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THE EFFECT OF SHADE ON GERMINATION AND SEEDLING GROWTH OF TWO DOGFRUIT (*Pithecellobium jiringa*) GENOTYPES

Aprizal Zainal[1], Benni Satria[1], Idel Mawati[1], Trisia Wulantika[*,2]

[1]Agrotechnology Faculty of Agriculture, Andalas University, Padang, Indonesia
[2]Seed Technology, Department of Plant Cultivation, Politenik Pertanian Negeri Payakumbuh, Lima Puluh Kota, Indonesia

*Corresponding author
Email: wulanpolitani@gmail.com

Abstract. *Dog fruit (Pithecellobium lobatum Benth, synonyms P. jiringa, Archidendron pauciflorum) is one of the popular tropical plants. The objectives of this research are to determine the best (i) the best genotype for germination and growth of dogfruit seedlings (ii) combination of shade and genotype, (iii) the best percentage of shade and. This research was carried out by direct observation of seed germination and seedling formation. The study was carried out in an experimental garden located ± 255 meters above sea level. The average temperature and mean humidity during the experiment were 27 ºC and 65%, respectively. The experiment used a completely random design consisting of two factors. The first factor was shade (0%, 40%, or 80% shading). The second factor was genotype (bareh and lokan). Data were analysed using analysis of variance and significant differences were further analysed using Duncan's New Multiple Range Test at the 5% level. Observations for determining the time of radicle appearance, root length, radicular colour, and germination type seeds were germinated in seedbeds. Temperature and humidity were recorded in every observation. The best interaction with respect to leaf area is 80% shade cloth and the lokan genotype. Eighty percent shade cloth is the best for germination and growth of Dogfruit seedlings. The best genotype for germination and growth is lokan. It is recommended to use 80% shade cloth because it provides optimal growth of Dogfruit seedlings.*
Keywords: *dogfruit; germination; growth; seedling; shading.*

1. Introduction

Dog fruit derives from the Mimosa family *(Mimosaceae*). Jengkol bean has a broad, round shape and reddish color. The beans grow in large, dark purple pods (3-9 beans/pod) on the jenkol tree, which grows to 25 m (82 ft) in height. These beans resemble a large, flattened horse chestnut, and the crushed bean emits a faint sulfurous odor (Donald, 2009). Currently research about jengkol carried out in the fields of seeds, agronomy, processing etc (Yuniar *et al*. 2023).

Dog fruit (*Pithecellobium lobatum Benth, synonyms P. jiringa, Archidendron pauciflorum*) is one of the popular tropical plants. The level of dog fruit consumption in Indonesia is quite high. The fruit that also known as Jengkol or Jering has many health benefits such as an anti-cancer substance (Yanti *et al*., 2016), an alternative food supplement to reduce the risk of obesity (Yanti *et al*., 2017) and its rind extract has benefit for wound healing process (Afiyah & Medawati, 2017). The level of dog fruit consumption in Indonesia is quite high (0.01330 kilograms or 0.6779 kilograms per year per capita). The fruit that also known as Jengkol or Jering has many health benefits such as an anti-cancer substance. Two genotypes of Dogfruit are found in Padang, West

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Sumatra (*bareh* and *lokan*). Their fruit differ in shape and texture; *bareh* fruit are thick and crunchy, *lokan* fruit are flat and soft (Fauza *et al*., 2015).

Across Indonesia the Dogfruit population is diminishing, causing genetic erosion. This is due to changing patterns of land use, climate change and the lack of interest in Dogfruit by both farmers and local government. Statistical data for 2009-2014, shows that across Indonesia the production of Dogfruit fluctuates. In 2009 Dogfruit production was 62,475 tons, in 2010 50,235 tons, in 2011 65,830 tons, in 2012 62,189 tons, in 2013 61,147 tons and in 2014 53,661 tons (Taufik, 2015) and 155.909 Ton in 2023.

Dogfruit trees are very useful, providing materials for processed food ingredients, medicines, furniture and building materials as well as for conservation. However, plant breeding programmes for Dogfruit and studies of Dogfruit cultivation are few. Among the things that need to be studied are germination and breeding. One of the factors that influences seed germination and seedling growth is light intensity. It is necessary to find the appropriate light intensity for the optimal development of seedlings (Susanto & Sundari, 2016).

