Growth and Yield of Two Mustard Varieties (Brassica Juncea L.) at Various Shading Levels

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Research Paper

Growth and Yield of Two Mustard Varieties (*Brassica Juncea* L.) at Various Shading Levels

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Abstract

Mustard greens are one of the vegetable commodities plants. The part used is the young leaves, which can be processed into traditional medicinal and vegetable ingredients that benefit human health. This research aims to determine the level of shade tolerance on the growth and yield of mustard plants and determine mustard varieties that are tolerant of minimum sunlight conditions. This research was carried out in experimental fields using artificial fields in June – July 2023. This research used a split-plot design with 2 factors. Tafif shade as the main plot consists of no shade 0%, 55%, 70%, and 95%. The sub-plot varieties consist of the Tosakan variety and the Kumala variety. The results of the research indicate that sunlight intensity reduction negatively impacted the growth and yield of mustard plants. However, under 55% shade conditions, there was no significant difference observed in the growth and yield of mustard plants compared to those grown without shade. The Tosakan and Kumala varieties did not show any differences in the growth or yield of mustard plants.

Keywords

Artificial shading, Suboptimal, Light intensity

1. INTRODUCTION

Vegetables are one of the superior commodities because they can fulfill daily needs. Vegetables have economic value, and the harvest period is short. One of the vegetables that many people consume is mustard greens. Various types (species) of mustard greens include cuisine, bitter mustard greens, and pak choy. Mustard greens are one of the popular vegetable crops with the public and contain several types of vitamins, such as folate, carotenoids, and vitamins A, C, E, and K, which are beneficial for human health (Fitriani et al., 2019). Besides vitamins and minerals, mustard greens also contain antioxidants, which prevent cancer and support bone health. They contain calcium, phosphoric acid, and magnesium and can be mixed into healthy, refreshing drinks Ataribaba et al. (2021). Demand for mustard greens is currently increasing, and data on mustard production in Indonesia is also increasing yearly. However, the production of mustard plants is still limited, and one of the problems is the need for land to cultivate mustard plants (Saepuloh et al., 2020). To meet the level of demand for mustard greens, efforts and development of innovation in mustard greens productivity are needed.

The need for mustard greens is high, while production is still low. So, efforts must be made to increase mustard green production by improving the cultivation system and expanding planting land. One of them is by using shaded ground (Novianto et al., 2020). Mustard greens are generally cultivated in the lowlands or highlands. Mustard greens are plants that produce leaves, and mustard greens do not require whole light. If they are grown in tropical areas, they need to be provided with shade so that the intensity of sunlight received is to the plant's needs (Wibowo et al., 2018).

Sunlight is a source of energy for all living organisms. For plants, sunlight is one of the determining factors in photosynthesis (Sari and Yustisia, 2022). However, the high daily sunlight intensity during the vegetative growth could induce wilt, so it is necessary to strive for an environment that suits the mustard greens' needs (Dwiana, 2022). Providing treatment in the form of the density level of the shade paranet used also influences the intensity of sunlight hitting the plants (Andini and Yuliani, 2020). The use of shade is an effort to regulate the intensity of sunlight, which can create environmental conditions suitable for the growth of mustard greens (Tanari and Vita, 2017). Cultivating plants under shade is a vegetable growing technique that can overcome problems associated with planting in open areas and optimize the intensity of sunlight received

by plants to greatly influence various plant activities (Lathifah and Jazilah, 2019). Therefore, this research aims were to determine the level of shade tolerance on the growth and yield of mustard greens and to determine mustard varieties that are tolerant of minimum light conditions. The need for mustard greens is high, while production is still low. So, efforts must be made to increase mustard green production by improving the cultivation system and expanding planting land. One of them is by using shaded ground (Novianto et al., 2020). Mustard greens are generally cultivated in the lowlands or highlands. Mustard greens are plants that produce leaves, and mustard greens do not require whole light. Therefore, if they are grown in tropical areas, they need to be provided with shade so that the intensity of sunlight received is to the plant's needs (Wibowo et al., 2018).

2. EXPERIMENTAL SECTION

2.1 Research Location and Study Area

Research has been carried out on the off-campus research area of Permata Baru Village (104046'44"E ;3001'35"S) South Sumatra, Indonesia, from June to July 2023. This research activity used equipment, i.e., Smartphones, digital calipers, Luxmater Benetech GM1030, meter (Soil plant analysis development), analytical balance scale, and digital thermometer. Meanwhile, the materials used were mustard seeds of Tosakan and Kumala varieties, 30x15 cm poly bags, labels, manure, and NPK fertilizer (16:16:16).

