# Effect of light intensity and carbon dioxide on the Morphological growth characteristics of Epipremnum aureum

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**Abstract** :

This study was conducted in the Lathhouse belonging to the Department of Horticulture and Landscape Architecture, Faculty of Agriculture, University of Tikrit, for the period from February 15, 2024, to June 15, 2024, during the spring season of 2023-2024 Jade variety of Epipremnum aureum. The study aimed to investigate the response of pothos plant (Epipremnum aureum) to two levels of light intensity (2000 and 4000 lux) and two concentrations of carbon dioxade (2000 and 3000 ppm) The results indicate clear significant differences between the different treatments, as the interaction of factors (light intensity and carbon dioxide concentration) played a major role in improving most of the studied traits. The findings suggest that optimal growth of Epipremnum aureum (pothos) can be achieved under moderate light intensity combined with elevated carbon dioxide levels within enclosed environments, such as indoor or protected cultivation systems. This combination appears to enhance the plant's morphological development under controlled conditions. If the goal is to increase aerial root growth, light intensity can be increased to 4000 lux while maintaining the same carbon dioxide concentration. The results showed That the used of the medium light intensity (2000 lux) with the highest concentration of carbon dioxide (3000 ppm) led to obtain highest values in most of the plant traits studied.

**Introduction** :

Plants play a fundamental role in ecological balance, as they contribute effectively to the absorption of carbon dioxide ($CO_2$ ) and the release of oxygen, in addition to their role in carbon sequestration and improving air quality. The efficiency of plants in performing these vital functions depends on multiple environmental factors, foremost among which are light and carbon dioxide, due to their direct impact on photosynthesis and overall plant growth. Environmental factors are among the most important influences on plant growth and development. Perhaps the most prominent of these factors, which play a pivotal role in photosynthesis, are light intensity and carbon dioxide concentration 1. Light is the primary source of energy for plants, which use it to activate a series of physiological processes that result in the production of organic compounds necessary for growth. The plant's response to light depends on the quantity, quality and duration (photoperiod) of the light. Each plant has a specific optimal light level at which it achieves maximum productivity 2.. When light falls below this threshold, the plant's ability to produce dry matter is affected, while excessive light can lead to photostress, which reduces photosynthetic efficiency. On the other hand, carbon dioxide is one of the essential elements involved in photosynthesis, as plants use it to produce sugars through the Calvin cycle. Multiple studies have shown that increasing the concentration of $CO_2$ in the growing environment leads to improved growth rates, increased biomass, and improved water use

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efficiency. However, this increase may be accompanied by changes in the chemical composition of the plant, including a decrease in the concentration of certain minerals in the tissues, as a result of what is known as the dilution effect. With the development of cultivation systems in protected and closed environments, such as greenhouses and indoor rooms, there is a need for a deeper understanding of how light intensity and $CO_2$ affect plant growth and nutritional composition, especially ornamental plants that are commonly grown indoors with limited ventilation and heavy reliance on artificial lighting (3(.

pothos plant (Epipremnum aureum) is a climbing ornamental plant that is very popular in indoor gardening due to its tolerance of low light conditions, ease of care, and attractive appearance. It is an herbaceous evergreen perennial plantperennial plant and one of the most commonly used indoor plants. This species grows horizontally (creeping) on the ground or climbing (4). It is also effective at purifying the air and absorbing certain harmful compounds, making it a popular choice for homes and offices. Despite these advantages, information on its response to changes in light and carbon dioxide concentration remains limited, both in terms of vegetative growth and the mineral composition of its leaves. The growth of this plant depends on many environmental factors related to plant growth, such as light, temperature, irrigation, etc. The plant is commonly used as an indoor plant and can grow in a container without any soil or even nutrient-free water for a long time if the water is changed regularly. Pothos plants can grow on the natural salts found in water. They can survive without adding nutrients to the water (5). The study of the indoor environment in urban areas has become a focus of scientific interest, as people spend up to 87% of their time indoors, either in their homes (68.7%), offices and factories (5.4%), restaurants (1.8%), or inside compounds (5.5%) (6 .(

Objectives of the study :

The study aimed to investigate the effect of light intensity carbon dioxide and there interactions on vegetative growth of pothos plants Epipremnum aureum ,as indoor plant .

