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Adaptation Test Variety of Cabbage Plant on The Reduction of Light Intensity

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ABSTRAK

Kubis (*Brassica oleracea*) merupakan salah satu jenis sayuran yang memiliki nilai ekonomi tinggi sehingga banyak dibudidayakan oleh petani. Pada tahun 2013 luas panen kubis di Indonesia adalah 65.248 ha, dengan produksi 1.480.625 ton dan produktivitas 22,69 ton/ha (Badan Pusat Statistik dan Ditjen Hortikultura). , 2013). Peluang pengembangan usaha kubis semakin luas. Masyarakat umum mulai semakin menyukai kubis karena selain rasanya yang enak dan sebagai bahan makanan nabati juga karena kandungan gizinya yang cukup tinggi. Unsur iklim seperti suhu udara, radiasi matahari, dan kelembaban mendukung dan berperan penting dalam produksi tanaman. Hal ini dikarenakan tumbuhan membutuhkan unsur iklim, terutama intensitas penyinaran matahari. Setiap tanaman memerlukan kisaran intensitas penyinaran matahari tertentu untuk pertumbuhannya, ada tanaman yang membutuhkan intensitas cahaya tinggi dan ada pula yang rendah. Proses pada tumbuhan yang dapat dipengaruhi oleh intensitas cahaya adalah fotosintesis, transpirasi, respirasi, reduksi nitrat, sintesis protein, produksi hormon, translokasi, penuaan, pertumbuhan akar dan penyerapan nitrat (Struik dan Deinum, 1982). Dalam pengembangan budidaya kubis salah satu permasalahan yang berpotensi terjadi pada pengembangan tanaman tersebut adalah rendahnya intensitas sinar matahari yang diterima tanaman akibat naungan berbagai benda atau tanaman lain sehingga tanaman tidak mendapatkan sinar matahari yang cukup untuk pertumbuhan mereka. Oleh karena itu, diperlukan kajian untuk mempelajari bagaimana adaptasi tanaman kubis terhadap penurunan intensitas cahaya. Menurut Wolff dan Coltman (1990) pengurangan intensitas sinar matahari hingga 30% sampai 47% masih dapat ditoleransi oleh tanaman kubis. Oleh sebab itu pertumbuhan tanaman tidak terganggu.

Kata Kunci: *Kubis, Unsur Iklim, Intensitas Cahaya*

ABSTRACT

Cabbage (Brassica oleracea) is a type of vegetable that has high economic value, so it is widely cultivated by farmers. In 2013 the cabbage harvest area in Indonesia was 65,248 ha, with production of 1,480,625 tons and productivity of 22.69 tons / ha (Central Statistics Agency and Directorate General of Horticulture , 2013). Opportunities for cabbage business development are increasingly widespread. The general public began increasingly fond of cabbage because in addition to good taste and as a vegetable food ingredient also because it contains quite high nutrition. Climate elements such as air temperature, solar radiation, and humidity support and play an important role in plant production. This is because plants need climate elements, especially the intensity of solar radiation. Each plant requires a certain range of solar radiation intensity for its growth, there are plants that require high light intensity and some are low. Processes in plants that can be affected by light intensity are photosynthesis, transpiration, respiration, nitrate reduction, protein synthesis, hormone production, translocation, aging, root growth and nitrate absorption (Struik and Deinum, 1982). In the development of cabbage cultivation one of the problems that has the potential to occur in the development of these plants is the low intensity of sunlight received by plants due to the shade of various objects or other plants so that plants do not get enough sunlight for their growth. Therefore, studies are needed to study how the adaptation of cabbage plants to a decrease in light intensity. According to Wolff and Coltman (1990) a reduction in the intensity of sunlight up to 30% to 47% can still be tolerated by cabbage plants. Therefore plant growth is not disturbed.

