

Effect of Natural Auxin in *Aloe vera* and Synthetics on the Growth Success Level of *Syzygium aqueum* Cuttings

Raden Ajeng Diana Widyastuti^{*}, Hayane Adelin Warganegara^{**}, Fitri Yelli^{***},
 Ir Rugayah^{****}, Agung Putra Wijaya^{*****}, Alika Fadhillah^{*****}

ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received: February 12, 2026 Accepted: March 28, 2026 Published: March 31, 2026</p>	<p>Water apple (<i>Syzygium aqueum</i>) is a horticultural fruit commodity with high economic value and continues to be developed through vegetative propagation to obtain uniform and high-quality seedlings. However, the success of water apple propagation through cuttings is still influenced by differences in cultivars and plant responses to the application of growth regulators, especially auxins. Information regarding the interaction between water apple cultivars and auxin types on the initial growth of cuttings is still limited. This study aims to evaluate the effect of cultivars and auxin types on shoot growth and rooting of water apple cuttings to support vegetative propagation of water apple. The study was arranged using a factorial randomized block design (5 × 4). Factor I: rose apple cultivars (Citra, Dalhari, Kancing Merah, Black Kingkong, and Madu Deli), Factor II: auxin application (control (without auxin, 4000 ppm IBA, 4000 ppm NAA and 30% Aloe vera). Each treatment was replicated four times, resulting in 80 experimental units, with each experimental unit consisting of 10 plant cuttings. Observations were made at 4, 6, and 8 weeks after planting. The results showed that the Madu Deli cultivar produced a higher number of shoots, number of roots, wet and dry root weights, and plant weight compared to other cultivars. Auxin application increased root growth of water apple cuttings compared to those without auxin, especially in the parameters of root number, root length, and root weight. The treatment of IBA and NAA 4000 ppm gave the best results and was consistently higher than the 30% Aloe vera treatment and the control. Although Aloe vera was able to increase cutting growth compared to those without auxin, its effectiveness was still lower than synthetic auxin. This study is important as a scientific basis in selecting the right cultivar and type of auxin to increase the success of vegetative propagation of water apple, especially in the Madu Deli cultivar.</p>
<p><i>Keywords:</i> IAA, NAA, plant growth, seedling, vegetative</p>	

Journal of Agriculture and Rural Development Studies (JARDS). © 2025 is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Water apple (*Syzygium aqueum*) is a horticultural fruit commodity with high economic value and considerable development potential. Successful water apple cultivation requires the availability of uniform and high-quality seedlings. Vegetative propagation through cuttings is widely applied because it maintains the superior characteristics of the parent plant, accelerates the fruiting phase, and produces relatively uniform plants compared to generative propagation (Cox, 2018; Yusnita et al., 2017).

^{*}, ^{**}, ^{***}, ^{****}, ^{*****}, ^{*****}, ^{*****} Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia. E-mail addresses: rdiana.widyastuti@fp.unila.ac.id (Corresponding author – Widyastuti RAD), Hayane.adeline@fp.unila.ac.id (H.A. Warganegara), fitri.yelli@fp.unila.ac.id (F. Yelli), rugayah@unila.ac.id (I. Rugayah), imamsujadi@staff.uns.ac.id (A.P. Wijaya), alikakf19@gmail.com (A. Fadhillah).

The success of water apple propagation through cuttings is largely determined by the cutting's ability to form roots and support early plant growth. Adventitious root formation is a critical stage that determines cutting viability and subsequent vegetative development. The rooting process is influenced by various internal and external factors that interact during the rooting phase (De Klerk et al., 1999).

Cultivar differences and the application of plant growth regulators, particularly auxins, are considered important factors affecting rooting and shoot growth of cuttings. However, information regarding the response of different water apple cultivars to various types of auxins remains limited. Therefore, this study was conducted to evaluate the effects of cultivar and auxin type on shoot growth and rooting of water apple cuttings as a basis for developing more effective vegetative propagation techniques.

