Agrogenesis Journal of Sustainable Agriculture and Innovation. 2025. 1(1); 100-109

AGROGENESIS
Journal of Sustainable Agriculture and Innovation
www.agrogenesis.umi.ac.id

Growth of Cocoa Put Joint Seedlings (*Theobroma cacao* L.) In Varieties and the Number of Boots

Muh Ishar Musa [1]*, Netty Syam[1], Abdul Haris[1]

[1] Agrotechnology Study Program, Faculty of Agriculture, Universitas Muslim Indonesia, Urip Sumoharjo km 5, Panaikang, Panakukkang District, Makassar City, South Sulawesi 90231, Indonesia.

ARTICLE INFO

Keywords:
Cocoa
Bud eyes
Connect to shoots
Variety

Article History:
Received: May 17, 2025
Accepted: June 26, 2025

*) Corresponding author:
E-mail: netty.said@umi.ac.id

ABSTRACT

This research aims to find out which varieties provide success in shoot grafting of cocoa seedlings, to find out the effect of the number of shoots on the success of shoot grafting of cocoa seedlings and to find out the interaction between the type of variety and the number of shoots in providing a better response to the success of shoot grafting of cocoa seedlings. This research was carried out in the form of a randomized block design with 2 factors, the first factor was variety with 3 levels, namely MCC 02 variety, Sulawesi variety 1 and Sulawesi variety 2. The second factor was the number of shoots with 3 levels, namely 2 shoots, 4 shoots and 6 shoots. From these two factors, 9 treatment combinations were obtained, with 3 repetitions to obtain 27 experimental units. The results of the research showed that the use of the MCC 02 variety had a positive effect on the growth of cacao shoot grafting seedlings at the time of shoot emergence, namely 15.33 DAT and the number of leaves, namely 3.98. The use of 2 buds had the best effect on the growth of cacao shoot grafting seedlings with a number of leaves of 4.42 and shoot length of 7.72 cm. The interaction between the Sulawesi 1 variety with 2 buds gave the best influence on the growth and shoot grafting success of cocoa seedlings on the number of leaves, namely 4.67 pieces and the interaction between the Sulawesi 2 variety with 2 buds gave the best influence on shoot length, namely 8.07 cm.

INTRODUCTION

Cocoa plays an important role as a plantation commodity in the agricultural sub-sector in Indonesia's economic activities. In addition to oil and gas, cocoa is also one of the important commodities that generates foreign exchange for Indonesia's exports (Izzatin et al. 2023). According to the Ministry of Industry (2022), one of Indonesia's plantation export commodities is cocoa. Based on data from the International Cocoa Organization (ICCO) in 2021/2022, Indonesia is ranked third in the world as a country processing cocoa products. In addition, Indonesia is ranked sixth in the world as the largest producer of cocoa beans.

According to the Directorate General of Plantations (2020), cocoa plants in Indonesia are still experiencing a decline from 2019 total production of 783,987 tons to 2020 around 739,483 tons. This is still very low considering that Indonesia is the third largest producer in the world. The causes of this condition are poor selection of planting materials, less than optimal cultivation techniques, old plants, and problems with attacks by plant-disturbing organisms (Keytimu, 2023). The vegetative propagation technology most widely applied by cocoa farmers is grafting. This technology is easy to do, the materials used are easy to obtain, and the cost is cheap. Grafting is a plant propagation technique by combining the rootstock of a selected and adaptive parent tree in the local area with the scion of a superior variety that produces high yields. Grafting is also intended to improve the properties of the scion and obtain plants that produce quickly (Naim & Sirdam, 2022).

The grafting technique is carried out by making a gap in the lower stem and inserting the upper stem (scion) which has at least 3 buds (Agustina, 2019). Using too many buds will have an impact on the efficiency of seedling use and abnormal plant growth, due to non-uniform seedling growth (Zaini, et al. 2017). The number of buds is very important for the root initiation process, because the roots are also a place to produce auxin which will be translocated to the base of the cuttings and is needed for cell differentiation. Zaini et al. (2017) stated that the more buds planted, the longer the initial germination of the plant, because the food reserves in

ISSN: 3090-2657
DOI: https://doi.org/10.33096/agrogenesis.v1i1.736

the seeds are greater, allowing for longer germination. Therefore, the germination of longer grafted seedlings and the number of buds is greater, the germination is not uniform.

MATERIALS AND METHODS

This research was conducted in Lambara Harapan Village, Burau District, East Luwu Regency. Located at an altitude of ± 10 m above sea level, the average annual rainfall is around 116 mm/month, the average daily air temperature is 32 oC according to Schmidt Ferguson. This research took place from September to October 2024. The materials used were cocoa seeds, 3 varieties of grafts, namely MCC 02, Sulawesi 01 and Sulawesi 02, and shade. The tools used were cutting knives, pruning shears, elastic plastic, plastic covers (ice plastic), labels, meters/rulers and stationery.

