Growth Pattern of Sunflower on Some Light Intensity in The Coastal Land

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Abstract. Growth is quantitative development. Crop growth determined crop yield level, so that needs studied. Affecting factor of crop growth pattern is light intensity. Crop response on light intensity different for each crop species. This research aimed to study Sunflower growth pattern on some light intensity at the coastal land. Research conducted in the Bugel II coastal land, Bugel Village, Panjatan District, Kulonprogo Regency, Yogyakarta Province. The research was conducted by a single factor experimental method. Light Intensity variation with three levels is the intensity of 100%, 75%, and 45% tested in this research. The treatment tested was arranged by Randomized Complete Block Design (RCBD). That studied variable, are Leaf Area Index (LAI), Net Assimilation Rate (NAR), Crop Growth Rate (CGR), the correlation between CGR with LAI, the correlation between CGR with NAR, and Harvest Indeks. The research result showed that LAI, NAR, and CGR increased by increasing light intensity. LAI increasing followed by CGR increasing, and Harvest Index decreased on low intensity. Generally, Sunflower growth patterns in the coastal land increased along with increasing light intensity.

Keyword: pattern, growth, sunflower, light intensity, coastal land

1. Introduction

Sunflower oil has many benefits. This vegetable oil is obtained from sunflower seeds. The productivity of sunflower seeds recorded in Blitar reaches 3 tons/Ha/season [1]. Apart from Blitar, sunflowers are also planted in Malang. The oil content of sunflower seeds is 48-52% (Lisa, 2010).

The development of sunflower oil production ranks fourth of the world's vegetable oils, even though its consumption volume is in third place [2]. Sunflower seed oil fulfills world vegetable oil consumption by 8.5% [3]. Sunflowers can grow in hot areas with full sun but are not affected by photoperiodicity [8]. Sunflower yields can be modified due to environmental influences (seasonal differences). Sunflower leaf area increases in summer [4].

Sunflower is a plant that is given the ability to convert physical energy/light into chemical energy. This energy is then transferred to other living things through the process of eating, which is then converted into kinetic energy (motion), so that life becomes dynamic. The absorption rate of irradiation intensity depends on the character of the plant species. The absorption of light by plants is then processed through photosynthetic reactions, resulting in chemical energy. Plants are classified based on the initial photosynthetic compound products produced, namely C-3 and C-4 [3]. Sunflowers are included in the C-3 plant group with characteristics, including saturation of full light (full sunlight), relatively moderate temperature, and high air CO2 content.
Some plants that like light, such as the sugarcane variety PS881 which is classified as a C4 plant, can grow well in shaded conditions by 20% (Myta, 2014). Plant growth and yield are a display of plant physiological processes. The process of plant physiology is an interaction between genetic and environmental factors [5]. Sunflowers are a class of C-3 plants that do not need full radiation intensity in their lives, however, the presence of light remains a major factor in determining the rate of photosynthesis. As mentioned above, in Indonesia today, sunflowers are widely planted in Blitar and Malang areas. Until now, there has been no information about the growth patterns of sunflowers planted in Indonesia (tropical areas) at different radiation intensities.

Coastal land is one of the marginal lands because it has major limitations, namely water, and mineral nutrients. However, this land has the advantage, namely abundant sunshine accompanied by high temperatures. One land with such characteristics is found on the south coast of Yogyakarta. High-intensity conditions are very beneficial for plant growth, one of which is the sunflower. Therefore, it is necessary to study the growth patterns of sunflowers that grow on the land on the south coast of Yogyakarta at the different light intensity.

2. Research Method

Research on the light intensity on sunflower plants was carried out on the coast of Yogyakarta, to be precise in the coastal land of Bugel, Panjatan, Kulonprogo. The experimental method was used in this study, while the treatment design applied was a single factor. The light intensity is the treatment tested in this study with three levels, intensity 100%, 75%, and 45%. To obtain the light intensity according to the treatment carried out by 1) 100% light intensity, meaning that sunflower planting is not given shade (fully open); 2) The intensity of the light is 75%, the plant is given 25% para net shade, and 3) light intensity of 45%, planting was given 55% para net shade. The research environment design was prepared using a Randomized Complete Block Design (RCBD). Each treatment was repeated 3 times. Observation data were used for plant growth analysis. The analysis variables were leaf area, leaf area index, net assimilation rate, plant growth rate, and harvest index.

