Jurnal Belantara Vol. 8, No.2, August (319-326)
DOI: 10.29303/jbl.v8i2.1121

E-ISSN 2614-3453
P-ISSN 2614-7238

OPTIMIZING EUCALYPTUS PELLITA SEEDLING GROWTH THROUGH NPK FERTILIZER AND LIGHT INTENSITY REGULATION

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Received: 20/02/2025, Revised: 28/07/2025, Approved: 30/07/2025

ABSTRACT

Eucalyptus pellita is a type of fast-growing plant (a fast-growing species). The advantage of this plant is that it is a short-rotation or fast-growing plant, with fewer disease attacks. The benefits of the plant are quite numerous and it has high economic value. Considering that the optimal light intensity for eucalyptus seedling growth is not yet known, it is necessary to test the effects of various light intensities using shade in the form of a paranet. This research was conducted using a factorial Completely Randomized Design (CRD) with a split-plot experimental pattern consisting of 4 treatment levels. Each treatment was repeated 3 times, The results of the study on the effect of NPK fertilizer and light intensity on the growth of eucalyptus seedlings indicate that the interaction of 5 g NPK fertilizer per seedling and 100% light intensity is a better treatment compared to other treatments. This is suspected because eucalyptus is a plant that requires sufficient light intensity to experience the growth of eucalyptus seedlings. The growth of eucalyptus seedlings is influenced by light intensity, which supports the increase in height, stem diameter, and number of leaves. Based on the results of this study, it can be concluded that the treatment of NPK fertilizer and light intensity has a significant effect on the increase in stem diameter. In the treatment P2C0, which is NPK fertilizer 7g/seedling and light intensity 100%, there is no significant difference compared to treatments P1C0 and P3C0, which are 5 g and 9g/seedling of NPK fertilizers under 100% light intensity.

Keywords: *Eucalyptus; Light Intensity; NPK Fertilizer*

INTRODUCTION

The eucalyptus genus comprises numerous species worldwide, and it is often referred to as *Rainbow eucalyptus*. The geographical origin of this plant is Australia, with some species also being found in Papua New Guinea, the Philippines, and Indonesia. Eucalyptus has demonstrated considerable potential in various industrial applications, particularly within the paper industry, and is often recommended as a substitute for *Acacia mangium*. The advantages of eucalyptus include fast growth, short rotation, low incidence of disease, numerous benefits, and high economic value.

There is a growing global demand for wood and wood-based products ((Lock et al., 2021; McEwan et al., 2020)), where it increased from 168 million Ha in 1990 to 278 million ha in 2015, and is expected to increase to 345 million ha by 2030 (Nepal et al., 2019). In North Sumatra, *Acacia mangium* production declined from 22–35 m3/ha/yr to ≤15 m3/ha/yr, due to infections by *Ganoderma philippii* and *Ceratocystis spp* (Hardiyanto et al., 2021). This trend is consistent with observations in South Sumatra, where *Acacia mangium* plantations have been increasingly replaced by *Eucalyptus pellita* due to damage caused by monkeys and squirrels (Nambiar & Sands, 1993). Consequently, approximately 1 million ha of land previously cultivated with *Acacia mangium* have been converted to *Eucalyptus pellita* (Brawner et al., 2022).

According to (Food and Agrcultural Organisation of the United Nations, 2010), as well as market demand and site conditions, Eucalyptus species have been selected to support plantation forest productivity due to their wood properties that are desirable to the market. In order to support productivity improvements, further research is needed to enhance the quality of *Eucalyptus pellita* seedlings prior to planting. This study aims to analyze the interaction between NPK fertilizer and light intensity on the growth of *Eucalyptus pellita* seedlings, as well as to determine the NPK fertilizer dosage and light intensity percentage that support the growth of *Eucalyptus pellita* seedlings.

METHODS

This study was conducted at the Forest Education and Nursery Laboratory of the Forestry Department, Faculty of Agriculture, University of Jambi, Pinang Masak Campus, Mendalo Indah Village, Jambi Province, over a period of 3 months, from October to December 2022.

The materials required for this experiment include *Eucalyptus pellita* clone 361 seedlings, obtained from PT Wirakarya Sakti, that are 2 months old, have five to eight leaves, and have a diameter of 2 to 3 cm. The seedlings should have pink leaf tips, topsoil, and NPK compound fertilizer. The necessary tools for this experiment include paranet (0%; 25%; 50% and 75%), 20 cm x 25 cm polybags, a hoe, a ruler, a thermohygrometer, a luxmeter, an oven, digital scales, markers, white thread, a camera, and writing implements.

