**The effect of different light intensities on some morphophysiological traits in two *Vicia* L. species.**

**ABSTRACT**

In this research, two vicia L. species (*Vicia sativa* and *Vicia hybrida*) were exposed to different light intensities (50,000, 30,000 and 3,000 lux) with a 14:10 light: dark cycle. Our aim was to investigate their effect on photosynthetic pigments` content and leaf area, as the most important traits regarding photosynthesis and productivity. The chlorophyll and carotenoid contents varied significantly in both species with increasing light intensity, as they increased in *V. sativa* with higher light intensities, while they decreased in *V. hybrida* under high light intensities. As for the leaf area, it increased in low light intensity in *V. hybrida*, in contrast to *V. sativa*, which showed a considerable decrement. Results indicated that *V. sativa* is more tolerant to high light intensities in terms of photosynthetic pigment`s content and leaf area compared to *V. hybrida*.

**Keywords:** Vicia, chlorophyll, carotenoids, photosynthesis, leaf area, light intensities.

1. **Introduction**

The genus *Vicia* L. belongs to the division Magnoliophyta, class Magnoliopsida, subclass Roseoidae, order Fabales, and family Fabaceae (Cronquist, 1981). It comprises approximately 140 species (Boulos, 1999), of which about 38 species and several varieties are found in Syria (Mouterde, 1970). The plant primarily reproduces through seeds, that serve as a source of plant protein (Magdalhães *et al*., 2017). The various parts of the plant provide fodder for livestock due to their high protein content (Han *et al*., 2021), and it holds agricultural significance as a nitrogen-fixing plant through its root nodules (Hamada and EL-Enany, 1994). In addition, the seed coat is a source of numerous secondary compounds (phenolics) that play important roles as antioxidants, anti-inflammatory agents, anticancer and substances (Singh *et al*., 2017; Salehi *et al*., 2020). Light is one of the most vital environmental factors affecting plant morphology, metabolism, growth and development through changes in its intensity, quality, and duration (Yang *et al*., 2018). In this context, light intensity is a crucial factor affecting morphophysiological traits (such as the photosynthetic pigments, sugar and protein contents, plant height, leaf surface area, weight, number of pods, etc.) in green plants generally (Kisman *et al*., 2021; Rascher *et al*.,2010).  
High light stress leads to a phenomenon known as photoinhibition, which damages the photosynthetic apparatus and reduces plant productivity (Zhang *et al*., 2022). Conversely, low light decreases the effectiveness of the photosynthetic apparatus and reduces plant productivity (Wang *et al*., 2022).

1. **Aim of the Research:**

Leguminous plants, particularly those of the Vicia genus, have significant economic value as they serve as both forage and food crops. And their productivity is directly related to the exposed intensities. This research aims to investigate the effects of different light intensities on certain morphophysiological traits (photosynthetic pigment content and, leaf area) of two Vicia species widespread in Syria, namely: *Vicia sativa* L. and *Vicia hybrida* L. (Figures 1, 2).



**Figure 1: *Vicia hybrid* Figure 2: *Vicia hybrid*a**

**3. Materials and Methods:**   
**1-3. The Plant Material:**   
Seeds of two species of wild Vicia L. (*V. sativa* and *V. hybrida*) were collected from Tishreen University garden (Figures 3 and 4)

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**Figure 3:** ***V. sativa* seeds Figure 4: *V. hybrida* Seeds**

**2-3** **Experiment design:**

The seeds were soaked in water and then disinfected with 70% ethyl alcohol and 10% calcium hypochlorite. Subsequently, they were rinsed with distilled water and planted in Petri dishes with three replicates for each treatment, then placed in a incubator at 25 ْC in the dark.

Uniform 10-day-old seedlings were planted in plastic pots (diameter: 25 cm) filled with soil collected from the Tishreen University garden (plant environment). The pots were then divided into three groups and allowed to grow for 40 days in plant growth chamber at 25±1 ْC and 70 ± 5% humidity, with three light intensity levels (3000, 30000 and 50000 lux), under a photoperiod of 14 hours light/10 hours dark. The pots were irrigated every ….With water. The planting were done in 2023, and all experiments were conducted in the laboratories of the Plant Biology Department at the Faculty of Science at Tishreen University.

**1-2-3. Determination of Photosynthetic Pigment content:** The concentrations of pigments were determined by extracting the pigments from 40-day-old plant leaves after grinding them with acetone (80%). The extracts were centrifuged, and the optical density of the supernatants was measured at different wavelengths (470, 645, 647, 663 and 664 nm) using a spectrophotometer. After that, the photosynthetic pigment contents were estimated according to the appropriate equations (Lichtenthaler, 1987).

**2-2-3. Leaf Area:** The average length and width of the leaf and leaflets were measured using a millimeter paper, and the area of the leaf was calculated according to the following equations (Khattab 2018)

The area of a single leaflet = length of the leaflet × width of the leaflet × correction factor for faba beans (0.583)  
The area of the leaf = area of the leaflet × number of leaflets on the leaf  
The area of the plant leaves = area of a single leaf × number of leaves on the plant, according to Khattab (2018).