Different species of plants thrive in different intensities of sunlight. Copper Meranti seedlings (*Shorea leprosula*) require 50% - 90% shade (Setiawan *et al*., 2015). Irawan and Hidayah (2017) found that 50% shade resulted in the best growth and quality of Cempaka Wasian seedlings (*Magnolia tsiampaca*). All these species like Dogfruit produce recalcitrant seeds.

The shade requirements of Dogfruit are important information for those handling seeds from a plant breeding programme. The purposes of this study are to determine the interaction of shade cloth and genotype on germination and growth of Dogfruit seedlings, to determine the best shade cloth for germination and growth of Dogfruit seedlings, and to determine the best genotype with respect to germination and growth of Dogfruit seedlings.

2. Methods

2.1. Materials

The genotype of the Dogfruits seeds used was established according to the description provided by Fauza *et al*. (2015). The seeds used were from healthy trees that were more than 10 years old. The trees were physiologically mature, uniform in size and in good condition. The seeds were collected from mature Dogfruit fruits, that is hard fruit with a blackish-brown skin and a brownish epidermis.

2.2. Methods

This research was carried out by direct observation of seed germination and seedling formation. The study was carried out in an experimental garden located ± 255 meters above sea level. The average temperature and mean humidity during the experiment was 27 ºC and 65%, respectively.

A completely randomized factorial design, with 3 levels of shade (0, 40 and 80% shade cloth; main plot), 2 Dogfruit genotypes (bareh and lokan; subplot) and 3 replicates, was used. Each experimental unit consisted of 6 seeds. Qualitative data were analysed descriptively. Quantitative data were analysed statistically using the F-test at the 5% level. Significant differences were further analysed using Duncan's New Multiple Range Test also at the level of 5%.

2.3. Observations

For determining the time of radicle appearance, root length, radicular colour, and germination type seeds were germinated in seedbeds. For determining the time until emergence of the epicotyl, epicotyl growth and colour, time until appearance of the first leaf, time until opening of the first leaf, first leaf colour, first leaf area, and seed height seeds were germinated in poly-bags. Temperature and humidity were recorded with every observation. The observations were analysed descriptively to determine the phenology of Dogfruit seed germination.c

3. Results and Discussion

This study took place in the wet season, rainfall from September to November 2018 was 348 mm. Shade is required to produce good quality Dogfruit seedlings. C3 plants have low photosynthetic efficiency because the Rubisco enzyme has a dual role, namely (a) as a carboxylase in carbon dioxide fixation and (b) as an oxygenase in photorespiration.

For both genotypes of Dogfruit, seeds showed better growth and development with 80% shade compared to 0% or 40%. Dogfruit plants are dicotyledons and their seeds undergo hypogeal germination (Figure 1).

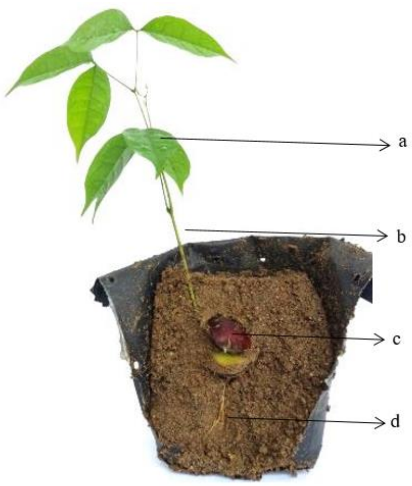


Figure 1. Hypogeal germination of Dogfruit seeds.
Description: Cotyledons do not emerge above the ground. (a) first leaf; (b) stem; (c) cotyledons; (d) roots

