Journal of Tropical Horticulture
Vol 4, No 1, April 2021, pp. 16-21
ISSN 2622-8432 (online)
Available online at http://jthort.org

RESEARCH ARTICLE

The Effect of Three Scion Varieties and Grafting Techniques on the Success of Durian *(Durio zibethinus)* Seedling Grafting

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ARTICLE HISTORY

Received : 10 January 2021
Revised : 20 March 2021
Accepted : 25 April 2021

KEYWORDS

Durian;
Scion varieties;
Grafting;
Technique;

ABSTRACT

Durian *(Durio zibethinus)* is a Southeast Asian plant with a high nutritional content, delicious taste, and many good benefits. Durian has a high economic value with a wide and varied market range (traditional to modern markets). This shows that durian is a commodity with a lot of potential for development. The increase in production is inseparable from various problems in the cultivation aspect, especially in the provision of quality durian seeds. Durian plants are generally propagated vegetatively. Vegetative propagation of durian can be done by grafting. In durian grafting, various varieties are used as scion. These varieties have been known to have their respective advantages and markets. This research aims to determine the effect of three varieties of scion and grafting techniques on the success of durian grafting. The research used a factorial randomized block design (RBD) consisting of two factors, which are the scion varieties and grafting techniques. There are three varieties of scions, which are umpang duk (V1), monthong (V2) and bintan (V3). Meanwhile, the grafting technique consists of top grafting (T1) and side grafting (T2).

1. INTRODUCTION

Durian *(Durio zibethinus)* is a Southeast Asian plant with high nutritional content, good taste, and numerous benefits (Sudjijo, 2009). Durian plants are also one of Indonesia's favorite non-oil and gas export commodities, including the Aceh region. Due to its distinctive taste and aroma, durian is known as the king of fruit. It is very popular with various groups of people, so cultivating it is profitable and exciting (Aryanto, 2009). Durian fruit is highly marketable in Indonesia, with traditional and modern markets. This shows that the durian commodity can be developed (Sobir et al., 2010).

Durian production centers in Indonesia are located in several provinces within Java and outside Java. Based on the average production in 2013, East Java contributed 84,670 tons /53.47%, North Sumatra 31,406 tons/39.26%, West Java 7,903 tons /16.19%, Central Java 18,604 tons /26.75%, Banten 31,576 tons/77.35%, West Sumatra 31,406 tons /39.26% and North Sumatra 31,46 tons/16.19%. In Aceh Province, durian production, from year to year, experienced instability in production levels. A significant decrease in durian production occurred in 2015, which was 16,148 tons; in 2011, durian production reached 27,044 tons (Dirjen Hortikultura, 2016).

The process of increasing production is inseparable from the presence of various problems in the cultivation aspect, especially in the provision of quality durian seeds. Durian plants are generally propagated vegetatively. Vegetative propagation of durian can be done by grafting (Prastowo & Roshetko, 2006). There are several ways of grafting, including budding and grafting, such as shoot grafting, side grafting, and plant grafting, so the scion and rootstock are still connected to their respective roots. The best technique for durian plants is shoot grafting with a cleft grafting model (Hanoto, 2000).

Shoot grafting is one of the most common techniques used in durian plant propagation. Grafting is the merging of rootstock and scion of different plant varieties so that the cambium of the rootstock and scion will continue to grow to form new plants (Ermansyah, 2012). Some advantages of the side grafting method are that the new plants produce fruit faster with easier implementation than budding (Suhendi, 2008).

Propagation by the grafting method is expected to improve the quality and quantity of fruit production by combining the two superior traits derived from the two parent trees and having a long breeding period.

Durian trees derived from generative propagation, the juvenile period frequently ranges from 10-12 years, whereas those propagated vegetatively range from 6-8 years.

In durian grafting, the scion used as an entry has various varieties known to have their advantages and a good market (Tirtawinata, 2006). The rootstock used for grafting can be taken from any durian seedling. Durian seedlings are usually derived from local durian because it is also easy to obtain apart from its various types, and its good properties have been known. The research aimed to determine the effect of various scion varieties and grafting techniques on the success of durian seedling grafting. The success of this research is beneficial for the continuity of sustainable agriculture.

2. MATERIALS AND METHODS

This research was conducted in Putoh Village, Peusangan District, Bireun Regency. The research was conducted from August to November 2020.