Materials and Methods:

Location of the experiment :

The experiment was conducted in a protected environment "caravan room inside a wooden canopy" refers to a mobile or semi-permanent agricultural unit housed within a protective wooden structure. This setup is designed to create a controlled environment for plant growth, shielding plants from direct sunlight, precipitation, and wind, while allowing adequate ventilation. belonging to the Horticultural Department of Horticulture and Landscape Architecture at the Faculty of Agriculture, University of Tikrit, during the spring season of 2023-2024 on the Jade variety of Epipremnum aureum .

-2-3Seedling preparation:

Materials and Methods

Plant samples was obtained from an agricultural nursery located in the Al-Krayat area, Baghdad Governorate, on November 16, 2023. On the following day, 72 cuttings were prepared by separating the plants; two cuttings were taken from each node of the mother plants. Each cutting was planted individually in plastic pots measuring 10 cm × 10 cm. The growth substrate consisted of a sterilized mixture of perlite and peat moss in a 1:2 ratio. Sterilization was performed using Beltanol

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pesticide at a concentration of 0.5 ml/L. After sterilization, one cutting was placed per pot.

Irrigation was performed daily in the morning using a 5-liter sprinkler system, applying approximately 100 ml of water per pot. The potted plants were initially maintained in a greenhouse to protect them from environmental fluctuations.

Subsequently, the plants were transferred to a controlled environment within a caravan room housed inside a wooden shed constructed of sandwich panels measuring 3 m (length) × 4 m (width) × 2.5 m (height). The windows were sealed with 1 mm thick aluminum foil (cellophane paper) fixed with silicone to block external light penetration and reduce environmental variability. The reflective nature of the foil served to minimize sunlight ingress and mitigate temperature fluctuations.

For carbon dioxide enrichment, a $CO_2$ gas cylinder was installed in one corner of the caravan room. The cylinder was connected to a gas regulator equipped with two gauges: one indicating cylinder pressure in bars, and the other measuring gas flow rate in liters per minute, enabling precise control over $CO_2$ concentration within the growth chamber.Study and design factors Experiment :

•The first factor: represents light and is symbolized by L, which includes two levels: 2000 and 4000 lux

The lamps were distributed for the above two levels according to the levels. There may be one lamp, two lamps to equal 2000 lux (-+ 100 lux), or four lamps to equal 4000 lux (-+ 100 lux.(

•The second factor: represents enrichment with carbon dioxide gas $CO_2$ , symbolized by G, which includes three levels (0, 2000 and 3000 ppm) parts per million

Studied characteristics :

The vegetative growth indicators of the experimental unit plants were measured.

.1Rate of increase in the diameter of the main stem of the plant (cm. Plant-1(

.2Rate of increase in the number of nodes on the main stem (nodes. plant-1(

The number of nodes on the main stem was counted at the end of the study season.

.3Rate of increase in the length of Nodes or internodeson the main stem (cm. plant-1(

At the end of the study season, the length of the main stem was measured using a Vernier caliper.

.4Leaf area ratio of the plant (cm2(

The leaf area of five fully expanded leaves from different locations on the same plant was measured, and their total area was divided by five to obtain the average leaf area per plant using the Digimizer program to measure the leaf area of the plant.

.5Rate of increase in secondary branch length (cm. plant-1(

At the end of the study season, the length of the secondary branch was calculated using a measuring tape.

.6Rate of increase in secondary branch diameter (cm. plant-1Measured using calipers for the secondary branches.

.7Rate of increase in the number of secondary branches (secondary branch. Plant-1(

All secondary branches of the plants were counted .

Results and Discussion

.1diameter of the main stem of plant .

The results in Table (1) indicate a significant effect of 2000 lux lighting, with the highest average stem diameter recorded at 0.59 mm, while the lowest average stem diameter was 0.51 mm at 4000 lux.

As for the second factor, carbon dioxide concentration, significant differences were also observed. The 3000 ppm concentration showed the highest average stem diameter of 0.60 mm, compared to the control treatment (0 ppm), which recorded the lowest average stem diameter of 0.50 mm.