Table 1. Germination of Dogfruit without shade cloth

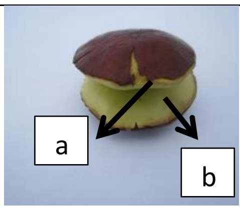
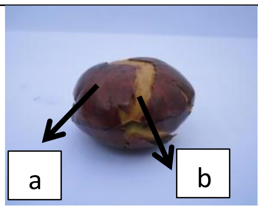
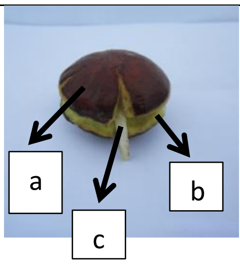
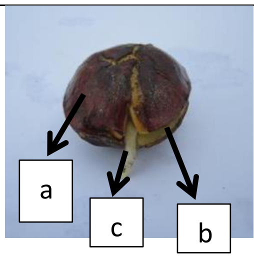
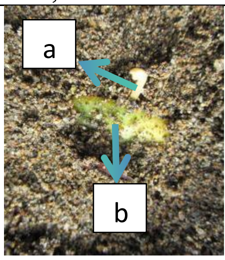
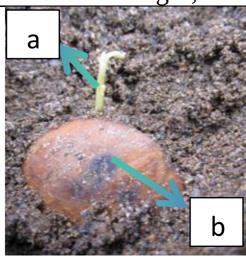
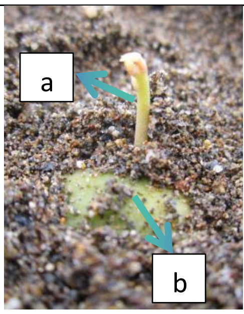
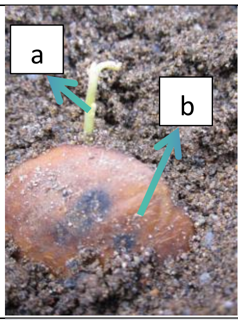
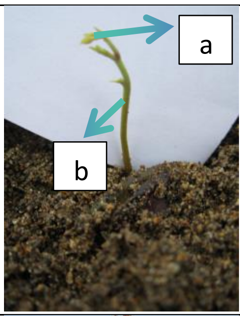
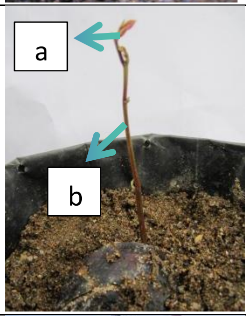
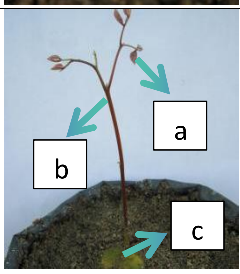
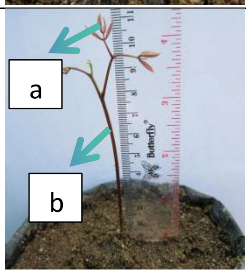
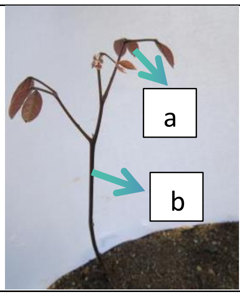
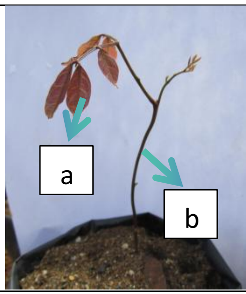
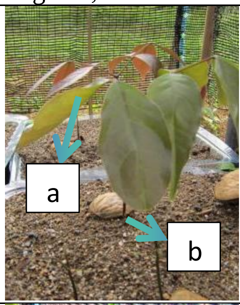
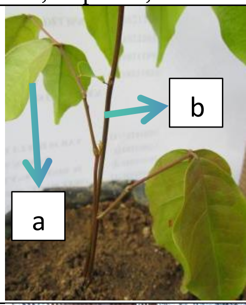
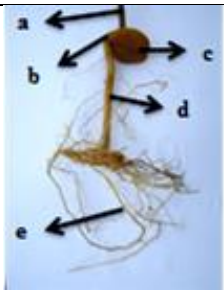
Germination	Genotype		Explanation
	Bareh	Lokan	
1.1 Seed coat ruptures and radicle emerges			
Seed coat ruptures			• Bareh day 3 and lokan day 4. • Cotyledon colour bareh are green yellow and lokan yellow a. seedcoat b. cotyledon
Radicle emerges			• Bareh day 4 and lokan day 5. • Cotyledon colour bareh green and lokan yellow • Radicle colour bareh and lokan white. a. seedcoat b. cotyledon c. Radicle
1.2 Epicotyl emerges from soil , Seed coat released, First leaf emerges, First leaf opens, First leaf turns red			
Epicotyl emerges from soil			• Bareh day 16 and lokan day 20. • Epicotyl colour bareh and lokan white. a. epicotile b. cotyledons
Seed coat released			• Bareh day 18 and lokan day 20. • Cotyledon colour bareh green and lokan brown. • Epicotyl colour bareh greenish yellow and lokan green a. epicotile b. cotyledon
First leaf emerges			• Bareh day 24 and lokan day 30. • Stem colour bareh and lokan brown. a. first leaf b. stem
First leaf opens			• Bareh day 25 and lokan day 32. • Stem colour bareh and lokan brown. • Cotyledon colour bareh green and lokan brown. a. first leaf b. stem c. cotyledon

