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Impact of Scion Length and Cover Type on the Success of Durian Grafting

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Grafting has become a technique with high potential for increasing the efficiency of modern and intelligent crop cultivation, and shows its adoption of power and robustness under different inspection situations. This study aims to determine impact of interaction between scions length and cover type on the success of durian grafting. It was carried out using a Split Plot Design method, with the main plot being the cover type composed of individual and mass of cover type, while the subplot consists of 10 and 20 cm scions length. The observed variable were time of bud emergence, percentage of bud emergence, bud length, leaves of number and grafting of success. The data were analyzed by Analysis of Variance (ANOVA). If there are significantly different treatments then proceed with the Least Significant Difference test at 5% level. The results showed that the interaction between scions of length and cover type treatment did not affect grafting technique. However, the treatment of cover type affected the percentage of bud emergence, bud length, leaves of number, and grafting success. The treatment of scions of length also affected the leaves of number. The mass cover type resulted in 93.5% bud emergence, 1.5 cm bud length, 2.73 increase in the leaves of number, and 93% grafting success. Meanwhile, the treatment of scions of length 20 cm increased the leaves of number by 2.13 strands. Scions of length that is successfully connected to grow and form new shoots has an impact on the development of healthy stems. The cover type in this study was able to protect grafting plants from direct exposure to sunlight, maintain plant moisture, prevent pests and diseases, protect from rain so that grafting can be successful.
Keywords: Durian grafting, scions length, cover type, mass and individual, vegetative propagation.

INTRODUCTION

Indonesia is among the countries with the highest number of durian variants globally. However, the production of durian in from 2016 to 2017 showed a decline, with a decrease of 2.65% (Azizah *et al.*, 2020). This decline makes it necessary to increase durian productivity, as the demand for durian continues to rise both domestically and internationally. Currently, most of the durian are local varieties that have been cultivated for generations, with morphological characteristics of 50 m high and a crown diameter of up to 10 m. The growth of durian which tends to be high with a wide canopy poses a challenge for maintenance and harvest. This makes the control of pests and diseases difficult, leading to high harvest costs (Rahmatika & Setyawan, 2018a).

Grafting techniques have long been applied for efficient propagation and for modification of favorable characters, such as fruit quality, environmental stress tolerance, tree size, and plant disease resistance (Adhikari *et al.*, 2022). Techniques for increasing durian production through the use of superior seeds vegetatively such as grafting techniques that combine rootstocks and scions so that combinations and unions are achieved which grow into more potential new plants (Sunandar *et al.*, 2018). Grafting techniques are also able to modify the phenotype of the scion of mango plants such as fruit quality where this is done according to market demand (Shivran *et al.*, 2023). Grafting of the rootstock age of 6, 9, and 18 weeks on breadfruit (*Artocarpus altilis*) can improve the development of commercial breadfruit. However, appropriate protocols such as ensuring scions quality and creating a suitable post-grafting environment are two important factors (Solomon *et al.*, 2021).

Grafting has become a technique with high potential for increasing the efficiency of modern and intelligent crop cultivation, and shows its adoption of power and robustness under different inspection situations. Plant grafting is done to develop tolerance to variations in temperature, salt stress and heavy metal content in the soil. Structural development and

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biological graft between scion and rootstock has gone through three basic phases which are joining scion and rootstock, callus formation around the joint and establishing continuity at the joint through vascular re-differentiation (Noor *et al.*, 2019). The best selection of rootstocks and scions based on area, species and cultivars under different conditions.
(Suharjo, 2020) stated that the source of the scion had a significant effect on the total leaf area and stem diameter of the durian plant, while the best success and compatibility of the connection was obtained from the treatment of the scion source which came from secondary branches and the storage time was 4 days. Research on scions of length is related to the adequacy of food/energy reserves for the recovery of cells damaged by injury in the mango grafting technique where the longer the entries, the more assimilate reserves (Maulana *et al.*, 2020).
A combination study of various types of environmental protection using grafting techniques on single and group cucumber plants produced superior cucumber performance in naturally ventilated polyhouses (NVP) compared to insect net houses (INH) and shade net houses (SNH). The protective type of naturally ventilated polyhouse (NVP) produces a more suitable microclimate pattern such as air temperature, humidity and light and is able to maintain the potential for plant water loss and leaf mineral status in cucumber plants (Khapte *et al.*, 2021).
One of the causes of the failure of durian grafting is the selection of the inappropriate scions. Therefore, there is a need to determine the most suitable scions source for grafting on each variety. The source of scions is obtained from various primary, secondary, and tertiary branches of potential durian. According to (Thalib, 2019) the ideal scions is fresh upper stem taken from a 10 year old plant with a length of around 10 cm (4 leaves). (Rahmatika & Setyawan, 2018b) stated that a scion length of 7.5 to 10 cm produces optimal shoot length and number of leaves in propagation using the grafting technique. Based on the description above, it is necessary to do research on impact of scion length and cover type on the success of durian grafting.

