly those related to pollen and other floral components, is crucial for optimizing fruit production, but different from research Kepok banana cultivars mostly have similar flower structures, except for Batu Kepok, which has different characteristics such as pollen sac color, pigmented compound tepals, free tepal color, free tepal peak shape, and pistil shape, these differences are caused by various carotenoid pigments in the pistil and environmental factors like light, pH, and temperature influencing their absorption (Ernawiati et al., 2021),

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and then the study by Welsiliana et al. (2020), male flowers of the Musa genus exhibit varying flower sizes, number of flowers/comb, anther color, and pollen stickiness. The pollen is medium to large, single pollen, and has no aperture (inaperturate). Pollen can be used to identify changes in the local and regional vegetation. In pollen taxonomy, the relationship of various plant taxa is reviewed in terms of male reproduction (Indrayanti et al., 2024).

Agustin and Garvira, (2021) studied the flowering and pollination phenology of *Cereus jamacaru* in the Bogor Botanical Gardens. Flowers bloom at night (around 10 pm to 12 pm) and only last one night. Pollination is assisted by nocturnal bees, such as Apis indica, which have a short anthesis phase and flowers that fall off the next day. This study highlights the crucial role of nocturnal pollinators in the reproductive success of this plant. Sali and Sheil (2023) found that in Uganda's montane forests, tree flowering and fruiting were strongly influenced by the seasons (peak flowering in the early dry season, fruiting in the rainy season), with new leaves emerging most strongly at the end of the rainy season. This phenomenon is related to variations in light and rainfall.

Phenology can be quantified using Growing Degree Days (GDD). This concept predicts the optimal timing for strawberry fruit development based on air temperature, which serves as the primary regulator of plant development (Timotiwu et al., 2021). The combination of physiology, phenology, and agronomy can help banana farmers address problems, achieve optimal yields, and prevent infection by Fusarium disease through precision farming (Shukoor et al., 2023).

The heat unit method, also known as "heat units," is a concept used to measure the effect of temperature on plant growth and development. It helps predict when a plant will reach specific developmental stages, such as flowering, fruiting, or harvest (Handoko, 1999), as in the study Fabro-Realin et al. (2022) developed BanaTech, a smart application to estimate the harvest date of Lakatan bananas (*Musa acuminata*) and Saba/Cardaba (*Musa acuminata* × *balbisiana*). This application is designed as a decision-making tool for farmers, agronomists, and other stakeholders, so that harvests can be optimized in a timely manner. According to Syakur (2012), the concept of heat units can be applied to determine the phases of plant growth and development. For example, the heat unit requirement for tomato plants grown in a greenhouse was found to be 1,661 degree days, with an average air temperature of 27.1°C, an average relative humidity of 74.2%, and an average solar radiation intensity of 9.3 MJ per m² per day. In the study by Widodo et al. (2023) the application of 650 degree daysas a measurable harvest criterion for Mas Kirana bananas was validated across three different locations: the Parakansalak PTP VIII plantation in Sukabumi (elevation 450–810 meters above sea level), during the fruit development period of October to December 2018; Kandang Tepus Village, Senduro, Lumajang, East Java (500–700 masl); and the Sukamantri Experimental Station of Institut Pertanian Bogor at an elevation of 560 masl during the period of December 2021 to January 2022.

The results from these trials demonstrated that variations in anthesis time did not affect either the harvest age or the duration of ripening. Furthermore, differences in elevation and fruit development period also had no significant effect on the harvest and ripening age of Mas Kirana bananas, as long as they were harvested at 650 degree days and measured at the same postharvest maturity level.

The heat unit requirement varies for different types of banana plants. Siregar et al. (2024) studied the use of heat unit accumulation in Tanduk 1035-1444 degree days bananas with a harvest age of 70-100 DAA as an indicator of measurable harvest time in Tanduk bananas (*Musa eumusa*, AAB Group). For instance, the "Popoulu" variety needs 1125.50 degree days, days from flowering to fruiting, Nendran needs 5338 degree days, Karpuravalli variety requires 7114 degree days, and Ney Poovan needs 2031.50 degree days to develop from flowering to fruiting. The heat unit requirement of different varieties ranges from 22,219 to 41,519 degree days to reach the flowering stage. This difference in heat units is influenced by environmental factors such as location and altitude (Kumar et al., 2022). In the ratoon cropping system of coconut-shaded banana, the flowering phase can be affected. The shaded Velchi banana variety (ratoo) produces few leaves during winter and takes only 399 days to flower, while others flower after 430 days (Arunachalam et al., 2023). The theory of heat unit accumulation in banana fruit provides a crucial framework for understanding how environmental heat affects different aspects of banana growth and ripening. By utilizing concepts such as Growing Degree Days (GDD), farmers and researchers can plan and optimize cultivation practices to enhance banana yield and quality. A good understanding of heat accumulation also helps in addressing the challenges posed by climate change and environmental variability, ensuring sustainable and efficient banana production.

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Conclusions

The phenology phase pattern of the banana "Rejang" begins with the emergence of flag leaves at 102 days after planting (DAP), accompanied by the accumulation of 1,800-degree days of heat units. Flower formation then occurs 134 days after planting, with an additional accumulation of 2,330-degree days. The duration from flower formation to anthesis is 4 days after anthesis, the time interval from anthesis to bract opening is 3 days after anthesis, from bract opening to bract rolling is 7 days after anthesis, from bract rolling to banana heart emergence is 10 days after anthesis, and from banana heart emergence to bunch stalk formation is 7 days after anthesis. The Banana "Rejang" entered the generative phase 165 days after planting, with a total heat unit accumulation of 2,833-degree days. The generative phase starts from flag stalk formation to the emergence of the fruit comb at 5 days after anthesis, the emergence of the fruit comb to the emergence of the rachis at 5 days after anthesis, and the emergence of the rachis to the emergence of the perfect fruit, which is 12 days after anthesis. The optimal harvest time for Rejang bananas is achieved when the accumulation reaches 1,700-degree days and 90 days after anthesis.

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