Table 2. Germination of Dogfruit without shade cloth (Continued)

<table>
<tr><th rowspan="2">Germination</th><th colspan="2">Genotype</th><th rowspan="2">Explanation</th></tr>
<tr><th>Bareh</th><th>Lokan</th></tr>
<tr><td>First leaf turns red</td><td>
</td><td>
</td><td>• Bareh day 27 and lokan day 34.
• Stem colour bareh and lokan brown.
a. first leaf
b. stem</td></tr>
<tr><td colspan="4">1.3 First leaf turns brownish green, All leaves are green, Tap root, Leaf colour</td></tr>
<tr><td>First leaf turns brownish green</td><td>
</td><td>
</td><td>• Bareh day 34 and lokan day 40.
• Stem colour bareh and lokan brown.
• Leaves colour bareh reddish green and lokan greenish green
a. first leaf
b. stem</td></tr>
<tr><td>All leaves are green</td><td></td><td></td><td>• Bareh day 36 and lokan day 42.
• Stem colour (bareh) and (lokan) are brown.</td></tr>
<tr><td>Tap root</td><td>
</td><td>
</td><td>• roots bareh and lokan day 90.
a. stem
b. root neck
c. cotyledon
d. root stem
e. root branch</td></tr>
<tr><td>Leaf colour</td><td></td><td></td><td>• leaf colour (bareh) and (lokan) day 90.
• Leaf colour: reddish green</td></tr>
</table>

If the size of the cotyledon is greater than the strength of the radicle, then the seed will experience hypogeal germination. Hypogeal germination is where the appearance of the radicle is followed by elongation of the plumula. The hypocotyl does not extend to the surface of the ground, while the cotyledons remain in the seed skin below the surface (Kamil, 1979). An example is pea seeds (*Pisum sativum*). White lice (*Bemisia tabaci*) attack Dogfruit seedlings grown without shade.

White ticks develop around the cotyledon. Symptoms of attack are rotten cotyledons, white lice present on the cotyledons, wilted seedlings, leaf fall and finally dead seedlings. High rainfall triggers the development of white lice that then cause seedlings to die or rot.

Table 3. Germination of dogfruit under 40% shade cloth

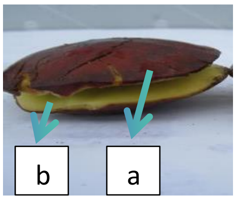
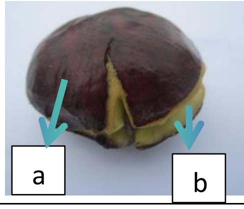
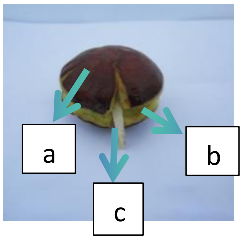
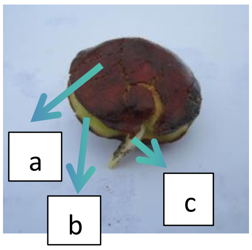
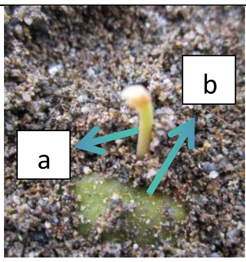
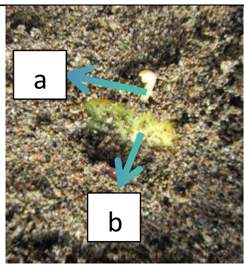
Germination	Genotype		Explanation
	Bareh	Lokan	
Seed coat ruptures, radicle emerges. epicotyl emerges from soil, first leaf opens			
Seed coat ruptures			• Bareh and lokan day 4 • cotyledon colour bareh and lokan yellow. a. seedcoat b. cotyledon
Radicle emerges			• Bareh and Lokan day 5 • cotyledon colour bareh and lokan green. • radicle colour Bareh and Lokan white. a. seedcoat b. cotyledon c. Radicle
Epicotyl emerges from soil			• Bareh day 22 and Lokan day 24. • Epicotyl colour bareh dan lokan green. • cotyledon bareh yellow and lokan yellowish green. a. epicotile b. cotyledon
Fisrt leaf opens			• Bareh day 26 and lokan day 28. • Stem colour bareh dan lokan brown • Cotyledon colour bareh dan lokan brown first leaf. Stem, cotyledon
First leaf opens			Bareh day 28 and lokan day 30. Stems colour bareh and lokan brown. cotyledon colour bareh and lokan brown.