MATERIALS AND METHODS

This study was carried out from April 2022 to July 2022 at Perintis Lake, Huloduotamu Village, Suwawa District, Bone Bolango Regency. The materials used were paranet, plastic binding tape, polybags, transparent plastic covers, raffia rope, durian seeds, and Monthong durian scions. the tools used were cutting knives, twigs, and scissors.
The experimental design used a Split Plot Design method, with the main plot being the cover type consisting of individual and mass of cover type, while the subplots were 10 and 20 cm in scions length, as shown in Table 1. There were 4 treatment combinations, with 3 block, making a total of 12 experimental units. Each treatment unit consisted of 5 plants, hence, 60 plants are required. The basis for determining scions treatment of 10 and 20 cm is based on research (Rahmatika & Setyawan, 2018b) which has examined scions length of 5, 7.5 to 10 cm. So we tried to examine scions lenght which is longer.
Prepare 60 polybags with rootstock durian seeds that are 3 to 4 months old. The rootstock is taken from a plant that is 3 months old and is in a healthy condition so it is ready to be grafted. The scion criteria used in this research were scions taken from durian plants over 6 years old. Scions are collected in the morning and evening so that the cambium is still intact. Scions are taken from healthy plaigotrope branches that are not affected by pests and disease. Scions were stored at room temperature 20^0C with humidity 75%. Before being stored, scion is first wrapped in newspaper that has been sprinkled with water but not too wet, then wrapped again in banana stems. Scions were stored for 6 days, 4 days, and 2 days after being taken from the parent tree.
Grafting technique was carried out by cutting the rootstock horizontally with a height of 30 cm and the center was sliced vertically 2-3 cm long. The lower base of scions was slashed obliquely on both sides to form a triangle and inserted on the rootstock. In this process, the two cambiums must meet for the diameter of the rootstock and scions to be the same. The binding process used was plastic and after bonding, the containment process was carried out using plastic. The observed variable were time of bud emergence (days) (Eq 1), percentage of bud emergence (%), bud length (cm), leaves of number (strands), and grafting of success (%) (Eq 2). Data were analyzed by Analysis Of Variance (ANOVA). If there are significantly different treatments then proceed with the Least Significant Difference test at the 5% level.

$$\frac{\text{Number of bud emergence}}{\text{Total Grafting}} \times 100 \qquad \text{(Eq 1)}$$

$$\frac{\text{Number of grafting success}}{\text{Total Grafting}} \times 100 \qquad \text{(Eq 2)}$$

Table 1. Treatments used in this experiment

Treatment	Description
The main plot, namely the cover type (T) consists of two levels namely :	
T1	Individual Cover
T2	Mass Cover
Subplots namely the scion of lenght (P) consist of two levels namely :	
P1	10 cm
P2	20 cm

RESULTS AND DISCUSSION

Time of Bud Emergence (days): ANOVA showed that the interaction between cover type and scions length in grafting technique was not significantly different in time of bud emergence parameters. This was because cover type and scion length of treatment had their specified level of compatibility and were not related. Cover type affected pattern of plant microclimatic conditions, while scions length influenced deposit of mineral content in the formation of plant tissue. Cover type has same relative role as the net house which has potential to reduce various biotic and abiotic challenges during production in certain seasons in open field, while creating a microclimate that positively affects the productivity and quality of grafts (Ilić *et al.*, 2020). Cover type characters with colored nets combined with grafting provide an alternative strategy to achieve higher fruit yields and avoid or reduce crop degradation caused by environmental stresses such as radiation and excessive summer temperatures (Milenković *et al.*, 2020).

Different cover type structures and scion-rootstock combinations may have a tremendous effect on grafted plants with the use of different types of shade. The effect of protected structure and grafting was evident on various parameters of plant growth, yield and quality. The cover type structure affects the principle of microenvironment primarily as a result of changes in the intensity and diffusion quality of light which interact with various physio-biochemical plant processes depending on the type of shielding material and the configuration of the structure (Khapte *et al.*, 2021).

