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Impact of Solar Irradiation on Photosynthetic Activity of Chili (*Capsicum annuum L.*) Leaves

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Abstract

The photosynthetic activity of chili (*Capsicum annuum* L.) leaves greatly influences sunlight radiation, the role of photosynthesis produces food that can help in plant growth and development. If a plant lacks light, it will not produce chlorophyll so it will be pale in color. Abnormalities in the photosynthesis process will also affect the formation of carbohydrate compounds in the leaves. The carbohydrate content of chili leaves plays an important role in the metabolism of chili plants. This research aims to determine the effect of solar radiation on the photosynthetic activity of chili leaves using the Sach test . This research method uses descriptive methods. Sampling was carried out by purposive sampling and giving the chili leaves a closing and opening treatment using aluminum foil under direct sunlight. The data analysis technique used is a qualitative descriptive analysis model, where this model is included in the type of qualitative research which is described descriptively. The results of the research showed that the parts of the leaves that were exposed to sunlight produced more

chlorophyll, the leaf color was darker green, and produced starch which was characterized by a blue-black or dark purple reaction when given an iodine solution. Meanwhile, the parts of the leaves that are not exposed to sunlight show less yield, the color of the leaves is paler or yellowish.

Keywords*:* Sollar Irradiation*, Capsicum annuum,* Chili Leaf, Photosynthesis

A. Introduction

Photosynthesis is a fundamental mechanism used by plants to convert light energy into chemical energy in the form of glucose, using carbon dioxide and water as reactants, and releasing oxygen as a by-product. The sun, as the main natural light source on Earth, plays an important role in photosynthesis. The influence of the sun on this process can be understood through several aspects, namely light intensity, light wavelength, and duration of irradiation.(Lumbessy et al., 2020)

Photosynthesis is a chemical process that allows plants, algae and some types of bacteria to convert light energy (generally from the sun) into chemical energy stored in the form of glucose or sugar. This process occurs inside chloroplasts, which are predominantly found in plant leaves. Chlorophyll, the green pigment in chloroplasts, plays a crucial role in absorbing light energy.(Kustanto & Talkah, 2023). Exposure to sunlight also affects the production of chlorophyll, the pigment that gives leaves their green color and plays a role in absorbing light. Under optimal light conditions, chlorophyll is synthesized in adequate amounts, making the leaves appear dark green. In contrast, under low light conditions, chlorophyll synthesis is inhibited, resulting in a paler or yellowish leaf color.(Asmawan & Hartatik, 2022)

Amylum, a form of energy storage in plants, is produced as a result of photosynthesis. Light-exposed parts of the leaf produce large amounts of amylum as reflected by a positive reaction with iodine, indicating that photosynthesis is taking place efficiently. In contrast, less light-exposed parts show negative or minimal results to the iodine test, indicating low or no photosynthesis. In addition to biochemical processes, light exposure can also affect plant morphology, including the way leaves are arranged, as an adaptive response to maximize the absorption of available light. Plants growing in the shade often have larger or thinner leaves in an effort to capture as much light as possible.(Kusuma et al., 2023)

The intensity of sunlight falling on plant leaves affects the rate of photosynthesis. At low intensity levels, the rate of photosynthesis will increase as the light intensity increases. However, after reaching the optimum point, a further increase in light intensity will not have a significant effect on increasing the rate of photosynthesis because it has reached the maximum capacity of photosynthesis that can be carried out by the leaves.(Zahara et al., 2021)

In their natural setting, plants face fluctuations in light intensity, wavelength, and duration of exposure to sunlight every day and throughout the year. These factors affect not only the rate at which photosynthesis occurs but also the overall growth and development of the plant. Plants have adapted to specific light conditions in their habitat to maximize photosynthetic efficiency. For example, plants in the tropics have mechanisms for regulating leaf orientation and leaf structure that allow them to utilize sunlight efficiently, while plants in temperate regions may evolve to maximize light absorption at low angles during winter or low-light conditions (Anggraeni & Supriatno, 2020)