**3-3. Statistical Study:**

The mean and standard deviation were calculated from the descriptive statistics in all treatments. Additionally, the Least Significant Difference (LSD) test was performed as a post hoc analysis following the one-way ANOVA, applied to the treatments that met the conditions for this test. For the other treatments, the Kruskal-Wallis test was utilized to determine the significance of differences between the means of the treatments at a significance level of 0.05, considering the differences significant if the Sig. values were less than or equal to the significance level. This analysis was conducted using IBM SPSS Statistics 23

**4. Results and Discussion:**

**1-4 The Effect of Different Light Intensities on the Photosynthetic Pigments:**

Photosynthetic pigments, namely chlorophyll a (Chl.a), chlorophyll b (Chl.b), and carotenoids (Car.), are primary pigments within the photosynthetic apparatus of higher plants. Therefore, their concentration in chloroplasts is one of the factors affecting the plant's response and adaptation to light intensity.

In *V. sativa*, Chl.a content increased gradually with increasing light intensity (1.559, 1.626 and 2.207 mg/g of plant tissue). Similarly, Chl.b content increased steadily with increasing light intensity (0.640, 0.632 and 0.505 mg/g of plant tissue).

There was also a significant increase in total chlorophyll (Chl.a + Chl.b) content, reaching 2.859 mg/g of plant tissue under 50000 lux intensity, while carotenoid content recorded 0.909 mg/g of plant tissue. However, the concentrations of these pigments remained lower than those observed in *V. hybrida*, as shown in Table 1.

The increase in total chlorophyll can be explained by the plant's efforts to enhance its adaptation to high light in order to utilize light in photosynthesis. These results are consistent with other studies on faba beans (Hendry and Price, 1993; Goncalve *et al*., 2001). Conversely, the decrease in total chlorophyll under low light conditions aligns with findings of previous studies on different plants (Zhu *et al*., 2017; Fan *et al*., 2018; Wittmann *et al*., 2001), and it is a typical symptom of reduced chlorophyll biosynthesis rates under this condition (Smirnoff, 1993).

In *V. hybrida*, total chlorophyll content was higher under low-light conditions compared to high-light ones as shown in Table 1. This finding is consistent with previous studies on various plants (Rascher *et al*., 2010; Tang *et al*., 2022). A significant decrease in total chlorophyll content was also observed under high-light conditions in *V. hybrida* (reaching 2.711 mg/g plant tissue), which was accompanied by a considerable increase in carotenoid content (1.768 mg/g plant tissue) as shown in Table 1. The accumulation of carotenoids with increasing light intensity is an important mitigating mechanism to high light stress, as carotenoids are responsible for dissipating the excess absorbed light energy as heat (Ayash, 2010), thereby preventing chlorophyll degradation caused by intensive light through photo-oxidation.

**Table 1: Photosynthetic pigment contents (mg/g tissue) in two Vicia L. species under different light conditions**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *V. sativa* | | | | *V. hybrida* | | | | Light Intensity |
| Car | Chl.a+Chl.b | Chl.b | Chl.a | Car | Chl.a + Chl.b | Chl.b | Chl.a |
| 0.659± 0.141 | 2.160 ±0.227 | 0.505± 0.133 | 1.559± 0.142 | 0.831± 0.180 | 2.479 ±0.364 | 0.530± 0.063 | 1.988 ± 0.111 | 3000 lux |
| 0.843 ± 0.214 | 1.826 ±0.574 | 0.632± 0.038 | 1.626± 0.565 | 1.025± 0.077 | 2.806 ±0.206 | 0.724± 0.149 | 1.791 ± 0.322 | 30000 lux |
| 0.909 ± 0.108 | 2.859± 0.696 | 0.640± 0.107 | 2.207± 0.464 | 1.768± 0.004 | 2.711± 0.093 | 0.492± 0.287 | 1.087 ± 0.002 | 50000 lux |

Liu et al. (2014) indicated that low light conditions lead to a change in the quantity of pigments within the photosynthetic apparatus (Chl a, Chl b, Car), which are important pigments involved in the absorption of solar energy and its conversion into electrochemical energy.

A significant difference was observed in Chl.a content *V. hybrida* at high light intensity, with a p-value of 0.04. In contrast, the difference in the concentration of Chl.a for *V. sativa* was at a p-value of 0.2 under the same light intensity. Additionally, a significant difference was found in the concentration of total chlorophyll (Chl.a + Chl.b) in *V. hybrida* at high light intensity, with a p-value of 0.023, whereas the difference in concentration for *V. sativa* was at a p-value of 0.452 under the same light intensity. Furthermore, a clear significant difference in carotenoid concentration was noted in *V. hybrida* at high light intensity, with a p-value of 0, while no significant difference was observed in *V. sativa* at this light intensity Table 2.