Table 4. Germination of dogfruit under 40% shade cloth (Continued)

Germination	Genotype		Explanation
	Bareh	Lokan	
First leaf turns brown, first leaf turns brownish green, All leaves are green, Tap root, leaf color			
First leaf turns brown			• Bareh day 33 and lokan day 36. • Stem colour bareh and lokan brown. • cotyledon colour bareh and lokan brown.
First leaf turns brownish green			• Bareh day 37 and lokan day 40. • Stem colour bareh and lokan brown. • Cotyledon colour bareh and lokan brown.
All leaves are green			• Bareh day 39 and Lokan day 45. • stem colour bareh and lokan brown.
Tap root			• Roots bareh and lokan day 90 a. Stem b. Root neck c. cotyledon d. root stem e. root branch
Leaf colour			• Leaf colour bareh and lokan day 90 • Leaf colour: green

The seed germination type of dogfruit same with the result research of Trimanto *et al*. (2022) which found that *M. acuminata* var. flava was observed as hypogeal. In this type of germination, the cotyledons remain below the germination media due to rapid elongation of epicotyl (part of the stem above the cotyledon), while the hypocotyl (part of the stem below the cotyledon) remains the same in length. Then, the epicotyl pushes the plumule above the germination media, and followed by the formation of leaves

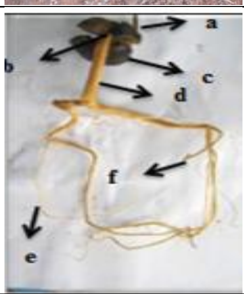
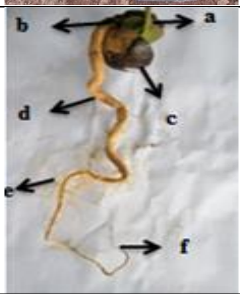
a. Seed Germination

The stages of germination of Dogfruit seeds in various shade conditions are shown in the following tables (Table 1, Table 2, Table 3, Table 4, Table 5, & Table 6).

Table 5. Germination of dogfruit under 80% shade cloth

Germination	Genotype		Explanation
	Bareh	Lokan	
Seed coat ruptures, Radicle emerges, epicotyl emerges from soil, first leaf emerges, first leaf opens			
Seed coat ruptures			• Bareh day 3 and lokan day 4. • Cotyledon colour bareh and lokan yellow
Radicle emerges			• Bareh day 4 and lokan day 5. • Cotyledon colour bareh and lokan yellow • radicle colour bareh and lokan white
Epicotyl emerges from soil			• Bareh day 18 and Lokan day 13 • Cotyledon colour bareh and lokan brown • epicotyl colour bareh and lokan green
First leaf emerges			• Bareh day 23 and lokan day 18. • Epicotyl bareh brownish green and lokan green • Cotyledon colour bareh green and lokan brown

Table 6. Germination of dogfruit under 80% shade cloth (Continued)

Germination	Genotype		Explanation
	Bareh	Lokan	
First leaf opens			• Bareh day 25 and lokan day 22. • stems colour bareh and lokan brown • cotyledon colour bareh yellow and lokan brown
First leaf turns bareh green brown and lokan red, first leaf turns bareh brownish green and lokan brown, all leaves green, tap root, leaf colour			
First leaf turns bareh green brown and lokan red			• Bareh day 28 and lokan day 24 • stems colou bareh and lokan brown • cotyledon colour bareh green and lokan brown
All leaves: green			• Bareh day 38 and lokan day 34 • stems colour bareh and lokan brown
Tap root			• Roots of bareh and lokan day 90 a. Stem b. Root neck c. cotyledon d. root stem e. root branch
Leaf colour			• Leaf colour bareh and lokan day 90 • Leaf colour green

