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Comparative Performance of Montong and Musang King Durian Under Different Grafting Models Implications for Vegetative Propagation Success

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ABSTRACT

Durian (*Durio zibethinus Macropyllus*) has high economic value, but plants grown from seeds generally exhibit variable quality, so elite cultivar seedlings need to be continuously supplied through vegetative propagation. This study evaluates the effect of grafting method, cultivar, and their interaction on the success of durian top-grafting in Tongko Village, Baroko Subdistrict, Enrekang Regency (May–June 2025). The experiment used a two-factor factorial Randomized Complete Block Design: grafting method (top-grafting/M1, wedge grafting/M2, side grafting/M3) and scion cultivar (Montong/V1, Musang King/V2), with 3 replications (18 units). The rootstock was Enrekang local durian aged 1.5–3 months, while scions were taken from healthy plants approximately 5 years old; grafts were tied with polyethylene plastic and covered to maintain humidity. Parameters included time to bud emergence, bud length, number of buds, number of leaves, and success percentage at 50 days after grafting; data were analyzed with Anova and HSD 5% test. Grafting method significantly affected the number of buds, number of leaves, and success percentage; M1 was best (2.22 buds; 4.00 leaves; 100%), while M3 was lowest (1.39 buds; 2.42 leaves). Cultivar significantly affected the number of buds; V1 was higher (2.04) than V2 (1.46). Time to bud emergence and bud length did not differ significantly. There was a significant interaction on success percentage; M1V1 and M1V2 reached 100%, M3V2 was lowest (44.40%).

INTRODUCTION

Durian (*Durio zibethinus* Murr.) has emerged as one of the most economically valuable tropical fruit crops in Southeast Asia, driven by rapidly increasing domestic consumption and expanding international markets. Premium cultivars such as Montong from Thailand and Musang King from Malaysia dominate commercial trade because of their superior fruit quality, high consumer preference, and premium market prices (Sonkaew et al., 2026). Consequently, the demand for genetically uniform and high-quality planting materials has increased substantially to support commercial orchard expansion and sustainable durian production. However, conventional propagation through seeds remains unsuitable for commercial cultivation because it produces high genetic variability, prolonged juvenile periods, and inconsistent fruit quality (Memoranda & Rahayu, 2023). Vegetative propagation has therefore become indispensable for maintaining cultivar identity and ensuring rapid orchard establishment (Shmakov et al., 2024).

Among vegetative propagation techniques, grafting is recognized as the most reliable approach for producing true-to-type durian seedlings while combining the desirable fruit characteristics of elite scions with the vigor and adaptability of seedling rootstocks (Putri et al., 2024). Successful graft union formation depends

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on complex physiological processes involving cambial alignment, vascular reconnection, carbohydrate transport, hormonal signaling, and wound healing (Kim et al., 2026). Failure of these processes results in graft incompatibility, delayed shoot emergence, reduced vegetative growth, or complete seedling mortality. Consequently, grafting success is influenced not only by rootstock–scion compatibility but also by the grafting method employed during propagation (Bhandari, 2021).

Several grafting techniques, including top grafting, side grafting, and insertion (splice) grafting, are commonly applied in commercial nurseries. Previous studies have demonstrated that grafting techniques significantly affect graft survival, shoot emergence, seedling vigor, and subsequent plant development. Likewise, grafting performance varies among cultivars due to differences in anatomical structure, cambial activity, and physiological compatibility (Bartusch & Melnyk, 2020). Nevertheless, existing studies have predominantly evaluated either grafting techniques or cultivar effects separately, whereas comparative assessments integrating elite commercial cultivars with multiple grafting models remain limited (Djidonou et al., 2020).

Recent research has further emphasized that optimizing grafting efficiency requires consideration of multiple biological factors beyond the grafting technique itself, including scion diameter, hormonal regulation, and rootstock quality. While these factors contribute to improved propagation success, the interaction between cultivar characteristics and grafting models remains poorly understood, particularly for internationally important cultivars such as Montong and Musang King (Márkus et al., 2024). Differences in shoot vigor, cambial activity, and healing capacity between cultivars may lead to contrasting responses to identical grafting techniques, ultimately influencing nursery productivity and seedling quality (Musa et al., 2025).