This study used a completely randomized factorial design, incorporating a split-plot experimental pattern comprising two factors. Each treatment was replicated 3 times, resulting in a total of 144 seedlings. The following treatment combinations were utilized in this study:

Table 1. The Combination of NPK fertilizer treatment and light intensity

Fertilizer (gram)	**Light Intensity**			
	100% (12481.11 *luxmeter*) C0	75% (3339.16 *luxmeter*) C1	50% (2500.83 *luxmeter*) C2	25% (1532.05 *luxmeter*) C3
0 (P0)	P0C0	P0C1	P0C2	P0C3
5 (P1)	P1C0	P1C1	P1C2	P1C3
7 (P2)	P2C0	P2C1	P2C2	P2C3
9 (P3)	P3C0	P3C1	P3C2	P3C3

The variables observed in this study were plant height increment, stem diameter increment, leaf number increment, root dry weight, shoot dry weight, and shoot-root ratio. To evaluate the effect of treatments on the observed variables, the data obtained in this study were statistically analyzed using *analysis of variance* (ANOVA), followed by a Duncan Multiple Range Test (DMRT) at a 5% significance level. The DMRT was conducted to determine which treatments differed significantly from each other by comparing all possible pairs of treatment means.

RESULTS AND DISCUSSION

Eucalyptus pellita is a fast-growing species that responds well to nutrient addition during the early growth phase, especially in plantation forests established on low-fertility soils with repeated rotations, where nutrient supplementation is crucial. This study used Ultisol soil as the growing medium, a type of soil characterized by high acidity and very low phosphorus (P) availability. (Syahputra et al., 2015) According to (Hutapea et al., 2023), fertilizer application can significantly enhance the growth of Eucalyptus, as indicated by increases in Leaf Area Index (LAI), plant height, and basal stem area. However, this response depends on the quality of the soil and the availability of the nutrient.

Eucalyptus is classified into three genera: Angophora, Corymbia, and Eucalyptus. The genus Eucalyptus is further subdivided into eight subgenera: Eudesmia, Symphyomyrtus, Eucalyptus, Acerosae, Cruciformes, Alveolata, Cuboidea, and Idiogenes (Brune, 2021). Variable soil and climatic conditions significantly affect Eucalyptus growth. Additionally, precipitation and temperature play important roles in determining its growth rate. Eucalyptus exhibits high sensitivity to weed competition for water, nutrients, and light, especially under dry-season conditions and in shallow soils (Nambiar et al., 2018).

The most essential nutrients required by Eucalyptus for optimal growth are nitrogen (N), phosphorus (P), and potassium (K). These nutrients are particularly important in plantation forests that implement a rotational harvesting system (Bassaco et al., 2018). All three nutrients are needed at the beginning of planting, and the required amounts are adjusted according to soil condition. According to a study conducted in Riau (Pamoengkas & Maharani, 2019) the application of 150 g NPK fertilizer per plant combined with 300 g of rock phosphate per plant increased growth performance. In a separate study in South Sumatra (Inail et al., 2019) reported that the addition of 30kg/ha phosphate increased stand volume by 32.6m3/ha.

Table 2. The Analysis of Variance Results for the Growth Response of Eucalyptus pellita Seedlings to Treatment Combinations

Treatment	F-value							F-table value	
	ΔT (cm)	ΔD (mm)	ΔJD (Helai)	ΔBKA (g)	ΔBKT (g)	ΔBKTt (g)	ΔR	5%	1%
Interaction	1,83 tn	4,70*	1,41 tn	2,65*	4,35*	4,31*	1,66 tn	2,3	3,26
Light Intensity	68,40**	142,20**	8,90*	158,47**	33,12**	61,24**	62,57**	4,07	7,59
NPK Fertilizer	28,60**	37,69**	11,02**	6,83*	14,57**	21,40**	0,46 tn	3,01	4,72

Notes: tn no significant effect *have a significant effect **highly significant effect

According to the data shown in Table 2, it can be observed that there is a significant interaction between light intensity treatment and NPK fertilizer treatment affecting stem diameter, root dry weight, shoot dry weight, and total dry weight. Eucalyptus is a fast-growing species that requires nutrients such as nitrogen (N) and phosphorus (P) during its early growth stages. In the long term, nutrients that have accumulated become biomass and will be harvested. Therefore, maintenance in the form of fertilization is necessary to ensure that nutrients are available in the soil.