Table 2 showed that individual cover type of treatment has an average time of bud emergence faster than mass cover type, although was not significant. In the 10 cm scions length of treatment, average time for buds was faster than 20 cm of scions length, however, two treatment levels were not significantly different. This is due to low supply of assimilate and early adaptation to grafting process. (Rahmatika & Setyawan, 2018b) states that the initial growth of grafted plants is influenced by nutritional and hormonal factors where initial growth of grafted durian plants is still unable to produce carbohydrates normally. (Suharjo, 2020) states that grafting success can also occur in durian scions which contain sufficient nutrients for the formation of new callus and cambium.

Table 2. Average of time of bud emergence (days) parameter of durian based on impact of scion length and cover type on the success of durian grafting.

Treatment		Average of time of bud emergence (days)
Cover type	Individual cover	13,00
	Mass cover	22,77
LSD 5 %		-
Scion lenght	10 cm	17,40
	20 cm	18,37
LSD 5 %		-

Figure 1. Grafting technique

Connectivity of scion and rootstock is very important for optimal growth, absorption of water and nutrients and transport of assimilates. Deficiency of mineral and air nutrients can cause stunted growth of scion and low concentration of carbohydrates in bud shoots will reduce shoot growth. This also causes low absorption of air and nutrients, as well as reduced availability of carbohydrates as an energy source for active uptake of ions. In other words, physiological disturbances caused by impaired vascular union in the graft grafting process can cause growth inhibition due to disturbed connectivity between scions and rootstocks. Therefore, apart from the compatibility and proper combination of scion and rootstock for the intended purpose such as stress resistance as well as care must be taken when grafting to achieve optimal joint between the rootstock and scion (Martínez-Ballesta *et al.*, 2010).

Percentage of Bud Emergence (%): Based on ANOVA, cover type of treatment was significantly different in percentage of bud emergence parameter, but there was no significant variation in scion length and interaction between two treatments. This was because cover type of treatment that acted as a shade can protect against extreme environmental conditions. (*Rohman et al.*, 2018) stated that shading is carried out to avoid extreme environmental conditions that can cause failure during grafting. Cover types and their characteristics lead to changes in the microclimate. The plastic shade has the ability to modify by blocking incoming radiation, while the net shade protective structure allows radiation to pass through. Light transmitting properties affect air temperature and humidity within the protected structure, which in turn affects plant respiration, as well as changing water availability (Khapte *et al.,* 2021). The grafting of success of durian plants is due to environmental conditions, rootstock characters and grafting technique skills. Successful grafting will spur the transformation of nutrients and water to all parts of the scion plant which will affect other growth components such as shoot development and plant height (Widiatmoko & Ashari, 2018).

Table 3. Average of percentage of bud emergence (%) parameter of durian based on impact of scion length and cover type on the success of durian grafting.

Treatment		Average of time of bud emergence (%)
Cover type	Individual cover	43.5 a
	Mass cover	93.5 b
LSD 5 %		-
Scion lenght	10 cm	60.0
	20 cm	76.5
LSD 5 %		-

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% Least Significant Difference test level

Figure 2. Layout of individual cover and mass cover

Based on Table 3, mass cover type of treatment was significantly different from individual. It resulted in an average percentage of buds emergence which was 93.5% higher than the 43.5% obtained in the individual cover type treatment. This was because the bulk cap type triggered suitable microclimate for the growth of plant shoots, especially air temperature. According to (Rohman *et al.,* 2018), the moderate air temperature at grafting site results in high tissue adhesion in grafted plants. (El Omar *et al.,* 2020) also stated that climatic and environmental conditions affected the success of self and cross-grafting on annona and cherimoya plants by increasing the growth of the vegetative parts and affecting fruit quality.

Absorption of water and nutrients in grafted plants as a result of increased vigor by the root system of the rootstock and its effect on crop yields. So water plays a role in the relationship between the rootstock and scion systems, as well as its influence on the grafted part and the transportation of water and nutrients to the upper parts, which are able to withstand environmental stresses (Martínez-Ballesta *et al.,* 2010). Grafting begins by forming a callus at the graft interface, which allows water to flow from the rootstock to scion as the callus develops to form vascular bundles. Inadequate vascular connections and joints between scion and rootstock can reduce water flow. When the absorption of water by the roots is being hampered in grafted part, the stomata and scion conductance will experience a decrease in growth. Thus, hydraulic architecture becomes very important, because the continuous flow of water controls many plant processes such as growth of vegetative parts, mineral nutrition, photosynthesis and transpiration. The resulting hydraulic resistance of the graft reflects the water flow pattern determining the hydraulic resistance in the grafted part. The main hydraulic connection becomes functional during the initial grafting period.