\[
\begin{align*}
\text{LA} &= \text{leaf area index; } \text{LA} = \text{leaf area; } \text{LdA} = \text{land area} \\
\text{NAR} &= \frac{(W_2 - W_1) \ln \text{LA}_2 - \ln \text{LA}_1}{T_2 - T_1} \quad \text{(g.cm}^2\text{.day}^{-1}) \\
\text{CGR} &= \frac{(W_2 - W_1)}{(T_2 - T_1)} \frac{1}{\text{LdA}} \\
\text{HI} &= \frac{\text{B}}{100}\% \\
\end{align*}
\]

\[\text{We}\]

\[\text{LAI} = \frac{\text{LA}}{\text{LdA}}\]

\[\text{NAR} = \frac{(W_2 - W_1) \ln \text{LA}_2 - \ln \text{LA}_1}{T_2 - T_1} \quad \text{(g.cm}^2\text{.day}^{-1}) \]

\[\text{CGR} = \frac{(W_2 - W_1)}{(T_2 - T_1)} \frac{1}{\text{LdA}}\]

\[\text{HI} = \frac{\text{B}}{100}\% \]

W1 and W2 = crop dry weight on the first and second observation
LA1 and LA2 = leaf area on the first and second observation
T1 and T2 = observation on first and second times
We = economic weight
B = biomass
(Javahery, 2016; Pandey et al., 2017)

The analysis result is dished by the histogram graph, so that trend of light intensity affect more than reading. So, that result is analyzed by descriptive-explanative [6].

3. Result and Discussion
Plant growth patterns can be described by analysis of plant growth. Plant growth can be different due to the influence of different light intensity.

Leaf Area
Sunflower’s response to the light intensity that is cultivated at the coastal land is dished in Figure 1.

Figure 1 shows that the leaf area of the sunflower increases with the increase in light intensity. The response of plants to the increased intensity of light in the growing environment is not saturated. The 100% (8975 cm2) light intensity was significantly higher than 45% and 75%. This proves that sunflowers are responsive to the intensity of light. This means that a decrease or increase in the intensity of the light can decrease or increase the sunflower leaf area. This response is in accordance with the character of sunflowers which are classified as C-4 plants (sun plant).

Leaf Area Index (LAI)
Leaf area index increases as the plant leaf area increase to some extent. The results of the analysis showed that 100% intensity was not different from the intensity of 75%, with leaf area indexes of 0.06435 (a) and 0.05064 (ab). However, the intensity of 75% and 45% with LAI 0.05064 (ab) and 0.03780 (b) are not significantly different.

The 45% intensity experienced an increase in the leaf area index not higher than the 100% intensity, according to the increase in the number of leaves and leaf area experienced by sunflowers. The final
observations of LAI on the intensity of 75% treatment showed that the leaf area index was not high. This happens because, at the final observation stage, the plant has entered the final vegetative phase, so that leaf growth has begun to decrease both in the increase in the number of leaves and the area. Also besides, leaf growth could not inhibit leaf aging so that the increase in leaf area index was not significant. The cause of aging is generally due to the mobilization and levy of minerals and organic nutrients to more competitive use areas, such as young leaves and roots. The number of leaves and leaf area index (LAI) peaks and then remains constant until a general aging process begins, where the balance will occur as the rate of leaf aging equals the rate of new leaf production [7]. The plant has reached a stationary phase.

Net Assimilation Rate (NAR)

NAR is a measure of the average efficiency of leaf photosynthesis in a cultivated plant community, also known as the rate of accumulation of dry weight per unit leaf area per unit time [7]. The sunflower shows that plants at the end of the vegetative phase have a decreasing net assimilation rate. The intensity of 100% showed the highest net assimilation rate compared to the other two treatments, both in the initial and final NAR observations. Initial NAR is known that the rate of assimilation in various treatments is almost the same, where a sharp change occurs at an intensity of 45% this happens because the number of leaves that carry out photosynthesis is still small, it is known that this treatment has a low affect on the increase in the number of leaves, so that this little leaf performs photosynthesis optimally because there are no obstacles due to the leaf canopy.

![Effect of light intensity on NAR](image)

Figure 2. Effect of light intensity on Net Assimilation Rate

When the growth is in its maximum phase where the leaves have formed a stratified canopy, the photosynthesis rate decreases due to the lack of light intensity. This causes the assimilation rate to drop drastically in the NAR observations at the end of the vegetative phase. NAR has the highest value when the growth is still small and most of the leaves are exposed to direct sunlight, the net assimilation rate does not take into account non-laminar photosynthesis, namely photosynthesis that uses plant parts other than leaves such as petioles, stems, leaf sheaths and flower parts [7].