This research was conducted in the form of a 2-factor randomized block design, the first factor was the variety with 3 levels, namely the MCC 02 variety, the Sulawesi 1 variety and the Sulawesi 2 variety. The second factor was the number of shoots with 3 levels, namely 2 shoots, 4 shoots, and 6 shoots. From these two factors, 9 treatment combinations were obtained, with 3 replications, thus obtaining 27 experimental units, each experimental unit using 5 plant units, so that the total number of plants used was 135 plants.

RESULTS AND DISCUSSION

1. Shoot Appearance Time

The results of observations on the emergence time of shoots of cocoa grafted seedlings with the treatment of various types of cocoa varieties and the number of buds and analysis of variance showed that the use of various types of cocoa varieties and the number of buds and the interaction between varieties and the number of buds did not have a significant effect on the emergence time of shoots of cocoa grafted seedlings.

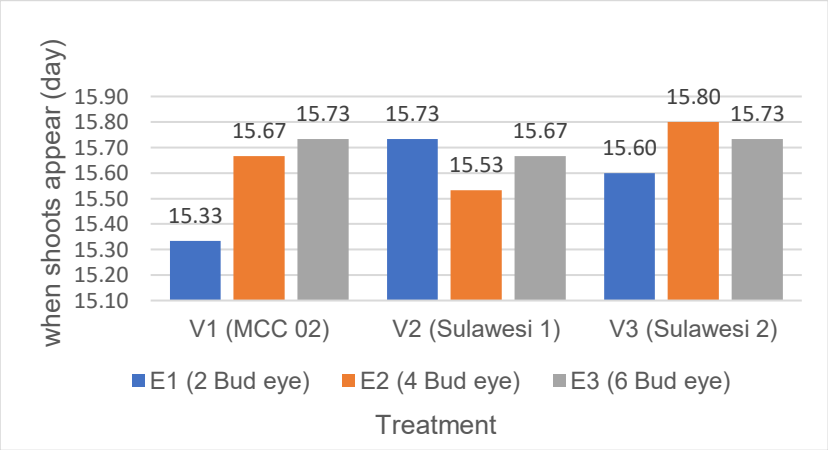

Figure 1. Average time for shoots to appear on cocoa grafted seedlings for various varieties and number of buds.

Based on figure 1, In the study of grafted cocoa seedlings, the rate of shoot emergence is critical for assessing the performance of different varieties and grafting techniques. The findings suggest that using the MCC 02 variety with two buds (designated as V1E1) yields a notably quicker shoot emergence time, averaging 15.33 days, compared to the Sulawesi 2 variety with four buds (V3E2), which averages 15.80 days. The emergence time is a vital parameter, reflecting the physiological compatibility and the efficiency of the grafting process.

Grafting success and subsequent growth can be significantly influenced by the choice of rootstock and scion characteristics, including the number of buds utilized in the grafting process. This phenomenon is supported by findings in other species for instance, variations in shoot emergence times have been documented depending on rootstock and cultivar combinations in different studies (Öztürk, 2021). Similarly, research has shown that scion characteristics, such as the number of buds, impact shoot growth rates and the overall success of grafting ventures, aligning with the data observed in the cocoa seedlings (Asmawati et al., 2023).

Evidence indicates that grafting is not merely a mechanical process but rather a physiological interaction that underscores the importance of both rootstock and scion vigor. Studies have demonstrated that successful grafting is contingent upon the alignment of graft tissues and compatibility between plant segments. This relationship affects not only callus formation but also subsequent shoot and root growth, as noted in broader grafting research (Kermite et al., 2024). Furthermore, optimizing grafting conditions including environmental factors can significantly accelerate shoot emergence and enhance growth performance. For example, light treatments have been shown to positively influence growth metrics in grafted seedlings (Moosavi-Nezhad et al., 2021).

Moreover, the physiological response of different scion and rootstock combinations can influence the time it takes for shoots to emerge after grafting. In the context of cocoa, the rapid emergence of shoots from MCC 02 indicates notable compatibility and vigor traits promoting efficient growth processes. Conversely, the Sulawesi 2 variety's longer emergence period may reflect less ideal compatibility or vigor characteristics in comparison to MCC 02 (Meilani et al., 2023), the differential emergence times observed between the MCC 02 and Sulawesi 2 varieties underscore the significance of careful selection of both bud count and varietal characteristics in cocoa grafting operations. Understanding these dynamics is crucial for achieving optimal growth and yields in cocoa cultivation.