2.2 Research Methods

The treatments were arranged by a Split Plot Design in completely randomized block design with three reps used as block. The main plot was four levels of shade as control (no shade 0%), shade 55%, shade 70%, and shade 95%, in addition to two subplots of mustard varieties, namely Tosakan (TS) and Kumala (KM). This research consequently had 24 experimental units. Each experimental unit contained 5 test plants, so the total number of plants was 120 plants.

This research was carried out using shadow houses with dimensions of 4x2 meters each, each made with three levels of paranet density, which are 55%, 70%, and 95%. Plants were planted using 10 kg polybags using a planting medium mixed with soil and manure (2:1), which were then incubated for ten days. Mustard seeds are implanted directly into the set planting medim. The research sample of plants was harvested in 4th week after planting. Additional fertilizer is applied using NPK fertilizer (16:16:16), carried out eight days after planting (DAP) at a rate of 5 g per planting. Plant maintenance as watering and eradicating pests and diseases was carried out if necessary.

2.3 Growth Variables and Data Analysis

This research carried out growth observations which were carried out once a week during plant growth starting from the plant being planted until the plant was ready to be harvested. Observations included plant height, number of leaves, leaf greenness level (SPAD), leaf length, leaf width, and canopy diameter. Destructive observations made when planting plants aged 30 HST included root length, root weight, stem weight, leaf weight, and petiole weight. The microclimate was observed to ensure the plant's environmental conditions, i.e., soil temperature (0°C), air temperature (0°C), and sunlight intensity. Data were analyzed with a personal computer using R Studio statistical analysis software.

3. RESULTS AND DISCUSSION

3.1 Plant height

Plant height Variables increase over time; the mustard greens with 55% shade grow taller at the beginning of growth. The following week, the highest plant height was in the 70% shade treatment. During the initial week, the Tosakan variety exhibited greater height, whereas, in the final week preceding harvest, there was a disparity in plant height compared to the Kumala variety (Figure 1).

Sunlight is a source of energy for all living organisms; for plants, sunlight is one of the determining factors in photosynthesis (Sari and Yustisia, 2022). Cultivating plants under shade is a vegetable growing technique that can overcome problems associated with planting in open areas and optimize the intensity of sunlight to greatly influence various plant activities (Lathifah and Jazilah, 2019). Some plant varieties grown in the shade can adapt well to maximize photosynthetic efficiency under low light interception. Molecular mechanisms that increase the photosynthesis efficiency of plants growing in the shadow and at high altitudes ultimately increase biomass production (Wimalasekera, 2020).

The research results showed that the height variables of saw plants were highest in 70% shade, which was very different from the control shade treatment. That is in line with the results of research (Fikri et al., 2015), which states that the level of shade has a real influence on the growth of mustard greens. Plants experience changes in several morphological and physiological characteristics at low light intensity. Plants can change their morphology and physiology according to light conditions. Plants will grow slowly in high-light environments. Plants can reduce canopy branching and increase the specific area of leaves, leaf stalks, and internodes in response to light.

3.2 Number of Leaves

In the number of leaves parameter, in the first week, the number of leaves was the highest at 55% shade. Still, in the third week until harvest, the number of leaves was the highest in the treatment without a shadow because the lower the intensity of sunlight, the more it inhibited the increase in mustard leaves. The number of leaves of the Kumala and Tosakan varieties at the beginning of growth is similar. However, in the second week until just before

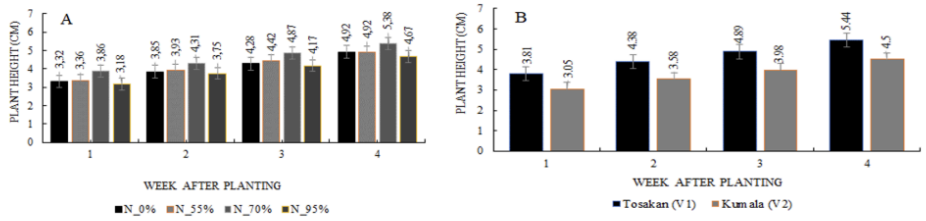

Figure 1. Effect of various levels of shading(A) and varieties (B) of mustard greens on plant height