The tools used in this research are cutters, plastic masks, rulers, vernier calipers, cameras, paranet, watering cans, straps, labeling paper, and other tools that support the research. The materials used were rootstocks from durian plants that had been sown and scions from durian plants with local varieties (Umpang Duek), Monthong varieties, and Bintan varieties that were ± five years old, had much production and were free from pests and diseases.

This research used a factorial Randomized Block Design (RBD) with two treatment factors, which are the scion variety (V) and grafting technique (T). Factor I: Scion variety (V) consists of 3 levels, which are V1 (Local /Umpang), V2 (Monthong), and V3 (Bintan). Factor II: The grafting technique (T) consists of two levels, which are T1 (shoot grafting) and T2 (side grafting). Thus, there are six treatment combinations with 3 replications, with 18 experimental units.

This research consisted of rootstock preparation, scion preparation, top grafting, side grafting, and maintenance. The variables observed in this study were shoot burst time, grafting success percentage (%), shoot length (cm), number of leaves (leaflet), leaf length (cm), leaf width (cm), leaf area (cm), leaf chlorophyll (CCI) and shoot diameter (mm). Data analysis was performed with ANOVA. If the analysis shows different results, it will be continued with Duncan's Multiple Range Test (DMRT) at the 0.05 level.

3. RESULTS AND DISCUSSIONS

3.1 Results

3.1.1. Leaf Area and Chlorophyll

The interaction between scion varieties and grafting techniques was only seen in leaf area and leaf chlorophyll. Further test data on the interaction between scion varieties and grafting techniques are presented in Table 1. The results showed that the interaction of the two factors can increase the leaf area and leaf chlorophyll in durian plants.

Table 1. Interaction of Scion Variety and Grafting Technique on Leaf Area and Leaf Chlorophyll

Treatment		Leaf Area (cm)	Leaf Chlorophyll (Cci)
Scion Variety	Grafting Technique		
Umpang Duek	Shoot Grafting	25.47 ab	41.99 b
Umpang Duek	Side Grafting	31.12 ab	36.33 b
Monthong	Shoot Grafting	37.34 a	61.29 a
Monthong	Side Grafting	20.92 b	28.63 b
Bintan	Shoot Grafting	30.01 ab	44.64 b
Bintan	Side Grafting	31.85 ab	39.82 b

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

3.1.2. Grafting Success, Shoot Burst Time, Shoot Length and Number of Leaves

The interaction between scion varieties and grafting techniques did not affect the grafting success, shoot burst time, shoot length, and number of leaves on durian plants. However, individually, both showed a significant effect. The results of further tests of scion varieties and grafting techniques on the grafting success, shoot burst time, shoot length, and number of leaves on durian plants are presented in Table 2.

Table 2. The Effect of Scion Variety and Grafting Technique on Grafting Success, Shoot Burst Time, Shoot Length, and the Number of Leaves on Durian Plants

Treatment	Grafting Success (%)	Shoot Burst Time (DAG)	Shoot Length (cm)	Number of Leaves (Leaflet)
Scion Variety (V)				
V1 (Umpang Duek)	56.67 a	12.77 a	7.83 ab	3.83 a
V2 (Monthong)	53.33 a	14.94 a	9.20 a	3.66 a
V3 (Bintan)	56.67 a	16.00 a	7.25 b	3.72 a
Grafting Technique (T)				
T1 (Shoot Grafting)	60.00 a	12.96 a	8.70 a	4.22 a
T2 (Side Grafting)	51.11 a	16.18 a	7.48 a	3.25 b

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test. DAG

Table 2 shows that scion varieties can increase the shoot length of durian plants. The best treatment is V2 (Monthong). The grafting technique affects the number of leaves on durian plants. The best treatment is T1 (Shoot grafting).

3.1.3. Leaf Length, Leaf Width, and Shoot Diameter

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The interaction between scion varieties and grafting techniques did not affect durian plants' leaf length, width, and shoot diameter. However, individually, both showed a significant effect. The results of further tests of scion varieties and grafting techniques on leaf length, leaf width, and shoot diameter of durian plants are presented in Table 3.

