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The Effect of Grafting Time and Plant Growth Regulator (PGR) Application on Graft Union Success Rate in Jackfruit (*Artocarpus heterophyllus Lamk*)

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A B S T R A C T

Jackfruit (Artocarpus heterophyllus Lamk.) is a tropical fruit plant that has the potential to be developed through vegetative propagation. This study aims to determine the effect of splice time and cytokinin concentration on the success of jackfruit seed linking. The research was carried out at the Sidera Horticultural Food Crop Seedling Center, Sigi Biromaru District, January-March 2025, using a factorial Group Random Design (RAK) with two factors, namely splice time and cytokinin concentration. The results showed that there was no interaction between the two factors. Splicing at 15.00–16.00 gave the best results with a linking time of 3.62 days, a bud length of 7.50 cm, the number of leaves 11.47 leaves, the success of linking 73.33%, and a live connection of 89.33%. Cytokinin 250 ppm produces the fastest linking time of 3.79 days, the success of linking 73.33%, and the highest number of leaves of 47.50 leaves. Thus, the linking time of 15.00–16.00 and cytokinin 250 ppm are the best treatment for jackfruit seedlings.

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INTRODUCTION

Jackfruit (Artocarpus heterophyllus Lamk.) is one of the tropical fruits that is widely grown and cultivated in Indonesia and has high economic value due to its distinctive aroma and sweet taste (Anna et al., 2017). Based on data from the Central Statistics Agency (BPS), jackfruit production in Indonesia in 2022 reached 813,756 tons, then decreased to 789,200 tons in 2023 or decreased by 24,556 tons (3.02%).

Based on the characteristics of texture, taste, and size of the fruit, jackfruit is grouped into two main types, namely pulp jackfruit which has soft, finely fibrous, and juicy fruit pulp so that it is widely used as a processed ingredient, and salak jackfruit which has dense, crispy, bright yellow pulp, and is more often consumed as fresh fruit. In addition to these two types, there are also several other varieties such as mini jackfruit or midget jackfruit which are suitable for cultivation in pots because they are relatively short in size and bear fruit quickly, as well as Betawi jackfruit which has medium fruit size, thick flesh, and medium aroma. The diversity of these types and varieties needs to be supported by propagation techniques that are able to maintain the superior properties of the parent plant.

Generative propagation through seeds often results in non-uniform offspring and takes a relatively long time to fruit, whereas vegetative propagationable to produce plants that have The genetic properties are the same as the parent and accelerate the fruiting period. One of the vegetative propagation techniques that is widely applied to jackfruit plants is grafting, which combines rootstocks that have a strong root system with the upper stem (entres) of superior parent plants so that it is expected to produce plants that have good growth, high productivity, and uniform fruit quality. Trinurani et al. (2020) stated that grafting on jackfruit is able to accelerate the fruiting period and produce uniform fruit quality because the grafting comes from the parent tree that has been proven to be productive.

In addition, Kurniawan and Nuraini (2021) explained that the appropriate use of rootstocks is also able to increase plant adaptability to certain environmental conditions. Hendra et al. (2019) added that grafted plants have the advantage of a faster fruiting life and the aroma and taste of fruit that remains in accordance with the properties of the parent. The success of shoot grafting is influenced by various factors, including the physiological condition of the plant, the quality of the rootstock and entres, the accuracy of the grafting technique, the cleanliness of the tool, environmental conditions such as temperature and humidity, the use of growth regulators (ZPT), and the time of grafting. The timing of grafting is closely related to environmental conditions and plant physiological activities, such as temperature, humidity, and transpiration rates that affect the process of uniting the cambium tissue between the rootstock and the upper stem.

Grafting should be done when the rootstock is in optimal physiological condition and has a healthy and strong root system because this factor greatly determines the success of the formation of connective tissue. The selection of entres from superior parent plants is also an important factor in obtaining plants

with fast growth, high productivity, and better resistance to environmental stresses and diseases (Sudidjo, 2020).