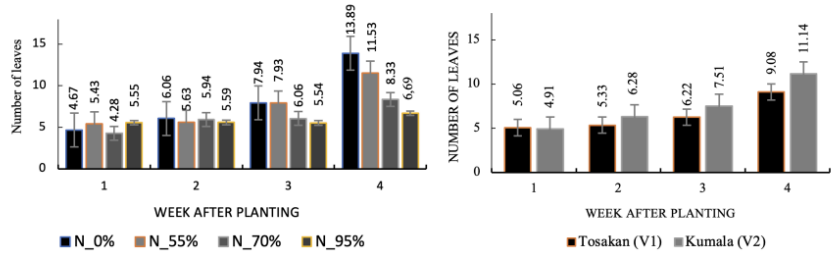

Figure 2. Influence of different levels of shade level (A) and variety (B) on the number of plant leaves

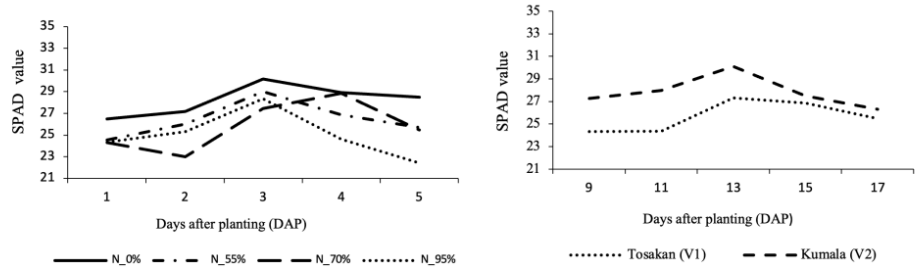

Figure 3. Response of mustard greens SPAD values to various levels of shade (A) and different varieties (B)

harvest, the number of leaves of the Kumala variety will be significantly greater (Figure 2).

The number of leaves is more significant on plants that are not shaded. The number of leaves formed in each shade showed different results, but a tendency was found that the number of leaves was getting smaller with the presence of paranet (Ahmad et al., 2020). This is because mustard plants in the treatment without shade receive sufficient sunlight, so they can carry out good metabolism and growth, which is not comparable to other shade treatments. Plant height parameters increase over time, from the beginning of growth of mustard plants in 70% shade they are more dominantly tall and for the Tosakan variety from the first week to the last week before harvest they are more dominantly taller than the Kumala variety. This is in line with the results of research (Fikri et al., 2015) which states that the level of shade has a real influence on the growth of mustard greens. At low light intensity, plants experience changes in several

Table 1. Morphology of mustard greens at various shade levels and varieties

Treatment	SPAD	LL (cm)	LW (cm)	TLA (cm^2)	CA (cm)	LT (cm)	SD (cm)	RL (cm)
Shading Level								
Control 0%	28.06a	16.95a	11.75a	810.4a	685.14ab	0.55a	7.58a	14.80a
Shade 55%	26.60a	16.80a	11.40a	825.5a	1263.27a	0.55a	5.93b	13.66a
Shade 70%	25.29ab	12.40c	8.50a	318.6b	380.66ab	0.38a	3.33c	10.45b
Shade 95%	22.41b	4.00c	2.47a	29.81c	19.25b	0.69a	1.47d	2.69c
LSD 0.05	3.43	1.52	1.07	104.99	1077.21	0.85	1.13	2.81
Mustard Varieties								
Tosakan (T)	25.56a	12.53a	8.62a	478.9a	434.30a	0.35a	4.33a	10.35a
Kumala (K)	25.62a	12.54a	8.43a	513.2a	739.86a	0.60a	4.82a	10.45a
LSD 0.05	1.85	1.45	0.99	109.63	638.05	0.59	0.96	1.66
Interaction (Shadex Variety)								
0% K	29.16a	16.32ac	11.68ab	694.0b	651.30b	0.58a	7.30a	14.64a
55% T	27.79ab	15.03c	10.6b	590.8b	529.11b	0.25a	4.37b	12.24ab
55% K	25.40bcd	18.57a	12.17a	1060.17a	1997.44a	0.31a	7.50a	15.07a
70% T	25.72abc	13.84d	9.75b	369.85c	480.63b	0.45a	3.73b	11.58bc
70% K	24.86bcd	10.96d	7.24c	267.54c	280.68b	0.32a	2.93c	9.32c
95% T	21.78d	3.69e	2.31d	28.49d	8.48b	0.20a	1.38c	2.63d
95% K	23.04cd	4.32e	2.64d	31.13d	30.01b	1.17a	1.56c	2.76d
BNT Rate 5%	3.70	2.91	1.98	2.91	1276.10	1.19	1.93	3.32