Shade affects seedling germination and growth. Ahmed *et al.* (2014) found that medium shade resulted in fast rate of germination and high germination percentage. Also, it gave higher values for the seedling growth variables and produced erect and strong shoot. Seeds require two or three times their dry weight of water for germination. Water absorption activates seed embryonic cells, so that water absorption accelerates germination. Water absorbed by seeds softens the seed coat and causes embryo and endosperm development. This causes a break or tear of the seed skin. Dry cell walls are hardly permeable to gases, but if the cell wall is imbibed by water, the gases will enter the cell by diffusion. If the seed skin cell walls and embryo absorb water, the oxygen supply increases in living cells, allowing more active respiration. Water is useful to thin the protoplasm so that it can activate various metabolic reactions in cells. Water is also useful as a food transport medium from the endosperm or cotyledons to the growth points needed to form new protoplasm. The importance of water is in agreement with Hamama and Murniati (2010). The obstruction of seed germination caused by drought stress would decrease seed germination, because water availability influences seed metabolism.

Cotyledons containing food reserves shrink as new leaves and root branches form. In seeds that are three months old cotyledons have escaped from the root neck. The cotyledon's color changes yellow and turns brown then black and the cotyledons begin to shrink. Seedlings gradually depend on external nutrients through the roots.

Dogfruit leaves are classified as 'incomplete leaves' because they only have leaves and leaf stalks. The leaf stalk is round and not hollow. The upper leaf surface is slippery, the undersurface like paper. The leaves have non-serrated edges and are pinnately veined with a mid-rib that divides asymmetrically. There are secondary veins that branch and then unite with other veins. In general, the leaf is oval with a pointed tip and a rounded base.

Dogfruit seed germination is determined by environmental conditions. At 80% shade the seeds split, the radicle and epicotyl appear sooner than in those seeds germinated in 0% or 40% shade. Shade determines the amount of light, humidity and temperature experienced by the seeds. Good imbibition occurs when seeds are germinated under conditions of low light intensity, high humidity, low temperature, low evapotranspiration and regular watering. Without shade, the genotype *bareh* germinated faster than the genotype *lokan.* The *bareh* seeds are smaller than the *lokan* seeds. The seed size was positively correlated with the area and weight of the cotyledons. Small seeds absorb water faster than large seeds so the germination process takes place faster. But small seeds will not always germinate faster than large seeds. For *Shorea leprosula*, germination tends to improve with increased seed size (Rayan & Cahyono, 2011). Large size seeds have a lot of food reserves so they show better germination and germination rates compared to smaller seeds. The best medium for dog fruit seedling growth until six months after planting was soil: rice husk charcoal = 1 : 1 (Emilda *et al.,* 2021).

Dogfruit seed germination is determined by environmental conditions like temperature and light. Motsa *et al.* (2015) on research Effect of light and temperature on seed germination of selected African, the results suggested that under South African conditions, seeds of the eight species will typically germinate optimally as temperatures rise during spring before the occurrence of very hot temperatures in summer. Due to their positive response to light, germination of B. rapa subsp. chinensis, C. lanatus and S. retroflexum seeds is expected to be optimal when sown at or close to the soil surface. Result of research Flores *et al*. (2016) also found that Seed mass was an important factor because with higher seed mass there was lower dependence to light. These findings support the hypothesis that small seed mass and light requirements have coevolved as an adaptation to ensure germination. The research result is the same with of Simlat *et al*. (2016), Bu *et al.* (2017), Bhatt *et al.* (2022), and Belmehdi *et al.* (2018).

Shading also increase plant productivity. Result of research by Suansa and Al-Mefarrej (2019), the seedling growth was significantly increased by shading treatment, even though target plant species (V. farnesiana) is categorized as intolerant species. Basically, shade helps to generate the favorable local environment for supporting plant growth. This treatment with an appropriate consideration might become an alternative practice for increasing plant productivity.

b. Seedling Growth

1) Root length

The average length of the roots for plants growing in 0% and 80% shade were indistinguishable (Table 7). Strong or weak light intensity helped faster root system growth compared to the in between light intensity tested. Increased root growth under stress conditions facilitates plants finding a water supply.