2. Literature review

Cultivar selection is a key internal factor in the success of water apple propagation through cuttings. Each cultivar has distinct genetic characteristics that result in different growth responses. Several studies have reported variations in rooting ability and cutting growth among water apple cultivars (Mega et al., 2025). Cultivars with higher genetic vigor generally exhibit better root formation and shoot development. However, most previous studies have been limited to certain cultivars, while information on other superior cultivars remains scarce. In fruit crops, research has predominantly focused on flowering regulation and canopy management to enhance productivity (Widyastuti et al., 2019), whereas studies on cultivar responses during early vegetative propagation through cuttings are still limited.

In addition to genetic factors, plant growth regulators play an important role in improving the success of cutting propagation. Auxins are known to stimulate cell division and differentiation in basal cutting tissues, thereby accelerating adventitious root formation (Davies, 2010). Synthetic auxins such as indole-3-butyric acid (IBA) and naphthaleneacetic acid (NAA) are widely used in horticultural crop propagation due to their effectiveness in increasing root number and quality (Cox, 2018; Giriprasath et al., 2025). In malay apple, the application of IBA and NAA at a concentration of 4000 ppm has been reported to enhance root growth of cuttings compared to untreated cuttings (Yusnita et al., 2018).

Recently, natural auxin sources have gained attention as alternative plant growth regulators. *Aloe vera* contains auxin and other bioactive compounds that may support plant growth (Surjushe et al., 2008). Nevertheless, comparative information on the effectiveness of natural auxins versus synthetic auxins in water apple cutting propagation, particularly across different cultivars, is still limited and requires further investigation.

3. Materials and Methods

The research was conducted from March to August 2024 in the greenhouse of the Integrated Field Laboratory of the Faculty of Agriculture, University of Lampung, Indonesia. The experimental design used was a factorial randomized block design (5 x 4) consisting of: Factor I: rose apple cultivars (Citra, Dalhari, Kancing Merah, Black Kingkong, and Madu Deli), Factor II: auxin application (control (without auxin, 4000 ppm IBA, 4000 ppm NAA and 30% *Aloe vera*). Each treatment was repeated 4 times, resulting in 80 experimental units. Each experimental unit consisted of 10 cuttings, resulting in a total of 800 plant cuttings.

Observations on cuttings were conducted at 4, 6, and 8 weeks after planting (WAP) for the variables of shoot number, leaf number, root number, root length, root wet weight, root dry weight, and plant weight. Root dry weight was obtained by oven-drying the roots wrapped in newspaper at 60°C for 24 hours. Data were analyzed using analysis of variance, significant treatment groups were followed by a 5% Tukey test using IBM-SPSS software version 26.

4. Results

Madu Deli cultivar cuttings had the highest number of shoots, followed by Citra and Black Kingkong, followed by Kancing Merah and Dalhari, which had the lowest number of shoots (Table 1). The application of growth regulators had no effect on the number of shoots of water apple cuttings. The number of shoots remained the same, whether the cuttings were 4, 6, or 8 weeks after planting (WAP)

Table 1. Effect of cultivars and growth regulator application on shoot number of water apple cuttings

Treatment	Number of shoots*		
	4 WAP**	6 WAP**	8 WAP**
Cultivars			
Citra	7.02b	7.06b	7.02b
Dalhari	3.42a	3.47a	3.42a
Kancing Merah	3.31a	3.16a	3.31a
Black Kingkong	6.87b	7.06b	6.87b
Madu Deli	7.99c	7.77c	7.99c
Material			
Control (without material)	5.55a	5.61a	5.55a
4000 ppm IBA	5.78a	5.73a	5.78a
30 % <i>Aloe vera</i>	5.75a	5.68a	5.75a
4000 ppm NAA	5.80a	5.79a	5.80a

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.

Madu Deli water apple cuttings had the highest number of leaves compared to other cultivars, whether at 4, 6, or 8 WAP. The number of leaves on cuttings from the cultivars Citra, Dalhari, Kancing Merah, and Black Kingkong was not significantly different. The application of growth regulators did not affect the number of leaves on water apple cuttings (Table 2). The condition of leaves on water apple cuttings can be seen in Figure 1.