Figure 4. Morphology of mustard plants without shade (A), 55% (B), 70% (C), and 95% (D)

morphological and physiological characteristics. Plants are able to change their morphology and physiology according to light conditions. The rapid increase in plant height at low light intensity is called etiolation. Etiolation is a condition that occurs in plants that grow tall or elongated with stems and leaves that look somewhat pale in color and experience symptoms of disproportionate growth (Mukaromah et al., 2019). Etiolation can occur because during the initial growth period the plant does not receive sufficient sunlight intensity. Plant growth and productivity are influenced by the surrounding environment. Sunlight is a factor that influences plant productivity because not all plants require the same light intensity in the photosynthesis process.

3.3 Greenness Level Leaf

The leaf greenness level parameter occurs in almost every treatment after fertilizing. This is an indication of the plant's response to the NPK fertilizer that has been given. The SPAD value reached its highest at 13 and 15 HST, which decreased because the reaction to the influence of fertilizer nutrients was reduced. At 70% shade, the response to the level of leaf greenness was slower than other treatments. However, the peak SPAD value was at 13 HST and then decreased. From the start, the SPAD value in the treatment without shade was the highest compared to the shade treatment. In the 95% shade treatment, there was a significant decrease. The Tosakan and Kumala varieties have different values, and the Kumala variety is superior to the Tosakan variety (Figure 3).

Table 2. Yield of mustard greens at various levels of shade and varieties

Treatment	RFW (g)	SFW (g)	LFW (g)	PFW (g)	RDW (g)	SFW (g)	LFW (g)	PFW (g)
Shade Level								
Shade 0%	2.93a	4.50a	38.06a	27.03a	0.61a	0.42a	3.82a	1.26a
Shade 55%	1.86ab	3.95a	30.40b	25.08a	0.26ab	0.32a	3.17a	1.29a
Shade 70%	0.26b	5.88a	9.68c	8.36b	0.07b	0.14b	1.20b	0.44b
Shade 95%	0.11c	0.11b	0.39d	0.22c	0.00b	0.01b	0.06c	0.25b
LSD 0.05	1.86	1.69	6.00	3.40	0.41	0.14	1.04	0.53
Mustard Varieties								
Tosakan (T)	0.83a	2.67a	18.84a	15.3a	0.25a	0.21a	1.79a	0.76a
Kumala (K)	1.75a	2.40a	20.42a	15.0a	0.23a	0.23a	2.33a	0.86a
LSD 0.05	1.01	0.37	3.32	4.10	0.08	0.08	0.85	0.37
Interaction (Shade x Variety)								
N_0% T	1.95abc	4.86a	41.88a	32.14a	0.86a	0.43a	3.92a	1.16ab
N_0% K	3.92a	4.14a	34.23b	21.93b	0.36a	0.42a	3.73ab	1.36a
N_55% T	0.95bc	3.55b	20.02c	16.70bc	0.08ab	0.25a	2.04b	0.92abc
N_55% K	2.77ab	4.35a	40.77a	33.47a	0.43ab	0.38a	4.30a	1.66a
N_70% T	0.31c	2.16c	13.03d	12.30cd	0.06b	0.15b	1.14cd	0.50bcd
N_70% K	0.22c	1.01d	6.33e	4.43de	0.08b	0.13c	1.26cd	0.39cd
N_95% T	0.13c	0.12e	0.45e	0.21e	0.00b	0.01c	0.08d	0.47bcd
N_95% K	0.10c	0.10e	0.34e	0.24e	0.00b	0.00c	0.04d	0.03d
LSD 5%	2.02	0.74	6.65	8.21	2.02	0.17	1.70	0.74

Note: Leaf length (LL), leaf width (LW), total leaf area (TLA), canopy area (CA), leaf thickness (LT), stem diameter (SD) and root length (RL), Tosakan variety (T), Kumala variety (K)