Table 3. The Effect of Scion Variety and Grafting Technique on Leaf Length, Leaf Width, and Shoot Diameter of Durian Plants

Treatment	Leaf Length (cm)	Leaf Width (cm)	Shoot Diameter (mm)
Scion Variety (V)			
V1 (Umpang Duek)	11.18 a	3.39 a	2.65 ab
V2 (Monthong)	10.24 a	3.66 a	2.89 a
V3 (Bintan)	10.39 a	3.54 a	2.49 b
Grafting Technique (T)			
T1 (Shoot Grafting)	12.11 a	3.79 a	2.83 a
T2 (Side Grafting)	8.96 b	3.27 b	2.51 b

Note: The numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

Table 3 shows that scion variety affects shoot diameter. The best treatment is V2 (Monthong). The grafting technique treatment affected the leaf length, leaf width, and shoot diameter. The best treatment is the T1 (Shoot grafting).

3.2 Discussions

The results showed that shoot grafting can increase the success percentage. The success of grafting can occur as the stems used are still very young (1 month old). The shoot grafting technique is the most frequently used, with a high success rate (>85%). The young age of the rootstock causes the cell level to be still very high so that the grafting process will be faster.

Tirtawanita (2003) states that the wound-healing process in young mangosteen seedlings aged three months takes place quickly. The callus is quickly formed and fills the space left by the incision marks so that 15 days after the treatment, the initial incision has almost no visible scar. This is also to the research of Handayani et al. (2013), which stated that based on the results of tissue analysis on mangosteen micro grafting (the age of the plant is still very young), the wound healing speed and grafting growth are better than those of the older field grafting. The younger the plant age being grafted, the higher the success rate. The percentage of grafting success is also affected by the physiological age of the scion. This is in line with the opinion of Sukarman (2011), who stated that young scions contain relatively low carbohydrates, while old scions have a higher carbohydrate content. High carbohydrate content also produces high energy to stimulate growth. Apart from carbohydrates, the cambium content of the scion also affects its growth capacity. Low cambium content causes a decrease in the success rate of vegetative seed propagation.

Suryadi (2009) added that the grafting success and quality between the scion and rootstock are determined by the balance of source (carbohydrate availability) and sink (carbohydrate utilization). If the number of sinks is within the number of sources, the grafting between the scion and rootstock will be better. Rahardjo et al. (2013) stated that the exact size of rootstock and scion tends to increase grafting success. Moreover, Firman and Ruskandi (2009) added that the decrease in the grafting success percentage is not only caused by the incompatibility of the scion and rootstock, either stem size, physiological age, attachment, or binding but also by extreme climates, such as heavy rains or extreme heat. Failure of grafting at the beginning of the observation period is due to the presence of fungi, which causes decay on the scion and joint. Apart from the presence of fungi, the death of grafted plants is also caused by drought, which begins at the top of the plant and slowly extends to all parts of the scion—the high temperature and low humidity cause the dryness of the scion during the day.

Yuniastuti (2002) states that the unequal size of the rootstock and scion will cause improper cambium positioning, leading to grafting failure. The presence of dead seedlings indicates that the seedlings experienced grafting failure. This is due to the wounds of the scion and rootstock that are not grafted so that there is no connection between the xylem and phloem, causing the nutrients and water coming from the soil or photosynthesis not to be distributed. The function of the lid in the grafting process is to protect it from incoming sunlight and evaporation caused by sunlight.

Based on the results of the research, it is known that the fastest shoot burst age is found in the use of local varieties (eumpang duek), which is 12.77 days after grafting and is not significantly different from the use of monthlong and Bintan varieties. While the slowest shoot burst, age is found in the Bintan variety. According to Sutami and Noor (2009), differences in the time of shoot burst are thought to be due to the differences in the plant's ability to form connections, which are related to the number and speed of callus formation. Shoot burst time is characterized by the length of shoots that have reached 5 mm from the release of leaf shoots.

Faster and more complete observation between the scion and rootstock cambium will cause the process of shoot and leaf formation to accelerate. Moreover, if the translocation of nutrients, water, hormones, enzymes, and photosynthesis between the scion and rootstock goes well, the grafted shoots will grow faster. Success is affected by several factors, including the joining power between the scion and rootstock and the growth activity of the rootstock. The success of grafting requires compatibility between the scion and rootstock and the ability of the scion itself to burst and grow (Anindiawati, 2011). Mahfudz et al. (2001) stated that grafting would be perfect when higher air humidity is achieved because it affects the formation of calli, which begins with increased cell damage.