Table 7. Effect of shade cloth on root length.

Shade cloth	Genotype (cm)		Mean
	Bareh	Lokan	
Without shade	23.07	25.10	24.08 a
40% shade	20.97	22.67	12.82 b
80% shade	28.57	32.73	30.65 a
Mean	24,20	26,83	
KK = 15.92%			

The numbers on the same row followed by the same lowercase letters are not significantly different according to DNMRT at the 5% real level

The rate of root extension is faster in dry soil than wet soil. The difference in the depth to which roots extend reflects differences in root development that are affected by groundwater conditions, and this is related to shade or light intensity. High light intensity increases the soil temperature causing evapotranspiration and root growth rate to increase. According to Budiastuti *et al*. (2020), light intensity affects root length, root fresh weight, root biomass, and the number of nodules. Beside light intensity, seedling root growth was affected by the weight of the seed variety. According to Rahmawati *et al*. (2019) Seedling root growth was affected by the weight of the seed of a variety. Seeds that have greater grain weight affect the length of the primary root because they provided greater energy to help the root growth.

2) Epicotyl length

The higher the level of shade the longer the epicotyl (Table 8). The spread of auxin in plants is faster in places with little light compared to places with a lot of light (Khoiri, 2010). Under low levels of shade, the auxin hormone will stimulate the extension of stem cells and inhibit the development of lateral buds, so that dissolved materials available for formation of new cells are used for plant growth. At low light intensity, seedling growth tends to be fast because in this condition etiolation occurs, namely stem extension, due to reduced degradation of auxin, with the aim that plants can capture sufficient light. According to Lakitan (2001), plants that are able to lengthen their stems in shaded conditions are generally responsive to gibberellic acid which serves to stimulate shoot growth. Plants that need shade at the beginning of their growth will stimulate faster growth of shoots to get enough sunlight in accordance with the plants requirements, but light intensity that is too low will cause etiolation.

Table 8. Effect of shade cloth on epicotyl length.

Shade cloth	Genotype (cm)		Mean
	Bareh	Lokan	
Without shade	9.17	10.17	9.67 a
40% shade	12.67	13.77	13.22 b
80% shade	16.67	14.33	15.50 a
Mean	12.84	12.76	
KK = 21.15%			

The numbers on the same row followed by the same lowercase letters are not significantly different according to DNMRT at the 5% real level

3) Leaf Area (cm^2)

Table 9. Effect of shade cloth on leaf size.

Shade cloth	Genotype (cm^2)	
	Bareh	Lokan
Without shade	19.31 b	25.05 b
	B	A
40% shade	15.97 b	33.50 a
80% shade	A	B
	33.13 a	33.7 a
	C	B
Mean	22.8	30.75
KK = 6.17%		

Numbers that are followed by different lowercase letters in the same column and different uppercase letters on the same row are significantly different according to DNMRT at the 5% real level

Both the level of shade and the genotype influenced Dogfruit leaf size (Table 9). For bareh the higher the level of shade the bigger the leaf. Leaves play an important role in the process of photosynthesis. Plants that grow under conditions of high shade or low light intensity increase their total leaf area. This is an effort to increase the surface area for light absorption. Plants also reduce the number of leaves to compensate for the limited amount of light. Pantilu *et al*. (2012) reported that an increase in the area of trifoliate leaves in a shaded environment was one of the mechanisms to improve light capture efficiency, while maintaining balanced photosynthate use.

If the rate of photosynthesis decreases, the resulting photosynthate decreases so that vegetative growth, especially leaf growth, decreases. It appears that Dogfruit seedlings are shade tolerant under the conditions tested. According to Buntoro *et al*. (2014) without shade (high light intensity) transpiration and absorption of water by plant roots are unbalanced resulting in insufficient plant water. Stomata closure will occur in leaves that experience a lack of water as a result of a decreased rate of photosynthesis, while transpiration rates increase. High light intensity results in smaller leaf cells, clumping of thylakoids and less chlorophyll, so the leaves are smaller, thicker, the texture of the leaves is hard.