2. Number of leaves

The results of observations on the number of leaves of cocoa grafted seedlings with the treatment of various types of cocoa varieties and the number of buds and analysis of variance showed that the use of various types of cocoa varieties did not provide a significant effect, while the use of the number of buds had a very significant effect on the number of leaves and the interaction between the type of variety and the number of buds had a significant effect on the number of leaves of cocoa grafted seedlings.

Table 1. The average number of leaves (strands) of cocoa grafted seedlings on various types of varieties and the number of buds

Treatment	Bud eye			LSD 5%
	2	4	6	
MCC 02	4,23$^{a}_{x}$	3,80$^{a}_{x}$	3,90$^{a}_{x}$	1,09
SULAWESI 1	4,67$^{a}_{x}$	4,13$^{a}_{x}$	2,70$^{b}_{y}$	
SULAWESI 2	4,37$^{a}_{x}$	3,80$^{a}_{x}$	3,47$^{a}_{x}$	

Note: Numbers followed by different letters in the same row (a,b,c) and column (x,y,z) are significantly different at the 5% LSD test level.

Table 1 shows that the highest average number of leaves was obtained based on the LSD test results, which revealed a significant difference in the average leaf count across grafting treatments of the Sulawesi 1 variety. The highest average, 4.67 leaves, was recorded in seedlings grafted with two buds (V2E1), whereas the lowest average, only 2.70 leaves, was observed in those grafted with six buds (V2E3). This stark contrast emphasizes the influence of bud number on the physiological growth parameters of grafted cocoa seedlings.

The variation in leaf number can be attributed to the physiological advantages associated with the number of buds used. Research on grafting practices supports that both the quantity and quality of buds can significantly affect the success of graft union formation and the subsequent growth of grafted seedlings (Wei et al., 2022). Specifically, although the referenced study focuses on the variation of metabolic compounds in different Camellia oleifera varieties and their relationship with grafting success, it highlights the importance of bud composition in achieving optimal growth, which indirectly supports the findings of this study. Therefore, it is highly plausible that V2E1 benefited from more favorable conditions that stimulated leaf development compared to V2E3.

Importantly, the differences in leaf production are also consistent with other studies that demonstrate the relationship between bud number and plant vigor. Although Asmawati et al. (2023) discuss the success and growth of grafted durian seedlings in relation to rootstock age and the number of scion buds, their study captures the fundamental idea that grafting parameters influence overall growth performance, even though it does not directly pertain to cocoa seedlings. Hence, while it broadly supports the concept of graft effectiveness, it lacks specificity to our current context.

Furthermore, the literature indicates that variations in grafting methods can significantly impact growth outcomes, suggesting that optimizing grafting techniques is crucial (Liu et al., 2021). This aligns with the current finding that V2E1 exhibited a higher leaf count compared to V2E3. Some studies have demonstrated that grafting techniques influence overall plant performance and vigor, indicating the need for more robust methods to increase grafting success.

In addition, environmental factors, including differences in grafting techniques, may also explain the disparities observed in relation to bud number. Studies suggest that the physiological condition of the graft union and its responses to environmental factors can significantly affect growth parameters (Solórzano et al., 2023; Wahyudi et al., 2023). Although the LSD test results indicate that grafting with two buds in the Sulawesi 1 variety yields a higher leaf count than with six buds, this insight fits within the broader context of grafting research, particularly regarding the influence of bud number on plant vigor. Further research that investigates the specific physiological mechanisms affecting graft success and growth parameters will be essential to optimize cocoa propagation techniques.

3. Number of shoots

The results of observations on the number of shoots of cocoa grafted seedlings with the treatment of various types of cocoa varieties and the number of shoot eyes and variance analysis showed that the use of various types of cocoa varieties and the number of shoot eyes and the interaction between the type of variety and shoot eyes did not have a significant effect on the number of shoots of cocoa grafted seedlings.

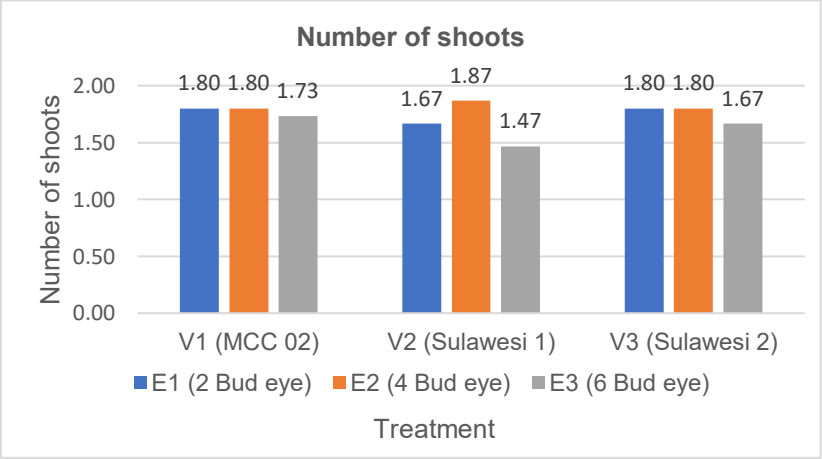

Figure 2. Average number of shoots of cocoa grafted seedlings of various varieties and number of shoot eyes