The highest shoot length was found in monthong varieties at the age of 85 DAG, which was 9.20 cm. This is thought to be because the scion and rootstock of the monthong variety have a better linking process. It can be concluded that the acceleration of the link between the scion and rootstock is affected by the activity of nutrients and the formation of meristem cells that take place properly so that the shoots grow faster. Basri (2008) said that the results of perfect grafting will cause an increase in the shoot length of the grafted plants. The increase in shoot length significantly affects the three varieties of scion; it is suspected that each variety of scion and rootstock can connect and fuse perfectly to form a new tissue.

Statistically, the shoot and side grafting techniques differed significantly at 55 DAG. However, on average, the shoots found in shoot grafting treatment at the age of 85 DAG were longer, reaching 8.70 cm compared to one with side grafting treatment. This is presumably related to a better bonding process in shoot grafting. The increase in shoot length found in Table 4 is also affected by the perfect linkage between the rootstock cambium and scion. According to Soegito et al. (2002), the grafting success will stimulate the transfer of nutrients and water to all parts of the scion plant, affecting other growth components such as leaves and plant height.

The grafting technique, shoot or side grafting, showed that the scion and rootstock of the plants can connect and fuse to form new tissues or shoots. The success rate of grafting varies greatly; however, in cocoa plants, many are by shoot grafting. Basri (2009), the grafting success of different plants has a different success rate. Moreover, the grafting success is also determined by the increase in grafting skills. According to Campbell et al. (2003), auxin is a hormone that functions as a cell elongator in developing young shoots so that the shoots will continue to elongate to the maximum.

The results showed that the highest number of leaves due to the three scion varieties can be found in the use of Local varieties (Umpang Duek), which is 3.05 at the age of 55 DAG, 3.77 at the age of 70 DAG and 3.83 at the age of 85 DAG. The shoot grafting technique that produces the highest number of leaves is at the age of 55 DAG (3.48), 70 DAG (4.14), and 85 DAG (4.22). Sukarmin and Ihsan (2012) found that the number of leaves resulting from the grafting process varied on the scion. The more significant number of leaves indicates that the grafting between the rootstock and the scion has fused perfectly so that the supply of nutrients from the roots to the shoots of the plant can occur correctly.

Large and medium-diameter rootstock sizes affect the number of leaves produced. This is because there is a large amount of xylem tissue in these sizes, which optimizes the transformation of nutrients and water. Furthermore, the grafting success can stimulate the transformation of nutrients and water to all parts of the scion plant, affecting other growth components, such as leaves and plant height (Soegito et al., 2002). Firman and Ruskandi (2009) stated that the number of leaves will increase if the grafting quality is better. A perfect connection between the scion and rootstock characterizes the quality of a reliable graft.

The increase in leaf length is also affected by the perfection of the graft between the rootstock and stem cambium. According to Soegito et al. (2002), grafting success can stimulate the transformation of nutrients and water to all plant parts. Proper grafting will deliver nutrients the roots absorb to the leaves and vice versa. Cell division requires high energy, which is absorbed by the roots. If the metabolic process in the plant is disrupted due to poor plant tissue, the biosynthesis of hormones will not work optimally. As a result, the growth and development of the leaves will be inhibited in the scion, which will affect the growth component.

The result of the perfect grafting will cause an increase in the number of leaves and the length of the leaves of the grafted plant; the connection between two compatible plants will produce solid and long-lived plants. This statement is supported by the opinion of Mahfudz et al. (2001), who stated that perfect grafting occurs when higher air humidity is achieved because low humidity will affect the formation of calli, which begins with an increased rate of damaged cells.

Sukarmin and Ihsan (2012) found varied leaf widths of the scions. The wider leaf indicated that the grafting between the rootstock and the scion had fused perfectly, so the supply of nutrients from the roots to the plant shoots could occur correctly. The grafting success between the rootstock and the scion is the foundation for optimal water and nutrient growth, absorption, and transportation.

Shoot growth occurs after the connection between the scion and rootstock occurs. One of the indicators that the shoots are growing is the increase in diameter.