This knowledge gap is particularly relevant because commercial nurseries frequently apply a single grafting technique across all cultivars without considering cultivar-specific physiological responses. Such generalized propagation practices may reduce grafting efficiency, increase production costs, and limit the availability of high-quality planting materials. Developing cultivar-specific recommendations based on scientific evidence is therefore essential for improving nursery performance and supporting the sustainable expansion of the durian industry (Suharjo & Nadja, 2021).

The present study addresses this gap by comparing the vegetative performance of Montong and Musang King under three commonly used grafting models, namely top grafting, side grafting, and insertion grafting. Unlike previous studies that focused primarily on graft survival, this research comprehensively evaluates vegetative propagation success through multiple growth parameters, including graft survival, shoot emergence, shoot length, leaf production, and overall seedling vigor. This integrated approach provides a more comprehensive understanding of how cultivar characteristics interact with grafting models during the early stages of nursery development (Pembengo & Adnyana, 2024).

The novelty of this research lies in the comparative evaluation of two globally important premium durian cultivars across multiple grafting models to identify the most effective propagation strategy for each cultivar. The findings are expected to provide evidence-based recommendations for commercial nurseries, improve propagation efficiency, enhance seedling quality, and contribute to the advancement of vegetative propagation technologies for tropical fruit crops.

MATERIALS AND METHODS

This study was conducted from May to June 2025 in Tongko Village, Baroko District, Enrekang Regency. The materials used included local Enrekang durian rootstocks (aged 1.5 to 3 months) and scions of Montong durian and Musang King durian, compost fertilizer, rice husk charcoal, topsoil, and 20 x 25 cm polybags. The equipment used included grafting shears, budding knives, rulers, measuring tapes, markers, pens, watering cans, notebooks, and plastic bags.

This study employed a Randomized Block Design with two factors. The first factor was grafting technique, consisting of three levels: top grafting (M1), wedge grafting (M2), and side grafting (M3). The second factor was cultivar type, consisting of two levels: Montong cultivar (V1) and Musang King cultivar (V2). Each treatment combination was replicated three times, resulting in a total of 18 treatment units.

RESULTS AND DISCUSSION

1. Time of Shoot Emergence

The observations indicate that the use of various grafting methods and different varieties, as well as the interaction between the use of various grafting methods and different varieties, does not have a significant effect on the time of shoot emergence.