Keywords: *Cabbage, Climate elements, light intensity*

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INTRODUCTION

Cabbage (Brassica oleracea) is a vegetable commodity that has high economic value so it is widely cultivated by farmers in various countries. In 2013, cabbage harvested area in Indonesia was 65,248 ha, with production of 1,480,625 tons and productivity of 22.69 tons / ha (Central Statistics Agency and Directorate General of Horticulture, 2013). Cabbage business development opportunities are increasingly widespread. The general public began increasingly fond of cabbage because in addition to good taste and as a vegetable food ingredient also because it contains quite high nutrition.

Climate elements such as air temperature, solar radiation, and humidity support and play an important role in plant production. This is because plants need climate elements, especially the intensity of solar radiation. Each plant requires a certain range of solar radiation intensity for its growth, there are plants that require high light intensity and some are low. Processes in plants that can be affected by light intensity are photosynthesis, transpiration, respiration, nitrate reduction, protein synthesis, hormone production, translocation, aging, root growth and nitrate absorption (Struik and Deinum, 1982). Physiologically, light affects both directly and indirectly for the body of the plant. Its effects on metabolism directly through photosynthesis. While the indirect effect through plant growth and development is a metabolic response and is more complex (Fitter and Hay, 1991).

In the development of cabbage cultivation one of the problems that has the potential to occur in the development of these plants is the low intensity of sunlight received by plants due to the shade of various objects or other plants so that plants do not get enough sunlight for their growth. Therefore, studies are needed to study how the adaptation of cabbage plants to a decrease in light intensity. The aim of this research is to find varieties of adaptive cabbage plants cultivated in various light intensities.

MATERIALS AND METHOD

This experiment was carried out in Kepuharjo Village, Karangploso District, Malang Regency, East Java. Located at an altitude between ± 550 meters above sea level and temperatures ranging from 20 ° C - 24 ° C. Average humidity ranges from 54% - 65%. This experiment was carried out in July - October during the dry season. The experimental design used was a nested.design with two factors, namely light intensity as a free factor and plant varieties as an independent factor (nested in intensity). The light intensity factor consists of 4 levels, namely: 100% Light Intensity, 75% Light Intensity, 50% Light Intensity, and 25% Light Intensity. Factors of plant diversity consist of Grand 11 Varieties, Healthy Varieties, and KK Cross Varieties. The plot of the experiment was 150 x 150 cm with a spacing of 40 x 40 cm. The experiment was carried out three times and each plot consisted of thirty-five plants.

Experimental Parameters.

The observed variables consist of plant growth components which include

1. Leaf area index

$$\mathrm{LAI} = \frac{\mathrm{LA}}{\mathrm{GA}} (\mathrm{m}^2 / \mathrm{m}^2)$$

2. Crop Growth Rates

$$\mathrm{CGR} = \frac{1}{\mathrm{GA}} \mathrm{X} \frac{\mathrm{W}_2 - \mathrm{W}_1}{\mathrm{t}_2 - \mathrm{t}_1} (\mathrm{g}\ /\mathrm{hari}^{-1})$$

The component of the yield observed is

3. Crop Fresh Weight
4. Chlorophyll

Hasil dan pembahasan

Leaf Area Index

The leaves are important organs for plants where the process of photosynthesis takes place in the leaves.

Leaf area is an important parameter needed to determine the growth of a plant. Based on observations, it shows that the leaf area index has increased in each observation period in all treatments. The graph of increasing leaf area index for three types of varieties is presented in Figure 1.