Based on Figure 2, the effectiveness of the Sulawesi 1 variety in relation to the number of shoots produced in grafted cocoa seedlings provides valuable insights into the biology of grafting in cacao plants. The results show that seedlings grafted with four buds (V2E2) produced an average of 1.87 shoots, which is higher than the 1.47 shoots produced by seedlings grafted with six buds (V2E3). This phenomenon indicates that the number of buds used in the grafting process can influence shoot development and the overall vigor of the seedlings.

The variable shoot numbers can be attributed to the physiological responses of the seedlings based on the number of buds. Research shows that optimal bud numbers can enhance grafting success rates, which is critical for initiating robust growth in grafted plants. For instance, with less competition among buds, as seen with two-bud grafts, resources may be more readily diverted to developing a greater number of shoots (N'Zi et al. ,2023). This aligns well with findings that highlight the importance of rootstock-scion compatibility and proper tissue alignment, both of which can substantially influence growth outcomes (Olayemi et al., 2022).

Furthermore, the underlying physiological processes associated with varying bud numbers could explain the disparity in shoot counts. Rootstock-scion interactions play a significant role in the size and growth of grafted plants, suggesting that certain grafting configurations could lead to superior shoot

proliferation due to improved physiological integration and nutrient uptake (Ruseani et al., 2022). In essence, the physiological characteristics of the scion, influenced by the number of buds, can determine how effectively seedlings can allocate resources to shoot development.

The notion that fewer buds may facilitate better shoot emergence is reinforced by principles found in other species, where it has been documented that reduced bud competition leads to higher levels of biomass allocation toward desirable growth metrics, including shoot density (Akpalu et al., 2021). Although the study focused on different plant types, it provides a compelling justification for the observed differences in shoot counts among various bud configurations.

Moreover, adopting effective grafting strategies and understanding their implications on aspects such as nutrient allocation and water relationships is paramount for improving cocoa seedling performance. Consistent watering, for instance, has been shown to affect shoot development critically; thus, ensuring adequate environmental conditions may further amplify the benefits of utilizing effective grafting practices (Zasari et al., 2023), the improved shoot counts for the Sulawesi 1 variety with four buds (V2E2) may be attributed to more favorable physiological conditions that arise when less bud competition is present. This aspect of grafting techniques is significant as it informs growers about the importance of choosing optimal bud numbers to enhance seedling performance, ultimately supporting better cocoa production outcomes.

4. Shoot length

The results of observations of the average length of shoots of cocoa grafted seedlings with the treatment of various cocoa varieties and the number of buds and analysis of variance showed that the use of various cocoa varieties did not provide a significant effect, while the use of several numbers of buds had a very significant effect on the length of shoots and the interaction between varieties and several buds had a significant effect on the length of shoots of cocoa grafted seedlings.

Table 2. The Average shoot length (cm) of cocoa grafted seedlings on various types of varieties and number of shoot eyes

Treatment	Bud eye			LSD 5%
	2	4	6	
MCC 02	$7,45^{b}_{x}$	$6,87^{b}_{x}$	$6,08^{b}_{x}$	1,75
SULAWESI 1	$7,63^{b}_{x}$	$6,42^{b}_{x}$	$5,04^{b}_{y}$	
SULAWESI 2	$8,07^{a}_{x}$	$5,54^{b}_{x}$	$7,00^{b}_{x}$	

Note: Numbers followed by different letters in the same row (a,b,c) and column (x,y,z) are significantly different at the 0.05% LSD test level.

Based on table 2 of the LSD test indicate that the interaction of the Sulawesi 2 variety with two buds (V3E1) yielded the highest average shoot length of 8.07 cm, significantly greater than the averages for other treatments. Specifically, the Sulawesi 1 variety with six buds (V2E3) recorded an average shoot length of only 5.04 cm. This difference underscores the importance of both varietal selection and bud number in the growth performance of grafted cocoa seedlings.

The variance in shoot length suggests that the Sulawesi 2 variety exhibits enhanced growth potential under conditions involving fewer buds compared to the Sulawesi 1 variety. Previous studies have indicated that plant vigor and growth rates can be substantially influenced by the physiological and genetic attributes of the cultivar used, particularly regarding techniques like ring budding, which can enhance compatibility and nutrient allocation in grafted plants Wahyudi et al. (2023).

