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Growth Optimization of Several Varieties of Vanilla Plants (*Vanilla Planifolia* Andrews) using Various Light Intensities

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ABSTRACT

Vanilla (*Vanilla planifolia* Andrews) is one of the plantation commodities in Indonesia that has high economic value. The vanilla plant requires specific climatic conditions to thrive. This research was conducted to determine the influence of sunlight intensity on the growth of various vanilla varieties and to identify the optimal light intensity for developing superior and local vanilla plants. The study took place at the Ayem Farmers Group in the Learning House unit of Vanilla mBajing located in Sinogo Village, Pagerharjo, Samigaluh District, Kulon Progo Regency, Yogyakarta, from May to July 2023. A complete randomized design (CRD) factorial experiment was applied, with the first factor being the varieties - Vania 2 and local vanilla - and the second factor being the types of shade - no shade, jackfruit tree shade, and teak tree shade, resulting in 6 treatment combinations with each treatment consisting of 4 replications. The research results indicated no growth differences between Vania 2 and local vanilla varieties. The light intensity received by vanilla plants varied depending on the shading. Teak and jackfruit trees can be used as shading options in vanilla cultivation as they provide optimal sunlight intensity, resulting in 36% and 46% yields, respectively.

Keywords: *Light intensity, shade, growth, variety, vanilla*

1. INTRODUCTION

Vanilla plants are a type of plantation crop that holds high economic value. Vanilla plants (Vanilla planifolia Andrews) are tropical plants extensively cultivated in countries such as Madagascar, Indonesia, China, and Mexico. These plants are perennial and belong to the Orchidaceae family, growing widely in tropical regions Juniardi *et al.,* (2021). Vanilla extract is used as a spice source in food and beverages.

Even though vanilla holds high market value, not all farmers can easily cultivate it. Many farmers experience failures in growing vanilla plants. These failures occur due to inadequate post-harvest handling, management, and cultivation, as noted by Susetya in Juniardi *et al.* (2021). According to Hadipoentyanti in Juniardi *et al.* (2021), the issues faced by vanilla entrepreneurs in Indonesia include suboptimal productivity and quality, as well as insufficient cultivation techniques by farmers that do not meet the requirements for sunlight intensity and the use of some local vanilla varieties.

The intensity of sunlight is one-factor influencing plants' growth and productivity. This influence is because plants require varying light intensities during the photosynthesis cycle. Plants need solar light energy to complete the 2 phases of photosynthesis response, particularly the light reaction that occurs in the thylakoid and the Calvin cycle in the stroma. (Yustiningsih, 2019).

According to Fitter & Hay, as cited in Zahara and Fuadiyah (2021), sunlight intensity directly influences photosynthesis and indirectly impacts morphogenesis.

Sunlight is crucial for the development and growth of vanilla. Light plays a vital role in determining the flowering and fruit formation phases in vanilla plants. The light requirements for vanilla plants vary at each stage of their development. During the vegetative stage, less light is needed compared to the generative phase. Low light intensity during the generative stage can prevent the plants from flowering. Providing light between 35-55% yields the best results, although a 55% light intensity is necessary to achieve a high vanillin content (Rosman, 2020).

Vanilla plants thrive best within a temperature range of 20 to 30 degrees Celsius (Parada-Molina et al., 2022), with a minimum annual rainfall of 2,000 mm (Fouché & Jouve, 1999). The air humidity should be maintained between 65 and 75 percent (Tombe et al., 2001), with the plant receiving sunlight at 30 to 50 percent. They require a dry period of 2 to 3 months and a wet period of 7 to 9 months each year (Rosman, 2015).

The planting of shade trees is carried out to reduce the intensity of sunlight received by vanilla plants. Using shade trees as shade plants with good development will mitigate the side effects of excessive sunlight (Puthur, 2005). In the physiological processes of plants, light significantly impacts respiration, flowering, and stomatal closure during development and growth in plants (Susilawati et al., 2016).

The mismatch between the vanilla varieties cultivated and the environmental conditions will decrease the productivity of vanilla plants. Local vanilla varieties have already adapted to local environmental conditions, unlike hybrid varieties such as Vania 2. According to (Supriadi et al., 2014), microclimate conditions, especially sunlight intensity and temperature, greatly affect vanilla plants' vegetative and generative growth. The response of each vanilla variety to sunlight intensity is not yet known. Therefore, research is needed on the influence of sunlight intensity on several vanilla plant varieties as a driving factor to help enhance plant growth and production.

