WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effect of Various Types of Organic Mulch on the Growth of Agarwood (*Aquilaria Malaccensis* Lamk) Seedlings

Zulkaidhah[1]*, Dewi Wahyuni[2], Rahmawati[3], Abdul Hapid[4], Hamka[5]

[1,2,3,4,5] *Department of Forestry, Faculty of Forestry, Tadulako University, Palu, 94118, Indonesia*

DOI : https://doi.org/10.55248/gengpi.5.1124.3117

A B S T R A C T

Agarwood is a plant that does not easily adapt to highly variable environmental conditions. One of the obstacles faced is the problematic planting site. Improvement of planting land can be done by adding organic mulches such as straw organic mulch, sawdust organic mulch, bamboo leaf litter mulch, rice husk mulch. The purpose of this study was to determine the effect of various types of organic mulch on the growth of agarwood seedlings (Aquilaria malaccensis Lamk). This research was conducted for three months from March to June 2023, which took place in the Permanent Nursery of BPDAS Palu-Poso located at Tadulako University, Central Sulawesi. This study used a completely randomised design method with five treatments. Each treatment was repeated 6 times. The observation parameters were seedling height, diameter, number of leaves. The results showed that the provision of organic mulch on agarwood seedlings had a significant effect on the increase in height, diameter and number of leaves of agarwood seedlings. Based on the results of further tests, it shows that the average increase in height, diameter, number of leaves of agarwood seedlings in Treatment M4 (Rice Husk Mulch) gives the best effect on the growth of agarwood seedlings compared to other treatments with an average height increase of 8.50 cm, an increase in the number of leaves with an average of 9.0 strands, with an increase in diameter with an average of 1.43 mm.

Keywords: Agarwood, Organic mulch, seedling height, seedling diameter

1. INTRODUCTION

Agarwood (Aquilaria malaccensis Lamk) is a tree of the Thymelaeaceae tribe. This species can be found in Indonesia, Malaysia, Iran, Bangladesh, Bhutan, India, Laos, Myanmar, Philippines, Singapore, and Thailand. (Tamyiz et al., 2022). The plant has a high economic value, so the harvest is very high, which causes the habitat to be damaged (Ador et al., 2021; Tamyiz et al., 2022) . Agarwood is a raw material for making various types of fragrances, so it has high benefits. Agarwood stems can release resin in the form of oil which produces a distinctive fragrance, the resin can be used for various kinds such as incense, room fragrances in the Middle East, seed oil and others (Shivanand et al., 2022).

During this time, agarwood was taken directly from natural forests so that the population of this plant was almost extinct. Since 1994, agarwood-producing plants have been threatened with extinction and included in CITES (Convention on International Trade in Endengered Species of Wild Fauna and Flora), including the APENDIX II category (rare), so that the export trade of agarwood is monitored and limited by quotas (Nath et al., 2023; Satria et al., 2008) . This condition is caused by the limited number of agarwood seedlings to be cultivated in order to preserve the agarwood plant. (Rindyastuti et al., 2019) . The planting of agarwood-producing trees of the type (A. malaccensis Lamk) carried out on vacant land or open places in semi-arid areas is currently considered to have a low growth success rate (less than 30%). (Noviolla & Suparjo, 2018) . One of the cultivation techniques to increase optimal agarwood growth is by modifying the microclimate around the plant. One of the microclimate modification techniques is by using mulch (Auri et al., 2021).

Mulch is a type of artificial ground cover that is widely used for crop cultivation activities, aiming to obtain favourable changes in a particular soil environment. (Chopra & Koul, 2020; Ye et al., 2023) . The use of mulch is aimed at improving the state of the root environment and soil properties which will affect the growth and production of the plants concerned. (Ye et al., 2023).

Organic mulch is mulching whose material comes from plants or agricultural residues. (Iqbal et al., 2020). Mulch derived from crop residues has many advantages including improving fertility, structure, soil water reserves and is available in large quantities (Chopra & Koul, 2020) . In addition, crop residues can attract soil animals due to stable soil moisture and the availability of organic matter as food. This affects aeration and the soil's ability to absorb water will be better (Limonu et al., 2021).

Organic mulch is a ground cover material in the form of plant residues such as rice straw, rice husks, sawdust, corn stalks and sugarcane stalks that are spread on the soil surface. (Sari, 2022) . Mulch is useful for protecting the soil surface from exposure to rain, erosion and maintaining moisture, structure, soil fertility as well as inhibiting the growth of weeds (weeds) and providing positive effects for plants (Sari, 2022) . In addition,

crop residues can attract soil animals such as worms, due to high soil moisture and the availability of organic matter as food for worms. The presence of worms and organic matter will help improve soil structure (Hasibuan et al., 2022).

The provision of mulch strongly supports the growth of seedlings as needed by plants. Information on the provision of organic mulch on the growth of agarwood seedlings is still very limited. Therefore, it is necessary to conduct research on the effect of various types of organic mulch on the growth of Gaharu seedlings. This study aims to determine the effect of several types of organic mulch on the growth of Gaharu seedlings.