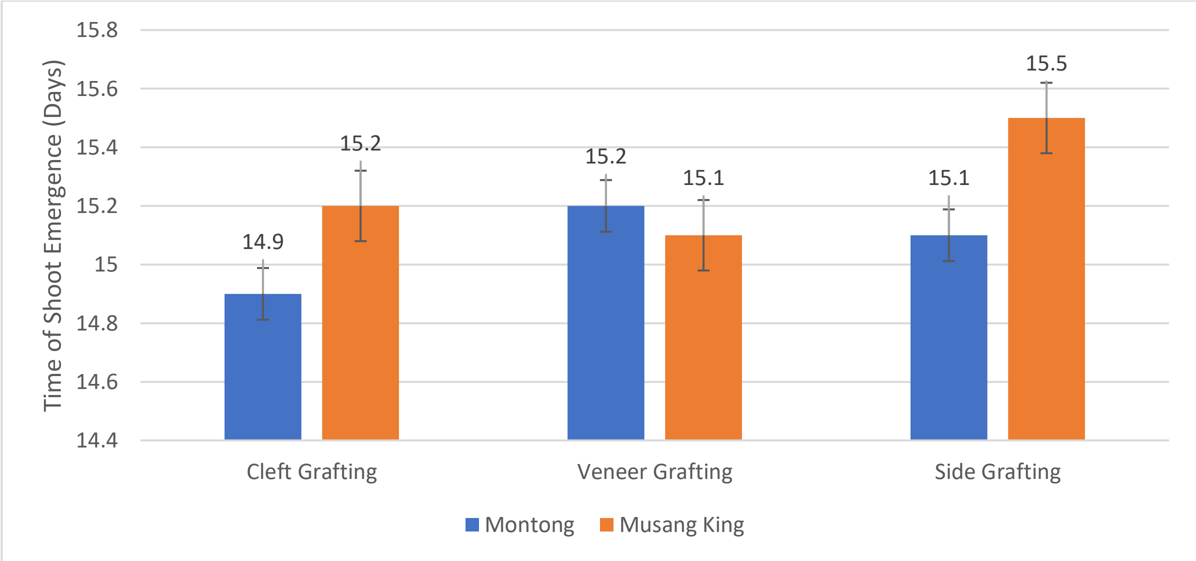

Figure 1. Average time to bud emergence (days) for durian top-grafted plants across various grafting models and durian varieties

The results showed that the Montong variety propagated using the top grafting method had the fastest bud emergence time, namely 14.9 days. Next, the bud emergence time for the Montong variety with the side grafting method and the Musang King variety with the wedge grafting method was relatively the same, at 15.1 days each, while the Montong variety with the wedge grafting method and the Musang King variety with the top grafting method required 15.2 days. The longest bud emergence time was observed in the Musang King variety using the side grafting method, at 15.5 days.

The differences in the timing of bud emergence indicate that each variety responds differently to the grafting method. The Montong variety tends to produce buds more rapidly compared to Musang King, especially when using the top grafting method (Lesilolo et al., 2023). This suggests that the Montong variety has a higher level of compatibility with the top grafting technique, resulting in faster cambium union (Ananto et al., 2024). A successful cambium union accelerates the formation of callus tissue, followed by the development of new xylem and phloem tissue, which enables optimum distribution of water, nutrients, and photosynthetic products. This condition supports the acceleration of metabolic activity in the bud eyes, allowing buds to develop more quickly (Turley & Etchells, 2021).

On the other hand, the Musang King variety exhibited a relatively longer shoot emergence time, especially with the side-grafting method. This is thought to be related to a more prolonged physiological adaptation process prior to the complete union of tissues (Asmawati et al., 2023). Genetic character differences between varieties may affect the speed of callus formation, cambium cell division activity, as well as the balance of growth hormones such as auxin and cytokinin, which play a crucial role in tissue regeneration after grafting. If the formation of vascular tissue occurs more slowly, the supply of water and nutrients to the bud will also be delayed, resulting in a longer time to shoot emergence (Zhai & Xu, 2021).

In the approach of approach grafting, both varieties exhibited nearly identical bud emergence times. This indicates that the approach grafting technique is able to provide relatively uniform tissue union conditions in both varieties, so that differences in genetic characteristics do not significantly affect the speed of bud emergence (Pardo-Alonso et al., 2020). Thus, this method can be considered to have a fairly good level of compatibility in both the Montong and Musang King varieties (Ei & Ismail, 2022).

Although there were differences in values between treatments, the range of sprout emergence time was only around 14.9–15.5 days, so biologically all grafting methods were still able to produce relatively good initial growth (Boonsrangsom et al., 2025). However, the Montong variety propagated through the top grafting method tended to produce shoots more quickly, indicating that this technique has the potential to accelerate the production of ready-to-plant seedlings. Conversely, the Musang King variety required slightly more time to develop shoots, especially when using the side grafting method, which suggests a difference in physiological response to the grafting technique (Bariyyah & Istianingrum, 2021).

The results of this study confirm that shoot emergence speed is influenced by the compatibility between the genetic characteristics of the variety and the grafting method used. Therefore, selecting a grafting technique that matches the variety's characteristics becomes an important factor to improve the efficiency of vegetative propagation of durian and to produce high-quality seedlings in a shorter period of time (Memoranda & Rahayu, 2023).