In addition to these factors, the use of cytokinin as one of the growth regulators is known to play an important role in stimulating cell division, tissue differentiation, callus formation, vascular tissue development, and the growth of shoots and leaves. Cytokinin is produced naturally in young root tissues and translocated through xylem vessels to plant stems and shoots. Exogenous administration of cytokinin aims to increase hormone levels in plants so that it is able to activate cell cycle regulatory genes, stimulate the formation of new tissues, accelerate the union of cambium tissue, and increase the success of joint linking.

In this study, several levels of cytokinin concentrations were used, namely 100, 150, 200, and 250 ppm, as well as control without the administration of ZPT. The concentration of 100 ppm was chosen as the initial dose that was able to provide basic hormonal stimulation for the formation of callus without causing negative effects (Lestari et al., 2022).

A concentration of 150 ppm is used for evaluate the cell division response at a moderate level that is able to optimize shoot growth (Rahmawati & Santoso, 2020). Concentration 200 ppm was chosen because it is reported to be able to accelerate the formation of vascular tissue and increase the success of linkages in woody plants (Putra et al., 2021; Nugroho & Prasetya, 2022), while the concentration of 250 ppm is used to determine the maximum response of plant tissues to cytokinin while evaluating the possibility of inhibition due to hormonal imbalances at higher concentrations (Hidayat et al., 2023; Fauzan et al., 2023). Control treatment was used as a comparison to assess the effectiveness of cytokinin administration on callus formation, bud growth, and grafting success percentage. The use of this concentration range is expected to be able to determine the most optimal cytokinin dose and provide information about its interaction with grafting time in increasing grafting success.

Based on this description, it is considered necessary to conduct a study entitled "The Effect of Grafting Time and ZPT Use on the Success Rate of Grafting in Jackfruit Plants (Artocarpus heterophyllus Lamk.)" in order to obtain the most effective combination of grafting time and ZPT concentration in increasing grafting success and producing superior jackfruit seedlings.

THEORETICAL REVIEW

The success of grafting techniques in jackfruit plants is influenced by the selection of plant materials, the compatibility of rootstocks and upstems, and environmental conditions. The upper stem should come from a healthy parent plant and have superior properties, while the rootstock must have a strong, healthy root system, and be able to adapt to environmental conditions. The upper stem that is too young or too old can hinder the linking process. In addition, the suitability of size between the upper stem and the rootstock is very important so that the process of tissue union and translocation of water and nutrients can take place optimally (Purnomo, 2017; Nordey, 2020).

The use of growth regulators (ZPT), especially cytokinins, also plays a role in supporting grafting success because it can stimulate cell division and

differentiation and callus formation in the graft area. Environmental conditions such as temperature and humidity also determine the success of grafting. Temperatures around 25–30°C and high enough humidity can help maintain the freshness of the upper stem, reduce water loss, and support the formation of new tissue. Therefore, post-grafting maintenance, such as maintaining moisture and protecting the joints from direct sunlight and strong winds, is needed to support the healing process and growth of grafted seedlings (Nugraha et al., 2019; Hartmann et al., 2022; Taiz et al., 2023).

The timing of grafting is one of the important factors that can affect the success of grafting. Grafting when the plant is in an active physiological condition can support the healing process and tissue union between the upper and lower stems. The success of grafting is also highly determined by the accuracy of the implementation, environmental conditions, freshness of the inserts, and compatibility between the two parts of the plant. The mismatch in the size of the upper stem and rootstock can cause the cambium tissue to not meet perfectly, thereby inhibiting the translocation of water and nutrients and increasing the risk of grafting failure. Thus, the selection of grafting time, healthy and compatible plant materials, and supportive environmental conditions are the main factors in increasing the success of grafting in jackfruit plants.