Shaded plant leaves experience a reduction in the palisade layer and mesophyll cells, so the leaves become thinner. Thin leaves allow more solar radiation to penetrate downward so that the light is more evenly distributed to the lower part of the leaf. This thinning of the leaves is accompanied by an increase in leaf area so that a lot of sunlight can be collected. This increases the efficiency of light capture for each unit area of photosynthesis. According to Hariyadi *et al*. (2012) the higher the level of shade the more plants will adapt by increasing the efficiency of light capture for each unit area of photosynthesis.

Shaded leaves appeared more green, an adaptation to absorb light more effectively, while leaves exposed to direct sunlight were reddish green. This pigment is thought to be an anthocyanin which functions to protect chlorophyll and protochlorophyll from damage caused by photooxidation. This pigment also functions to help chlorophyll in capturing light in the process of photosynthesis. The increase in leaf area was significantly different from the leaf area in the absence of shade. According to Setiyowati (2014) plant adapt to shade stress or low light intensity by increasing leaf area and reducing the amount of light transmitted and reflected. So the increase in leaf area will expand the light capture area.

4) *Plant height*

Table 10. Effect of shade cloth on plant height.

Shade cloth	Genotype (cm)		Mean
	Bareh	Lokan	
Without shade	27.00	27.88	27.44 c
40% shade	32.89	33.33	33.11 b
80% shade	43.38	44.93	44.15 a
Mean	34.42	35.38	
KK = 5.28%			

The numbers on the same row followed by the same lowercase letters are not significantly different according to DNMRT at the 5% real level

The shade cloth tested had a significant effect on the height of the plants (Table 10). The higher the level of shade, the taller the plants. There is an increase in the rate of photosynthesis, so that the translocation rate is faster and the CO_2 fixation rate is increased. The higher the level of CO_2 fixation, the more efficient the plant is in synthesizing carbohydrates, breakdown of proteins and keto acids which is used to produce energy. This energy is used for cell division and will form new cells in the tissue. Under low intensity, light plants tend to grow higher, this is due to increased auxin activity in the apical meristem. The speed of cell division and formation of new cells under 80% shade cloth, showed maximum results but in terms of the quality of new cells formed, it was relatively low and affected the strength of the stem.

No shade produced the shortest plants, because the plants are under light stress. Maximum sunlight during the day will affect the rate of photosynthesis that is too high, thus inhibiting photosynthetic translocation in spurring the CO_2 fixation rate in synthesizing carbohydrates. The processes of cell formation and enlargement are slower. Auxin activity decreases, so the plants were shorter.

According to Gardner *et al*. (1991) the stem is composed of segments that stretch between the stem nodes where the leaves are attached. For stem height, growth occurs in the intercalary meristem (meristem which exists between differentiated tissues) of the segment. The segment extends as a result of an increase in the number of cells and the expansion of cells, and cell division occurs at the base of the segment (ie 224ntercalary) rather than at the end of the meristem. In strong light the content of auxin will decrease and plant height also decreases so that plant growth becomes restricted, while in shaded conditions, the stem is longer and auxin degradation by light is reduced.

However, the etiolation symptoms lasted only until the seedlings were two months old. After three months, the seedling stems began to become solid and thick green just like the seedlings that grew under 40% shade cloth or without shade. Wu *et al*. (2016) in research responses to shade and subsequent recovery of soya bean in maize-soya bean relay strip intercroppin found that soya bean expressed significant plant height elongation in INT treatment during coexisting period.

Seedling length and number of leaves also influenced by shade. Abutaba *et al.* (2020) found that seedlings under shade recorded the longest seedling length (25.3 cm) and number of leaves showed high significant under sun (18.2 leaves). There is a hardening and rapid establishment of seedlings that were planted outside the shade and this appears by increasing the number of leaves for the seedlings, and these are advantages of plantation establishment for their dependence on photosynthesis. Leão *et al*. (2019) found the 50% shading is the most suitable condition for the production of P. multijuga seedlings with the highes. Roque *et al.* (2021) also found that Cercidium andicola, P. ferox (Woody species) both species germinated better under shade and with high irrigation

4. Conclusions

The best interaction with respect to leaf area is 80% shade cloth and the *lokan* genotype. Eighty percent shade cloth is the best for germination and growth of Dogfruit seedlings. The best genotype for germination and growth is *lokan*. It is recommended to use 80% shade cloth because it provides optimal growth of Dogfruit seedlings.

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