2. MATERIALS AND METHODS

2.1 Time and Place

This research was conducted for three months, from May to September 2024, at Persemaian Permanen Balai Pengelolaan Daerah Aliran Sungai Palu Poso, Sulawesi Tengah, Indonesia

2.2 Tools and Materials

The materials used in this study are:

a. Agarwood seedlings (Aquilaria malaccensis Lamk) were used as the object of research, age, height, diameter, number of leaves.

b. Labels, used to annotate plants

c. Manure, as a base fertiliser

d. Straw, sawdust, bamboo leaf litter, rice husk as mulch

The tools used in this study are:

a. Spade, for digging soil holes,

b. Paranet, for shade,

c. Mistar, used to measure seedling height,

d. Calipers, used to measure seedling diameter,

e. Camera, used for research documentation,

f. Laptop, used to process research data,

g. Stationery, used to record measurement results.

2.3 Research Methods

This study uses the method of Completely Randomised Design (CRD) which consists of 5 treatments, namely:

M0 = No Mulch (Control)

M1 = Straw Mulch 100 g/plant

M2 = Sawdust Mulch 100 g/plant

M3 = Bamboo Leaf Litter Mulch 100 g/plant

M4 = Rice Husk Mulch 100 g/plant

Each treatment was repeated 6 times, so there were 5 x 6 = 30 Treatment Units / Experiments.

The treatment randomisation layout is presented in the following figure:

$M4_1$	$M2_1$	$M0_6$	$M4_2$	$M3_2$	$M2_2$	$M0_4$	$M4_4$	$M1_3$	$M3_4$
$M1_1$	$M2_5$	$M3_1$	$M0_5$	$M1_2$	$M4_3$	$M3_3$	$M2_3$	$M0_3$	$M0_2$
$M2_4$	$M3_5$	$M1_6$	$M3_6$	$M4_6$	$M1_4$	$M4_5$	$M0_1$	$M2_6$	$M1_5$

Randomisation Layout of the Treatment Experiment

(Zulkaidhah et al., 2022)

2.4 Research Procedures

Provision of Materials

The provision stage of this research material, namely:

1. 6-month-old Aloe's seedlings obtained from the Permanent Nursery of BPDAS Palu Poso
2. Setting up a paranet shade that is installed on the ground
3. Preparing the base fertilizer
4. Straw, Coconut Wood Sawdust, Dried Bamboo Leaf Litter, Rice Husk, as Mulch Media.

Research Implementation

1. Land Preparation. Site preparation is carried out by clearing the land of any interfering vegetation, then measuring the land. Plant spacing of 3 m x 2 m and making plant holes measuring 50 cm x 50 cm x 50 cm.
2. Seedling Preparation. Agarwood (Aquilaria malaccensis Lamk) seedlings were selected with the best quality, having the same relative height and age range of 6 months from the BPDAS Palu Poso Permanent Nursery.
3. Seedling arrangement. After the planting holes were ready, manure was mixed with the excavated soil, after the paranet was prepared the agarwood seedlings (Aquilaria malaccensis Lamk) were planted in the prepared holes by inserting the seedlings into the holes and then filling them with soil mixed with 500 g cow dung (base fertiliser).
4. Mulching. After the agarwood seedlings (Aquilaria malaccensis Lamk) were planted, mulch was applied according to the treatment, each plant 100g.
5. Maintenance. Seedling maintenance during the study was only carried out 1 time watering 2 times a day (Morning and Evening).

2.5 Observation Parameters

1. Seedling height. Observations of seedling height (cm) were made at the beginning and end of the study, namely 1 week and 11 weeks after planting, by measuring the height of the plant from the base of the root to the top of the stem. The difference between the final measurement and the initial measurement is the seedling height increase data.
2. Seedling diameter. Seedling measurements were calculated at the beginning and end of the study at the age of 1 week and 11 weeks after planting, by measuring the diameter of the seedling from the base of the root.
3. Number of leaves, observation the number of seedling leaves was calculated at the beginning and end of the study, namely 1 week and 11 weeks after planting, by counting fully developed leaves. The difference between the calculation of the final and initial data is the data on the increase in the number of leaves.

2.6 Data Analysis

Data were analysed using the analysis of variance F test at the 5% level, to determine whether the treatment effect was real or not. Treatments that had a real effect were further tested by using the Least Significant Difference (LSD) test. The mathematical formula of the Completely Randomised Design (CRD):

$$Yij = \mu + \alpha i + \varepsilon ij$$

Where:

Yij= Result of observation in the i-th treatment, and j-th replication

μ= General mean value of seedling growth

αi= Preliminary treatment factor at the i-th level

εij= Experimental error/error

i-j= 1,2,3,4

3. RESULTS AND DISCUSSIONS

3.1 Results

Seedling height increase.

To determine the effect of mulch treatment given to the height increase of agarwood seedlings, the analysis of variance is presented in Table 1.