Solar irradiance is a highly variable factor and is affected by many conditions such as clouds, weather, and seasons. Determining how to measure the intensity and duration of sunlight in a consistent and accurate manner can be challenging. To understand the impact of solar irradiation, it is necessary to control other factors that affect photosynthesis, such as humidity, temperature, CO2 concentration, pathogen, and soil nutrients. Creating a system that can control all these variables for research can be complicated and expensive (Ulinnuha & Syarifah,2021). One of the research results resulted in the growth and productivity of chili plants using an indoor system with red and blue LED light intensity (Roziqin, 2021).

Knowledge of the impact of solar irradiation on photosynthesis of chili leaves can support more efficient cropping strategies, including thinning and crop rotation techniques, which optimize light absorption. Optimizing the absorption of sunlight in chili leaves is very important to increase photosynthesis efficiency with growth hormone indicators, leaf pruning and planting location (Sokmawati, 2021).

In another aspect, this study can provide new insights into the mechanism of photosynthesis, which is a fundamental biological process. Through this study, scientists were able to explore how external variables such as sunlight affect the photosynthetic process in a

specific species, namely chili peppers, and how this may vary compared to other plants. This contributes to our basic understanding of plant biology and photosynthesis. Based on the above background, this research raises the research title "the impact of sunlight on the photosynthetic activity of chili leaves".

B. **Literature Review**

Photosynthesis is a process of preparing carbohydrate substances using light as a source of energy as its energy source. Organisms that have photosynthetic pigments are able to perform photosynthesis, because photosynthetic pigments are able to capture energy from light. The organic substance produced from this photosynthesis process is carbohydrate (Cn(H2O)n) derived from CO2 molecules and H2O as a by-product. The process of photosynthesis requires light with certain quality (wave type) and quantity (light intensity) (Zahara et al., 2021; Mbakaan, 2023). Under normal conditions, sunlight meets these requirements, so naturally sunlight is a source of energy for photosynthesis. Photosynthetic pigments that function to capture sunlight energy are chlorophyll or carotenoids. The substrate of photosynthesis is CO2 which comes from the remaining oxidation in photosynthetic tissues or taken from the atmosphere through the diffusion process through the stomata and H2O which comes from the environment through the absorption process in the roots or other absorption parts. The main result of photosynthesis is glucose which will be immediately translocated to other parts of the plant body or translocated to other parts of the plant body (Solovchenko et al., 2019). The main result of photosynthesis is glucose which will be immediately translocated to other parts of photosynthesis is high, some of the carbohydrates formed from photosynthesis will be deposited in chloroplasts as amylum. Photosynthesis by products in the form of O2 will be released into the atmosphere as gas or will be utilized in respiration in cells where photosynthesis occurs. Many factors affect the process of photosynthesis both internally and externally. These factors include: leaf structure, root structure, light intensity, soil water conditions, or atmospheric conditions (Li et al., 2024)

Clasification of chili plant, the chili plant, scientifically known as *Capsium Annum*, can be classified as follows: Kingdom Plantae, Division Magnoliophyta, Class Mangnoliopsida, Orde*r* Solanales, Family Solanacea, Genus Capsicum, Spesies *Capsicum anuum*. Description, the chili plant is a perennial plant from the Solanaceae family. Chilies come ini various shapes and sizes, ranging from small and round to long and pointed, the color of chili peppers varies from green, yellow, orange, to bright red, depening on the type and ripeness. Chili plants have leaves that are oval to lance-shaped with a smooth surface and green color. The flowers are white or purple, usually growing singly in the leaf axils. The fruit of the chili plant has a distinctive spicy taste due to the presence of capsaicin. This plant generally grows well in tropical and subtropical regions, requiring sufficient sulight and fertile, well-drained soil. Chilies are widely used as a spice in cooking and have health benefits, such as being rich in vitamin C and boosting metabolism (Sofian et al., 2023).