Moreover, the observation that the six-bud treatment (V2E3) resulted in a shorter shoot length (5.04 cm) may indeed reflect potential competition among the buds for resources. Research indicates that increased intra-plant competition can lead to suboptimal growth conditions for individual shoots, thereby stunting their development (Meilani et al., 2023). Having more buds may diminish the resources available for each shoot, leading to reduced shoot length and vigor. This is consistent with findings in the literature that suggest fewer buds can enhance growth performance by reducing intra-plant competition and improving resource allocation to more viable shoots (Aziz et al., 2024).

The analysis aligns with broader agricultural insights regarding grafting and its implications for plant growth. Techniques such as grafting have been shown to improve yield and growth characteristics of

cocoa plants by optimizing grafting interactions, which can be significantly influenced by the choice of techniques and bud management (Meilani et al., 2023). By optimizing these biological processes, growers can significantly enhance agricultural outcomes.

External factors such as environmental conditions and growing practices can also greatly influence the performance of these varieties (Uljanah & Uyun, 2021). Variations in nutrient availability, moisture content, and disease resistance associated with specific grafting combinations are critical to the overall success and growth of cocoa seedlings. Hence, understanding and optimizing these growth conditions is vital for sustainable cocoa production, the interaction between the Sulawesi 2 variety with two buds (V3E1) leading to the highest shoot length can be viewed as a manifestation of effective bud management and varietal selection within the grafting framework. This observation suggests a need for further exploration into the physiological mechanisms underlying these growth patterns, as well as their implications for practices aimed at enhancing cocoa production efficiency.

5. Leaf area

The results of observations of the leaf area of cocoa grafted seedlings with various types of cocoa varieties and the number of shoot eyes and variance analysis showed that the use of various types of cocoa varieties and the number of shoot eyes and the interaction between the type of variety and shoot eyes did not have a significant effect on the average leaf area of cocoa grafted seedlings.

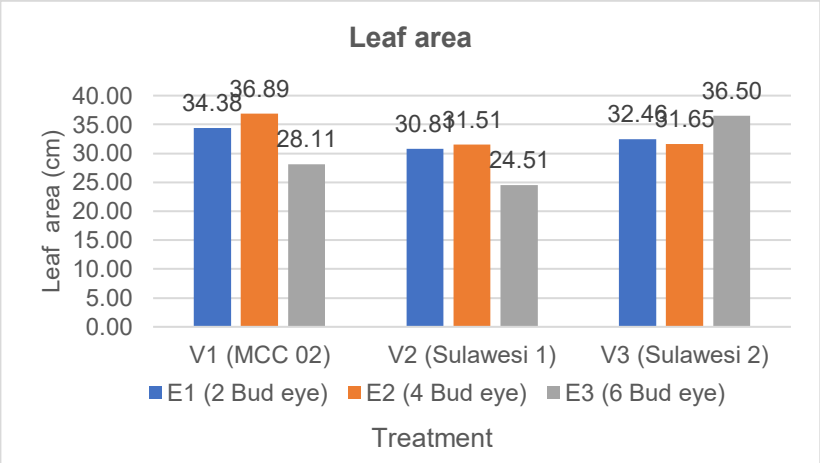

Figure 3. Average leaf area of cocoa grafted seedlings of various varieties and number of shoot eyes

The results presented in Figure 3 indicate that the use of the MCC 02 variety with four buds (V1E2) significantly increases the leaf area of grafted cocoa seedlings, with an average of 36.89 cm². In contrast, the Sulawesi 1 variety with six buds (V2E3) exhibited a much lower leaf area, at 24.51 cm². This difference highlights the importance of varietal selection and the number of buds used in optimizing the growth performance of cocoa seedlings.

The relationship between bud quantity and leaf area can be attributed to how the number of buds affects resource allocation and plant vigor. In grafted plants, fewer buds may lead to enhanced growth rates for individual shoots due to reduced competition for nutrients, water, and light. This aligns with the findings of Ruseani et al., which demonstrate the influence of scion genotype on plant biomass and growth responses, suggesting that certain cocoa clones, like MCC 02, may possess superior traits that enhance leaf area development compared to other varieties Ruseani et al. (2022).

Furthermore, the beneficial outcomes observed with the MCC 02 variety could be linked to its genetic disposition. The higher leaf area seen in the MCC 02 variety could therefore be indicative of its superior capability to allocate resources efficiently when fewer buds are present. This genetic advantage is crucial when considering the grafting method employed, as it plays a substantial role in shaping the physiological responses of the grafted seedlings.