Regarding the interaction between lighting and carbon dioxide concentration, the highest significant value for stem diameter (0.63 mm) was recorded in the interaction between 2000 lux lighting and 3000 ppm gas concentration, while the lowest significant value (0.42 mm) was recorded in the interaction between 4000 lux lighting and 2000 ppm gas concentration

**.Table (1) Effect of light intensity and carbon dioxide on the diameter of the main stem of E. aureum**

| Light intensity (lux) | Carbon dioxide concentration mg/L$^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | **0** | **2000** | **3000** | |
| **2000** | 0.57 a | 0.58 A | 0.61 b | 0.59 A |
| **4000** | 0.63 A | 0.42 b | 0.47 b | 0.51 B |
| **Carbon dioxide concentration** | 0.60 A | 0.50 B | 0.54 ab | |

Values with the same letters for single transactions and their overlaps are not significantly different from each other according to Duncan's multiple range test at a 5% significance level.

.2Small number of nodes on the main stem (node. Plants-1 :(

Table (3) shows that the best values for the length of nodes on the main stem of the pot plant were under an intensity of 2000 lux, reaching a value of 5.94 nodes. Plant-1 had the lowest significant value under an intensity of 4000 lux, reaching 3.66 nodes. Plant-1.

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On the other hand, it was observed that the best significant values for the second factor, carbon dioxide, were for a concentration of 3000 ppm, reaching 6.25 nodes. Plant-1 had the lowest value of 3.95 internodes ad a concentration of 2000 ppm

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**Table (2) Effect of light intensity and carbon dioxide on the number of nodes on the main stem of the plant E. aureum (node. Plant-1.(**

| Light intensity Lux | Carbon dioxide concentration mg/$L^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | **0** | **2000** | **3000** | |
| **2000** | 5.25 b | 4.75 B | 7.83 a | 5.94 A |
| **4000** | 3.16 c | 3.16 C | 4.66 b | 3.66 b |
| **Carbon dioxide concentration** | 4.20 b | 3.95 B | 6.25 a | |

Meanwhile, the highest values for light intensity below 2000 lux and carbon dioxide at a concentration of 3000 ppm were 7.83 salamites. Plant-1 had the lowest values for the interference coefficient under light intensity of 4000 lux for two levels of zero gas, which reached 3.16 internodes had the same value for two different gas concentration coefficients Values with the same letters for single transactions and their overlaps are not significantly different from each other according to Duncan's multiple range test at a 5% significance level .

.3length of the main stem internodes (cm. Plant-1 .(

The data in Table (4) show that there is a significant effect of the study treatments on the length of the internodes of the pot plant, where the treatment under 2000 lux light intensity outperformed the others and gave the highest significant difference of 2. 67 cm compared to the treatment under 4000 lux light intensity, which gave the lowest significant difference of 1.81 cm .

We note from the same table for the second factor of carbon dioxide concentration that there was a significant increase in the length of the pedicels for the treatment under the influence of a gas concentration of 3000 ppm, which amounted to 3. 09 cm, compared to the smallest significant difference under the influence of a gas concentration of 2000 ppm, which was 1.61 cm .

The interference treatment led to a significant increase in the length of the salami under an intensity of 2000 lux and the effect of a carbon dioxide concentration of 3000 ppm, which amounted to 3. 81 cm, while the lowest value with the 2000 ppm interference treatment under an intensity of 4000 lux was 10 cm .

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**Table (3) Effect of light intensity and carbon dioxide on the length of the main stem (cm) of the plant E. aureum (stem cm. Plant-1(**

| Light intensity Lux | Carbon dioxide concentration mg/$L^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | 0 | 2000 | 3000 | |
| 2000 | 2.39 b | 1.81 bc | 3.81 a | 2.67 a |
| 4000 | 1.66 c | 1.40 c | 2.38 b | 1.81 b |
| Carbon dioxide concentration | 2.03 b | 1.61 b | 3.09 a | |

.4Leaf area (cm2 (

The results of the statistical analysis of Table 6 showed significant differences between the treatments for the first factor, light intensity, as the treatment under 2000 lux light intensity exceeded the highest value of 9.93 cm2. Plant-1 exceeded the other treatments, which recorded the lowest value at 4000 lux, reaching 8.59 cm2. Plant-1 .

As for the second factor, carbon dioxide concentration, the treatment with a gas concentration of 3000 ppm significantly exceeded the other treatments and recorded the highest value of 11.44 cm2. Plant-1 compared to the lowest significant difference, which was below 7.12 cm2. Plant-1 0 ppm.