2. MATERIAL AND METHODS

The research was conducted between May and July 2023 at the Ayem Farmer Group, Subunit of the Vanili mBajing Learning House located in Sinogo Village, Pagerharjo, Samigaluh District, Kulon Progo Regency, Yogyakarta with coordinate points -7.65991,110.14444.

The materials used in the research include 6-month-old vanilla plants of the Vania 2 and local varieties originating from cuttings, dead branches as climbing media, burnt rice husks, cocopeat, and water. The equipment used consists of a Luxmeter, a Thermohygrometer, a ruler, a measuring tape, writing utensils, and documentation tools. Observations on microclimate variables such as temperature, air humidity, and sunlight intensity are conducted daily at 8, 12, and 15 o'clock.

This study applies the factorial Completely Randomized Design (CRD) method, with 2 factors: varieties and types of shading. The first factor, vanilla varieties, consists of V1 = Vania 2 variety and V2 = local variety. The second factor is the type of shading, consisting of N0 = no shading, N1 = jackfruit tree shading, and N2 = teak tree shading. Thus, 2 x 3 = 6 treatment combinations are obtained. Each includes 4 replications. With 1 plant sample for each treatment combination, 24 plants are acquired.

The observational parameters in this research study include environmental condition observations (microclimate) and agronomic characteristics observations of vanilla plants. The ecological condition observations encompass sunlight intensity, temperature, and air humidity measurements. The agronomic characteristics observations involve vine length, leaf count, stem diameter, branch count, internode length increment, internode count, and chlorophyll content analysis.

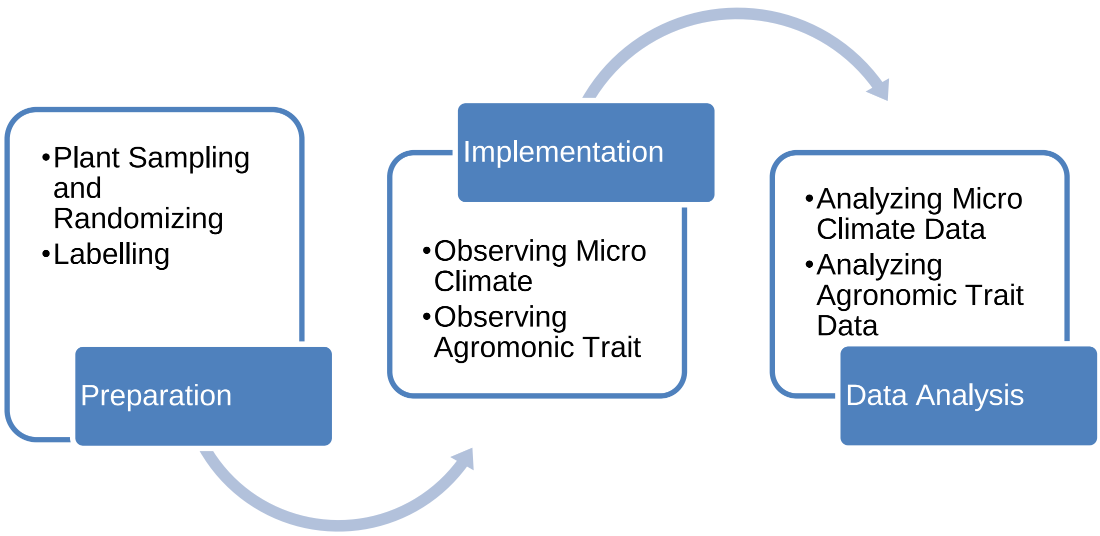

Figure 1. Research Implementation Flow Diagram

The data is analyzed using analysis of variance (ANOVA) at a significance level of 5%. In case of a significant difference in treatments, the study is continued with the Duncan multiple range test at a 5% significance level.

3. RESULT AND DISCUSSION

Microclimate is a crucial environmental factor that significantly influences the growth of vanilla plants.

Table 1 Effect of shade on microclimate

Parameter	Shade		
	No Shade	Jackfruit Shade	Teak Shade
Light intensity (%)	75,12 ±1,34 a	45,75 ± 1,30 b	36,00±0,25c
Air Temperature (0C)	30,00 ± 0,08 a	29,12 ± 0,08b	27,87±0,78c
Air Moisture (%)	70,62 ± 0.14 c	74,37 ± 0.13 b	78,00±0,12a

Note: Means followed by the same letter in the row show no significant difference based on DMRT at the 5% level.

Shading significantly influences microclimate parameters such as light intensity, temperature, and humidity. Teak and jackfruit shading provide the best growing conditions for vanilla plants, with light intensity under teak shading at 36% and under jackfruit shading at 45.75%. The temperature around the plants is lower (27.87°C for teak shading and 29.12°C for jackfruit shading) compared to no shading. Similarly, in terms of air humidity, teak shading results in higher humidity compared to jackfruit shading and no shading.