***Bud Length (cm)*: ** ANOVA showed that cover type of treatment had a significant difference in bud length of parameter. However, scions length of treatment and interactions between two treatments were not significantly. The growth of bud length of durian is strongly influenced by supply of solar radiation, nutrients and growth regulators. The low light intensity due to character of cover types results in disruption of metabolism of grafted plants, causing a decrease in rate of photosynthesis and carbohydrate synthesis (Rohman *et al.,* 2018).

Scion length of treatment was not significantly different because there were several incompatible grafting results resulting in relatively shorter shoot lengths. Graft incompatibility is categorized as translocation and localization which is characterized by obstructions in transport of metabolites (mainly carbohydrates) flowing from scion to rootstock, therefore it is called translocation incompatibility. Subsequent events are characterized by overall network discontinuity of the graft partner due to aberrant growth of the partner network. The anatomical and physiological factors underlying response mismatch may differ from one graft combination to another; incompatible combinations, in general, have poor connectivity. Initial mismatch, which often indicates failure of tissue connections in graft unions, graft combinations that are incompatible after years of apparently normal growth. For a start it was such an invisible incompatibility (Adhikari *et al.,* 2022).

Table 4. Average of bud length (cm) parameter of durian based on impact of scion length and cover type on the success of durian grafting.

Treatment		Average of of bud length (cm)
Cover type	Individual cover	0.63 a
	Mass cover	1.59 b
LSD 5 %		-
Scion lenght	10 cm	0.98
	20 cm	1.24
LSD 5 %		-

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% Least Significant Difference test level

Figure 2. Observation of bud lenght

Based on Table 4, mass cover type of treatment was significantly different from individual. It resulted in a higher average of bud length of 1.59 cm compared to individual cover type of treatment of 0.63 cm. This was because, in mass cover type of treatment, all plant parts were protected from extreme environmental conditions compared to individual where only the grafted part of the plant was protected. In individual cover type of treatment caps, the rootstock parts were not protected, hence, the plants received relatively extreme temperatures and humidity which triggered root decay. The grafted plant parts protected by a combination of scion and rootstock may have a substantial effect on plant growth, yield and quality parameters. In the protected part it affects the microenvironment due to changes in light intensity and quality and has an impact on plant physio-biochemical processes, thereby affecting plant growth and development (Khapte *et al.,* 2021).

Grafting failure occurs due to the presence of fungus on the scion and the rotting joints of the joints. Symptoms of dead grafted plants begin with drought which starts from the shoots of the plants which slowly extends to all parts of the scion. Dry scion caused by high temperatures and low humidity during the day. Graft combination requires the completion of a series of molecular and physiological events at the graft joint such as cell dedifferentiation, cellular recognition, formation of callus bridges, removal and clearance of necrotic tissue, cell redifferentiation and establishment of vascular connections. Graft incompatibility is often the result of failure/delay of one or more of these physiological steps (Adhikari *et al.,* 2022).

Leaves of number (strands)**:**ANOVA showed that cover type and scions length of treatment were significantly different in the leaves of number of parameter. However, there was no significant difference in the interaction between two treatments. Cover type and scions lenght of treatment were significantly different separately so that they did not produce an interaction effect between two treatments. The effect of cover type on the grafted plants is in form of producing both individual and mass cover type so that it triggers different microclimatic conditions than without shade. The effect of scion length is difference in the availability of initial assimilate supply. Post grafting condition is another factor that is not evaluated directly. However, it emerged as an important factor. The use of a specific shade leads to optimum temperatures between 26 and 29°C, relative humidity levels above 80% which are favorable for the graft union healing process and to minimize water loss. The use of scion quality that is appropriate and matches the stock of rootstock, especially the same diameter size (Solomon *et al.,* 2021).

Plant parts have mineral and nutrient reserves in various organs such as roots, stems and leaves. These organs have considerable influence on absorption and translocation of mineral nutrients. It plays an important role in physiological processes such as growth, signal transduction, and development. Effect of rootstock and scion on mineral content is associated with physical characteristics of root system, such as lateral and vertical development, which results in increased water and mineral uptake. This became one of main motives for the widespread use of grafted rootstocks and scions. The strength of scion and root system has an important role in the absorption and translocation of nutrients in grafted plants. Therefore, the content of macro and micro nutrients is influenced by the characteristics of rootstock and scion and depends on the elements and environmental conditions (Martínez-Ballesta *et al.,* 2010).

Table 5. Average of leaves of number parameter of durian based on impact of scion length and cover type on the success of durian grafting.