According to Martade and Basri (2011), the diameter of the scion shoots determines the growth rate and diameter of the shoot. Furthermore, the base of the stem with a larger diameter has a greater number or mass of meristem cells. The larger the stem base, the faster the division, enlargement, and elongation of the cells so that the elongation and enlargement of the shoots also become faster. It is known that several factors affect the growth of planting material, including external factors (environment such as climate, soil, and applied technology) and internal factors (genetics, including the quality and mass size of the meristem cells contained in the planting material).

The content of the food supply is in a balanced state so that the cell division, enlargement, and differentiation also run in a balanced manner. In this balanced condition, the food reserve content in each treatment length is equally sufficient for grafting. The success of grafting is primarily determined by the strong connection of the two connecting stems' cambium (Parsaulian et al., 2012).

The analysis of variance showed an interaction between the three scions and the grafting technique on the leaf area at the age of 85 DAG. The ability of leaves to produce photosynthate products is determined by productivity per unit leaf area and total leaf area. Meanwhile, the distinguishing factor of leaf area in the three scion varieties is the different varieties and the size of the leaves in each type of plant, which has different sizes and weights in each leaf, and lighting factors also cause it.

Measurement of leaf area using various methods shows a different level of consistency. The greater the leaf area of a plant, the higher the photosynthetic yield, the heavier the biomass produced, and the more effectively the crown can absorb solar radiation. The initial growth of the leaf is actually due to the presence of meristem tissue whose cells undergo intercalar division, which is randomly scattered, causing an increase in leaf size, followed by growth of the apex and leaf edges (Gembong, 2005).

Cytokinin inhibits stem elongation but stimulates leaf expansion. It plays a role in shoot differentiation but plays less of a role in the first process of leaf opening. The size of the leaf area also has a role in photosynthesis. The leaf area determines photosynthetic yield per plant. With a larger leaf surface area, it is possible to capture light better and have a higher photosynthetic yield value.

The analysis of variance showed an interaction between the three scions and the grafting technique on leaf chlorophyll at the age of 85 DAG. Chlorophyll is a pigment that gives green color to plants, algae, and photosynthetic bacteria. This pigment plays a role in the photosynthesis process of plants by absorbing and converting light energy into chemical energy. Sunlight contains all the visible spectrum colors from red to violet, but not all wavelengths are well absorbed by chlorophyll. Chlorophyll can accommodate the light absorbed by other pigments through photosynthesis, so chlorophyll is the central pigment of photosynthetic reactions (Bahri, 2010).

The amount of leaf chlorophyll is affected by the amount of pigment and the leaf surface area. Moreover, the size of the leaf area also has a role in photosynthesis. The leaf area determines the result of photosynthesis per plant. With a larger leaf surface area, it is possible to capture light better and have a higher photosynthetic yield value (Saiful, 2007).

Chlorophyll content is also affected by a plant's morphological and anatomical structure. The larger the leaf size of a plant, the more chlorophyll it contains. On the other hand, the smaller the leaf size of a plant, the less chlorophyll it contains. However, the older the leaf age, the ability to photosynthesize will also decrease, causing damage to chlorophyll as its function is not running correctly even though the leaf area is increasing (Musyarofah *et al*., 2006).

Sumenda et al. (2011) stated that based on visual observations, the color of the leaves turns very dark green along with the increase in leaf age. The green color of the leaves is closely related to the chlorophyll content. Generally, the older the leaf, the greener the leaf color, and the higher the chlorophyll content. This is related to the difference in chlorophyll content at each level of leaf development. The difference in leaf color also shows the difference in the type of pigment in the leaf. Chlorophyll in young leaves is still in the form of protochlorophyll, and the leaves become green after the transformation of protochlorophyll. Factors that affect the formation of chlorophyll are light and the elements N, Mg, and Fe, which are formers and catalysts in the synthesis of chlorophyll (Hendriyani & Setiari, 2009).

4. CONCLUSIONS

1. The differences in scion varieties had no significant effect on all variables but significantly affected leaf width at 70 and 85 Days after grafting (DAG).
2. The grafting technique significantly affected the leaf number, leaf length, leaf width, leaf chlorophyll, and shoot length at 55 DAG, leaf chlorophyll, and shoot diameter. However, it did not significantly affect the success percentage, shoot burst time, shoot length at 70 and 85 DAG, or leaf area.
3. There is an interaction between the three scion varieties and grafting techniques in the leaf area and leaf chlorophyll.

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