The same table showed significant differences in the interference treatments under light intensity and carbon dioxide concentration, with the treatment under 2000 lux light intensity and 3000 ppm carbon dioxide concentration significantly outperforming the others, reaching a maximum of 12. 25 cm2. Plant-1 compared to the lowest significant difference for the treatment under light intensity of 4000 lux and carbon dioxide concentration of zero parts per million, which reached 6.64 cm2. Plant-1 .

**Table (4) Effect of light intensity and carbon dioxide on the leaf area ratio of E. aureum (cm2(**

| Light intensity Lux | Carbon dioxide concentration mg/$L^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | 0 | 2000 | 3000 | |
| 2000 | 7.61 e | 9.94 c | 12.25 a | 9.93 a |
| 4000 | 6.64 f | 8.51 d | 10.62 b | 8.59 b |
| Carbon dioxide concentration | 7.12 c | 9.22 b | 11.44 a | |

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.5branch length (cm

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The results shown in Table 9 indicate a significant difference in the length of the secondary branch, with the highest length of the plant at an intensity of 2000 lux reaching 3.33 cm compared to an intensity below 4000 lux, which gave the shortest length of the plant at 2.53 cm.

We find that the treatment with carbon dioxide at a concentration of 3000 ppm was superior, with the highest length reaching 4.09 cm, while the comparative treatment, which had a concentration of 0 ppm, gave the lowest significant difference of 1.72 cm .

The treatment with an overlap of 2000 lux light intensity and a gas concentration of 3000 ppm gave the highest value of 4.43 cm, compared to the lowest treatment of the overlap treatments, which was 4000 lux light intensity and a gas concentration of 0 ppm, which gave a value of 1.16 cm .

**Table (5) Effect of light intensity and carbon dioxide on the length of secondary branches of E. aureum plants (cm. Plant-1(**

| Light intensity Lux | Carbon dioxide concentration mg/L$^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | 0 | 2000 | 3000 | |
| **2000** | 2.28 d | 3.29 bc | 4.43 a | 3.33 a |
| **4000** | 1.16 e | 2.70 cd | 3.75 b | 2.53 b |
| **Carbon dioxide concentration** | 1.72 c | 2.99 b | 4.09 a | |

.6branch diameter (cm (

The data in Table No. (10) indicates that there is a significant effect of the study treatments on the diameter of the secondary branch, with the highest diameter of the secondary branch occurring in the treatment with light intensity below 2000 ppm, reaching 0.28 cm, compared to the lowest diameter of 0.18 cm in the treatment with light intensity of 4000 lux.

We also find a significant difference for the second factor of carbon dioxide concentration, as it gave the highest diameter of 0.35 cm, while the lowest diameter for the comparison treatment was 0.13 cm.

The same table shows that the effect of the interaction between light intensity below 2000 lux and carbon dioxide concentration of 3000 ppm reached 0.43 cm, compared to the lowest significant difference of 0. 10 cm under an intensity of 4000 lux and a concentration of carbon dioxide of 0 ppm .

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**Table (6) Effect of light intensity and carbon dioxide on the diameter of the secondary branch of the E. aureum plant (cm. Plant-1(**

| Light intensity Lux | Carbon dioxide concentration mg/L$^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | 0 | 2000 | 3000 | |
| 2000 | 0.16 cd | 0.26 b | 0.43 a | 0.28 a |
| 4000 | 0.10 d | 0.20 bc | 0.26 b | 0.18 b |
| Carbon dioxide concentration | 0.13 c | 0.23 b | 0.35 a | |

.7number of secondary branches (secondary branch. Plant-1 (

The results in Table 11 indicate that light intensity had a significant effect on the increase in the number of secondary branches at the 2000 lux level, which reached 2.55 secondary branches per plant -compared to the intense lighting equivalent to 4000 lux for the treatment, which reached 1.33 secondary branches Plant-1 .

As for the carbon dioxide enrichment treatments, there were significant differences for the 3000 ppm treatment, which reached 3.16 secondary branches per plant, compared to the no addition treatment, which reached 1 secondary branch per plant .

The overlap treatment showed us significant differences, as it gave the highest difference under an intensity of 2000 lux for a carbon dioxide level of 3000 ppm, which resulted in 3.66 secondary branches -1, compared to the no addition treatment, which resulted in 1 secondary branch -1. -1, compared to the treatment with an intensity of 4000 lux and a carbon dioxide level of zero parts per million, which did not produce any secondary branches .