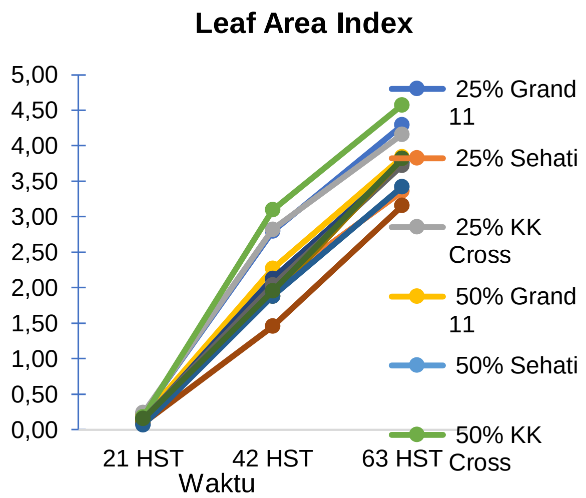

Figure 1. Graph leaf area index is due to the intensity of light at kind of plant

Mungara et al., (2013) stated that the optimum leaf area index ranged between 4-6. Variance analysis results showed that observations of leaf area index observed at 21, 42, and 63 DAP showed significant interactions between treatments as presented in Table 1.

At The last observation 63 days after planting, at a light intensity of 25% the Grand 11 variety was not significantly different in leaf area index compared to Sehati Varieties and KK Cross. At 50% light intensity the KK Cross Variety produced the highest leaf area index value compared to the Grand 11 and Sehati Varieties, while the Grand 11 Varieties were not significantly different when compared to the Sehati Varieties. At 75% light intensity, the Grand 11 variety was not significantly different in leaf area index compared to Sehati Variety and KK Cross. At 100% light intensity there was no significant difference in leaf area index in Varieties Grand 11, Sehati and KK Cross.

Table 1. Interaction between light intensity and kinds of variety to Leaf Area Index (m^2/m^2) of Plants at 21, 42 and 63 DAP

Observation Period 21 DAP	**Treatment Light Intensity**	**Leaf area index (m^2/m^2)**		
		Kinds of variety		
		Grand 11	Sehati	KK Cross
	25 %	0,226 de	0,218 de	0,238 e
	50 %	0,171 bcde	0,138 abcd	0,183 cde
	75 %	0,128 abc	0,092 ab	0,152 abcde
	100 %	0,122 abc	0,07 a	0,155 abcde
HSD 5 %		0,088		
CV %		17,33		
Observation Period 42 DAP	**Treatment Light Intensity**	**Leaf area index (m^2/m^2)**		
		Kinds of variety		
		Grand 11	Sehati	KK Cross
	25 %	2,794 b	2,028 ab	2,820 b
	50 %	2,269 ab	2,088 ab	3,096 b
	75 %	2,129 ab	1,458 a	2,036 ab
	100 %	1,880 ab	1,881 ab	1,954 ab
HSD 5 %		1,295		
CV %		19,29		
Observation Period 63 DAP	**Treatment Light Intensity**	**Leaf area index (m^2/m^2)**		
		Kinds of variety		
		Grand 11	Sehati	KK Cross
	25 %	4,290 bc	3,358 ab	4,369 bc
	50 %	3,840 ab	3,770 ab	5,198 c
	75 %	3,750 ab	3,156 a	3,722 ab
	100 %	3,817 ab	3,423 ab	3,818 ab
HSD 5 %		1,117		
CV %		9,78		

Note : Numbers with the same lowercase letters in the same row and the same upper case in the same column show not significant difference in HSD test ($P<0.05$), DAP = days after planting

From the factors of plant varieties on light intensity, Variety Grand 11 with a light intensity of 25% was not significantly different from the light intensity of 50%, 75% and 100%. Sehati varieties with 25% intensity were not significantly different than those at 50%, 75% and 100% light intensity. KK Cross varieties with 50% light intensity significantly produce leaf area index higher than 75% and 100% light intensity, but not significantly different when compared with 25% light intensity. While KK Cross Variety with 25% light intensity is not significantly different compared to 75% and 100% light intensity.

