Journal of Tropical Crop Science Vol. 13 No. 2, June 2026
www.j-tropical-crops.com

Received 2/6/2026; Revised 3/27/2026; Accepted 5/19/2026
https://doi.org/10.29244/jtcs.13.02.457-466

The Effect of Light Intensity and Watering Intervals on the Growth and Flowering of Pentas (*Pentas lanceolata*)

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Abstract

Pentas (*Pentas lanceolata*) is an African ornamental species widely cultivated in Indonesia for landscaping and potted plant production. However, the optimal combination of light intensity and watering interval for maximizing growth and flowering under potted conditions remains unclear. This study aimed to evaluate the interaction effects of light intensity and watering intervals on the growth and flowering of Pentas. The experiment was conducted from December 2024 to March 2025 in Sukun District, Malang, Indonesia (440 masl.), using a split-plot design with three replications. Light treatments consisted of full light (100% or ±18,898 lux), moderate light (75% or ±12,216 lux), and low light (50% or ±6,122 lux), while watering intervals were applied every 3, 4, or 5 days. Data were analyzed using analysis of variance (ANOVA) followed by Tukey's honestly significant difference (HSD) test. The results showed that light availability and watering interval influenced plant growth and flowering, with responses differing between growth stages. Optimal vegetative growth, indicated by the highest shoot dry weight, was achieved under moderate light intensity (75%) combined with a 4-day watering interval. In contrast, the best flowering performance was observed under full light conditions (100%) with the same watering interval. Full light increased the chlorophyll index by 28.73% compared to low light intensity (Figure 3), while moderate light accelerated flower initiation by approximately 19 days (9.40%) (Figure 4). Although watering alone had a limited effect, its interaction with light availability was crucial in regulating overall plant performance. These findings indicate that stage-specific management of light and watering is essential for optimizing the growth and flowering of potted Pentas.

Keywords: flowering, light intensity, ornamental plants, *Pentas lanceolata*, watering interval

Introduction

Pentas (*Pentas lanceolata*) is a popular ornamental plant widely cultivated in Indonesia for landscaping and potted plant production due to its attractive flowers and adaptability to tropical conditions. Despite its wide use, the growth and flowering performance of Pentas are strongly influenced by environmental factors, particularly light intensity and water availability. Light intensity plays a crucial role in regulating photosynthesis, biomass accumulation, and floral initiation in ornamental plants. Both insufficient and excessive light can disrupt physiological processes, leading to reduced growth and delayed flowering. Similarly, improper watering management may cause water stress or root damage, which negatively affects plant performance. Therefore, appropriate regulation of light and watering is essential for optimizing plant growth and flowering. Although several studies have reported the individual effects of light intensity or watering on ornamental plants, the optimal combination of light intensity and watering interval for maximizing the growth and flowering of Pentas under potted conditions remains unclear. Limited information is available on how varying light intensities interact with

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watering intervals across different growth stages of Pentas. Therefore, this study aimed to evaluate the single and interaction effects of light intensity and watering intervals on the growth and flowering performance of *Pentas lanceolata*. The findings are expected to provide scientific guidance for stage-specific management of light and irrigation to improve the production quality of potted Pentas.

Materials and Methods

The research was conducted in the Greenhouse of the Agricultural Development Polytechnic (Polbangtan II, Ministry of Agriculture), Sukun District, Malang City, East Java, from December 2024 to March 2025. The experimental site is located at an altitude of 440 m above sea level, with an average annual rainfall of 191.9 mm and an average temperature of 26 °C (Statistics Indonesia, 2021). The tools used in this study included pots (15 × 15 cm), shade nets (25% and 50%), bamboo stakes, trowels, measuring tapes, an analytical balance, a SPAD meter, an oven, measuring cups, buckets, labels, envelopes, and a camera. The materials consisted of *Pentas lanceolata* seedlings, planting media (rice husk, cocopeat, and soil), water, and fertilizers (NPK, SP-36, ZA, dolomite, KCl, Furadan (a.i. carbofuran), and NPK Mutiara 16:16:16). The experiment was arranged using a split-plot design with two factors: light intensity (I) as the main plot and watering interval (P) as the subplot, with three replications. Light intensity treatments consisted of I100% (±18,898 lux, without shade), I75% (±12,216 lux, 25% shade), and I50% (±6,122 lux, 50% shade). Watering intervals consisted of P3 (every 3 days), P4 (every 4 days), and P5 (every 5 days).