**Table (7) Effect of light intensity and carbon dioxide on the number of secondary branches of E. aureum (secondary branch. Plant -1(**

| Light intensity Lux | Carbon dioxide concentration mg/L$^{-1}$ | | | Light intensity Lux |
|---|---|---|---|---|
| | 0 | 2000 | 3000 | |
| 2000 | 2.00 bc | 2.00 bc | 3.66 a | 2.55 a |
| 4000 | 0.00 d | 1.33 c | 2.66 b | 1.33 b |
| Carbon dioxide concentration | 1.00 c | 1.66 b | 3.16 a | |

## Discussion

The results of the current study showed that the growth of the Jad variety of pothos (Epipremnum aureum) is significantly affected by light intensity and carbon dioxide ($CO_2$ ) concentration. Research indicates that these two factors enhance photosynthesis, which is essential for plant growth and biomass increaseand increased light intensity enhances photosynthesis, leading to increased biomass and plant height, plant length, fresh weight, dry weight, and leaf number. The positive interaction between moderate lighting and high carbon dioxide concentrations reflects the integration of environmental conditions that stimulate plant physiological processes, especially photosynthesis, as moderate light provides the energy necessary for photochemical reactions. while high $CO_2$ concentrations contribute to enhancing photosynthetic efficiency. This stimulation leads to an increase in the rate of cell division and tissue growth, which is clearly reflected in the development of plant vegetative growth. This is evident in the high rate of leaf production and the increase in plant biomass, whether fresh or dry (7 and 8)The decrease in plant height and fresh weight clearly indicates that the light intensity has exceeded the ideal level and may be due to light stress. This limits growth and negatively affects the physiological efficiency of the plant. When plants are exposed to excessive light, the photosynthetic apparatus's ability to utilize energy is exceeded, leading to the accumulation of excess energy and the generation of reactive oxygen species (ROS) that damage plant cells and inhibit photosynthesis, thereby reducing overall plant growth (8). These results indicate the efficiency of photosynthesis in converting organic matter into dry matter under these environmental conditions, which is consistent with similar results from other researchers (10). Studies indicate that the pot plant has a high capacity to absorb $CO_2$ , especially under suitable lighting conditions, and that the balance between light intensity and $CO_2$ concentration enhances photosynthetic efficiency and thus increases the fresh weight of the plant. High light intensity improves photosynthetic capacity by enhancing leaf orientation and regulating genes involved in the Calvin cycle, which increases carbohydrate accumulation and supports growth (11). In Pseudolatry amabilis seedlings, increased light intensity promotes plant height by increasing the number of leaves, biomass, and stem growth, indicating a direct relationship between light availability and vertical growth (12). High levels of carbon dioxide contribute to enhanced photosynthesis rates by increasing the maximum rate of light-saturated photosynthesis and carboxylation efficiency, leading to enhanced growth and dry matter accumulation (13.(

In lettuce, high carbon dioxide concentrations, combined with optimal light levels, contribute to a noticeable increase in fresh and dry weight, indicating improved growth performance and plant height (13). (13) The synergistic effect of increased light intensity and carbon dioxide concentration contributes to creating optimal growing conditions, as these factors work together to enhance photosynthesis and water use efficiency, leading to increased plant height (13). While increased light intensity and carbon dioxide concentration contribute to overall plant height, it should be noted that excessive levels of either factor may reduce yield or cause stress responses in plants. Optimal growing conditions require a balance, and studies have shown that there are specific thresholds of light and carbon dioxide that yield the best growth results (15). An increase in carbon dioxide contributes to enhanced

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photosynthesis, which improves plant growth and water use efficiency. In addition, high light intensity helps open stomata, facilitating carbon dioxide absorption, while high concentrations of this gas stimulate photosynthetic activity and growth (15). High light conditions contribute to improved leaf orientation and increased chlorophyll content, which is vital for effective light capture and energy conversion (13). Increased light intensity helps enhance photosynthesis, which requires high levels of carbon dioxide for optimal growth .

**Conclusions** :

The balance between light intensity and carbon dioxide ($CO_2$ ) concentration is a critical environmental factor for the growth of Epipremnum aureus. Exceeding the optimal levels of either factor leads to physiological stresses such as photostress or reduced nutrient uptake efficiency, which negatively impacts growth. The results confirm that achieving a delicate environmental balance between light and $CO_2$ is essential for achieving optimal growth efficiency and quality in horticultural plants .

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