METHODOLOGY

This research has been carried out at the Sidera Horticultural Food Crop Seedling Center, Sigi-Biromaru District. Furthermore, it will be held from January to March 2025.

The tools used in this study are calipers, grafting knives, trimming scissors, scissors, cutters, hoes, shovels, buckets, and writing stationery.

The materials used in this study are Tulo 5 and Beka Jackfruit plant seeds (the results of Adelina's research, 2019 which is 5 years old), Cytokinin, plastic cups, label paper, straps, 15 x20 cm polybags.

This study was prepared using a two-factor Group Random Design (RAK) consisting of:

The first factor is the time to implement grafting, which consists of two levels:

W1: 12.00 –14.00

W2: 15:00 -16:00

The second factor is the concentration of Cytokinin which consists of five levels:

Z0: Control (without cytokines) Z1: Cytokinin 100 ppm

Z2: Sitokinine 150 ppm Z3: Sitokinine 200 ppm Z4: Sitokinine 250 ppm

So that there were 10 experimental units and repeated three times so that there were a total of 30 experimental units. Each experimental unit had five sample plant samples that were observed resulting in 150 samples of jackfruit seeds.

RESULTS

Linking Time

The results of the observation of linking time are presented in Appendix Table 1a and the sample fingerprints are shown in Table 1b. The results of the variegated fingerprints show that the treatment of the timing of connection and the administration of cytokinin have a significant effect on the timing of linking, but There is no interaction. The average calculation of linking time based on connection time is shown in Table 1, while linking time based on cytokinin concentration is shown in Table 1.

Table 1. Average Linking Time by Connection Time (days)

	LINKING TIME	
Treatment (Hours)	Average	GDP 5%
12:00-14:00	4.20a	
15:00-16:00	3.62b	0,1

The results of the 5% BNJ Test in Table 2 show that the fastest average linking time was obtained at the time of connection at 15:00 to 16:00 for 3.62 days but it was different from the treatment of the connection time at 12:00-14:00 which was for 4.20 days. The success of higher shoot connection in the afternoon was due to lower temperatures and increased humidity thus maintaining Turgor cells, reduce the rate of transpiration, and accelerate the formation of calluses, while high temperatures during the day increase water retention which inhibits tissue union. These results are in line with the research of Ramadhani and Mulyanto (2022), Sari and Hutapea (2021), and Pratama and Kurniawan (2023) who stated that the physiological conditions of plants in the afternoon are more supportive of the callus formation process and increase grafting success compared to during the day.

Table 2. Average Linking Time by Cytokinin Concentration (days)

Treatment(Hours)	Average	GDP 5%
Controls	3.98c	
100 ppm	3.96bc	
150 ppm	3.93b	0,44
200 ppm	3,91b	
250 ppm	3,79a	

The results of the 5% BNJ Test in Table 3 show that the fastest linkage time at the injection of cytokinin concentration at 250 ppm shows the fastest linkage

time of 3.79 days in contrast to other cytokinin treatments. Cytokinins are able to accelerate callus formation, cell division, tissue differentiation, and the formation of vascular connections between entres and rootstocks, thereby increasing the success of splicing, although plant responses are still affected by cytokinin concentrations, tissue physiological conditions, age of entres, and rootstock compatibility (Rahmadani, 2021; Sitorus, 2022; Nababan, 2023).

Linked Success (%)

The results of the linkage success observations on 5 MSG and 8 MSG are presented in Appendix Table 2a and Appendix 3a and the sample fingerprints are shown in Table 2b and Appendix 3b. The results of the variegated fingerprints show that the time treatment splicing had a noticeable effect on 5 and 8 MSG while cytokinin treatment had an effect on 5 MSG but no different. The average percentage of linking time is presented in Table 4 and Figure 2.