Each experimental unit consisted of nine plants, selected for uniform initial growth and morphological characteristics to minimize variability among treatments, yielding a total of 243 plants. Observed parameters included plant height, number of leaves, number of branches, leaf area, canopy width, chlorophyll index, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, flowering time, number of flower clusters, cluster diameter, and total number of flower buds. Data were analyzed using analysis of variance (ANOVA) at the 5% significance level, and when significant differences were detected, mean separation was performed using Tukey's honestly significant difference (HSD) test at the 5% level.

Results and Discussion

The growth and flowering responses of *Pentas lanceolata* varied with the combination of light intensity and watering intervals used during the experiment. This indicates that plant performance was not determined by a single factor, but by the interaction between light availability and water supply, which influenced physiological processes at different growth stages.

Plant Height

Plant height of *Pentas lanceolata* varied across different combinations of light intensity and watering interval (Figure 1). Plants grown under moderate light intensity (75%) generally exhibited greater height, particularly when watered every four days, compared to those grown under full light intensity (100%) with longer watering intervals. In contrast, plant height under low light intensity (50%) showed relatively smaller variation among watering intervals. These results indicate that plant height responded differently to watering intervals depending on the level of light intensity applied.

Plant height is an important indicator of plant physiological activity, particularly photosynthesis, which supplies energy and assimilates required for vegetative growth, including stem elongation. Teran et al. (2019) reported that photosynthates are allocated to support vegetative development, such as stem elongation, which is reflected in increased plant height. Mahardika et al. (2023) also explained that light intensity strongly influences plant growth and development by regulating photosynthetic activity. In the present study, plants grown at 75% light intensity with a 4-day watering interval

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exhibited greater stem elongation than those subjected to longer watering intervals under full light, suggesting that moderate light availability combined with adequate water supply favored vegetative growth in Pentas.

Leaf Area

Leaf area of *Pentas lanceolata* varied under different combinations of light intensity and watering interval (Figure 2). Plants grown under moderate light intensity (75%) generally developed wider leaves, particularly when watered every four days, compared to those subjected to longer watering intervals under full light intensity (100%). Under low light intensity (50%), leaf area showed relatively smaller differences among watering intervals. These results indicate that leaf expansion responded differently to watering intervals at different light intensities.

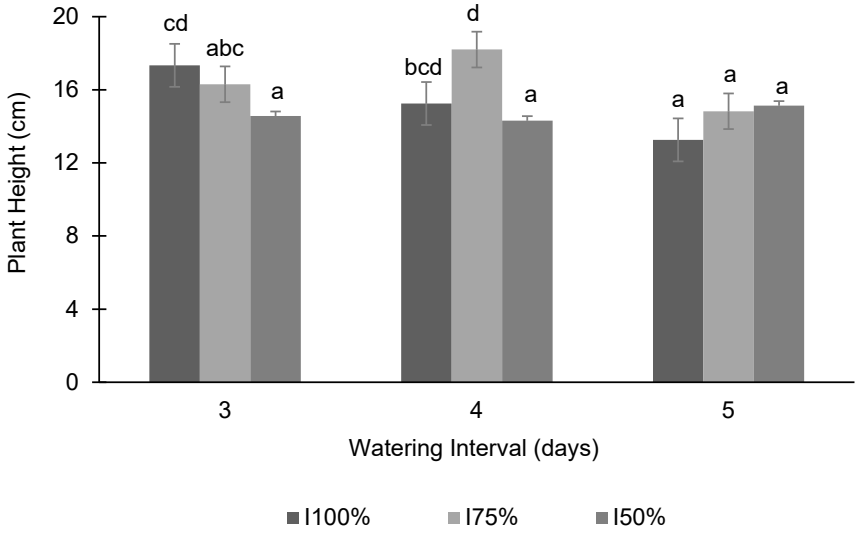
Leaf area is an important trait influencing photosynthetic capacity, as larger leaves provide a greater surface area for light interception. Dewi and Wahyuni (2015) reported that increased leaf area enhances light absorption, thereby supporting photosynthetic activity. Similarly, Sinuraya (2019) stated that optimal light intensity promotes photosynthate accumulation, which supports cell division and expansion in leaf tissues. In the present study, plants grown under full light intensity combined with a longer watering interval exhibited reduced leaf expansion, possibly due to limited water availability to support increased transpiration demand. In contrast, moderate light intensity (75%) combined with a 4-day watering interval provided a more favorable balance between light availability and water supply, resulting in wider leaf development in Pentas plants.