In agroforestry, teak and jackfruit trees can be utilized as shade trees. Teak trees, tall with broad leaves, and jackfruit trees, with their many branches, can protect surrounding plants by reducing the intensity of sunlight, regulating temperature, and maintaining air humidity. This finding aligns with Zaubin et al. (2011), who stated that the ideal light intensity requirement for vanilla cultivation in tropical regions is 30%-50%. In contrast, vanilla plants grown without shade were exposed to a light intensity of 75.12%. Such high light intensity is unsuitable for vanilla cultivation, as Claudia Díez et al. (2017) explained that high light intensity hinders the process of photosynthesis in vanilla plants.

The air temperature for vanilla plants under teak shade, jackfruit shade, and without shade is 27.87˚C, 29.12˚C, and 30˚C, respectively, which are considered highly suitable for vanilla cultivation. This finding is consistent with Menon & Nayeem (2013), who noted that the optimal growth temperature for vanilla plants in tropical regions is between 21-32˚C. The air humidity under teak shade, jackfruit shade, and without shade is 78%, 74.37%, and 70.62%, respectively. These humidity levels are highly conducive to the growth of vanilla plants, aligning with the findings of Parada-Molina et al. (2022), which suggest that the ideal air humidity for vanilla cultivation ranges between 60-80%.

Table 2 Correlation of light intensity with air temperature and humidity

No	Intensity Correlation	R	R Square
1	Light Intensity	1,000	1,000
2	Air Temperature	0,947	0,897
3	Air Moisture	0,977	0,954

Based on Table 2, there is a strong relationship between light intensity and air temperature. This result is indicated by a correlation value (R) = 0.947. The higher the intensity of sunlight, the higher the air temperature, and vice versa. Regarding air humidity, there is a strong relationship between light intensity and air humidity. This finding is indicated by a correlation value (R) = 0.977. The lower the light intensity, the higher the air humidity; conversely, the higher the light intensity, the lower the air humidity (Table 2).

Table 3 Effect of shade on agronomic traits of vanilla plants

Parameter	Shades		
	No Shade	Jackfruit Shade	Teak Shade
Tendrils Length (cm)	112,00 ± 10,9 a	63,87 ± 9,50 a	67,75 ± 10,0a
Number of Leaves (pieces)	22,12 ± 1,91 a	12,75 ± 0,90 a	13,75 ± 0,99 a
Bar Diameter (mm)	7,36 ± 0,21 a	6,23 ± 0,19 a	6,22 ± 0,20 a
Number of Branches	0,50 ± 0,08 c	0,87 ± 0,07 b	1,00 ± 0,09 a
Number of Sections	24,75 ± 2,04 a	15,00 ± 2,00 a	15,87 ± 2,00 a
Segment Length Increase (mm)	4,50 ± 0,30 a	4,37 ± 0,30 a	5,00 ± 0,31a
Chlorophyll Content (units)	32,50 ± 2,30 a	26,37 ±2,31 a	33,25 ± 2,00a

Note: Means followed by the same letter in the row show no significant difference based on DMRT at the 5% level.

The increased intensity of light and temperature generally enhances the process of photosynthesis. However, the photosynthesis process in vanilla plants will decrease when the received light intensity exceeds 50%. Research results indicate that the type of shading does not affect the chlorophyll content, vine length, stem diameter, leaf count, internode length, number of internodes, and internode length increase in vanilla plants but significantly influences the growth of branch numbers in vanilla plants. These findings differ from those obtained in the study by Ramírez-Mosqueda et al. (2017), which showed a significant impact of light intensity on the in vitro growth of vanilla plants. Light intensity with teak tree shading provides the best results in the branching process of vanilla plants compared to jackfruit shading and no shading.

Table 4. Correlation of sunlight intensity with some branches.

No	Intensity Correlation	R	R Square
1	Number of Branches	0,999	0,998

Based on Table 4, there is a strong relationship between light intensity and the number of branches. This finding is evidenced by the correlation value (R) = 0.999. Low light intensity enhances the branching process in plants. This result is consistent with the study by Issukindarsyah et al. (2020), which explains that light intensity significantly influences the number of branches in pepper plants. Widiastuti et al. (2004) state that a decrease in light intensity from 100 percent to 75% can increase the number of branches in chrysanthemum plants. This result is because focused energy makes chrysanthemum plants taller since most of the photosynthesis output is used for the growth of the main stem, with a small portion used for branch formation, resulting in fewer branches. When light is low, photosynthesis output is distributed throughout the plant tissues via the phloem vessels, stimulating bud growth, thus increasing the number of branches.