This is in line with the statement of Sutarmi (1983), low light intensity will produce plants that have wider and thinner leaves, thinner epidermal layers, less palisade tissue and greater intercellular space. This indicates that to increase the capacity of light capture in light deficit environments, shade tolerant varieties make efforts to increase leaf area. Avoidance mechanism of low light intensity also occurs in tolerant upland rice by increasing leaf area higher than sensitive genotypes (Sopandie et al. 2003; Soverda 2004) as well as in tolerant soybeans (Soverda, Evita & Gusniwati 2012; Pertiwi & Soverda 2012). In addition, lack of light during development will cause symptoms of etiolation, where plants will grow faster but weaker and the leaves are small, thin and pale (not green).

Crop Growth Rates

Crop growth rate is the ability of plants to produce the results of assimilation of dry weights for each unit of land area per unit of time which is widely used in plant growth analysis in the field. (Huang et al, 2016). Increasing the size and dry weight of plants reflects the increase in protoplasm, which occurs due to increased size and number of cells (Hopkins, 1999). According to Madhu and Jerry (2016) Dry weight of plants is a picture of the result of the translocation of photosynthate results to all parts of the plant as a process of the rate of photosynthesis in leaves in intercepting solar radiation.

The results showed that there was an interaction between light intensity and kinds of variety on the growth rate parameters (Table 2).

Table 2. Crop growth rate (g dm^2 day^{-1}) of Plants due to Treatment of Light Intensity and Kinds of Plant at 21 – 42, dan 42 – 63 DAP

Observation Period 21 - 42 DAP	**Treatment Light Intensity**	**Crop Growth Rate (g dm⁻² day⁻¹)**		
		Kinds of variety		
		Grand 11	Sehati	KK Cross
	25 %	0,00098 abc	0,00079 ab	0,00067 a
	50 %	0,00112 abc	0,00085 abc	0,00122 bc
	75 %	0,00116 abc	0,00086 abc	0,00088 abc
	100 %	0,00116 abc	0,00133 c	0,00134 c
HSD 5 %		0,00052		
CV %		17,15		
Observation Period 42 - 63 DAP	**Treatment Light Intensity**	**Crop Growth Rate (g dm⁻² day⁻¹)**		
		Kinds of variety		
		Grand 11	Sehati	KK Cross
	25 %	0,00211 a	0,00160 a	0,00227 a
	50 %	0,00253 ab	0,00241 ab	0,00456 c
	75 %	0,00248 ab	0,00233 a	0,00191 a
	100 %	0,00380 bc	0,00143 a	0,00215 a
HSD 5 %		0,00142		
CV %		19,62		

Note : Numbers with the same lowercase letters in the same row and the.same upper case in the same column show not significant difference in HSD.test (P<0.05), DAP = days after planting

The results of the analysis of variance showed that there was a real interaction between light intensity and plant type in the parameters of plant growth rates. At the last observation at 42 – 63 days after planting at 25% light intensity did not significantly differ in the rate of plant growth in various varieties of cabbage plants tested. At 50% light intensity the KK Cross variety significantly produced higher plant growth rates than the Grand 11 and Sehati Varieties, but the Grand 11 Varieties were not significantly different from the Sehati Varieties. At 75% light intensity, the Grand 11 variety did not significantly differ in the rate of plant growth compared to that of the one-day variety and KK Cross. At a light intensity of 100% the Grand 11 variety significantly produces plant growth rates compared to the Sehati and KK Cross varieties, while the Sehati Varieties are not significantly different from the KK Cross Varieties. Theoretically the greater the amount of solar energy absorbed will increase the amount of photosynthesis (Zervoukdakis et al., 2012). In addition to the high density, low received light intensity which causes the low energy available to combine CO2 and H2O, this condition causes the photosynthesis rate to be low, so naturally the rate of plant growth will be low. This is in accordance with the results of research Nagasubramaniam (2007), which states that good photosynthetic activity is found in the shade of about 60%. In this context, shade influences growth activity, morphological changes and physiological characteristics, metabolic activity of primary and secondary metabolites.