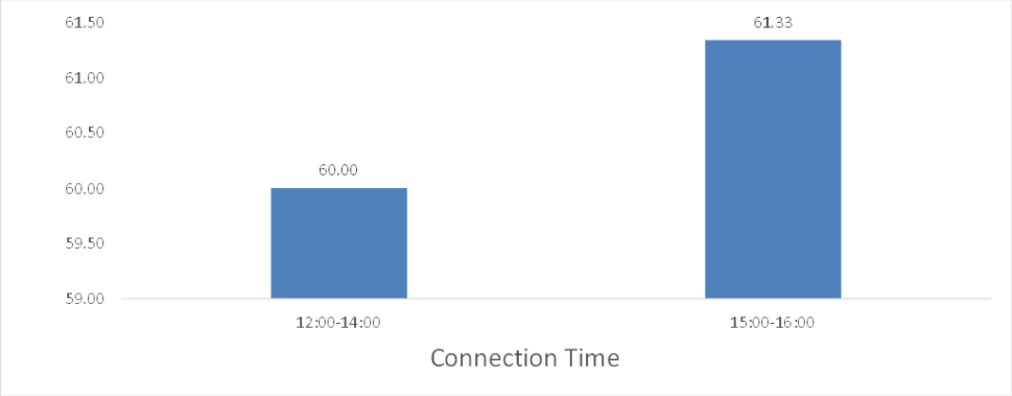

Figure 1. Percentage Successful linking based on connection time at 5 MSG

Based on Figure 2 of the percentage of connection time at 5 (MSG), it can be seen that the connection time at 15.00–16.00 shows a high divided success percentage, which is around 61.33%, but it is no different from the connection time at 12.00–14.00 which reaches 60.00% because the environmental conditions in the afternoon are more supportive, namely the temperature lower and higher humidity thereby reducing plant stress and maintaining metabolic stability. According to Pratama and Kurniawan (2023) and Sari and Pratama (2022), moderate temperatures increase the activity of cells, hormones, and enzymes, thereby accelerating callus formation, tissue unification, and increasing the success of splice compared to during the day.

Table 3. Average 5MSG Success Percentage Based on Treatment Cytokinin

Concentration	Average	GDP 5%
Control	53,33a	
100 ppm	56,67a	
150 ppm	50,00a	
200 ppm	56,67a	
250 ppm	73,33b	

The results of the 5% BNJ test showed that the 250 ppm cytokinin concentration treatment provided the highest success percentage, namely 73.33% and significantly different from the treatment control, 100 ppm, 150 ppm, and 200 ppm. Meanwhile, the control treatment, 100 ppm, 150 ppm, and 200 ppm were not significantly different because have the same letter notation. Cytokinins are capable of accelerates callus formation, cell division, tissue differentiation, and the formation of vascular connections between entres and rootstocks, thereby improving the success of splicing, although the response of plants is still influenced by the physiological conditions of the tissues, the age of the entres, and the compatibility of the rootstock (Rahmadani, 2021; Sitorus, 2022; Nababan, 2023).

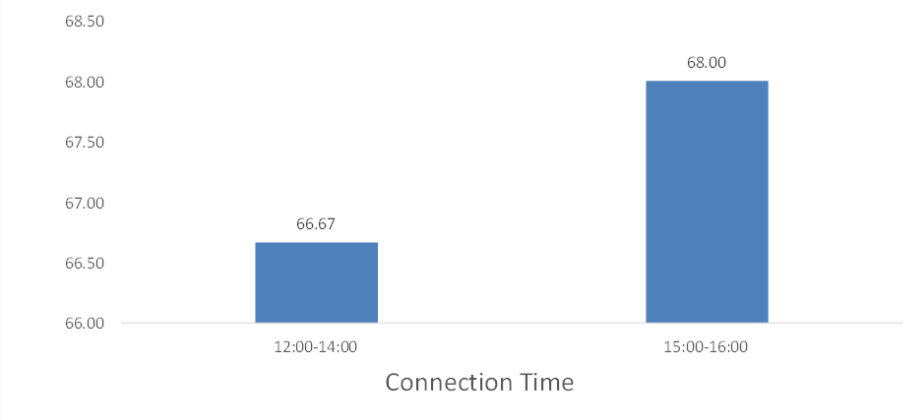

Figure 2. Percentage of Linked Success by Connection Time at 8 MSG

Based on Figure 3, the percentage of linking success based on connection time shows that the link time of 15:00–16:00 results in a percentage of linked success that tends to be higher at around 68%, while at 12.00-14.00 it reached 66.67%. This shows that the connection time is at 15:00-16:00 and 12; 00-14:00 is no different.