Table 2. Effect of cultivars and growth regulator application on shoot number of leaves water apple cuttings

Treatment	Number of leaves		
	4 WAP	6 WAP	8 WAP
Cultivars			
Citra	4.58a	4.68a	4.58a
Dalhari	4.64a	4.70a	4.64a
Kancing Merah	4.76a	4.72a	4.76a
Black Kingkong	4.45a	4.32a	4.45a
Madu Deli	5.64b	5.82b	5.64b

Treatment	Number of leaves		
	4 WAP	6 WAP	8 WAP
Material			
Control (without material)	4.87a	4.93a	4.87a
4000 ppm IBA	4.69a	4.79a	4.69a
30 % <i>Aloe vera</i>	4.84a	4.81a	4.84a
4000 ppm NAA	4.85a	4.84a	4.85a

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.

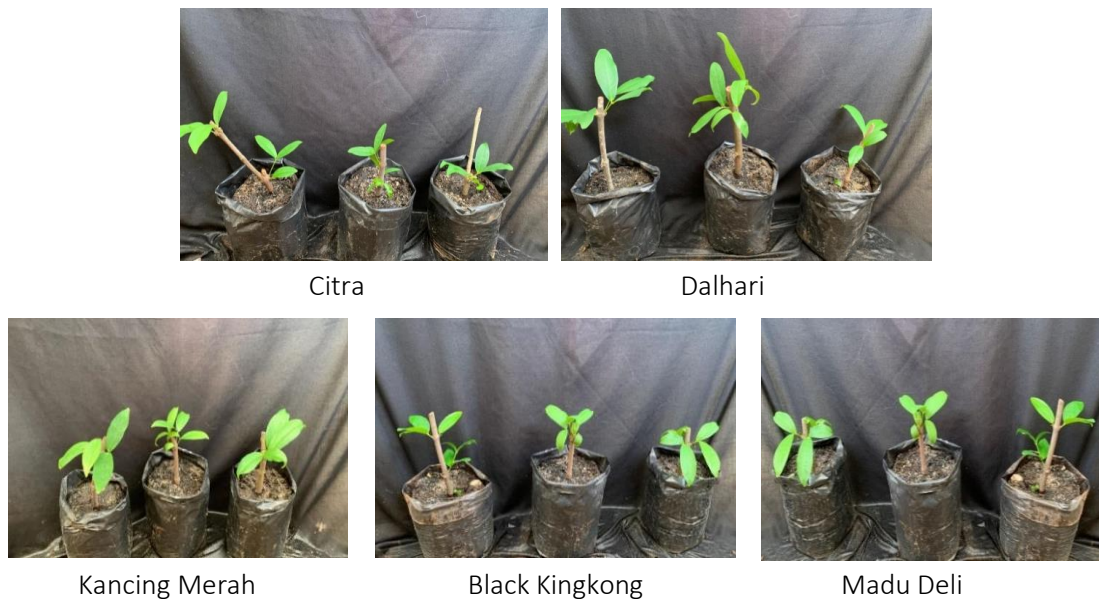


Figure 1. Description of the leaves condition of the water apple cultivars Citra, Dalhari, Kancing Merah, Black Kingkong, and Madu Deli

The Madu Deli cultivar had the highest number of roots compared to other cultivars at 4 and 8 weeks of cutting age (Table 3). The application of GR increased the number of roots of water apple cuttings at 4, 6, and 8 WAP compared to no GR treatment. Treatment of water apple cuttings with GR at 4000 ppm NAA resulted in the highest increase in the number of roots at 4 and 8 WAP. The root conditions of the water apple cultivars Citra, Dalhari, Kancing Merah, Black Kingkong, and Madu Deli can be seen in Figure 2.

Table 3. Effect of cultivars and growth regulator application on number of root apple cuttings

Treatment	Number of roots		
	4 WAP	6 WAP	8 WAP
Cultivars			
Citra	6.48a	6.52ab	6.48a
Dalhari	6.46a	6.14a	6.46a
Kancing Merah	6.46a	6.30a	6.46a
Black Kingkong	6.57a	6.58ab	6.57a
Madu Deli	7.17b	6.91b	7.17b

Treatment	Number of roots		
	4 WAP	6 WAP	8 WAP
Material			
Control (without material)	5.96a	5.83a	5.96a
4000 ppm IBA	6.82b	6.76c	6.82b
30% <i>Aloe vera</i>	6.52b	6.37b	6.52b
4000 ppm NAA	7.22c	7.00c	7.22c

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.



