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The Influence of Different Light Intensity on the Growth of *Zoysia matrella* Seeds

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Abstract. *Zoysia matrella is a type of highly valued grass, but the seedling time is very long due to the slow growth rate. Several studies have been conducted using artificial light as a light source to accelerate indoor plant production. However, this technology is yet to be widely used for seed production. Therefore, this study aimed to obtain optimal light intensity from artificial light in accelerating Zoysia matrella seedling time. The treatment in the form of Light Emitting Diode (LED) illumination given to increase the growth of Zoysia seedlings consisted of 5 levels, namely 20, 40, 60, 80, and 100 (µmol/m^2/s). The parameters studied were germination percentage, germination rate, and vegetative measurement in the form of seedling height in Zoysia nursery chamber equipped with artificial light. The results showed that the artificial illumination technology in the nursery chamber increased the speed of seedling time in the germination and growth phases of Zoysia seeds.*

Keywords: *Artificial Light; growth; intensity; seedling; Zoysia matrella.*

Type of the Paper: Regular Article.

1. Introduction

Zoysia is a type of grass that has three interesting roles, including conservation, aesthetics, and high economic value. As a vegetative soil conservation medium, Zoysia has the potential to decrease run-off, promote soil absorption, cleanse water in sediment and contaminants, limit erosion, and enhance the quality of soil [1]. One type of Zoysia, namely *Zoysia matrella*, is also used as a green roof. The green roof concept implemented at Nanyang Technological University has an aesthetic function and maintains an ambient temperature [2]. This type of landscape grass is frequently utilized as lawns, courses of golf, and soccer courts [2,3].

The major problem in cultivating Zoysia grass is the slow growth rate, either through vegetative (stolon) or generative (seed) propagation. Zoysia seed germination takes 10-15 days, and seedlings are ready for transplanting in 8-12 weeks [4] after the germination phase. The germination rate varies depending on the variance and microclimatic requirement, including seed germination temperature [5]. Soil temperature in Zoysia plantations depends on light level received because the rate of photosynthesis and respiration becomes higher in plants that receive more light [6]. In addition to soil temperature, moisture also affects the development of diseases (pathogenic fungi) that can attack Zoysia, where pathogenic fungi reduce seed germination and

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growth of landscape grass seedlings [3]. Soil moisture condition is a limiting factor in landscape grass production, where drought reduces population, stem density, as well as grass cover by 7% [7].

The sufficiency and accessibility of light strongly influence soil temperature and humidity in the plant environment. Light is a key climatic aspect, where the illumination level, irradiation, and quality affect plant expansion and growth [8] included in the nursery phase [9,10]. Insufficient light leads to unsuitable circumstances for the development of grasses, reducing the life span. Therefore, the addition of artificial light is needed to cover the deficiencies [11].

Artificial lighting technology for increasing crop yields is developed from several types of lights and modified for the plant being cultivated [12–15]. Light Emitting Diode (LED) is used as a light source to produce young plants with high density and relatively quick harvest time [16]. This technology is considered ecological sound because it emits no excessive heat or hazardous emissions and is more constant than other artificial lighting [17].

Artificial light technology with LED provides convenience and flexibility in the application to various plant varieties and plant growth phases by finding the optimal lighting formulation with parameters such as light intensity, spectrum composition, and irradiation time [13]. Using blue and red light spectrums may solve the requirements of light in crop productivity [18,19]. Therefore, this method is frequently used in PFAL technology (Plant Factory with Artificial Lighting). Several studies also reported that far-red irradiation (700-800 nm) in artificial light can increase stem elongation and the quality of plant seeds [20,21].

Many studies have been carried out to find optimal lighting formulas for several plants and growth phases related to lighting parameters including light intensity, spectral composition, and irradiance [13,22,23]. However, more efforts are required for seed production [20], such as Zoysia which takes a long time. Using artificial light to accelerate the seedling time requires Zoysia nursery technology. Therefore, this study aimed to obtain optimal light intensity from artificial light in accelerating *Zoysia matrella* grass seedling time.

2. Materials and methods

The experiment was conducted in the nursery chamber at the Control System Laboratory of Cilacap State Polytechnic, Indonesia, from August to November 2022. The setting was defined by an indoor microclimate with temperatures of 28^{o}C to 33^{o}C and humidity of 60% to 80%. This location contains latitude, longitude, and elevation from sea level of 7043’04” S, 109001’15” E, and 3 m, respectively.

