The effect of shading levels and varieties on the growth and yield of chili plants (*Capsicum annuum* L.)

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**Abstract.** This study was aimed to determine the effect of shading levels and chili variety and the interaction between both factors to the growth and yield of chili plant. This study was designed using Randomized Completely Design including 2 factors, namely shading and varieties. The shading factor consisted of 3 level namely non-shading, 25% shading and 50% shading, and the varieties of chili factors consisted of 3 level namely Perintis, Kopay and Bemeri. The observed parameters were plant height, number of leaves, number of primary and secondary branches, number of fruit per plant, length of fruit per plant, fruit weight each fruit, fruit weight per plant and potential yield. The result showed that the best growth and yield of chili was found on non-shading compared to the 25% and 50% shading treatment. The best variety of chili treatment was found in the Kopay which gave the best growth and yield compared to Perintis and Bemeri. The best combination treatment was found on non-shading treatment and Bemeri variety which showes the best result of growth and yield.

1. **Introduction**

*Capsicum annuum* L.) is one of the most important horticulture because of its high selling value and popularity in community. The high demand of chili causing it becomes strategic commodity in Indonesia. Chili pepper contains nutrients such as vitamin A, vitamin C, caroten, iron, potassium, calcium, phosphorus, and alcaloid such as capsaicin, flavenoid, and essential oil [1].

The yield of chili pepper in 2014 reached 1,074,611 ton by 128,734 ha harvested area. However, the yield on 2015 decreased to 1,045,200 ton by 12,847 ha harvested area. In 2016, the yield decreased to 1,045,601 ton by 123,404 ha harvested area. From the data, it shows that the yield of chili pepper in Indonesia has not been maximal yet [2]. According to [3], the maximal potencial production for chili in national scale has reached 1,206,659 ton by 142,547 ha harvesting area.

The increasing of chili demand in year by year and the profits gained, making farmers attracted to cultivate chili pepper. The shortage of supply on certains time, one of which caused by climate change which affect the cultivation of chili pepper. The growth of plant is depended on environment condition such as temperature, rainfall, and relative humidity. Cultivation of chili pepper should be adjusted to environment condition so that it is able to produce good fruit [4].

One way to solve the climate change problem is to maintain the chili cultivation using netting house. The netting house is made by plastic material which is known as paranet. Paranet is used to reduce the sunlight itensity which received by plants, also to decrease the air temperature around plants [5].
stated that chili pepper cultivation by using shading is one of the mitigation way for climate change. The use of shading material in chili cultivation may possible technically to be applied and economically profitable compared to the chili pepper cultivation in open field.

In addition to the use of shade, varieties are also a very important factor in increasing red chili production. One effort to increase red chili production is by using superior varieties. A superior variety in an area may not be superior in another region, because the superiority of the variety is influenced by environmental factors such as the state of nutrients in the soil [7].

Kopay chili is local high yielding varieties produced in the City of Paya Kumbuh West Sumatra Province. The advantages include long fruit 23-33 cm, resistant to virus attacks that cause yellow curly leaves, the potential yield of 18-21 ton ha⁻¹. Plant height can reach 120-150 cm, harvesting age of 90 Day After Transplanting (DAT), the advantage of Kopay chili are that the fruit taste is more spicy and the fruit produced is more durable when storing [8].

Bemeri chili is local varieties from the Gayo highlands, specifically in Central Aceh District and Bener Meriah Regency, Aceh Province. The Bemeri variety has advantages in addition to its long and spicy size which is also more durable when stored. Bemeri fruit size can reach 30 cm, plant height 106-108 cm, stem diameter 1.5 cm, leaf length 2-3 cm, leaf color is green, leaf surface is glossy, and ripe fruit is red. The spread of Bemeri variety in both districts is very good because it has high economic value [9].