Figure 2. Description of the root condition of the water apple cultivars Citra, Dalhari, Kancing Merah, Black Kingkong, and Madu Deli

All cultivars did not show any significant difference in the root length of water apple cuttings. The application of growth regulators increased the root length of water apple cuttings starting from the 4 until 8 WAP. The application of 4000 ppm IBA resulted in the highest root length, but was not significantly different from the use of 30% *Aloe vera* (Table 4).

Table 4. Effect of cultivars and growth regulator application on root length water apple cuttings

Treatment	Root length		
	4 WAP	6 WAP	8 WAP
Cultivars			
Citra	5.38a	5.42a	5.38a
Dalhari	5.61a	5.47a	5.61a
Kancing Merah	5.47a	5.42a	5.47a
Black Kingkong	5.39a	5.42a	5.39a
Madu Deli	5.57a	5.43a	5.57a
Material			
Control (without material)	4.26a	4.24a	4.26a
4000 ppm IBA	6.06c	6.08c	6.06c

Treatment	Root length		
	4 WAP	6 WAP	8 WAP
30 % <i>Aloe vera</i>	5.70b	5.59b	5.70b
4000 ppm NAA	5.92bc	5.82bc	5.92bc

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.

The Madu Deli water apple cultivar had the highest root wet weight at 4 and 8 WAP compared to other cultivars. There was no significant difference among the Citra, Dalhari, Kancing Merah, and Black Kingkong cultivars from 4 to 8 WAP. The application of GR increased root wet weight compared to the control. The application of GR with 4000 ppm IBA and 4000 ppm NAA produced the highest root wet weight, followed by the treatment with 30% *Aloe vera* (Table 5).

Table 5. Effect of cultivars and growth regulator application on root wet weight water apple cuttings

Treatment	Root wet weight (g)		
	4 WAP	6 WAP	8 WAP
Cultivars			
Citra	4.53a	4.39a	4.53a
Dalhari	4.59a	4.58ab	4.59a
Kancing Merah	4.55a	4.47a	4.55a
Black Kingkong	4.58a	4.56ab	4.58a
Madu Deli	4.90b	4.73b	4.90b
Material			
Control (without material)	3.96a	3.89a	3.96a
4000 ppm IBA	4.89c	4.87c	4.89c
30% <i>Aloe vera</i>	4.64b	4.54b	4.64b
4000 ppm NAA	5.02c	4.89c	5.02c

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.

Madu Deli water apple cuttings had the highest root dry weight at 4 and 8 WAP compared to other cultivars. There was no significant difference in root dry weight among the Citra, Dalhari, Kancing Merah, and Black Kingkong cultivars from 4 to 8 WAP. The application of GR increased root dry weight compared to the control. The application of 4000 ppm IBA and NAA resulted in the highest root dry weight, followed by water apple cuttings treated with 30% *Aloe vera* (Table 6).

Table 6. Effect of cultivars and growth regulator application on root dry weight water apple cuttings

Treatment	Root dry weight (g)		
	4 WAP	6 WAP	8 WAP
Cultivars			
Citra	1.59a	1.54a	1.59a
Dalhari	1.61a	1.6ab	1.61a
Kancing Merah	1.59a	1.57a	1.59a
Black Kingkong	1.60a	1.60ab	1.60a
Madu Deli	1.71b	1.66b	1.71b

Treatment	Root dry weight (g)		
	4 WAP	6 WAP	8 WAP
Material			
Control (without material)	1.39a	1.36a	1.39a
4000 ppm IBA	1.71c	1.70c	1.71c
30% <i>Aloe vera</i>	1.62b	1.59b	1.62b
4000 ppm NAA	1.76c	1.71c	1.76c

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.

The Madu Delehi water apple cultivar had the highest plant weight compared to other cultivars from 4 to 8 WAP, followed by the Citra and Black Kingkong cultivars. The application of GR did not affect the weight of water apple plants at 4, 6, or 8 WAP (Table 7).