Chlorophyll Index

The chlorophyll index of *Pentas lanceolata* showed a consistent response to light intensity, regardless of watering interval (Figure 3). Plants grown under full light intensity (100%) exhibited higher chlorophyll index values compared to those grown under moderate (75%) and low (50%) light conditions. In contrast, variations in watering intervals resulted in similar chlorophyll index values at the same light intensity, indicating that chlorophyll content was primarily influenced by light availability.

Figure 1

Plant Height of Pentas lanceolata under Different Light Intensities and Watering Intervals at 56 Days After Planting



Note. Bars represent mean ± standard deviation I : light intensity.

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Chlorophyll synthesis is closely associated with light availability, as light serves as the primary energy source for photosynthesis. Ai and Banyo (2011) reported that chlorophyll functions as the main pigment responsible for capturing light energy to support CO_2 fixation and carbohydrate formation. In the present study, exposure to full light intensity increased chlorophyll accumulation, resulting in a 28.73% higher chlorophyll index than plants grown under 50% light intensity. Similar findings were reported by Fatmawaty et al. (2024), who stated that increased light intensity generally promotes chlorophyll formation if it does not exceed the plant's tolerance threshold. Conversely, reduced light availability limited chloroplast activity, leading to lower chlorophyll content under shaded conditions. Although full light intensity can induce physiological stress, Pentas plants in this study appeared to tolerate high irradiance with adequate watering, thereby maintaining high chlorophyll synthesis and photosynthetic activity without severe photoinhibition.

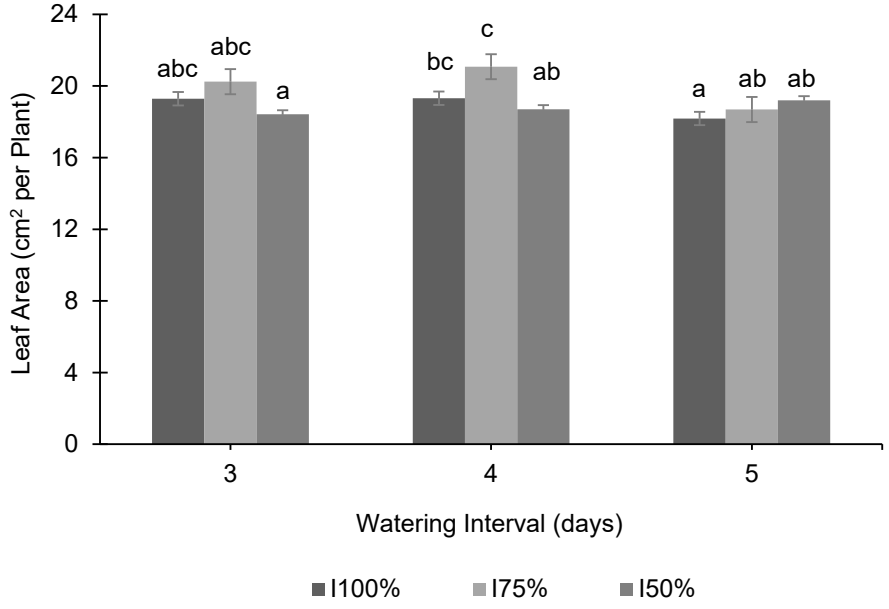
Dry Weight

Shoot and root dry weight of *Pentas lanceolata* varied depending on the combination of light intensity and watering interval applied (Table 1). Plants grown under moderate light intensity (75%) with a watering interval of every four days produced the highest shoot dry weight, indicating enhanced biomass accumulation in aboveground tissues. In contrast, the highest root dry weight was observed in plants grown under low light intensity (50%) combined with a five-day watering interval, suggesting a greater allocation of biomass to belowground organs under reduced light availability.

Dry matter accumulation reflects the balance between photosynthesis, respiration, and assimilate distribution within the plant. According to Hastuti and Titiaryanti (2022), total dry weight represents the net accumulation of photosynthates during plant growth. In the present study, moderate light intensity promoted wider leaf development and greater light interception,

Figure 2

Leaf Area of Pentas lanceolata under Different Light Intensities and Watering Intervals at 56 Days After Planting



Note. Bars represent mean ± standard deviation I : light intensity.