C. **Methodology**

1. Research Design

This research method uses a descriptive method. Sampling was carried out by purposive sampling which was carried out during the day and using 6 samples of chili leaves and the treatment of closing and opening of chili leaves using aluminum foil in direct sunlight. Then treatment was given for the effect of solar radiation on the photosynthetic activity of chili leaves using the Sach test. The Sach experiment is a photosynthesis test used to test the presence of glucose or amylum (C6H, 12, O6) as a result of photosynthesis. It is known that the components that make up glucose are carbon (C), hydrogen (H), and oxygen (O), where these components are the same components that make up carbohydrates.

2. Instruments

This research was conducted in a biology laboratory, the tools used were aluminum foil, tweezers, 500Ml and 250Ml glass jars, while the materials were broadleaf chili leaves, iodine. With the process of taking a piece of dark green/mature leaves that are able to photosynthesize optimally and wide chili leaves. The surface of the leaf is covered with aluminum foil and kept using tweezers or a clip to ensure the cover does not come off. This treatment is done at night or 24 hours to ensure that the part of the leaf under the foil is not exposed to sunlight, while the uncovered part will be exposed to light.

3. Technique of Data Analysis

Data analysis techniques used in this study include qualitative analysis of the presence of starch in chili leaves through reaction with iodine, which indicates effective photosynthesis. This qualitative analysis is based on a change in color to blue-black or dark purple which indicates the presence of starch as a result of successful photosynthesis.

D. Findings and Discussion

1. Findings

Photosynthesis is a biochemical process performed by green plants, algae, and some photosynthetic bacteria in converting carbon dioxide (CO2) and water (H2O) into glucose (C6H12O6) by utilizing light energy, usually from the sun. During this process, oxygen (O2) is released as a by-product (Maftukhah et al, 2023). Photosynthesis which is the process of converting solar light energy into chemical energy stored in organic compounds such as glucose. This process has two main phases: "light phase" (light-dependent reaction) and "dark phase" (Calvin cycle or light-independent reaction). In this study gave the following results from tests with iodine administration on chili leaves:

Figure. 1. Chili Leaves Covered with Aluminum Foil

Figure. 2. Chili Leaves Not Covered with Aluminum Foil

Figure. 3. Leaves covered with aluminum foil after being smeared with iodine

Figure. 4. Leaves not covered with aluminum foil after being smeared with iodine

Figure. 5. Leaves not covered with aluminum foil after being smeared with iodine

Figure. 6. Leaves Covered with Aluminum Foil After Iodine Treatment

Reaction with iodine shows a blue-black or dark purple color, iodine reacts with amylum, producing a blue-black or dark purple color. This indicates that photosynthesis has taken place effectively in this area, resulting in high amylum production. In the result of high amylum production, this condition makes it clear that the leaf area exposed to light can carry out photosynthesis productively, producing amylum as one of the results of the process

Reacting positively with iodine shows a blue-black or dark purple color due to the presence of amylum. This is a clear indication that photosynthesis has taken place in this area. Sunlight, through chlorophyll, triggers a chemical reaction that produces sugar (glucose) from CO_2 and H_2O. This glucose is then utilized by the plant for various needs, including growth, and excess sugar is stored in the form of amylum. Iodine reacts with this amylum, producing a distinctive coloration that signals the success of the photosynthesis process.

2. Discussion

Based on tests of the leaves of chili peppers that are not covered and exposed to sunlight, explaining the color of the leaves is darker green, this shows that leaves exposed directly to sunlight are able to produce a lot of chlorophyll. Chlorophyll is a vital pigment in leaves that is responsible for the absorption of light energy, which is essential in the process of photosynthesis. The reaction with iodine shows blue-black or dark purple, iodine reacts with amylum, producing a blue-black or dark purple color. This indicates that photosynthesis has taken place effectively in this area, resulting in high amylum production The high production of amylum indicates that the chili plant not only grows well but is also able to produce sufficient carbohydrate reserves in the form of amylum. This is important not only for plant growth but also for maximum yields (Habibah, 2022).