Table 7. Effect of cultivars and growth regulator application on plant weight water apple cuttings

Treatment	Plant weight (g)		
	4 WAP	6 WAP	8 WAP
Cultivars			
Citra	11.11b	11.3b	11.11b
Dalhari	8.31a	8.17a	8.31a
Kancing Merah	8.36a	8.39a	8.36a
Black Kingkong	10.84b	10.83b	10.84b
Madu Deli	13.16c	13.20c	13.16c
Material			
Control (without material)	10.29a	10.36a	10.29a
4000 ppm IBA	10.25a	10.27a	10.25a
30% <i>Aloe vera</i>	10.41a	10.37a	10.41a
4000 ppm NAA	10.46a	10.51a	10.46a

*Numbers followed by the same letter are not significantly different based on the 5% Tukey test.

**WAP is weeks after planting.

5. Discussion

The Madu Deli water apple cultivar demonstrated superior growth performance compared to the Citra, Dalhari, Kancing Merah, and Black Kingkong cultivars, as evidenced by higher shoot number, root number, fresh and dry root weight, and plant weight. Differences in growth responses among cultivars are closely related to plant genetic factors. Vegetative growth characteristics, such as shoot formation, rooting, and biomass accumulation, are controlled by the expression of genes that regulate cell division, cell elongation, and tissue differentiation; therefore, each cultivar has a different growth potential (Taiz et al., 2015). The Madu Deli cultivar is thought to possess higher genetic vigor and physiological capacity to support the initial growth of cuttings. This superiority is likely related to the cultivar's ability to allocate photosynthates to vegetative organs, particularly roots and shoots, during the early growth phase. According to Cox (2018), successful root formation and initial cutting growth are strongly influenced by the balance of endogenous hormones, carbohydrate reserves, and the activity of growth-regulating genes. The rapid growth and plant vigor of the Madu Deli cultivar are likely driven by the

expression of genes involved in auxin synthesis and sensitivity, thereby supporting more intensive root and shoot formation compared to other cultivars.

The results of this study also reinforce previous research on water apples, which has demonstrated differences in rooting ability among cultivars. Mega et al. (2025) founded that when applying different auxins (IAA, IBA, NAA) to water apple stem cuttings, the Citra Merah and Madu Deli Hijau cultivars exhibited significantly different rooting responses, with Madu Deli Hijau producing a higher average number of roots than Citra Merah under the same auxin treatment. Similarly, Singh et al. (2024) reported that the response of water apple cuttings to auxin application was significantly influenced by the cultivar used. However, previous studies have generally focused on local cultivars and the Citra cultivar, whereas information on the vegetative growth characteristics and rooting response of the Madu Deli cultivar remains limited. Therefore, the results of this study provide additional information on the early growth performance of the Madu Deli cultivar compared to other, more extensively studied water apple cultivars.

The application of plant growth regulators (GRs) in this study generally increased root growth parameters compared to the control without GRs. This increase is associated with the role of the hormone auxin in inducing adventitious root formation by stimulating cell division and differentiation in the basal tissue of the cuttings. Auxin is the primary hormone controlling root initiation by increasing the activity of enzymes involved in cell wall loosening and by regulating the expression of genes related to rooting (Davies, 2010). These results are consistent with previous studies on water apples, which reported that auxin application increased root growth of cuttings compared to those without auxin (Giriprasath et al, 2025; Singh et al., 2024).

Application of GRs at a concentration of 4000 ppm IBA and NAA provided the best rooting response, as indicated by higher root number, root length, and root weight compared to the GR treatment with 30% *Aloe vera* and control. This indicates that synthetic auxins are more effective and consistent in stimulating root formation and development in cuttings. IBA is known to be more stable against enzymatic degradation and to have better translocation ability within plant tissues, making it more effective in inducing root formation than natural auxin sources (De Klerk et al., 1999).