2. Shoot Length

observation results indicate that the use of various grafting models and different varieties, as well as the interaction between the use of various grafting models and different varieties, does not have a significant effect on shoot length.

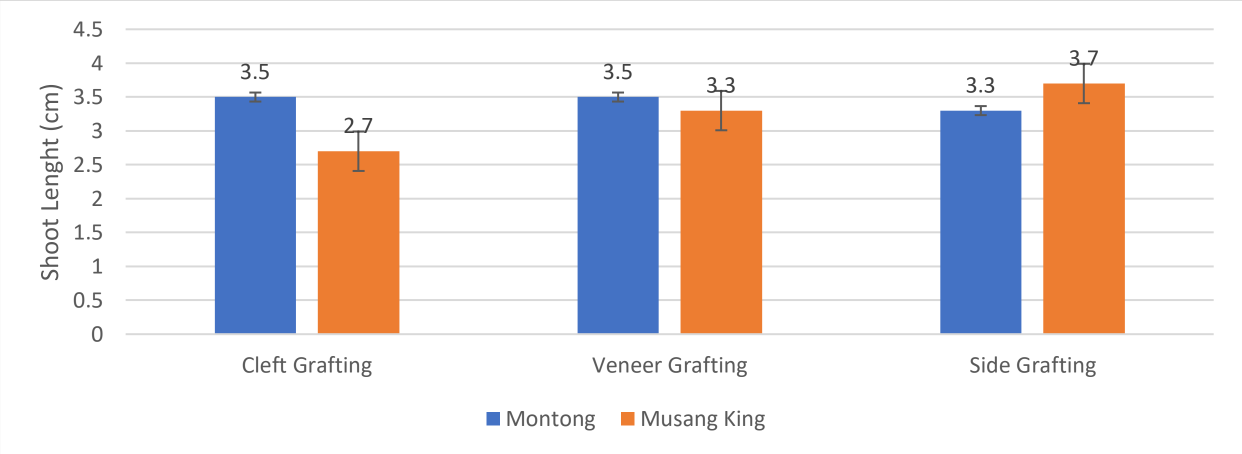

Figure 2. Average shoot length (cm) of durian grafts at 50 days after grafting (DAG) across various grafting methods and durian varieties

Based on the graph, shoot length exhibits different responses for each combination of grafting model and variety. In approach grafting (M1), the Montong variety (V1) produced a shoot length of 3.5 cm, which is higher compared to Musang King (V2), which reached 2.7 cm. This indicates that the approach grafting technique is more effective in promoting shoot elongation in the Montong variety (Kaur et al., 2020).

In patch budding (M2), the shoot length of the Montong variety was 3.5 cm, while Musang King reached 3.3 cm. The relatively small difference indicates that both varieties exhibited almost the same shoot growth response with the patch budding technique, showing that this method can produce relatively uniform shoot growth (Augstein & Melnyk, 2025).

Unlike the previous two models, in side grafting (M3), the Musang King variety produced the greatest shoot length, at 3.7 cm, while Montong reached only 3.0 cm. These results indicate that Musang King has a better capacity for shoot elongation when using the side grafting technique compared to the Montong variety (Ramayana et al., 2022).

The greatest shoot length was obtained with the side grafting combination using the Musang King variety (3.7 cm), while the shortest shoot length was found with top grafting using the Musang King variety (2.7 cm). However, the difference in shoot length among treatments was relatively small, indicating that both varieties are able to adapt to various grafting methods. The variation in shoot length observed is thought to be influenced by the degree of successful cambial union and the ability of each treatment combination to support the distribution of water, nutrients, and photosynthates to the growth point, thereby affecting the rate of shoot elongation in the early growth phase (Santoro et al., 2021).

3. Number of Shoots

The observations indicate that the use of various grafting models and different varieties had a highly significant effect; however, the interaction between the use of various grafting models and different varieties did not have a significant effect on shoot length.