Crop Growth Rate (CGR)
According to Gardner, et al., (1991) CGR is the increase in weight in the plant community per unit land area in units of time. The plant growth rate increased from the initial CGR observations to the final CGR, where each treatment had an increase except at 75% intensity treatment. Brougham stated in Gardner et al., [7] that CGR increases with increasing LAI. Based on the leaf area index treatment, the intensity of 75% decreased due to aging that occurred in other words, the plant had entered the generative phase, this affected the plant growth rate so that in the final observation the CGR had decreased, but not significantly the decrease in the leaf area index. This is possible due to the rate of assimilation that occurs in this treatment at the end of the observation has increased so that it supports the decrease in the existing leaf area index. Gardner et al. [7] stated that CGR is the product of the net assimilation rate with the leaf area index.

The intensity of 100% has the highest plant growth rate compared to the intensity of 45%. At 45% intensity, it has a lower CGR due to the net assimilation rate and leaf area index which also does not encourage more increases to exceed the 100% intensity plant growth rate. The intensity of 45% gets less than optimal irradiation so that it experiences a slower vegetative phase. Also besides, low-intensity conditions cannot increase the rate of photosynthesis because along with leaf growth, the opposite occurs, namely a slowdown in the rate of photosynthesis. Further increases in leaf area will only shade the lower leaves, which in turn are unable to produce enough photosynthesis to meet respiration requirements, and possibly those which use photosynthetic products from other leaves such as side shoots, thereby reducing the growth rate of cultivated plants [7].

Figure 3 shows that the higher the light intensity given, it will increase the CGR and ultimately increase plant growth. It appears that 100% light intensity produces the highest CGR, which confirms that sunflowers are included in the C4 plant group. The increase in LAI was followed by an increase in CGR (Fig. This shows that sunflowers do not experience saturation of irradiation intensity, so there is no critical point of light energy absorption. This phenomenon also proves that sunflower is a class C-4 plant or a sun plant. This result was in line with Mita et al. (2014) statement about sugarcane better growth on light intensity 80% than 100%, because no for Sunflower (100% is better).
Biomass is the accumulation of plant growth that occurs in all organs, such as leaves, stems, and roots, or a measure of total plant growth. Figure 4 above depicts a sharp increase in biomass at 100% (108.21 g) irradiation intensity of 75% intensity, while from 45% to 75% there is an increase of 19.69 g. This shows that the physiological process which is the interaction between plant genetic factors and the growing environment is going well. The main cause is the net assimilation rate, the plant growth rate is also going well, as mentioned in Figures 2 and 4 above.

The economic weight of the plant is the total dry weight of the economic value (salable) plant product. Plant products are the embodiment of plant growth and development. The rate of growth and development of plants determines the level of crop yield (economy). Figure 4 shows that the economic dry weight of the plant increases with the increase in biomass. The highest increase occurred at the intensity of 75% to 100%, namely 76.18 g, and almost four times higher than the intensity of 45% to 75% (21.25 g). These results indicate that the sunflower seed replenishment period runs well at high irradiation intensity levels. Instead, the process replenishment of seeds will be hampered by decreasing the intensity of irradiation during sunflower growth. Furthermore, the efficiency of the assimilate distribution can be seen in the harvest index variable.

**Harvest Index**

The harvest index is a measure of the proportionality of the distribution of plant assimilates between economic value products (salable) and plant biomass. The magnitude of the distribution between the two can be seen in Figure 5.
Figure 5 above illustrates the percentage distribution of assimilates which is influenced by the intensity of irradiation. The increasing intensity of irradiation causes the distribution to increase to the economic value product. The percentage increase occurred by 13% from 45% intensity to 75% and was greater than from 75% to 100% (only 6%). This shows that sunflowers cannot grow well and produce high economic products when faced with low irradiation intensity. This is due to the efficient photosynthetic rate of sunflowers at high irradiation levels (C-4 plants).

4. Conclusion
LAI, NAR, and CGR increased by increasing light intensity. LAI increasing followed by CGR increasing, and Harvest Index decreased on low intensity. Generally, Sunflower growth pattern in the coastal land increased along with increasing of light intensity.

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