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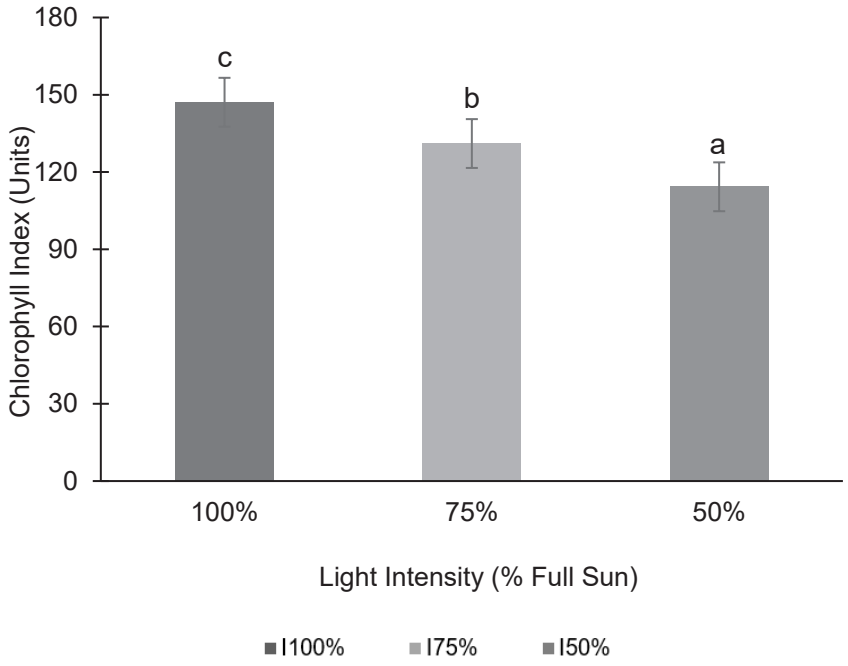
Figure 3

Chlorophyll Index of Pentas lanceolata under Different Light Intensity Treatments at 56 Days After Planting



Note. Bars represent mean ± standard deviation I : light intensity.

Table 1

Shoot Dry Weight and Root Dry Weight of Pentas lanceolata under Different Light Intensities and Watering Intervals at 56 Days After Planting

Treatments	Shoot dry weight (g per plant)	Root dry weight (g per plant)
100% light intensity + watering every 3 days	2.62 d	8.56 bcd
100% light intensity + watering every 4 days	2.66 d	9.14 bcd
100% light intensity + watering every 5 days	1.93 a	7.57 b
75% light intensity + watering every 3 days	2.39 bcd	8.98 bcd
75% light intensity + watering every 4 days	3.08 e	9.60 cd
75% light intensity + watering every 5 days	1.78 a	8.10 bc
50% light intensity + watering every 3 days	2.16 abc	5.86 a
50% light intensity + watering every 4 days	2.46 cd	8.72 bcd
50% light intensity + watering every 5 days	2.01 ab	9.81 d
HSD 5%	0.39	1.64

Notes. Mean values followed by the same letter within the same column are not significantly different based on Turkey's HSD test at the 5% level. Light intensity treatments were 100% (no shade), 75% (25% shade), and 50% (50% shade). Watering intervals were set to 3, 4, or 5 days.

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resulting in increased photosynthetic activity and shoot biomass accumulation. Adequate watering at four-day intervals further supported nutrient uptake and physiological processes required for biomass production, consistent with the findings of Sine et al. (2023), who reported that moderate watering intervals favor optimal root function and assimilate transport. Conversely, plants subjected to longer watering intervals under full or low light intensity showed reduced shoot dry weight or increased root dry weight, indicating a shift in assimilate allocation toward root development under stress conditions. This adaptive response may enhance water and nutrient acquisition but limit aboveground biomass accumulation. Overall, the combination of moderate light intensity (75%) and a four-day watering interval was most effective in promoting shoot biomass, while reduced light availability combined with extended watering intervals favored root dry weight accumulation.