The nursery chamber for Zoysia seedlings was fitted with artificial light technology in exchange for natural light. A closed-loop system was used to maintain light intensity according to the set point and the artificial growth light used was a red-blue LED light. LED lights used were High Power LED (HPL) with 4 royal blue (460 nm) and 1 red (625 nm) LED in series. The nursery chamber had a light intensity of 16,15 μmol/m^2/s at 8,5 Volts and 108,34 at 12 Volts. The nursery chamber of *Zoysia matrella* is shown in Fig. 1.

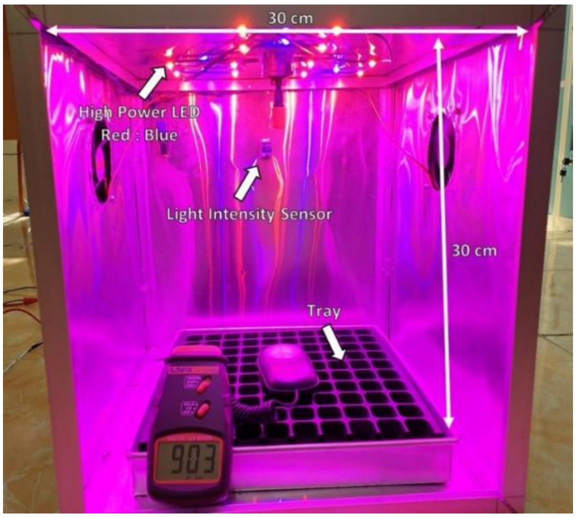

Fig. 1. Nursery chamber of *Zoysia matrella* seed

The nursery chamber used a light intensity sensor to assess light intensity of LED and surroundings. With a closed-loop system, precise lighting that reached the surface of the seedling was obtained, hence, the impact of the room light intensity did not affect the specified light setting. The system adjusted to the average time required of 11 seconds with a 3% inaccuracy.

Commercial seeds of *Zoysia matrella* were used to investigate the influence of light intensity from artificial light on germination and seedling stage. This study used a single-factor experiment in the form of different light intensities. The factor consisted of 5 light intensity levels, including P1 (20 μmol/m^2/s), P2 (40 μmol/m^2/s), P3 (60 μmol/m^2/s), P4 (80 μmol/m^2/s), and P5 (100 μmol/m^2/s). The experimental design of this study is shown in Fig. 2.

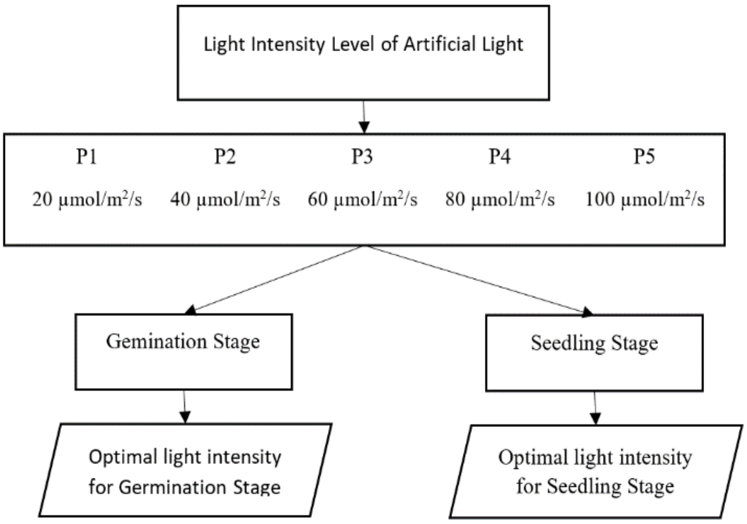

Fig. 2. Experimental Design of using Artificial Light for *Zoysia matrella* seeds.

For all investigations, germination percentage tests and determinations were conducted using 50 seeds/chamber, evaluated 10 days after sowing. Seeds were sprouted in a Petri dish on a tissue plate soaked with distilled water, then placed in each nursery chamber under artificial light at 27-28°C. The germination percentage was calculated based on the reported number of seeds sprouted with the total number that germinated 10 days after sowing. Germination speed was observed by observing the time the seeds started to sprout after sowing.