The Perintis chili is a local variety developed in Laweung Village, Pidie Regency, Aceh Province. It has a slightly shorter character than other types of chili varieties in general, but is resistant to aphids and also Gemini virus attacks that cause chili plants to become curly. This Pioneer variety of chili has an early maturity of ± 75-150 DAT and a production of 20-25 ton ha⁻¹. Suitable to be cultivated in low and middle land [10].

Based on the description above, it is necessary to conduct research on the cultivation techniques of chili plants using several levels of shade and varieties of chili. This research has been conducted by planting chilies in poly bags that were given some level of shade. The purpose of this study was to determine the effect of shade levels and chili varieties as well as the interaction between the two on the growth and yield of chili plants.

2. Material and Methods
This research has been conducted in the Experimental Station of the Faculty of Agriculture and Horticulture Laboratory, Syiah Kuala University, Darussalam, Banda Aceh from May to October 2018. Materials used in this study were Kopay, Bemeri and Perintis varieties of chili seeds in one pack (10 g) each. Manure, topsoil, NPK Mutiara fertilizer (16:16:16), Gandasil B 1 g L⁻¹, Gandasil D 1 g L⁻¹, Curacron 500 EC 2 ml L⁻¹, polybag (10 kg), meter, sifter, paranet as a shade, paranet supporting pole, hand sprayer, hoe, meter ribbon, sowing tray, digital scale, camera, calculators, and lux meter.

This study uses a Separate Plot Design of Factorial Randomizes Completely Block Design which consists of 2 factors, shade and variety. Shade consists of 3 levels namely N₀: non-shade (control), N₁: 25% shade (one layer of paranet) and N₂: 50% shade (two layers of paranet. While varieties consist of 3 levels namely, V₁: Perintis , V₂: Kopay and V₃: Bemeri. Thus the combination of treatments becomes 3 x 3 = 9 with 3 replications. There are 27 treatments, each treatment consists of 2 units of experiment polybags, therefore total of experiment polybags units are 54.

2.1. Work Procedure for Cultivation
2.1.1 Shade preparation. Shade was made using rectangular box wood with a size of 3 m x 1.5 m x 1.9 m. In this research, two shades were needed. Shade for treatment N₁ = onelayer of shade (consisted of 25% shade, and 75% sunlight) and N₂ = two layers of shade (consisted of 50% shade, and 50% sunlight) and N₀= non-shade (100% sunlight).
2.1.2. Sowing preparation. The seeds of Perintis, Kopay and Bemeri chilies that have been soaked were then sown in a seeding tray that has been filled with planting media. Planting media used for seedling were soil and manure with a ratio of 2: 1.

2.1.3. Preparation of growing and transplanting media. Planting media were prepared as much as 54 polybags. Growing media used in the form of soil with a mixture of manure with a ratio of 2:1 (v:v). The 24 days seedling was transfer to growing media, then polybags are labeled and arranged according to the location of the research chart.

2.1.4. Fertilization. Fertilizers were given in the form of NPK with a dose of 10 g L\(^{-1}\) water, each plant was given as much as 250 ml of fertilizer solution. The fertilizer of Gandasil D was given during the vegetative period 2 times (14 DAT and 21 DAT). Fertilizer of Gandasil B was given during the generative period is 2 times when the chili plants are 35 DAT and 42 DAT (noticed by the appearance of flowers). The dose of each fertilizer is 1 g L\(^{-1}\).

2.2. Observed parameter

The observed variables including plant height, number of leaves, number of primary and secondary branches, number of fruits per plant, length of fruit per plant, weight per fruit, fruit weight per plant and potential yield.

3. Result and Discussion

3.1. The Effect of shading levels to the growth and yield of chili pepper

Average growth and yield of chilli plants due to shade level treatment are presented in Table 1. The results showed that the shade level significantly affected the parameters of the number of leaves at 15 and 45 DAT, plant height at 60 DAT, number of primary branches at 45 DAT and 60 DAT, number of secondary branches at 45 DAT and 60 DAT, number of fruits per plant, fruit length per plant, weight per fruit, fruit weight per plant and potential yield. The level of shade has a significant effect on plant height parameters at 30 DAT and 45 DAT and has no significant effect on the parameters of the number of leaves at 30 DAT.