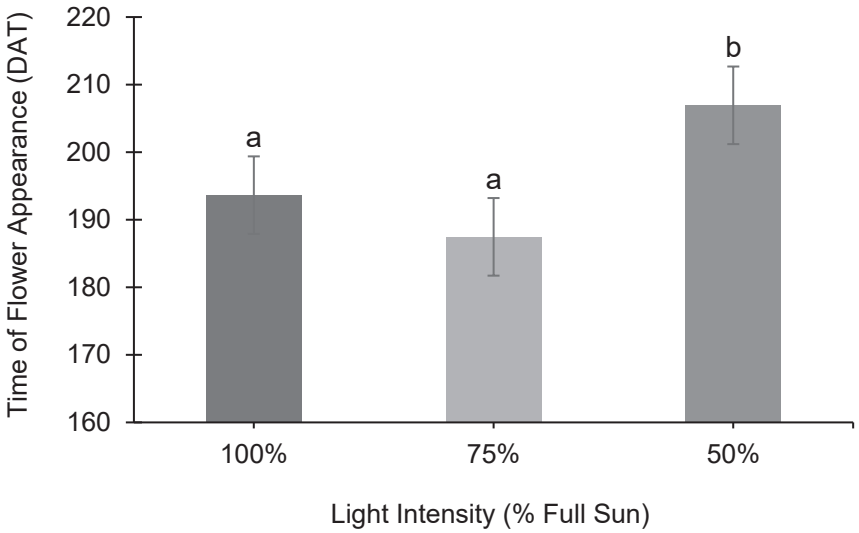
Time to Flower Initiation

Time to flower initiation in Pentas lanceolata varied among light-intensity treatments, whereas watering interval showed a relatively similar pattern within each light level (Figure 4). Plants grown under moderate light intensity (75%) initiated flowering earlier compared to those grown under low (50%) and full (100%) light intensities. In contrast, plants under 50% light intensity required a longer time to initiate flowering, indicating delayed reproductive development under shaded conditions.

Flower initiation is closely linked to the balance between photosynthetic assimilate production and environmental stress. Under low light intensity (50%), limited energy availability may reduce assimilate accumulation, thereby delaying the transition from vegetative to reproductive growth. Conversely, excessive light intensity (100%) may increase micro temperature and transpiration rates, which can disrupt physiological balance and slow floral initiation. Moderate light intensity (75%) provides a more favorable microclimate by supporting sufficient photosynthesis while minimizing heat and transpiration stress, resulting in earlier flower initiation. Similar results were reported by Rezazadeh et al. (2018), who found that moderate light intensity accelerated flowering

Figure 4

Time to Flower Initiation of Pentas lanceolata under Different Light Intensity Treatments at 56 Days After Planting



Note. DAT= days after treatment. Bars represent mean ± standard deviation I : light intensity.

Received 2/6/2026; Revised 3/27/2026; Accepted 5/19/2026
https://doi.org/10.29244/jtcs.13.02.457-466

in Firespike plants. In the present study, plants grown under 75% light intensity initiated flowering approximately 19 days (9.40%) earlier than those grown under 50% light intensity.

Number of Flower Clusters and Flower Buds

The number of flower clusters and total flower buds of *Pentas lanceolata* varied depending on the combination of light intensity and watering interval applied (Table 2). Plants grown under full light intensity (100%) generally produced more flower clusters and buds, particularly when combined with a moderate watering interval of four days. In contrast, a lower light intensity (50%) led to reduced cluster formation and fewer flower buds, especially with more frequent watering.

Flower formation during the generative phase requires a sufficient supply of assimilates to support floral induction and development. Full light intensity provides greater energy input for photosynthesis, thereby increasing the availability of assimilates for reproductive growth. El-Deen (2020) reported that adequate light intensity enhances metabolic activity and promotes flowering by increasing photosynthetic rates. In the present study, plants grown under full light intensity with a four-day watering interval produced the highest number of flower clusters and buds, indicating favorable conditions for reproductive development. Conversely, plants grown under reduced light intensity (50%) combined with frequent watering showed lower flower cluster and bud production. Limited light availability likely restricted photosynthetic activity, while excessive soil moisture may have disrupted root function and the partitioning of assimilates, resulting in reduced allocation to reproductive organs. Overall, the combination of full light intensity and moderate watering intervals (every 4 days) provided optimal conditions to maximize flower cluster and bud production in Pentas plants.