The role of leaf area is pivotal in terms of photosynthetic capacity and nutrient uptake. Increased leaf area enhances the plant's ability to capture light energy, thereby improving photosynthetic rates, essential for overall growth and yield potential. Given that the establishment of a healthy leaf area directly correlates

with the plant's efficiency in photosynthesis, the enhanced leaf area for MCC 02 (V1E2) is likely facilitating higher photosynthetic outputs compared to the Sulawesi 1 (V2E3), which has a constrained leaf area (Palad & Aminah, 2021).

In the broader context of cocoa cultivation, these findings support the notion that optimizing grafting methods by selecting both suitable varieties and appropriate bud counts can lead to greater leaf area development, thereby fostering healthier and more productive plants. The positive contributions of leaf area to growth, as indicated by Olayemi et al., emphasize that fostering conditions conducive to improving leaf area should be a primary focus in cocoa cultivation strategies (Olayemi et al., 2022). Significant difference in leaf area between the MCC 02 variety with four buds and the Sulawesi 1 variety with six buds illustrates the critical impact of variety and bud management in cocoa grafting. This finding highlights the importance of selecting suitable plant varieties and underscores the need for further research into the physiological mechanisms that underpin these growth responses.

6. Percentage of successful grafting

The percentage data of grafting success rate gives the lowest percentage of success rate in the V2E3 treatment. The use of Sulawesi 1 and 6 bud varieties with the lowest percentage is 80.00%. Based on the observation data, the percentage of cuttings growing is shown in the graph in the following figure.

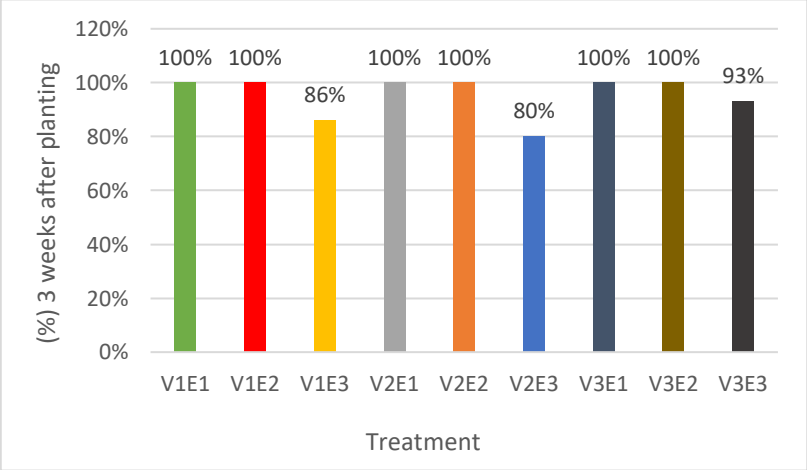

Figure 4. Percentage of success of cocoa seed grafting

Based on Figure 4, the grafting success rates among various plant varieties emphasize the importance of evaluating the specific outcomes of the Sulawesi 1 (V2E3), MCC 02 (V1E3), and Sulawesi 2 (V3E3) treatments. The Sulawesi 1 variety showed a relatively lower grafting success rate of 80%, which presents a notable challenge in achieving consistent results across different cocoa varieties. In contrast, the MCC 02 variety achieved a success rate of 86%, while the Sulawesi 2 variety recorded the highest rate at 96% (Imam et al., 2023; Ruseani et al., 2022; Arjoo et al., 2024).

The variation in grafting success can be attributed to several factors, including compatibility between rootstock and scion, the specific grafting technique used, and the environmental conditions during the grafting process (Sadeghi-Majd et al., 2022; Kouakou et al., 2021; Senthilvadivu et al., 2022; Imam et al., 2023). For example, studies on grafting methods have emphasized that techniques such as cleft grafting may produce different outcomes depending on the plant species and cultivation conditions, underscoring the importance of selecting the appropriate grafting method (Senthilvadivu et al., 2022; Das et al., 2023; Uyanık et al., 2022). Furthermore, the timing of grafting and the physiological condition of the plant materials at the time of grafting have been shown to significantly influence success rates (Mugal et al., 2024; Öztürk, 2021; Arjoo et al., 2024).

It is important to note that the grafting success rates measured at three weeks after grafting (WAG) reflect not only the initial graft union but also the fundamental compatibility between the scion and rootstock, which affects long-term plant development (Imam et al., 2023; Padrón et al., 2022). In addition, studies have reported that closer genetic relationships between scion and rootstock tend to improve compatibility and success rates supporting the results observed in the MCC 02 and Sulawesi 2 varieties (Ruseani et al., 2022; Purnama et al., 2023).