Based on research that has been done, the average height of chili plants given 25% shade has a higher plant height of 74,05 cm compared to the treatment non-shade with a height of 56,61 cm and 50% shade with a height of 31,00 cm. The reduced intensity of sunlight can cause etiolation of plants, therefore plants become higher. [11] stated that high light intensity tends to reduce plant height. The higher the light intensity, the broader the leaf area of the plant tends to be narrower. The results showed that at 50% shade, in the first observation of the growth of the plant height in all treatments was not the same, but in the second, third and fourth observations were inhibited. In the provision of 25% shade, plants grow taller than non-shade, while 50% shade the growth of chilli plants is not optimal due to reduced sunlight, causing photosynthesis to be inhibited, this explains that sunlight is also one of the factors that inhibit photosynthesis process [12].

The results of the study showed that the chili plants contained 25% shade provided the highest number of leaves at 45 DAT, 30.44 strands. The use of shade on chili plants can influence leaf growth compared to non-shade chili plants. This is related to the efforts to increase the rate of photosynthesis. Shade plants will increase the rate of photosynthesis including by increasing the amount of chloroplasts [13].

Based on observations of the number of fruits, fruit length, weight per fruit per plant, fruit weight per plant and yield showed that the treatment without shade is able to provide the best results than 25% shade and 50% shade. This is consistent with the statement from [14] that the influence of external factors can affect the growth and development of chili plants. External factors include food, water, temperature, humidity and light. Changing air temperature and humidity due to rain can cause differences in the ability of plants to receive light. Light as an energy source for anabolic photosynthesis reactions will affect the rate of photosynthesis.
Based on the results of the measurement of light intensity using a lux meter, the results obtained are for no-shading treatment was 1,418 lux, 25% shade was 386 lux and 50% shade was 1 lux. The results of measurements using a lux meter states that differences in the level of shade affect the intensity of light, humidity, air temperature and soil temperature around the plant environment, so the value of light intensity to be received by plants will also be different and will affect the availability of light energy that will be converted into energy heat and chemical energy. [15] explained that the greater the level of shade (the intensity of light received by plants is smaller), it can cause low air temperatures, and humidity will be higher, it will affect plant growth because the photosynthesis process will be disrupted.

Chili belongs to the C3 plant groups, plants from the C3 group have a low light compensation point and are limited by high photorespiration. Therefore, an increase in temperature and the value of the intensity of sunlight can cause the chili plants cannot grow optimally [6].

### 3.2. Effect of varieties on growth and yield of chili

The average growth and yield of chili plants due to varieties treatment is presented in Table 2. The results showed that the ratio of varieties significantly affected the parameters of fruit length per plant, weight per fruit, weight of fruit per plant, potential yield, significantly affected plant height at 30 DAT and number of leaves at 15 DAT and 30 DAT.

From all of the varieties used for growth and yield, the best chili plants was found in the Kopay variety. It was observed that the use of the Kopay variety has a strong adaptability to the environmental conditions used at the time of the study, so that the Kopay variety can grow well and stable to all observed parameters.