Total Number of Flower Buds

The total number of flower buds of *Pentas lanceolata* varied under different combinations of light intensity and watering intervals (Figure 5).

Table 2

Number of Flower Clusters and Total Number of Flower Buds of Pentas lanceolata under Different Light Intensities and Watering Intervals at 70 Days After Planting

Treatment	Number of Clusters (cluster per plant)	Total Number of Flower Buds (buds per plant)
100% light intensity + watering every 3 days	3.44 ab	83.44 cd
100% light intensity + watering every 4 days	4.44 b	84.78 d
100% light intensity + watering every 5 days	2.56 a	75.22 cd
75% light intensity + watering every 3 days	2.67 a	73.00 bcd
75% light intensity + watering every 4 days	2.56 a	76.56 cd
75% light intensity + watering every 5 days	2.44 a	67.44 abc
50% light intensity + watering every 3 days	2.22 a	55.78 a
50% light intensity + watering every 4 days	2.44 a	57.89 ab
50% light intensity + watering every 5 days	2.89 ab	72.22 bcd
HSD 5%	1.75	16.18

Notes. Mean values followed by the same letter within the same column are not significantly different based on Tukey's HSD test at the 5% level. Light intensity treatments were 100% (no shade), 75% (25% shade), and 50% (50% shade). Watering intervals were set to 3, 4, or 5 days.

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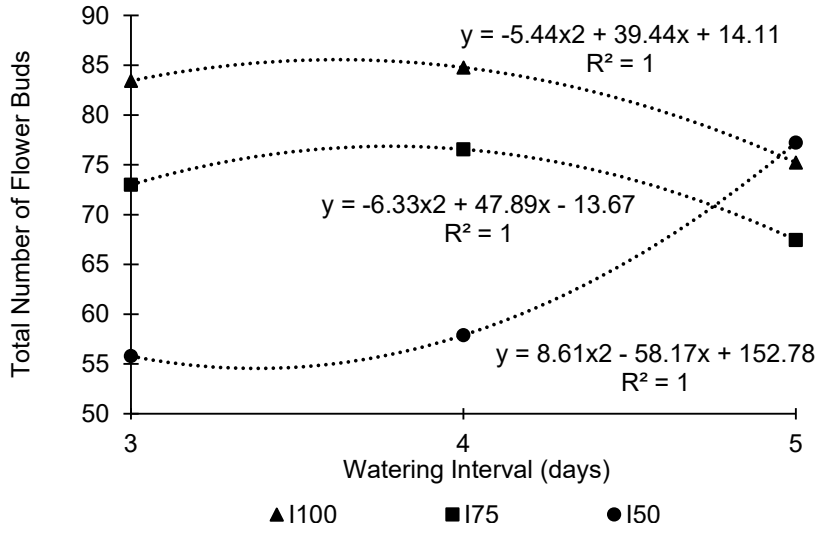
At 100% light intensity, the total number of flower buds was highest with watering intervals of once every 4 days. However, the number of buds tended to decrease when the watering interval was extended to 5 days. This indicates that plants grown under full sunlight require an adequate water supply to maintain metabolic processes and support flower formation. Herazo et al. (2020) reported that higher light intensity can increase plant growth rates by up to 9.5% compared to lower intensities. In this study, sufficient light availability was proven to be crucial in sustaining photosynthesis and flower development in ornamental plants. However, water availability was also shown to be equally important, as limited watering (every 5 days) caused water stress that inhibited cell division and enlargement, thereby reducing the number of flowers produced. At 75% light intensity, longer watering intervals also reduced flower numbers, showing that even under moderate light conditions, Pentas plants still required a consistent water supply to maintain productivity. Interestingly, at 50% light intensity, watering intervals of once every 5 days increased the total number of flower buds, as shown in Figure 6. Zahra and Sitawati (2023) reported that shaded plants generally have lower transpiration rates, so less frequent watering does not necessarily inhibit flower production.

These results emphasize that in ornamental plants such as Pentas, both the quantity and quality of flowers are critical commercial values. Therefore, understanding the interaction between light intensity and watering intervals is essential for optimizing flower production.