The high grafting success rates observed reaching up to 100% in other treatments under optimal conditions highlight the potential for further refinement of grafting practices (Mugal et al., 2024). Overall, this comparative analysis illustrates the importance of selecting compatible varieties and optimizing grafting techniques, timing, and environmental conditions to improve outcomes. Continued research in this field will be crucial in addressing the complexities and enhancing the success of grafting in cocoa and other horticultural crops.

CONCLUSIONS

The use of the MCC 02 variety tends to have a positive effect on the growth of grafted cocoa seedlings, as indicated by the emergence of shoots at 15.33 days after planting and an average of 3.98 leaves. The use of two buds showed the most favorable effect on the growth of grafted cocoa seedlings, with an average of 4.42 leaves and a shoot length of 7.72 cm. The interaction between the Sulawesi 1 variety and two buds resulted in the best performance in terms of leaf number, reaching an average of 4.67 leaves. Meanwhile, the interaction between the Sulawesi 2 variety and two buds yielded the best result in shoot length, with an average of 8.07 cm.

REFERENCES

Akpalu, M., Ofosu-Budu, G., Kumaga, F., Ofori, K., & Mintah, L. (2021). Field performance and survival of cocoa seedlings raised in different growing media. Acta Universitatis Sapientiae Agriculture and Environment, 13(1), 100-112. https://doi.org/10.2478/ausae-2021-0009

Asmawati, A., Inderiati, S., & Hambali, A. (2023). The survival rate and growth of grafted-seedling of durian (durio zibethinus murr.) using 3 rootstocks ages and 3 levels of scion buds. Asian Journal of Agricultural and Horticultural Research, 10(4), 432-439. https://doi.org/10.9734/ajahr/2023/v10i4283

Aziz, W., Abdulrahman, H., & Saeed, A. (2024). Response of some varieties of beans phaseolus vulgaris l. in the plastic house and spraying with zinc oxide nanoparticles in vegetative growth qualities. Iop Conference Series Earth and Environmental Science, 1371(4), 042004. https://doi.org/10.1088/1755-1315/1371/4/042004

Das, M., Sahoo, D., Ponnam, N., Acharya, G., Sahu, G., Tripathy, P., & Mahapatra, S. (2023). Germination and graft compatibilty study of wild solanum spp and brinjal root stocks with tomato scions. International Journal of Plant & Soil Science, 118-122. https://doi.org/10.9734/ijpss/2023/v35i12990

Imam, F., Memon, N., Leghari, M., & Sheikh, S. (2023). Optimizing tomato grafts for improved growth, yield and fruit quality. Journal of Applied Research in Plant Sciences, 5(01), 12-18. https://doi.org/10.38211/joarps.2024.05.01.211

Kermite, F., Widodo, W., & Hapsari, D. (2024). Optimization of nutmeg (myristica fragrans) grafting using multiple rootstock and scion types. Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy), 52(1), 54-63. https://doi.org/10.24831/jai.v52i1.53185

Kouakou, C., Kouakou, K., Dao, J., Koffi, K., & Bi, I. (2021). Effect of root trainer on the success of grafting and the survival rate of cashew tree [anacardium occidentale l.(anacardiaceae)] in field. Journal of Experimental Agriculture International, 21-30. https://doi.org/10.9734/jeai/2021/v43i430669

Liu, Y., Liu, H., Liu, K., Chen, J., Li, X., Chen, J., & Xue, Y. (2021). In vitro grafting procedure for facilitating growth of separated shoots in castor. Agronomy Journal, 113(2), 878-885. https://doi.org/10.1002/agj2.20522

Meilani, R., Putra, E., & Indradewa, D. (2023). Macronutrient contents and yield of cocoa resulting from two different rejuvenation techniques. Caraka Tani Journal of Sustainable Agriculture, 38(2), 387. https://doi.org/10.20961/carakatani.v38i2.57674

Moosavi-Nezhad, M., Salehi, R., Aliniaeifard, S., Tsaniklidis, G., Woltering, E., Fanourakis, D., … & Kalaji, H. (2021). Blue light improves photosynthetic performance during healing and acclimatization of grafted watermelon seedlings. International Journal of Molecular Sciences, 22(15), 8043. https://doi.org/10.3390/ijms22158043

Mugal, A., Mugal, F., Yadav, P., Yadav, V., & Yadav, A. (2024). Standardization of grafting techniques: unlocking the potential of pomegranate (punica granatum linn.). Journal of Experimental Agriculture International, 46(11), 756-761. https://doi.org/10.9734/jeai/2024/v46i113095

N'Zi, J., Koné, I., M'bo, K., Koné, S., & Kouamé, C. (2023). Successful grafting elite cocoa clones (theobroma cacao l.) as a function of the age of rootstock. Heliyon, 9(8), e18732. https://doi.org/10.1016/j.heliyon.2023.e18732