| Parameters                  | Shade |
|-----------------------------|-------|
|                             | $N_0$ | $N_1$ | $N_2$ | HSD Test |
| Plant Height 15 DAT         | 10.88 | 10.39 | 8.61  | -        |
| Plant Height 30 DAT         | 16.50 ab | 20.05 b | 13.38 a | 3.89 |
| Plant Height 45 DAT         | 24.11 a | 33.83 b | 19.44 a | 8.89 |
| Plant Height 60 DAT         | 56.61 b | 74.05 b | 31.00 a | 19.03 |
| Number of leaves 15 DAT     | 8.78 b | 9.33 b | 7.16 a | 0.87 |
| Number of leaves 30 DAT     | 14.11 b | 14.00 b | 8.50 a | 4.29 |
| Number of leaves 45 DAT     | 29.66 b | 30.44 b | 13.33 a | 6.05 |
| Primary Branches 45 DAT     | 2.33 b | 1.55 b | 1.16 a | 0.24 |
| Primary Branches 60 DAT     | 3.22 c | 2.17 b | 1.17 a | 0.12 |
| Secondary Branches 45 DAT   | 4.67 b | 3.56 b | 1.78 a | 0.47 |
| Secondary Branches 60 DAT   | 5.83 b | 4.89 b | 1.78 a | 0.53 |
| Number of Fruits per plant | 7.73 c | 6.25 b | 0.71 a | 0.85 |
| Length of Fruit per plant  | 3.54 b | 3.59 b | 0.71 a | 0.14 |
| Weight per fruit            | 1.75 b | 1.82 b | 0.71 a | 0.09 |
| Fruit Weight per plant      | 12.55 c | 10.78 b | 0.71 a | 1.47 |
| Potential Yield             | 3.81 c | 3.29 b | 0.71 a | 0.43 |

Numbers followed by same letter in the same rows is not significantly different at 5% (Tukey Honest Significant Different $0.05$)
Each variety has a different adaptation to the environment, both climate and growing media. This is in accordance with the statement of [16], stated that each variety consists of a number of different genotypes, where each genotype has a certain ability to adapt to the environment in which it grows. [17] stated that certain characteristics of a growth are influenced by genotypes while others are influenced by the environment. [18] stated that the high yield of a variety is due to the variety being able to adapt to its environment. Therefore, although genetically there are varieties that have high yield potential, but these results can only be achieved after interaction with the environment, and in this case the Perintis, Kopay and Bemeri varieties have sequentially better genotype characteristics.

### 3.3. Effect of interaction between shade level and varieties on growth and yield of chilli plants

Based on the results of the research that has been described shows that the interaction of the level of shade and varieties of chili has a very significant effect on the parameters of fruit length and weight per fruit of the plant, as well as a significant effect on the parameters of the number of fruits. But no significant effect on plant height at 15, 30, 45 and 60 DAT, number of leaves at 15, 30 and 45 DAT, number of primary branches at 45 and 60 DAT, number of secondary branches at 45 and 60 DAT, fruit weight per plant and yield potential (Table 3).

From all of the shading levels and varieties used, the best growth and yield of chilli plants are found in the shading treatment and Bemeri variety. While the lowest growth and yield was found in the provision of 50% shade for all types of varieties used.

[19] states that one of the external factors which has a big influence is sunlight. Sunlight is an important factor in the metabolic process of chlorophyll plants, therefore plant production is influenced by the availability of sunlight. Sunlight usually speeds up the process of flowering and

| Parameters                        | Varieties       |       |       |       |       | HSD Test |
|-----------------------------------|-----------------|-------|-------|-------|-------|----------|
|                                   | $V_1$           | $V_2$ | $V_3$ |       |       |          |
|                                   | (Perintis)      | (Kopay) | (Bemeri) |       |       |          |
| Plant Height 15 DAT               | 8.83            | 10.00 | 11.05 |       |       |          |
| Plant Height 30 DAT               | 15.27 a         | 16.11 ab | 18.55 b | 3.00 |       |          |
| Plant Height 45 DAT               | 23.83           | 25.44 | 24.16 |       |       |          |
| Plant Height 60 DAT               | 52.89           | 57.39 | 51.39 |       |       |          |
| Number of Leaves 15 DAT           | 7.78 a          | 8.33 ab | 9.16 b | 1.11 |       |          |
| Number of Leaves 30 DAT           | 11.83 ab        | 10.33 a | 14.44 b | 3.06 |       |          |
| Number of Leaves 45 DAT           | 23.83           | 25.44 | 24.16 |       |       |          |
| Primary Branches 45 DAT           | 1.61            | 1.22 | 1.83 |       |       |          |
| Primary Branches 60 DAT           | 2.11            | 2.22 | 2.22 |       |       |          |
| Secondary Branches 45 DAT         | 3.27            | 3.39 | 3.33 |       |       |          |
| Secondary Branches 60 DAT         | 4.33            | 3.94 | 4.22 |       |       |          |
| Number of Fruits per plant        | 4.45            | 4.76 | 4.74 |       |       |          |
| Length of Fruit per plant         | 2.40 ab         | 2.57 b | 2.38 a | 0.40 |       |          |
| Weight per fruit                  | 1.25 ab         | 1.30 b | 1.24 a | 0.33 |       |          |
| Fruit Weight per plant            | 6.83 a          | 8.55 b | 7.85 ab | 3.81 |       |          |
| Potential Yield                   | 2.37 a          | 2.81 b | 2.62 ab | 0.27 |       |          |