The germinated Zoysia seeds were transplanted into the planting medium and placed in the nursery chamber under artificial lights for the seedling stage. The planting medium was made from a mixture of manure from laying hens: cocopeat: sandy soil with a ratio of 2:1:1. The mixture was incubated with a composting technique for 3 weeks by fermentation of Effective Microorganism (EM4). The planting medium had sufficient nutrition as shown in in Table 1. During the seedling phase, watering was carried out 2 times/day to maintain humidity.

Table 1. Characteristics of planting medium

Parameter	Unit	Value	Permentan No 01/2019
C-organik	%	16.99	Minimum 15
N	%	1.60	N + P2O5 + K2O minimum 2
P	%	1.05	
K	%	0.19	
pH	%	6.19	4-9
C/N		10.63	<25

During the seedling phase, the shoot canopy height was measured two times, namely 7 days and 14 days after transplanting. After day 14, Zoysia seedlings and soil were carefully dug out from the tray cavity to observe the difference in growth development. Data were analyzed using correlation tests to find the interaction between light intensity and Zoysia seedling growth.

3. Results and Discussion

3.1. Germination Percentage

Data on the total germination percentage of *Zoysia matrella* seeds under various light intensities are shown in Fig. 3. The plot showed that germination of seeds occurred at low light intensities, namely P1 (20 µmol/^{2}/s) and P2 (40 µmol/m^2/s), while at higher intensities, no seeds germinated. The highest germination percentage was obtained from P1 treatment, at 10%, which did not statistically differ from P2 treatment, at 8%. The result is consistent with a previous study [24] stating that seed under low light intensity has higher germination rates than under high light. The low germination percentage is presumably influenced by the genetics of the grass seeds [5], with Zoysia [24] having a slow germination rate [25,26]. In the field conventional nursery, the different seed germination rate was affected by genetics [27].

In P3, P4, and P5 treatments, no seeds germinated, presumably because this type of seed belongs to the negative photoblastic type that requires little light in the germination process [24].

Therefore, at a higher light intensity level, no seeds germinated, presumably because excess heat inhibited the germination process. Several studies on artificial light at various light intensity levels in plant nurseries reported that low light intensity is more suitable for germination in the nursery phase, such as in tropical shrubs [24]. Light produced from the combination of red and blue HPL may not be suitable for the germination phase of Zoysia because every species requires a specific light for seedling [9,28].

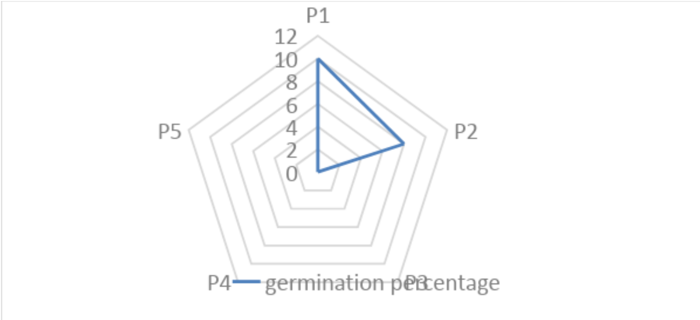

Fig. 3. Germination Percentage of *Zoysia matrella* under light intensity treatment

In P1 treatment, the height of Zoysia seed sprouts could reach 5 mm in a total of 10 days after sowing, while in P2 treatment, the height only reached 2 mm simultaneously. The lowest light intensity of 20 µmol/m^2/s (P1) from an artificial light source could break seed dormancy better than the higher intensity. At a light intensity of 40 µmol/m2/s (P2), the seed sprouts had less good performance than at an intensity of 20 µmol/m^2/s (P1). The difference in the performance of Zoysia sprout at the 2 levels of artificial light intensity is shown in Fig. 4.