**Table 2: Significant and insignificant differences values ​​for photosynthetic pigment content**

**(LSD 5%).**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *V. sativa* | | | | *V. hybrida* | | | | Light Intensity |
| Car | Chl.a + Chl.b | Chl.b | Chl.a | Car | Chl.a + Chl.b | Chl.b | Chl.a |
| 0.35 | 0.263 | 0.542 | 0.544 | 0.141 | 0.724 | 0.64 | 0.577 | 3000 lux |
| 0.064 | 0.087 | 0.182 | 0.682 | 0.923 | 0.649 | 0.674 | 0.191 | 30000 lux |
| 0.969 | 0.452 | 0.963 | 0.2 | 0 | 0.023 | 0.525 | 0.04 | 50000 lux |

Under high-light conditions, enhanced contents of total chlorophyll and carotenoids were observed in *V. sativa*, although these increases were less pronounced and statistically insignificant compared to *V. hybrida*. Based on the above, the results indicate that *V. sativa* is more suitable for growth and productivity in areas with high light intensity, and it did not suffer from high light stress, as was the case with *V. hybrida*. This finding aligns with earlier studies on various plants

(Khumaid *et al*., 2003; Muhuria, 2007; Perkasa *et al*., 2020).

**2-4 The Effect of Different Light Intensities on Leaf Area:**   
It has been shown that, when the species *V. hybrida* was exposed to low light, the leaf area values increased during the first month of cultivation, reaching 59.729 mm², and 80.642 mm² in the second month. However, in the third month, the leaf area began to decline overall, recording a value of 77.851 mm². Conversely, under strong light exposure, there was a decrease in leaf area to 55.805 mm² in the first month of cultivation, 68.156 mm² in the second month, and 67.453 mm² in the third month, Table 3.

In contrast, the results for *V. sativa* were inverse, as a decrease in leaf area values was noted under low light exposure, measuring 33.843 mm² in the first month, 38.799 mm² in the second month, and 35.936 mm² in the third month. Under high light intensity, however, the leaf area increased to 96.524 mm² in the first month, 130 mm² in the second month, and 91.801 mm² in the third month.

Regarding leaf area under medium light conditions (30,000 lux), the results were optimal for V. hybrida, with 98.947, 164.337 and 172.368 mm² in the first, second and third months, respectively. These results confirm that V. sativa has a higher light preference compared to V. hybrida (Table 3).

**Table 3: Average of Leaf Area (mm).**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *V. sativa* | | | *V hybrida* | | | Light Intensity |
| Third month | second month | First month | Third month | second month | First month |
| 35.936 | 38.799 | 33.843 | 77.851 | 80.642 | 59.729 | 3000 lux |
| 46.470 | 93.012 | 82.171 | 172.368 | 164.337 | 98.947 | 30000 lux |
| 91.801 | 130 | 96.524 | 67.453 | 68.156 | 55.805 | 50000 lux |

Elmaghalawy and Abdelhakam (2022) indicated in their study that the reduction in leaf area with increased light intensity may be attributed to decreased water loss under these conditions, as observed in *V. hybrida*. Conversely, leaf area increased significantly at moderate light intensity during the three months of the plant's age compared to other intensities, as this light intensity is considered optimal for it. It is well known that plants under good lighting conditions exhibit overall growth, with leaf tissues expanding and the number and size of chloroplasts increasing, which enhances leaf area and thickness and boosts their ability to perform photosynthesis due to the increased chlorophyll content within the chloroplasts (Terashima *et al*., 2005; Wu *et al*., 2016).

In the case of *V. sativa* leaf area, it decreased under low light conditions, while it gradually increased with increasing light intensity. This is due to an adaptive mechanism present in some plant species, where leaf area decreases and becomes thinner under low light intensity because of the lack of necessary energy for growth (Kim *et al*., 2005; Kozuka *et al*., 2005; Fan *et al*., 2013; Gong *et al*., 2014). The results also indicate the negative impact of low light on *V. sativa*, as leaf area decreased due to insufficient energy for growth, in contrast to *V. hybrida* under the same conditions. This is achieved through an adaptive mechanism involving changes in leaf anatomy and morphology to maximize light capture efficiency and photosynthesis, such as increasing leaf area in addition to reducing leaf thickness and the cuticle and wax layers (Levitt, 1980).

*V. hybrida* species recorded the highest number of leaves under low light intensity compared to high light. Meanwhile the greatest decrease in the number of leaves under low light was observed in *V. sativa*. The variation between the two species regarding leaf area and leaf count is consistent with the study by Kisman et al. (2021) on species of *Vicia* L.

**5. Recommendations**

* Studying the effect of different light intensities on the plant Vicia L. up to the flowering and fruiting stages due to the importance of this plant as a source of various bioactive compounds and nutrients.
* In-depth examination of the tissue structure of the leaf and its modification under different light intensities.

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