Although *Aloe vera* application resulted in a better growth response compared to the control, its effectiveness was still lower than that of IBA and NAA. This is likely due to the relatively lower and more variable natural hormone content in *Aloe vera*, which is influenced by the raw material and extraction method. *Aloe vera* contains auxins, cytokinins, and other bioactive compounds; however, their concentration and bioavailability are not as high as those of synthetic auxins applied at measured doses (Surjushe et al., 2008). Therefore, despite its potential as a natural and environmentally friendly growth regulator, *Aloe vera* has not been able to match the effectiveness of chemical growth regulators in optimizing root growth of water apple cuttings, particularly in the Madu Deli cultivar.

5. Conclusions

The Madu Deli water apple cultivar provided better cutting growth than the Citra, Dalhari, Kancing Merah, and Black Kingkong cultivars. This was indicated by the higher number of shoots, number of roots, wet and dry root weights, and plant weight. The application of growth regulators increased the root growth of water apple cuttings compared to without auxin. IBA and NAA treatments at a

concentration of 4000 ppm gave the best results in terms of root number, root length, and root weight. The application of 30% *Aloe vera* gave better results than the control, but not as good as the IBA and NAA treatments. The results of this study indicate that the growth of water apple cuttings is influenced by differences in cultivars and types of auxins. The selection of the Madu Deli cultivar with the application of 4000 ppm synthetic auxin can be used to increase the success of water apple cutting propagation.

Acknowledgements

The authors would like to express their gratitude to the University of Lampung for funding this research through the 2024 applied research grant.

References

1. Cox, D. A. (2018). Hartmann and Kester's plant propagation principles and practices (9th ed.). *HortScience*, 53(5), 741. <https://doi.org/10.21273/HORTSCI535bkrev-17>
2. Davies, P. J. (2010). *Plant hormones: Biosynthesis, signal transduction, action!* (3rd ed.). Springer. <https://doi.org/10.1007/978-1-4020-2686-7>
3. De Klerk, G. J., van der Krieken, W., & de Jong, J. C. (1999). Review of the formation of adventitious roots: New concepts, new possibilities. *In Vitro Cellular & Developmental Biology – Plant*, 35(3), 189–199. <https://doi.org/10.1007/s11627-999-0076-z>
4. Giriprasath, R. S., Umesh, B. C., Vinay, T. V., Jeevitha, D., Manjula, B. S., Ranchana, P., & Suresh, V. (2025). An investigation into the effects of varying seasons, indole-3-butyric acid (IBA), and rooting media on the rooting and longevity of air-layered water apples (*Syzygium samarangense* L.). *Agricultural Science Digest*, 45(1), 48–53. <https://doi.org/10.18805/ag.D-6030>
5. Mega, M. S. G. A. K., Yusnita, Y., Hapsoro, D., Karyanto, A., & Ramadiana, S. (2025). IAA was more effective than NAA and IBA in root formation of watery roseapple (*Syzygium aqueum* (Burm. f.) Alston) air layering. *Jurnal Agrotek Tropika*, 12(4), 794–803. <https://doi.org/10.23960/jat.v12i4.6822>
6. Singh, K., Bhowmick, N., Chakraborty, B., Chakraborty, A., Parameshwar, P., Chamling, N., & Samanta, D. (2024). Effect of different concentration of IBA on the success of hardwood and softwood cuttings of water apple (*Syzygium aqueum*). *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, 10(2), 123–128. <https://doi.org/10.53552/ijmfmap.10.2.2024.123-128>
7. Surjushe, A., Vasani, R., & Saple, D. G. (2008). *Aloe vera*: A short review. *Indian Journal of Dermatology*, 53(4), 163–166. <https://doi.org/10.4103/0019-5154.44785>
8. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.
9. Widyastuti, Y., Yusnita, Y., & Hapsoro, D. (2019). Flowering regulation of crystal guava (*Psidium guajava* L.) through strangulation timing application. *Journal of Physics: Conference Series*, 1155(1), 012013. <https://doi.org/10.1088/1742-6596/1155/1/012013>
10. Yusnita, Y., Jamaludin, J., Agustiansyah, A., & Hapsoro, D. (2018). A combination of IBA and NAA resulted in better rooting and shoot sprouting than single auxin on Malay apple (*Syzygium malaccense* (L.) Merr. & Perry) stem cuttings. *Agrivita Journal of Agricultural Science*, 40(1), 80–90. <https://doi.org/10.17503/agrivita.v40i0.1210>