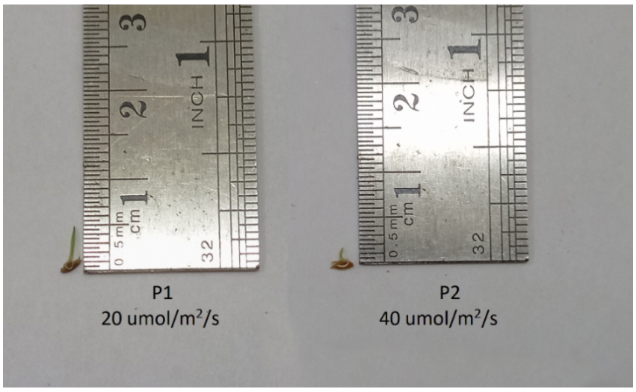

Fig. 4. The difference in Zoysia seed sprout performance

3.2. Germination Speed

The germination process using artificial light technology in Zoysia nursery chamber has a shorter germination time than the conventional method, which usually takes 10-15 days [4]. Data on germination speed can be known by counting the number of seeds germinating 10 days after sowing, as shown in Fig. 5. Among all the treatments given artificial light intensity, only P1 (20 µmol/m^2/s) and P2 (40 µmol/m^2/s) were able to germinate in 10 days. P1 (20 µmol/m^2/s) started sprouting on the 5th day after sowing, with 5 seeds germinated on day 10. P2 (40 µmol/m^2/s) started sprouting on the 6th day after sowing, with 4 seeds germinated simultaneously. The results imply that a high germination rate can be reached by limiting the amount of light intensity given to the seed. Slow germination speed is not only influenced by light intensity and seed genetics [28] but also requires other specific environmental conditions [29], such as temperature [30].

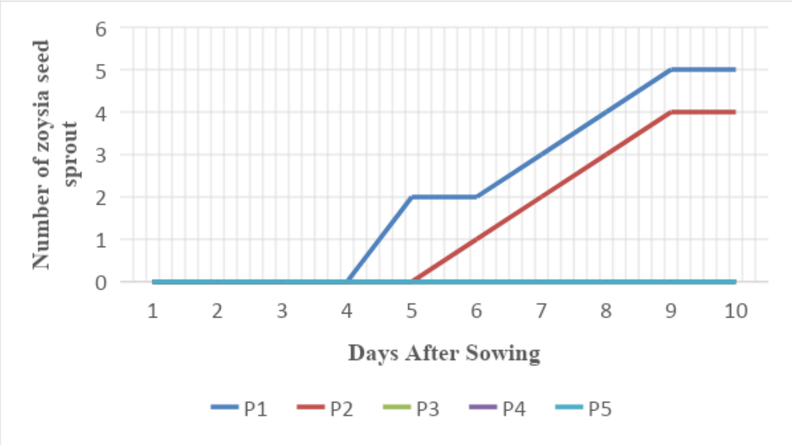

Fig. 5. Germination speed of Zoysia seeds

3.3. Zoysia Seedling Height

The increase in Zoysia grass height during the nursery processes is shown in Fig. 6. Based on the results, the plant height increased significantly from 7 and 14 days after planting (DAP). At low intensities (20 – 40 µmol/m^2/s), there was no significant increase in plant height. The lack of light caused a low photosynthesis rate and etiolated plant by reducing chlorophyll and carotenoid content [31]. In the nursery chamber with an intensity of 60 – 100 µmol/m^2/s, plant height increased significantly, almost 100%. This condition was supported by higher photosynthesis and respiration rates than under low light [32].

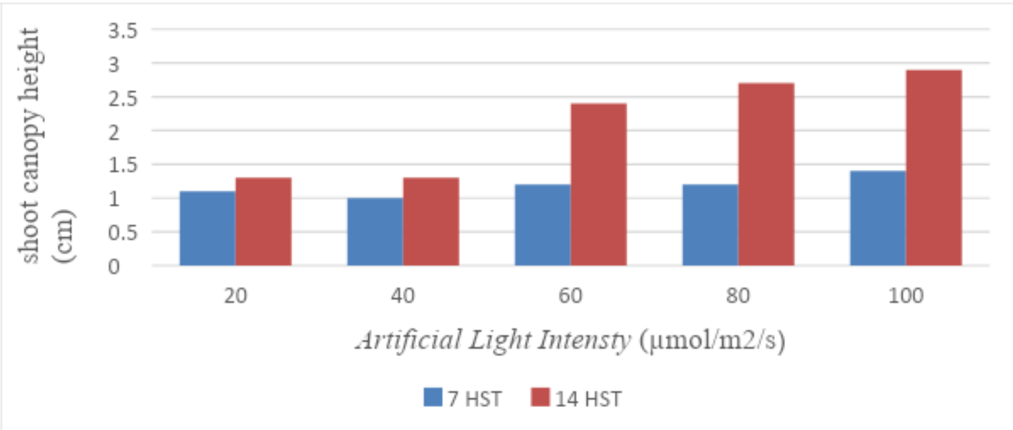

Fig. 6. Height Increase of *Zoysia matrella* Seedlings in a Nursery Chamber Using Artificial Light Technology