In the result of high amylum production, this condition makes it clear that the leaf area exposed to light can carry out photosynthesis productively, producing amylum as one of the results of the process. From the test results of chili leaves that are closed and not exposed to sunlight, the color of the leaves is paler or yellowish, this is caused by a lack of chlorophyll in leaves that do not receive sunlight. Without sufficient light exposure, chlorophyll production is disrupted, which results in a decrease in the capacity of the leaves to carry out photosynthesis, thus changing the color of the leaves to be paler or yellowish. The reaction with iodine showed a pale yellow or almost colorless color, indicating low to no amylum production in this part of the leaf. Without light, the photosynthesis process is ineffective, so no amylum is formed that can react with iodine. no amylum production, this is further evidence that without sufficient light absorption, the leaves cannot photosynthesize properly, thus not producing amylum (Roziqin, 2021). This proves that the sachs experiment of photosynthesis on leaves requires light and produces amylum and oxygen.

From the observation of the difference in color and reaction of chili leaves exposed to sunlight compared to those that are not, a deeper understanding of the photosynthesis process can be obtained. Photosynthesis is a vital process carried out by plants to produce energy, in which sunlight plays a major role. Photosynthesis takes place in two main phases: the light phase and the dark phase. In the light phase, energy from sunlight is captured by chlorophyll and used to break down water molecules (H_2O) into oxygen (O_2), protons (H^+) and electrons. This process produces ATP and NADPH which are used in the dark phase. The dark phase, also known as the Calvin cycle, does not directly require light. In this phase, the ATP and NADPH produced in the light phase are used to convert carbon dioxide (CO_2) from the air into sugar (glucose), which can then be stored in the form of amylum. With a lack of light exposure, the amount of energy available to produce ATP and NADPH is reduced. This results in a reduction of the main raw materials needed for the Calvin cycle to synthesize glucose from CO2. When the light intensity drops below the minimum threshold required, photosynthesis cannot proceed efficiently. Insufficient amounts of ATP and NADPH cause the Calvin cycle to be unable to function optimally, reducing the production of glucose and oxygen. Glucose synthesized through photosynthesis is the main source of energy for plants and is a precursor for the biosynthesis of many other important biomolecules. Lack of glucose can limit plant growth and reproduction (García et al., 2022).

Weak light conditions as well as light periods that are short or below the effective threshold can lead to a condition called photoinhibition. This occurs when the limited light energy is not enough to support all photosynthetic processes, but still enough to trigger the course of oxidative processes that can damage the photosynthetic apparatus if it does not immediately use the electrons produced. The part of the leaf exposed to light reacts positively with iodine showing a blue-black or dark purple color due to the presence of amylum. This is a clear

indication that photosynthesis has taken place in this area. Sunlight, through chlorophyll, triggers a chemical reaction that produces sugar (glucose) from CO_2 and H_2O. This glucose is then utilized by the plant for various needs, including growth, and excess sugar is stored in the form of amylum. Iodine reacts with this amylum, producing a distinctive coloration that signals the success of the photosynthesis process (Saputri et al., 2023)

The phenomenon of decreased photosynthetic efficiency that occurs when plants are exposed to light of very high intensity. In contrast, parts of the leaf that are not exposed to light do not react with iodine, indicating the absence or lack of amylum. This is because without light, plants cannot photosynthesize. Chlorophyll needs energy from light to start the process of making glucose. Without glucose production, no amylum is formed, so iodine shows no color reaction on this part of the leaf. The results that do not give a reaction are based on several factors that affect photosynthesis including light intensity, availability of carbon dioxide (CO2), water, and chlorophyll. If one or more of these factors is not optimal, then the results of photosynthesis testing are not as expected (Xu et al., 2024).