Light intensity does not significantly affect the length of shoots, number of segments, length of segments, and chlorophyll content. This result is due to the slow growth of vanilla plants. Claudia Díez et al. (2017) explain that low light intensity does not significantly affect vanilla photosynthesis. However, in the long term, it shows higher photosynthesis, biomass, and growth under moderate radiation levels. Meanwhile, excessively high sunlight intensity hinders the rate of photosynthesis in vanilla plants.

Poor choice of planting media and high temperatures are among the factors causing the slow growth of vanilla. The planting media used by farmers consists of a mixture of coco fiber, cocopeat, and burnt rice husks without any soil mixture. High temperatures and porous planting media result in low moisture and high evaporation. High temperatures affect the nutrient absorption process in the planting media. Mishra et al. (2023) explain that overall heat stress negatively impacts growth and physiological processes such as respiration, nutrient absorption, and water assimilation and can lead to membrane damage. Other detrimental effects of heat stress include biomass reduction, protein denaturation, decrease in protein concentration, and enzyme inactivation for photosynthesis and respiration.

Table 5. Microclimate conditions in some varieties

Parameter	Varieties	
	Vania 2	Local
Light intensity (%)	49,10 ± 1,34 q	55,50 ±1,25 p
Air Temperature (^{o}C)	28,83 ± 0,08 q	29,16 ± 0,07 p
Moisture (%)	74,66 ± 0,14 p	74,00 ± 0,13 q

Note: Means followed by the same letter in the row show no significant difference based on DMRT at the 5% level.

The microclimate conditions vary significantly among different varieties (Table 5). There are notable differences in light intensity, air temperature, and humidity. Direct observations show that unshaded Vania 2 exhibits yellowing and wilting leaves, and in severe cases, Vania 2 plants exposed directly to sunlight become dry and appear scorched, eventually leading to death (See Figures 2 and 3). Vania 2 variety originates from Clone 2 with a stem diameter of 1.84 cm, which is not significantly different from other clones (Udarno & Hadipoentyanti, 2011).

Figure 2. The plant burns the lower part

Figure 3. Plant top burned

There is a significant difference in the diameter of the stem and the length of the internode between the local variety and vania 2, with the local array outperforming vania 2. This result contrasts with a study by Udarno & Hadipoentyanti (2011), which stated that vanilla clones 3 and 4 showed the highest yields compared to local vanilla. The same trend is observed in the internode length, where vanilla clones 1 and 4 displayed higher yields than local vanilla.

Table 5. Effect of variety on agronomic traits of vanilla plants

Parameter	Varieties	
	Vania 2	Local
Tendrils Length (cm)	78,16 ± 10,9 p	84,25 ± 10,0 p
Number of Leaves (pieces)	18,25 ± 1,41 p	14,17 ± 1,35 p
Bar Diameter (mm)	5,68 ± 0,20 q	7,53 ± 0,19 p
Number of Branches	0,66 ± 0,08 p	0,91 ± 0,074 p
Number of Sections	20,41 ± 2,03 p	16,66 ± 2,00 p
Segment Length Increase (mm)	3,41 ± 0, 03 q	5,83 ± 0,025 p
Chlorophyll Content (units)	26,91 ± 2,02 p	34,50 ± 2,01 p

Note: Means followed by the same letter in the row show no significant difference based on DMRT at the 5% level.

The significant differences in agronomic traits between local vanilla varieties and Vania 2 are primarily attributed to variations in the size of the planted cuttings. Locally grown vanilla exhibits larger diameters and longer internodes with faster internode growth, whereas Vania 2 from Balitro has smaller stem diameters with shorter internodes.

Local variety and Vania 2 do not show significant differences in agronomic traits such as vine length, leaf number, internode number, and chlorophyll content. Consistent with the study by Udarno & Hadipoentyanti (2011), it is indicated that there is no significant difference in vegetative growth between clone 2 derived from the Vania 2 variety and the local variety. Similarly, findings from Melati et al. (2023) explain that there is no significant difference in the growth of vanilla plants between the Vania 1 and Vania 2 varieties.

4. CONCLUSION

There is no actual interaction between different types of shading and varieties in the growth of vanilla. Teak and jackfruit trees can be used as shade providers as they can provide suitable intensity for vanilla cultivation. There are significant differences in growth parameters, such as internode length and stem diameter, between vanilla type 2 and local vanilla, while there are no significant differences in other growth parameters.

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