Table 1. Average number of top grafted shoots of durian plants at 50 days after grafting (DAG) in various grafting models and durian varieties

Connection Model	Variety		Average	HSD 5%
	Montong	Musang King		
Cleft Grafting	2.33	2.10	2.22[a]	
Veneer Grafting	2.00	1.28	1.64[b]	0.5
Side Grafting	1.78	1.00	1.39[b]	
Average	2.04[a]	1.46[b]		
HSD 5%	0.4			

Description: Numbers followed by different letters a and b indicate a significant difference based on the HSD test at the 5% level, whereas numbers followed by the same letter indicate no significant difference.

Based on the results of the 5% HSD test on the interaction between grafting method and variety, it was found that the grafting method had a significant effect on the observed parameters. The top grafting method produced the highest mean value, namely 2.22, and was significantly different from approach grafting, which had a mean of 1.64, as well as side grafting with a mean of 1.39. Meanwhile, approach grafting and side grafting did not differ significantly from each other.

For the varietal factor, it was found that the Montong variety produced an average of 2.04, which was higher and significantly different compared to the Musang King variety, which had an average of 1.46 based on the HSD 5% test with a HSD value of 0.4. This indicates that the Montong variety has a greater ability to support grafting success compared to the Musang King variety.

Descriptively, the top grafting combination in the Montong variety produced the highest value at 2.33, followed by top grafting in the Musang King variety at 2.10. Conversely, the lowest value was obtained from side grafting in the Musang King variety at 1.00. These results indicate that using the top grafting technique provides a better response in both varieties, especially in the Montong variety (Choudhary & Padmanabhan, 2021). The differences in success between grafting models are thought to be related to the degree of compatibility in the union of the cambium tissue between the rootstock and scion, enabling faster and more efficient tissue integration in the top grafting technique compared to other grafting models (Rasool et al., 2020). In addition, the genetic factors of the varieties also play a role in determining the ability to form callus and the success of graft union, thus the Montong variety shows better performance than Musang King (Bariyyah et al., 2020; Xuan et al., 2024).

4. Number of Leaves

The observation results indicate that the use of various grafting models has a highly significant effect, whereas the use of different varieties and the interaction between various grafting models and varieties do not have a significant effect on shoot length.

Table 2. Average number of leaves (blades) of top-grafted durian plants 50 days after grafting under various grafting models and durian varieties

Connection Model	Variety		Average	HSD 5%
	Montong	Musang King		
Cleft Grafting	4.11	3.89	4.00[a]	
Veneer Grafting	3.67	3.06	3.36[a]	1,42
Side Grafting	2.83	2.00	2.42[b]	
Average	3.54	2.98		

Description: Numbers followed by different letters a and b indicate a significant difference according to the HSD test at the 5% level, while numbers followed by the same letter indicate no significant difference.

The results showed that the grafting method had a significant effect on the observed parameters, whereas the variety factor did not have a significant effect. The top grafting method yielded the highest average value of 4.00, followed by side insertion grafting at 3.36, and side grafting at 2.42. These results indicate that the grafting technique plays a greater role in determining growth success compared to varietal differences. Descriptively, top grafting provided the best response because it was able to create more optimal union conditions between the rootstock and scion (Manoharan et al., 2026).

The high values observed in the approach graft treatment are thought to be due to a better alignment of the cambium, thereby accelerating callus formation and the union of vascular tissues. Perfect cambial union allows for the formation of xylem and phloem connections, which function to transport water, nutrients, and photosynthetic products more efficiently (Feng et al., 2023). In contrast, in side grafting, the area of cambial contact is relatively narrower, increasing the likelihood of cambial misalignment. This condition causes the tissue regeneration process to proceed more slowly and results in less optimal plant growth (Neto & Onyenedum, 2023).

The variety factor did not show a significant effect, although descriptively the Montong variety had a higher average (3.54) compared to Musang King (2.98). This indicates that both varieties have a relatively similar level of compatibility with the rootstock used. The absence of significant differences suggests that the genetic factors of both varieties are still able to support good tissue union processes, so the growth response is determined more by the grafting method than by the characteristics of the varieties (Wulf et al., 2020).