Table 3. DMRT Test Results for the Interaction Between NPK Fertilizer and Light Intensity Treatments on Stem Diameter Increment of Eucalyptus Seedlings

NPK Fertilizer	Light intensity (%)			
	C0 (100%)	C1 (75%)	C2 (50%)	C3 (25%)
P0 0g/plant	2,3[e]	1,73[ef]	1,53[f]	0,76[g]
P1 5g/plant	4,1[ab]	2,96[cd]	3,1[cd]	0,93[g]
P2 7g/plant	4,23[a]	3,16[cd]	2,9[d]	0,8[g]
P3 9g/plant	4,1[ab]	3,56[bc]	3[cd]	0,8[g]

Notes: Numbers followed by the same letter in the same column are not significantly different at the 5% level of the DMRT test

Based on the results of the 5% DMRT presented in Table 3, the combination of 7 g NPK fertilizer per plant and 100% light intensity was found to be the most favorable treatment for plantation forest system. The development of suitable species is essential to ensure sustained productivity, particularly in terms of wood volume and biomass (Wirabuana et al., 2021). The volume of wood can be determined by the combined contribution of stem diameter and plant height. The diameter growth exhibited a strong correlation with the height growth, with elevated NPK doses resulting in increased plant growth (Nasrullah et al., 2015). Eucalyptus is a fast-growing hardwood species that is widely planted in tropical regions and has a high adaptability to various abiotic and soil conditions. According to (Binkley et al., 2020) and (Binkley et al., 2017) rainfall and temperature are significant climate variables that influence tree growth. The growth of eucalyptus trees is also influenced by the solar radiation intensity, which affects the quality and quantity of germination, growth, photosynthesis, as well as root and shoot development (Souza et al., 2024).

Response of Seedling Root Dry Weight to Treatment Combinations

Based on the results of analysis of variance, the interactions between light intensity and NPK fertilizer had a significant effect on the root dry weight of Eucalyptus seedlings.

Table 4. DMRT Results for the Interaction Between NPK Fertilizer and Light Intensity Treatments on Root Dry Weight of Eucalyptus Seedlings

NPK Fertilizer	Light intensity (%)			
	C0 (100%)	C1 (75%)	C2 (50%)	C3 (25%)
P0 0g/plant	6[b]	3,13[c]	2,6[cd]	0,96[d]
P1 5g/plant	9,63[a]	4,43[bc]	3,6[c]	1,03[d]
P2 7g/plant	10,26[a]	3,4[c]	4,56[bc]	1,06[d]
P3 9g/plant	8,46[a]	5,76[b]	4,06[bc]	1,13[d]

Notes: Numbers followed by the same letter in the same column are not significantly different at the 5% level of the DMRT test

This study used Ultisol soil as the growing medium. Ultisols cover approximately 25% of the land area in Indonesia. Ultisols exhibit chemical and physical properties that are not conducive to optimal plant growth. They are characterized by low levels of organic matter, essential nutrients, and phosphorus (P) availability. Ultisols are classified as acidic soils due to their low phosphorus (P) availability, a factor that limits plant growth (Fitriatin et al., 2014). Soil plays a pivotal role in determining tree growth due to its ability to retain water, hold nutrients, support root penetration, and maintain porosity. The productivity of E. pellita tends to be higher in areas with a wide range of rainfall levels (from low to high) and lower temperatures. In addition, other factors such as the duration of the dry season, genetic variation, and silvicultural practices (Harwood & Nambiar, 2014).

The interaction between NPK fertilizer treatment and light intensity on the variable of root dry weight indicated that the treatment of 7 g NPK per plant under 100% light intensity was the most favorable, as it does not significantly differ from the 5 g and 9 g NPK treatments at the same light intensity; however, it does differ significantly from all other treatment combinations. According to (Nasrullah et al., 2018), nitrogen is an essential nutrient that promotes the growth of stems, branches, and leaves, as well as chlorophyll formation in plants. The application of phosphorus (P) enhances root development and supports the formation of an effective root system, which is especially critical during the seedling stage (Natashya et al., 2023). Nutrient absorption efficiency is influenced by root development; consequently, higher fertilizer doses generally promote greater root elongation.

Response of Seedling Shoot Dry Weight to Treatment Combinations

Based on the results of the analysis of variance, the interaction between light intensity and NPK fertilizer had a significant effect on the shoot dry weight of Eucalyptus seedlings.