Olayemi, L., Agele, S., Adejobi, A., & Aiyelari, P. (2022). Effects of watering regime on the morphological, physiological and functional traits of seedlings of cacao provenances under screen house conditions. Journal of Plant Stress Physiology, 44-55. https://doi.org/10.25081/jpsp.2022.v8.7348

Padrón, I., Correa, C., & Diaz, C. (2022). Propagation of "valencia" orange (citrus x sinensis osbeck) by minigraft. Revista Facultad Nacional De Agronomía Medellín, 75(3), 10101-10106. https://doi.org/10.15446/rfnam.v75n3.99339

Palad, M. and Aminah, A. (2021). Response to state stomata to the use of microbes as potential biofertilizers in the rehabilitation of cocoa trees without logging.. https://doi.org/10.2991/assehr.k.210421.064

Purnama, S., Anggraeni, L., & Zubaidi, T. (2023). The sustaining agro-biodiversity through topworking approach: a case of local superior durian conservation on mount arjuna. Iop Conference Series Earth and Environmental Science, 1255(1), 012031. https://doi.org/10.1088/1755-1315/1255/1/012031

Ruseani, N., Vanhove, W., Susilo, A., & Damme, P. (2022). Cocoa clones reveal variation in plant biomass, root nitrogen uptake, and apparent nitrogen recovery at the seedling stage. Journal of Soil Science and Plant Nutrition, 22(4), 4727-4738. https://doi.org/10.1007/s42729-022-00955-0

Sadeghi-Majd, R., Vahdati, K., Roozban, M., Arab, M., & Sütyemez, M. (2022). Optimizing environmental conditions and irrigation regimes can improve grafting success in persian walnut. Acta Scientiarum Polonorum Hortorum Cultus, 21(2), 43-51. https://doi.org/10.24326/asphc.2022.2.4

Senthilvadivu, G., Pugalendhi, L., Saraswathi, T., Raguchander, T., Shanthi, A., & Jeyakumar, P. (2022). Studies on cleft grafting in brinjal (solanum melongena l.) with solanum rootstocks, their compatibility and growth performance under open field condition. International Journal of Plant & Soil Science, 519-526. https://doi.org/10.9734/ijpss/2022/v34i242668

Sharma, S. and Rajat, R. (2024). Interactive effects of grafting time and technique on the sprouting time and growth of guava grafts (psidium guajava l.). International Journal of Bio-Resource and Stress Management, 15(Feb, 2), 01-06. https://doi.org/10.23910/1.2024.5052a

Solórzano, C., Disca, V., Muñoz–Redondo, J., García, D., Sánchez-Parra, M., Zenteno, M., & Rodríguez-Solana, R. (2023). Effect of drying technique on the volatile content of ecuadorian bulk and fine-flavor cocoa. Foods, 12(5), 1065. https://doi.org/10.3390/foods12051065

Uljanah, I. and Uyun, S. (2021). Multi-layer inference fuzzy tsukamoto determining land suitability class of cocoa plants. Jurnal Teknik Informatika, 14(1), 1-10. https://doi.org/10.15408/jti.v14i1.13616

Uyanık, E., Kulaç, Ş., & BEYAZYÜZ, F. (2022). Effect of grafting method and time on grafting success in anatolian chestnut (castanea sativa mill.). Turkish Journal of Agriculture - Food Science and Technology, 10(10), 1972-1981. https://doi.org/10.24925/turjaf.v10i10.1972-1981.5418

Wahyudi, R., Putra, E., & Indradewa, D. (2023). Yield and yield components of superior cocoa (theobroma cocoa l.) clones rejuvenated by ring budding technique. Ilmu Pertanian (Agricultural Science), 8(1), 39. https://doi.org/10.22146/ipas.71385

Wei, L., Huang, G., Yao, X., Lv, L., Yu, C., & Wang, K. (2022). Untargeted metabolism approach reveals difference of varieties of bud and relation among characteristics of grafting seedlings in camellia oleifera. Frontiers in Plant Science, 13. https://doi.org/10.3389/fpls.2022.1024353

Zasari, M., Wachjar, A., Susilo, A., & Sudarsono, S. (2023). Physio-biochemical characteristics of prope legitimate seedlings of 13 cocoa clones under drought stress. Planta Tropika Journal of Agro Science, 11(2), 168-175. https://doi.org/10.18196/pt.v11i2.14315

Öztürk, A. (2021). The effects of different rootstocks on the graft success and stion development of some pear cultivars. International Journal of Fruit Science, 21(1), 932-944. https://doi.org/10.1080/15538362.2021.1948376