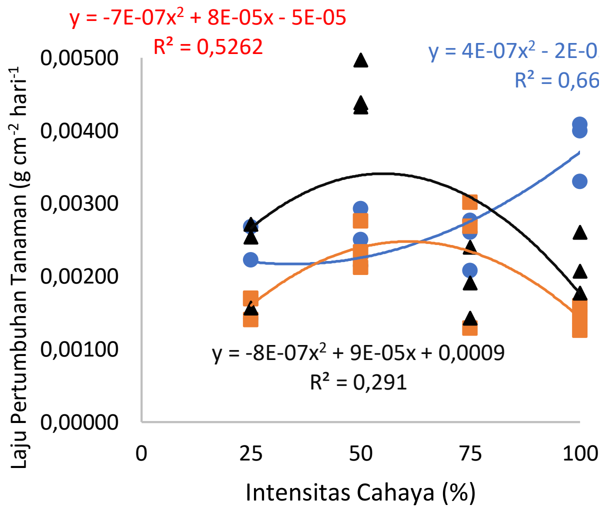

Figure 2. The effect of light intensity and kinds of variety toward total fresh weight.

According to Bilman (2001), the higher the density will stimulate the absorption of nutrients, water, and sunlight between plants at a certain area. Theoretically the greater the amount of solar energy absorbed will increase the amount of photosynthesis (Zervoukdakis et al., 2012) In addition to the high density, low received light intensity which causes the low energy available to combine CO_2 and H_2O, this condition causes the rate of photosynthesis low, then by itself the rate of plant growth will be low.

To see the relationship between Light Intensity (X) of Plant Growth Rate (Y) of the three varieties of cabbage plants, a regression analysis was carried out (Figure 2).

Regression analysis for cabbage plants Grand 11 showed that there was a relationship between leaf area index and light y = 4E-07x2 - 2E-05x + 0.0026 R^2 = 0.6603, while for the one-day variety the regression equation was y = -7E-07x2 + 8E -05x - 5E-05 R^2 = 0.5262 and for KK Cross Variety the regression equation is y = -8E-07x2 + 9E-05x + 0,0009 R^2 = 0.291.

The value of R2 is the coefficient of determination, for the coefficient of determination in the Variety Grand 11 of = 0.6603, which means 66% of the rate of growth of plants produced is influenced by light intensity. In one variety, the coefficient of determination is 0.5262, which means 52.6% of the rate of growth of plants produced is influenced by light intensity. While the KK Cross Variety determination coefficient of 0.291, which means 29.1% of the rate of growth of plants produced is influenced by light intensity.

Crop Fresh Weight

Crop Fresh Weight known that assimilates are energy which will be used for 3 activity processes in plants, namely: (1) some energy will be used as growth energy, (2) some will be stored as food reserves, and (3) some energy will be stored as sinks which is a form of economic yield of plants. The results of the analysis of variance showed that observations of cabbage crop crop weights contained real interactions between treatments presented in Table 3. At 25% light intensity Cabbage Varieties KK Cross produced higher crop weight compared to Sehati Varieties, but not significantly different from Grand 11 varieties. While Grand 11 Varieties were not significantly different from Sehati Varieties and KK Cross. At 50% light intensity the KK Cross variety produced higher crop crop weight compared to the Sehati variety, but it was not significantly different from the Grand 11. Variety. While the Grand 11 variety was not significantly different from the Sehati and KK Cross variety. At 75% light intensity, no significant difference resulted in crop crop weight in Grand 11, Sehati and KK Cross varieties. At 100% light intensity there was no significant difference in crop crop weight in Grand 11, Sehati and KK Cross varieties.