Bud Length

The bud length at weeks 3,5, and 7 MSG is presented in Appendix Tables 4a,5a, 6a while the sample fingerprints are shown in Appendix Tables 4b, 5b, 6b. The treatment of the timing of the connection has a noticeable effect, Conversely, the cytokinin concentration treatment had no noticeable effect

Table 4. Average Bud Length 3 MSG, 5, and 7 MSG based on Splicing Time

Treatment	Average Bud Length (MSG)		
	3	5	7
12:00-14:00	2,94a	4,88a	7.33a
15:00-16:00	3.97b	6.89b	7.50b
GDP 5%	0,12	0,10	0,09

The results of the 5% BNJ Test in Table 5, at 3 MSG show that the average length of the longest bud is obtained at the time of connection from 15:00 to 16:00 along 3.97 cm, but it is different from the treatment of the connection time at 12:00-14:00, which is 2.94 cm long.

Number of Leaves

The results of the calculation of the number of leaves at 7 MSG and 8 MSG are presented in Appendix Tables 8a, 9a and the variety fingerprints are shown in Tables 8b and 9b. The results of the variegated fingerprints show that the treatment of the timing of the connection and the application of cytokinin has a significant effect on the number of leaves. 7.50 cm long, but different from the treatment of the splicing time at 12:00-14:00, which is 7.33 cm long. Better shoot growth in the afternoon splicing is supported by lower temperatures and higher humidity, so that plant physiological activity, availability of photosynthesis results, callus formation, and tissue growth take place more optimally, while heat stress during the day can inhibit tissue regeneration and growth hormone activity (Hartman and Kester, 2011; Pratama and Kurniawan, 2023).

But there was no interaction. The average number of leaves based on the timing of the coupling of 7 MSG and 8 MSG is presented in Tables 6 and 7, while in the administration of cytokinin 8 MSG is presented in Table 8

Table 5. Average Number of Leaves (Leaf Strands) based on joining time at 7 MSG

Treatment(Hours)	Average	GDP 5%
12:00-14:00	7,93a	
		0,34
15:00-16:00	9,73b	

The results of the 5% BNJ test in Table 8 show that the highest number of leaves was obtained in the treatment from 15:00 to 16:00 as many as 9.73 pieces, but it was different from the number of leaves at the time of connection from 12:00 to 14:00, which was 7.93 pieces. This is suspected because the lower and stable afternoon temperature supports enzyme activity, cell division, and formation calluses, as well as tissue differentiation, thereby facilitating the formation of transport tissues, the distribution of nutrients and hormones, and increasing the growth of shoots and the number of leaves, while temperatures that are too high can inhibit metabolic activity (Sari and Pratama, 2022; Hakim and Nur Hayanti, 2021).

Table 6. Average Number of Leaves (Strands) at Spawning Time pad 8 MSG

Treatment(Hours)	Average	GDP 5%
12:00-14:00	9.60b	
		0,34
15:00-16:00	11.47a	

The results of the 5% BNJ Test in Table 7 show that the highest number of leaves was obtained in the treatment from 15:00 to 16:00 as many as 11.47 pieces, but it was different from the number of leaves at the time of connection from 12:00 to 14:00, which was 9.60 pieces. This is due to the lower afternoon temperature and stable so that enzyme activity, cell division, callus formation, and tissue differentiation are more optimal, which supports the formation of transport tissues, facilitates the distribution of nutrients and hormones, and increases bud growth and leaf count, while temperatures that are too high can reduce metabolic activity (Sari and Pratama, 2022; Judge and Nur Hayanti, 2021).