The results of the study confirm that the selection of grafting technique is an important factor in increasing the success rate of plant propagation. Top grafting is the most recommended technique because it produces the best growth response and is not significantly different from approach grafting, but both are superior to side grafting (Loupit et al., 2023). Therefore, the application of top grafting or approach grafting can be chosen as a more effective vegetative propagation method to obtain seedlings with higher graft union success and better growth (An et al., 2021).

5. Success Rate of Connections

The results of observations and analysis of variance indicate that the use of different grafting models has a highly significant effect, while the use of different varieties does not have a significant effect, whereas the interaction between the use of different grafting models and different varieties has a significant effect on the percentage of success.

Table 3. Average success rate (%) of top grafting in durian plants 50 days after grafting (DAG) for various grafting models and different durian varieties

Connection Model	Variety		Average	HSD 5%
	Montong	Musang King		
Cleft Grafting	$100.00^{a}{}_{x}$	$100.00^{a}{}_{x}$	100.00	44.6
Veneer Grafting	$55.50^{a}{}_{x}$	$77.73^{a}{}_{x}$	66.62	
Side Grafting	$77.73^{a}{}_{x}$	$44.40^{a}{}_{y}$	61.07	
Average	77.74	74.04		

Description: Numbers followed by different letters a and b indicate a significant difference according to the HSD test at the 5% level, while numbers followed by the same letter indicate no significant difference.

The results of the study indicate that the success rate of grafting is influenced by the combination of grafting method and cultivar. The apical grafting combination in both Montong and Musang King cultivars yielded the highest success rates, namely 100.00%, indicating that both cultivars have very high compatibility when the apical grafting technique is used. Conversely, using the wedge grafting method, the success rate decreased to 55.50% in Montong and 77.73% in Musang King, while side grafting resulted in values of 77.73% in Montong and 44.40% in Musang King. These results show that the effectiveness of each grafting technique differs for each cultivar, particularly in the side grafting method, which produced the lowest response in the Musang King cultivar (Memoranda & Rahayu, 2023).

The high success rate of top grafting is thought to be because this technique allows for a more precise alignment of the cambium between the rootstock and the scion. The correct positioning of the cambium accelerates callus formation, which then develops into new vascular tissue, enabling the flow of water, nutrients, and photosynthates to proceed unimpeded (Assunção et al., 2021). In addition, the incision surface in top grafting is relatively wider and more stable, making it easier for the scion to fuse with the rootstock. This condition supports the healing process of the graft union and reduces the risk of failure due to desiccation or infection at the graft site (Wang et al., 2024).

Side grafting shows a lower success rate, especially in the Musang King variety. This is thought to be because the side grafting technique results in a narrower cambium contact area, making tissue union more difficult if the cambium positions are not perfectly aligned. Differences in stem morphological characteristics, such as stem diameter, bark thickness, and cambium activity among varieties, can also affect grafting success (Suharjo & Nadja, 2021). Therefore, in the Musang King variety, the side grafting technique results in a lower success rate compared to Montong, indicating that this variety requires grafting techniques with a higher degree of precision (Pembengo & Adnyana, 2024).

The results of the study indicate that top grafting is the most effective technique for achieving a high grafting success rate in both varieties. This technique can achieve success rates up to 100%, thus it is more highly recommended as a method for vegetative propagation compared to approach grafting or side grafting (Bhandari, 2021). These findings confirm that grafting success is influenced not only by the genetic factors of the varieties but is also greatly determined by the accuracy of the grafting technique used (Hunter, 2021). Therefore, selecting the appropriate grafting model is a crucial step in producing high-quality, uniform seedlings with a high survival rate.

CONCLUSION

Grafting model significantly affected shoot number, leaf number, and grafting success, while variety had limited influence. The shoot grafting method consistently produced the highest grafting success (100%) and superior early seedling growth in both Montong and Musang King. Therefore, shoot grafting is recommended as the preferred propagation technique for producing vigorous and uniform durian seedlings, while future studies should evaluate its long-term field performance and fruit productivity.

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