Judging from the factor of plant variety on light intensity, Grand 11 variety with 100% light intensity significantly increased crop crop weight by 35.6% higher than light intensity 25%, but not significantly different from 50% and 75%

light intensity. Sehati and KK Cross varieties did not significantly differ in crop crop weight at various light intensities. Eugen et al., (2012) states that due to heavy shade on plants causes imperfect growth. This is in accordance with the conditions of plants in the field that occur in the treatment of cabbage plants Grand 11 varieties. Grand 11 varieties with 100% light intensity significantly produce crop crop weight of 35.6% higher than at 25% light intensity, but not significantly different than at 50% and 75% light intensity.

Chlorophyll

The measurement of chlorophyll content in leaves was carried out using a spectrophotometer with a wavelength of 646 nm to measure the chlorophyll B content and 663 nm to measure the chlorophyll A content. Analysis of the chlorophyll a, b and total chlorophyll content was carried out by the Arnon method (1949). The results of the analysis chlorophyll content analyzes are presented in (Table 4).

Table 3. Interaction between light intensity and kinds of variety to Crop Fresh Weight (g plant^{-1}) of Plants at 70 DAP

Treatment Light Intensity	Crop Fresh Weight (g plant^{-1}) Kinds of variety		
	Grand 11	Sehati	KK Cross
25 %	473,29 abc	428,35 a	708,70 bcde
50 %	563,01 abcde	459,56 ab	784,54 e
75 %	723,97 cde	540,82 abcde	632,87 abcde
100 %	746,17 de	490,54 abcd	744,98 de
HSD 5 %	263,20		
CV %	14,7		

Table 4. Chlorophyll Content (µm fresh weight $^{-1}$) of Plants due to Treatment of Light Intensity and Kinds of Variety

Treatment Light Intensity	Klorofil Kinds of variety		
	Grand 11	Sehati	KK Cross
25 %	9,96 abc	12,64 bc	9,17 abc
50 %	13,13 c	11,54 bc	7,64 abc
75 %	8,74 abc	9,52 abc	8,10 abc
100 %	12,55 bc	6,66 ab	3,95 a

BNJ 5 %	6,33

Chlorophyll can accommodate the light absorbed by other pigments through photosynthesis, so chlorophyll is called the central pigment of photosynthesis reaction (Bahri, 2010). Chlorophyll is more than shaded (dark) conditions. This is because the light absorbed by the chlorophyll pigment provides the light needed in the photosynthesis process.

At 1200 lux light intensity produces the highest chlorophyll content significantly 15.69% higher than at 800 light intensity and 31.54% significantly higher than at 400 lux light. Whereas at 800 light intensity was markedly higher 18.8% producing chlorophyll content compared to at 400 lux light intensity. Whereas mustard plants produce the highest average chlorophyll content compared to onion and cabbage plants. Leek plants did not significantly differ in chlorophyll content compared to cabbage plants.

A decrease.in light intensity due to shade will suppress the chlorophyll a / b ratio, due to the increased relative amount of.chlorophyll b compared to chlorophyll a. Low light. tolerant plant species in the shade conditions will increase chlorophyll content higher than sensitive. The greater chlorophyll content in the happy genotype group allows.plants to get more light energy which can then be processed into chemical energy in the form of excited electrons. Chlorophyll content.is related to the nature of leaves in plants that can determine the absorption of light by the leaves carried out by chlorophyll so that plant adaptation to low light intensity. Plant response will increase with an increase in temperature and light intensity in the plant growth environment. Solar radiation captured by chlorophyll can increase the energy of electrons generated from the oxidation of water in the process of photosynthesis (Sri Haryanti, 2010 in Hakimah, 2015).

CONCLUSION

It can be concluded from this study that there is a real interaction between the treatment of light intensity and varieties of cabbage plants on the parameters of leaf area index, plant growth rate, total fresh plant weight, crop weight, crop diameter, and chlorophyll content.

At 25% light intensity the three varieties did not significantly reduce leaf area index, plant growth rate, plant fresh weight and chlorophyll content. But it influences the head weight and crop diameter parameters.KK Cross varieties show better adaptation to be planted at 50% light intensity.

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