Table 7. Average Number of Leaves 8 MSG by Treatment Cytokinin Concentration

Concentration	Average	GDP 5%
Controls	17.00a	
100 ppm	23,50b	
150 ppm	31.00c	
200 ppm	39.00d	
250 ppm	47.50	

The 5% BNJ test in Table 8 shows that the highest number of leaves based on cytokinin administration was obtained at a concentration of 250 ppm as many as 47.50 leaves but it is different from other cytokinin concentrations. The results of the study show that increasing the concentration of cytokinin to the optimal level is able to increase the number of leaves by stimulating

Live Connection Percentage

The percentage of live connections is shown in Appendix Table 10a and the sample fingerprints are shown in Table 10b. The variegated fingerprints show that the timing of the connection has a noticeable effect whereas Cell division, tissue differentiation, and meristem activity at the point of growth, thereby accelerating bud growth and the formation of new leaves. The higher the concentration of cytokinins that are still in the optimal range, the more leaves are formed (Pratama and Kurniawan, 2023; Sari and Putri, 2022). Cytokinin

administration had no significant effect on the success rate of live connections. The average percentage of live connections is presented in Table 9.

Table 8. Average Connection Life Percentage Connection Time
LINKING TIME

Treatment (Hours)	Average	GDP 5%
12:00-14:00	60.00a	
15:00-16:00	89.33b	26,9

The results of the 5% BNJ test showed that the connection time at 15:00–16:00 provided the highest link success percentage of 89.33% and was significantly different from the connection time at 12:00–14:00 which only reached 60.00. The high percentage of live connections at the connection time at 15.00– 16.00 indicates that afternoon conditions are more favorable to grafting success because lower temperatures and higher air humidity are able to suppress the rate of transpiration, reduce water loss at the entres, and maintain

CONCLUSIONS AND RECOMMENDATIONS

Cell turgor during the initial phase before vascular connections with the rootstock are formed. These conditions also accelerate callus formation and vascular tissue union, increasing the success of live connections, while splicing at 12:00–14:00 tends to experience higher temperatures and light intensity, increasing evaporation, inhibiting callus formation, and decreasing the percentage of live connections due to heat stress in plant tissues (Hartmann et al., 2018; Pina & Errea, 2022; Taiz et al., 2023).

Based on the research conducted, the following results were obtained:

1. There was no interaction between the effect of splice time and the use of cytokinin concentration on the success rate of linkage in jackfruit plants.
2. The connection time at 15:00-16:00 provides a faster linking time which is for 3.62 days, the bud length is 7.50 cm, the number of leaves is more which is 11.47 leaves, the success percentage is 61.33% but it is not different when compared to the connection time at 12:00-14:00 which is 60% as well as the percentage of live connections which is 89.33% is no different which is 60%
3. The cytokinin concentration of 250 ppm produced the fastest linking time of 3.79 days, the success rate of linking was 56.67% no different from the cytokinin concentration of 250 ppm, which was 73.33%, the number of leaves in the cytokinin concentration treatment at 250 ppm gave a greater and different number of leaves, namely 47.50 leaves.

FURTHER STUDY

Future research is recommended to examine a wider range of grafting times and plant growth regulator (PGR) concentrations to identify the most effective combinations for improving grafting success in jackfruit (Artocarpus heterophyllus Lamk). Further studies could also investigate different types of PGRs, scion and rootstock characteristics, environmental conditions, and

grafting techniques. Long-term observations are needed to evaluate the effects of grafting treatments on plant growth, survival, productivity, and fruit quality. Such research may provide more comprehensive recommendations for efficient jackfruit propagation and support the development of improved cultivation practices.

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