Treatment		Average of leaves of number (strands)
Cover type	Individual cover	0.53 a
	Mass cover	2.73 b
LSD 5 %		1.97
Scion lenght	10 cm	1.13 a
	20 cm	2.13 b
LSD 5 %		0.85

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% Least Significant Difference test level

Based on Table 5, mass cover type of treatment was significantly different from individual, with average leaves of number, which were 2.73 and 0.53, respectively. Scions length 20 cm of treatment were significantly different, with average leaves of number of 2.13 strands higher than 10 cm. This was because longer scions contain more carbohydrates than smaller ones, which triggers an increase in number of durian. (Riady & Ashari, 2017) stated that excess carbohydrates in rootstock and scions stimulated the production of several calli, thereby allowing the restoration of the transport network through induction of plant hormones. (Hasana & Ashari, 2017) stated that multiple rootstocks caused an increase in the leaves of number parameter in durian due to the formation of mineral and nutrient transport compared to single rootstocks.

Grafts can grow through wound healing mechanisms and the formation of conductive vessels. Therefore, the formation of the vascular junction is the final and most critical stage in wound healing because after healing, the transport of water and solutes starts from the rootstock to the scion and graft union develops strength. The time required for the completion of the grafting stages is somewhat unpredictable because appropriate methods for assessing the progress of grafting do not yet exist. However, its development can be predicted by both destructive and non-destructive methods, including visual determination of the graft by thermal camera images, vertical cutting of the graft at the union to observe the vascular system, measurement of resistance from scion to rootstock assessing the tensile strength of the graft union and rootstock as an evaluation of hydraulic joint disturbances (Noor *et al.,* 2019).

***Grafting of success (%)*:**ANOVA show that cover type of treatment had a significant difference in grafting of success parameters. However, scions length and interaction between two treatments were not significantly different in grafting of success parameters. (Ghoffar and Ashari, 2017) stated that success of durian grafting was caused by differences in family, rootstock, diameter of the junction of both rootstock and enteres and shoot height. Successful grafting begins with the formation of callus proliferation from both rootstock and scion, formation of callus bridges, differentiation of new vascular tissue from callus cells and production of secondary xylem and phloem. Low or improper callus formation between rootstock and scion can lead to defoliation, decreased scion growth and low grafted plant survival. Thus, the vascular connections at the rootstock and scion interfaces can determine the translocation of water and nutrients, influencing other physiological properties. In addition, the effect of rootstock on nutrient and water uptake is mainly due to physical characteristics, such as lateral and vertical root development, or greater absorption ability (Martínez-Ballesta *et al.,* 2010).

Table 6. Average of grafting of success (%) parameter of durian based on impact of scion length and cover type on the success of durian grafting.

Treatment		Average of grafting of success (%)
Cover type	Individual cover	43 a
	Mass cover	93 b
LSD 5 %		24.84
Scion lenght	10 cm	60
	20 cm	70
LSD 5 %		-

Note: Numbers followed by the same letter in the same column are not significantly different at the 5% Least Significant Difference test level

Based on Figure 6, mass cover type of treatment was significantly different from individual, with average connection success of 93% and 43%. This was because maintenance and grafting technique required in depth attention to ensure a higher success rate. (Rahmatika & Setyawan, 2018a) stated that in the success of grafting technique, rootstock type, technical mastery of propagation, rootstock of maintenance and scions as well as maintenance after grafting must be considered. Grafting techniques through structural and biological mechanisms of grafting between scions and rootstocks were observed through three basic phases, namely joining scions and rootstocks, making callus around the joint and building continuity at the joint through re-differentiation blood vessels. Compatible graft combinations are expected to be mutually beneficial and support both scions and rootstocks where scions can influence different genetic and physiological behaviors causing changes in vegetative development of leaves and stems. The success of grafting can be through the mechanism of wound healing and the formation of conductive vessels. Therefore, the formation of the vascular connection is the last and most critical step in wound healing because after healing, the transport of water and solutes starts from the rootstock to the scion (Noor *et al.*, 2019).

***Conclusion*:** The interaction between cover type and scions of length treatment did not affect grafting technique. However, the treatment of cover type affected the percentage of bud emergence, bud length, leaves of number, and grafting success. The treatment of scions of length also affected the leaves of number. The mass cover type resulted in 93.5% bud emergence, 1.5 cm bud length, 2.73 increase in the leaves of number, and 93% grafting success. Meanwhile, the treatment of scions of length 20 cm increased the leaves of number by 2.13 strands.

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