Table 3. Observations of light intensity, air temperature and soil temperature in the shade treatment

Shade	Light intensity (kilo lux)				Temperature Air (°C)			Soil Temperature (°C)		
	Morning	Afternoon	Afternoon	Average	Morning	Afternoon	Afternoon	Morning	Afternoon	Afternoon
0%	70.33	89.57	36.13	62.85	34.63	37.73	36.73	28.60	34.60	28.70
55%	32.73	40.17	13.97	28.96	33.63	37.30	36.03	26.90	30.90	27.40
70%	20.63	24.73	9.48	18.28	33.30	36.77	35.93	26.40	29.70	26.90
90%	3.49	4.22	1.90	3.20	33.03	36.13	35.67	26.10	29.10	22.60

In general, the SPAD value of plants will increase after fertilization is carried out on the eighth day after planting. This shows the plant's response to the fertilizer given. The level of shade treatment greatly influences the level of greenness of the leaves, where the higher the level of shade, the lower the level of greenness of the leaves. The SPAD value of leaves is directly related to the nitrogen content because the SPAD value is measured based on the intensity of the green color of the leaves. Consumers generally like the power of the green pigment in leafy vegetables. Therefore, a high SPAD value can indicate the quality of green leafy vegetables.

3.4 Mustard Morphology

The leaf greenness indicated by SPAD on mustard greens without shade is the greenest color compared to other shading treatments. However, giving 55% shade to the plants provides a positive response to the growth and development of mustard greens, similar to mustard greens without shadow. However, at 95% nangan, the leaf size will be much smaller. Mustard greens without shade have more leaves, meaning they have the largest total leaf area (TLA). Only the degree of leaf greenness of the Tosakan and Kumala varieties differs, while other morphological characteristics show no differences (Table 1). The 55% shade level interaction with the Kumala variety provides better mustard plant

growth than the others. This is indicated by the values of canopy area (CA), stem diameter (SD), and root length (RL).

Means followed by the same letter in the same column indicated not significant difference by 5% level of difference LSD. Information: Leaf length (LL), leaf width (LW), total leaf area (TLA), canopy area (CA), leaf thickness (LT), stem diameter (SD) and root length (RL), Tosakan variety (T), Kumala variety (K).

Generally, there were no differences in the morphological characteristics of mustard leaves and stems without shade (control) up to a shade level of 70%. Meanwhile, at 95% shade, morphological features with the lowest value will be produced. This can be seen in Figure 4.

3.5 Mustard Biomass

Overall, mustard greens without shade will produce the highest biomass compared to shade treatment. Biomass is higher than all parts of the plant organ, including roots, stems, leaves, leaf blades, and leaf petioles. The higher the level of shade, the less biomass produced by mustard plants will decrease, both in terms of fresh and dry weight. The two varieties used were similar in yield regarding new or dry weight (Table 2).

3.6 Effect of Shade on Climatic Conditions

Differences in shade levels will affect the microclimate in the covered area, including light intensity, air temperature and soil temperature. The shade levels measured directly differ slightly at the paranet level. This can happen because the power of sunlight is different. The highest intensity of the sun occurs during the day and will decrease in the afternoon. Air temperature and ground temperature changes will follow increases and decreases in sunlight intensity, as seen in Table 3.

The intensity of sunlight influences the microclimate in the covered area, including light power, air temperature, and soil temperature. Direct measurements show that the sun's intensity is highest during the day, while the light intensity decreases in the afternoon. Changes follow increases and decreases in sunlight intensity in air and soil temperatures.

Morphological and physiological changes in plants show adaptation to light. Shade can reduce assimilation due to reduced solar radiation, which affects photosynthesis. If photosynthesis is disrupted, it will minimize photosynthesis/carbohydrate reserves in plant organs, causing a decrease in wet and dry weight. On the other hand, if photosynthesis is not disturbed, it will increase carbohydrate accumulation and the rate of photosynthesis. Increasing light intensity will produce higher biomass, dry weight ratio, root ratio, and specific leaf weight.

4. CONCLUSION

Based on the research findings, it is concluded that the Kumala mustard variety demonstrates tolerance to a shade threshold of 55%. However, increased levels of shading inhibit both growth and yield. Therefore, the Kumala variety is deemed suitable for cultivation within the confines of a 55% shade threshold.

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