Table 5. DMRT Results for the Interaction Between NPK Fertilizer and Light Intensity Treatments on Shoot Dry Weight of Eucalyptus Seedlings

NPK Fertilizer	Light intensity (%)			
	C0 (100%)	C1 (75%)	C2 (50%)	C3 (25%)
P0 0g/plant	$11{,}3^{de}$	$11{,}53^{de}$	$9{,}43^{e}$	$4{,}6^{f}$
P1 5g/plant	$14{,}06^{bcd}$	$15{,}1^{bc}$	$19{,}86^{a}$	$5{,}3^{f}$
P2 7g/plant	$13{,}7^{bcd}$	$12{,}36^{cde}$	$15{,}3^{bc}$	$5{,}9^{f}$
P3 9g/plant	$15{,}63^{b}$	$14{,}93^{bc}$	13^{bcd}	$6{,}53^{f}$

Notes: Numbers followed by the same letter in the same column are not significantly different at the 5% level of the DMRT test

Shoot dry weight is determined by the total dry weight of the stem and leaves. An increase in stem height and leaf number generally leads to a higher shoot dry weight. Starsy et al. (2018) stated that the dry weight of plants represents the nutritional level of plants related to the availability and absorption of nutrients.

As shown in Table 5, the interaction between light intensity and NPK fertilizer treatments on the variable of shoot dry weight indicated the best treatment was 5 g of NPK fertilizer per plant under 50% light intensity, showing a significant difference from all other treatments. This is consistent with the study by Nasrullah et al. (2015), who reported that in cocoa plants, the application of 5 g NPK was the optimum dose for shoot dry weight. However, in Eucalyptus seedlings, shoot growth decreased as light intensity declined. This was evident in the treatment with 0 g NPK and 25% light intensity, which resulted in the lowest shoot dry weight compared to all other treatments. Consistent with the findings of (Widiastuti et al., 2004; Panjaitan et al., 2011; Simangunsong *et al.,* 2016; Lumbanraja et al., 2021), with decreasing light intensity causes a reduction in shoot dry weight.

Response of Seedling Total Dry Weight to Treatment Combinations

Based on the results of the analysis of variance, the interaction of light intensity had a significant effect on the total dry weight of Eucalyptus seedlings.

Table 6. DMRT Results for the Interaction Between NPK Fertilizer and Light Intensity Treatments on Total Dry Weight of Eucalyptus Seedlings

NPK fertilizer	Light intensity (%)			
	C0 (100%)	C1 (75%)	C2 (50%)	C3 (25%)
P0 0g/plant	17,3[bcd]	14,66[de]	12,03[e]	5,56[f]
P1 5g/plant	23,7[a]	19,53[bc]	23,46[a]	6,33[f]
P2 7g/plant	23,96[a]	15,76[d]	19,86[bc]	6,96[f]
P3 9g/plant	24,1[a]	20,7[ab]	17,06[cd]	7,66[f]

Notes: Numbers followed by the same letter in the same column are not significantly different at the 5% level of the DMRT test

The total dry weight of seedlings is the sum of shoot and root dry weights. According to Gardner et al. (1991), total dry weight is the result of the efficiency of absorption and utilization of solar radiation available throughout the growing season of a plant.

As shown in Table 6, the interaction between light intensity and NPK fertilizer treatments on the variable of shoot dry weight indicated that the treatment of 9 g NPK per plant under 100% light was the most effective treatment. This treatment was not significantly different from the 5 g and 7 g NPK treatments under 100% light, and also not significantly different from the 5 g NPK treatment under 50% light. This is following the opinion of Simangunsong et al. (2016), who stated that NPK fertilizer is a compound fertilizer that provides essential nutrients required for plant growth.

The low growth of eucalyptus seedlings under 25% light intensity is presumed to result from insufficient light to meet the physiological requirements necessary for supporting growth. According to Leksono (2010), *Eucalyptus* sp. is suitable for cultivation in tropical regions, where sufficient solar radiation is required for optimal growth. The observation data in this study provide evidence that light intensity plays a dominant role in influencing the growth of eucalyptus seedlings.

CONCLUSIONS

The interaction between light intensity treatment and NPK fertilizer treatment had a significant effect on the increase in stem diameter, root dry weight, shoot dry weight, and total dry weight of eucalyptus seedlings. The treatment of 7 g of NPK fertilizer per plant and 100% light intensity proved to be more effective within the context of plantation forest development. This combination of treatments has the potential to enhance productivity, consequently contributing to the fulfillment of timber demands. The practice of forest plantation management requires the implementation of appropriate, effective, and efficient silvicultural techniques to ensure sustainable rotation and productivity.

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