Numbers followed by same letter in the same rows is not significantly different at 5% (Tukey Honest Significant Different $0.05$)

Table 2. Average growth and yield of chilli plants due to varieties treatment

Each variety has a different adaptation to the environment, both climate and growing media. This is in accordance with the statement of [16], stated that each variety consists of a number of different genotypes, where each genotype has a certain ability to adapt to the environment in which it grows. [17] stated that certain characteristics of a growth are influenced by genotypes while others are influenced by the environment. [18] stated that the high yield of a variety is due to the variety being able to adapt to its environment. Therefore, although genetically there are varieties that have high yield potential, but these results can only be achieved after interaction with the environment, and in this case the Perintis, Kopay and Bemeri varieties have sequentially better genotype characteristics.
fruiting. Conversely, decreasing the intensity of sunlight will extend the vegetative growth period of plants, so that fruiting is slow.

**4. Conslusion**

In this experiment, the best growth and yield of chili was found on non-shade treatment compared to 25% shade and 50% shade. The best chili variety treatment was found is Kopay chili that provided the best growth and yield compared to the use of other chili varieties (Perintis and Bemeri). The combination of several levels of shade treatment and the best chili varieties found in the non-shade treatment with the use of Bemeri chili that showed the best growth and yield.

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**Table 3. The interaction between shade level and varieties of chili plants on growth and yield**

| Number of Fruit per Plant | Average | V₁ (Perintis) | V₂ (Kopay) | V₃ (Bemeri) | HSD 0.05 |
|---------------------------|---------|---------------|------------|-------------|----------|
| N₀ (Non-Shading)          | 6.82 Ab | 7.94 Bc       | 8.43 Bc    |             |          |
| N₁ (25% Shading)          | 6.32 Ab | 6.11 Ab       | 6.33 Ab    | 1.38        |          |
| N₂ (50% Shading)          | 0.22 Aa | 0.22 Aa       | 0.22 Aa    |             |          |

**Fruit Length of Chili Plant**

| Average | V₁ (Perintis) | V₂ (Kopay) | V₃ (Bemeri) | HSD 0.05 |
|---------|---------------|------------|-------------|----------|
| N₀ (Non-Shading) | 3.56 Ab | 3.65 Ab | 3.42 Ab |          |
| N₁ (25% Shading) | 3.41 Ab | 3.85 Bb | 3.52 Ab | 0.26     |
| N₂ (50% Shading) | 0.22 Aa | 0.22 Aa | 0.22 Aa |          |

**Fruit Weight per Plant**

| Average | V₁ (Perintis) | V₂ (Kopay) | V₃ (Bemeri) | HSD 0.05 |
|---------|---------------|------------|-------------|----------|
| N₀ (Non-Shading) | 1.74 Ab | 1.83 Ab | 1.69 Ab |          |
| N₁ (25% Shading) | 1.70 Ab | 2.04 Bc | 1.71 Ab | 0.18     |
| N₂ (50% Shading) | 0.32 Aa | 0.32 Aa | 0.32 Aa |          |

Numbers followed by same letter are not significantly different at the HSD 0.05. Capital letters show the notation for each row, the lowercase letter show the notation for column.
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