At the highest light intensity treatment, Zoysia seedlings had the best plant vigor. This data shows an association between higher amount of light intensity and growth in the height of Zoysia seeds with a value of r2 = 0.89, as shown in Fig. 7. The correlation value indicates that Zoysia seedlings height increases linearly with higher light intensity in the nursery. The intensity of artificial light produced in the nursery chamber has proven to significantly affect the growth of

Zoysia seedlings through an optimal photosynthetic process [24]. The adequacy of light obtained in the treatment with the highest intensity was also supported by the adequacy of the nutrients available from the planting medium [33] used (Table 1) to produce seeds with good vigor.

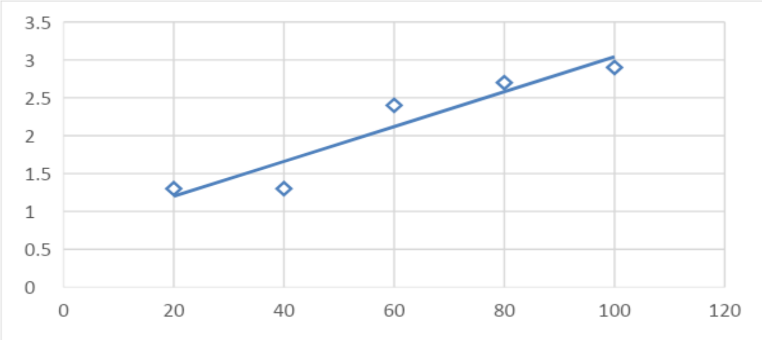

Fig. 7. Correlation between the increase in artificial light intensity and the increase in Zoysia seedling height

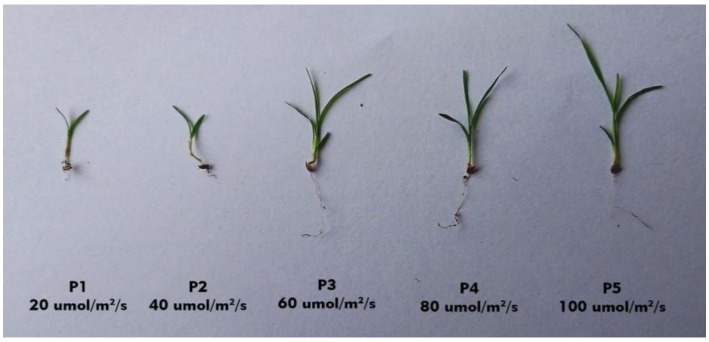

Fig. 8. *Zoysia matrella* seed performance under different Artificial light intensity levels

The difference in the performance of Zoysia seeds under artificial light intensity treatment is shown in Fig. 8. Based on the results, the intensity of artificial light in the nursery chamber, with the most significant effect on the growth of Zoysia seedlings, was 100 µmol/m^2/s. At higher light intensity, the photosynthesis of C-4 plants is more effective [34]. Meanwhile, at low-intensity levels, namely, 20 – 40 µmol/m^2/s, plant seeds did not grow. This is presumably because the lack of light inhibits physiological processes in plants, such as photosynthesis, leading to decreased carbohydrate production [35] and plant respiration. At light intensity of 60 – 80 µmol/m^2/s, the heat generated by the artificial light did not support optimal seedling growth.

4. Conclusions

In conclusion, the use of nursery chambers with artificial light technology was proven to increase germination rates of *Zoysia matrella* grass at low-intensity levels in the range of 20 µmol/m^2/s. In seedling *Zoysia matrella* grass, a maximum light intensity level of 100 µmol/m^2/s is required. Based on the results, high light intensity was recommended to support growth optimally in the nursery phase. Further studies are needed for the optimal result of light intensity in increasing germination and growth speed of *Zoysia matrella* grass.

Data Availability Statement

Data will be shared upon request by the readers.

Credit Authorship Contribution Statement

Sari Widya Utami: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft. Artdhita Fajar Pratiwi: Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft. Galih Mustiko Aji: Methodology, Software, Validation, Formal analysis, Data Curation, Writing - Original Draft.

Declaration of Competing Interest

The authors declare no competing interests.

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