Figure 5

Total Number of Pentas Flower Buds under Different Light Intensity and Watering Interval Treatments

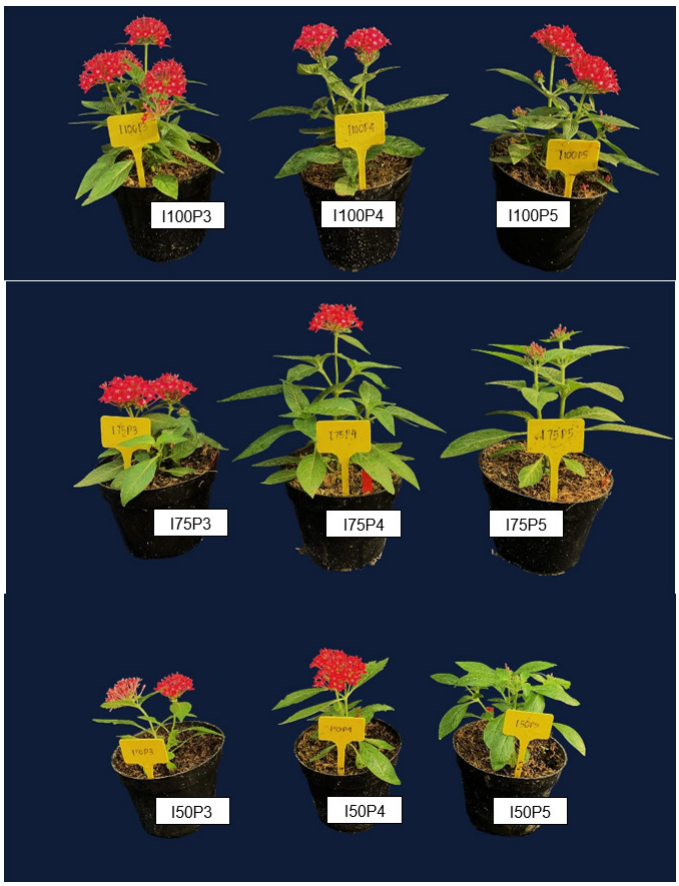


Note. I: light intensity (%).

Received 2/6/2026; Revised 3/27/2026; Accepted 5/19/2026
https://doi.org/10.29244/jtcs.13.02.457-466

Figure 6

Vegetative and generative phases of Pentas under different light intensity and watering interval treatments at 70 days after planting



Note. Light intensity treatments consisted of I100% (±18,898 lux, without shade), I75% (±12,216 lux, 25% shade), and I50% (±6,122 lux, 50% shade). Watering intervals consisted of P3 (every 3 days), P4 (every 4 days), and P5 (every 5 days).

Conclusions

The growth and flowering of *Pentas lanceolata* were strongly influenced by the combined management of light intensity and watering interval, indicating that plant responses depend on the balance between light availability and water supply. Under lower light intensity, plants required less frequent watering, likely due to reduced transpiration and metabolic activity. In contrast, plants exposed to higher light intensity required an adequate water supply to sustain photosynthesis, biomass accumulation, and reproductive development. During the vegetative phase, optimal growth, as reflected by dry weight accumulation, was achieved under moderate light intensity (75% ± 12,216 lux with 25% shade) combined with watering every four days. This condition provided sufficient light for photosynthesis while maintaining adequate water availability for nutrient uptake and shoot development. Conversely, during the flowering phase, full light intensity (100% ± 18,898 lux without shade) combined with the same watering interval produced the best flowering performance, as higher light availability supported assimilate production for flower formation. These findings indicate that Pentas cultivation requires stage-specific management strategies. Moderate light intensity with adequate watering is recommended

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during the vegetative stage to promote biomass accumulation, whereas higher light intensity combined with sufficient water supply is more suitable during the generative stage to maximize flowering. In addition, full light exposure enhanced chlorophyll accumulation by 28.73% compared to low light conditions, while moderate light intensity accelerated flower initiation by approximately 19 days. Overall, adjusting light and watering management according to plant growth stages is essential for optimizing both growth and flowering of *Pentas lanceolata* under potted cultivation systems.

Acknowledgement

The authors would like to thank PT Bina Usaha Flora for providing Pentas plant materials, and the State Agricultural Development Polytechnic (POLBANGTAN II, Ministry of Agriculture) for the facilities and research site. The authors also acknowledge the support from the Laboratory of Environmental Resources, Faculty of Agriculture, Brawijaya University, and express gratitude to the academic supervisors for their valuable guidance.

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