Sunlight or other light sources are one of the most important photosynthetic factors. Insufficient light can hinder the efficiency of photosynthesis because the energy provided is insufficient for the process of converting CO2 and water into glucose and oxygen. In another aspect, it is influenced by the role of chlorophyll which is an important pigment in the photosynthesis process that functions to capture light energy. Plants that lack chlorophyll will have lower photosynthetic performance. This can occur due to genetic problems or unfavorable environmental conditions, this process can negatively affect the plant's ability to convert light energy into chemical energy through photosynthesis. When light intensity exceeds the limit that can be handled by the plant's photosynthetic mechanism, there is excessive accumulation of energy in the chloroplast, which can result in damage to the photosynthetic system, including damage to proteins that function in the photosynthetic process. As an adaptation or defense mechanism, plants have various strategies to reduce the risk of photoinhibition, by increasing the dispersion of excessive light energy or through repair and replacement of damaged photosynthetic components. This can significantly affect plant productivity and photosynthetic efficiency, given the importance of the photosynthetic process in biomass production and CO2 sequestration. Management of environmental factors, such as light intensity, is important to optimize photosynthesis and reduce the risk of photoinhibition (Bhutta et al., 2023).

Chlorophyll molecules respond to this light energy by undergoing electron excitation. These excited electrons are then used in further chemical reactions that produce the energy-carrying molecules ATP and NADPH in the light phase of photosynthesis, leaf color determined by the composition of chlorophyll pigments and other pigments not only affects the absorption of light for photosynthesis but also the adaptation of plants to certain environments. Pigments other than chlorophyll, such as carotenoids and anthocyanins, have protective and adaptive roles that impact plant survival under environmental stress conditions. Another factor is based on water shortage, which can affect stomatal opening and reduce the availability of CO2 in the leaf, which in turn reduces the rate of photosynthesis. On the influence of carbon dioxide which is one of the main reactants in the photosynthesis process. Low CO2 concentrations can inhibit photosynthesis because the reaction depends on the availability of this gas. Sunlight is a key external factor that determines photosynthetic efficiency. Adequate light availability is essential to produce enough ATP and NADPH to convert CO2 and water into glucose and oxygen. Without sufficient energy, the photosynthetic process becomes inefficient, leading to reduced energy and biomass production in plants. This can adversely affect the growth, development and long-term survival of the plant (Ansyah et al., 2024).

A research from Spaninks et al (2023) shows that optimal light intensity is very important the photosynthesis process. This research found that leaves exposed to moderate intensity light prodeced more chlorophyll and starch compared to leaves exposed to low or high light. This is in line with the observation that chili leaves exposed to direct sunlight show a dark green color and a positive reaction with iodine, which indicates high starch prodution. Another research highlighted the importance of clorophyll in capturing light energy for photosythesis process. In sufficient light conditions, chlorophyll is able to trigger a chemical reaction that converts CO2 and H2O into glucose and oxygen (Elias et al., 2024). In addiction research from Bhutta et al., 2023) show that photoinhibition can occur when plants are exposed to very high intesity light, which causes damage to the photosynthesis system. This explains why light intensity that is too high can decrease in glucose and starch production. Overall these new researchs streghten our understanding of how light intensity and chlorophyll affect photosynthesis, as well as the risk of

photoinhibition at very high light intesities. These results are relevant to the test observations on chili leaves mentioned previosly.

E. Conclusion

Based on the results of the study, it can be concluded that part of the leaf that is exposed to sunlight produces more chlorophyll, which makes the leaf color darker green, and produces amylum as shown by the blue-black or dark purple reaction when tested with iodine. While the part of the leaf that is not exposed to sunlight produces less chlorophyll, so the color is paler or yellowish, and does not produce amylum as shown by the almost colorless reaction when tested with iodine. This shows that without sunlight, chili leaves cannot photosynthesize effectively and do not produce amylum.

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