Table 1 - Results of Analysis of Variance of Height Increase (cm) of Agarwood Seedlings (Aquilaria malaccensis Lamk) Age 11 Weeks After Planting.

Source	degree of freedom	Sum of squares	Centre square	F Count	F Table
Treatment	4	48.87	12.22	2.80*	2.76
Error	25	109.,00	4.36		
Total	29	157.87			

Description: * = Significantly affected; Coefficient of Variance = 32%

The results of the analysis of variance showed that the treatment of organic mulch had a significant effect on the height increase of agarwood seedlings. To determine the difference in influence between treatments, further tests were carried out with the Least Significant Difference Test (LSD) which is presented in Table 2.

Table 2. Results of the Least Significant Difference Test (LSD) on Height Increase (cm) of Aloes Seedlings 11 Weeks After Planting

Treatment	Average Value	LSD 5%
M0 = No mulch (control)	4.83a	
M1 = Straw Mulch	7.67c	
M2 = Sawdust Mulch	7.00bc	1.01
M3 = Bamboo Leaf Litter Mulch	6.50b	
M4 = Rice Husk Mulch	8.67c	

Notes: Numbers Followed by the Same Letter Notation Show Different Not Significant at 5% BNT Test

The results of the study in Table 2 show that the highest aloes seedling height increase in the M4 treatment (Rice Husk Mulch) with a height increase of 8.67 cm, significantly different from the M3 treatment of Bamboo Leaf Litter Mulch with a height increase of 6.50 cm, not significantly different from the M2 treatment of Sawdust Mulch (100 g) with an average height increase of 7.00 cm, not significantly different from the M1 treatment of Straw Mulch (100 g) with a height increase of 7.67 cm. Treatment M0 (control) had a seedling height increase of 4.83 cm, significantly different from all treatments using organic mulch.

Seedling Diameter Increase

To determine the effect of treatment on the diameter increase of Agarwood seedlings, the analysis of variance is presented in Table 3.

Table 3. Results of Analysis of Variance of Diameter Increase (mm) of Agarwood seedlings (Aquilaria malaccensis Lamk) Age 11 Weeks After Planting.

Source	degree of freedom	Sum of squares	Centre square	F Count	F Table
Treatment	4	2.90	0.73	8.85*	2.76
Error	25	2.05	0.08		
Total	29	157.87			

Description: * = Significantly affected; Coefficient of Variance = 12%

The results of the analysis of variance in the table show that the provision of organic mulch has a significant effect on the increase in diameter of agarwood seedlings. Therefore, further tests were carried out with the Least Significant Difference Test (LSD) which is presented in Table 4.

Table 4. Results of the Least Significant Difference Test (BNT) on Diameter Increase (mm) of Agarwood Seedlings (Aquilaria malaccensis Lamk) Age 11 Weeks After Planting

Treatment	Average Value	LSD 5%
M0 = No mulch (control)	0.58a	
M1 = Straw Mulch	1.07d	
M2 = Sawdust Mulch	0.87c	0.14
M3 = Bamboo Leaf Litter Mulch	0.70b	
M4 = Rice Husk Mulch	1.47e	

Notes: Numbers Followed by the Same Letter Notation Show Different Not Significant at 5% BNT Test

Table 4 shows that the highest diameter increase of Agarwood seedlings was found in the treatment of M4 Rice Husk Mulch (100 g) 1.47 mm, significantly different from the treatment of M3 Bamboo Leaf Litter Mulch (100 g) with an average diameter increase of 1.70 mm, significantly different from the treatment of M2 Sawdust Mulch (100 g) with an average diameter increase of 0.87 mm, not significantly different from the treatment of M1 Straw Mulch (100 g) with a diameter increase of 1.07 mm, significantly different from the treatment of M0 as a control with an average seedling diameter increase of 0.58 mm. The average diameter increase of Gaharu seedlings (Aquilaria malaccensis Lamk) is significantly different between the 5 treatments above, organic rice husk mulch has the most diameter increase in the treatment (M4).

Seedling leaf number increase

To determine the effect of treatment on the diameter increase of Agarwood seedlings, the analysis of variance is presented in Table 5

Table 5. Results of Analysis of Variance of Number of Leaves (Helai) of Agarwood Seedlings (Aquilaria malaccensis Lamk) Age 11 Weeks after planting.

Source	degree of freedom	Sum of squares	Centre square	F Count	F Table
Treatment	4	62.20	15.55	10.90*	2.76
Error	25	35.67	1.43		
Total	29	97.87			

Description: * = Significantly affected Coefficient of Variance = 12%

The results of the analysis of variance showed that the provision of organic mulch had a significant effect on the number of leaves of agarwood seedlings (Aquilaria malaccensis Lamk). Therefore, further tests were carried out using the Least Significant Difference Test (BNT) which is presented in Table 6.

Table 6. Results of the Least Significant Difference Test (BNT) on the Increase in the Number of Leaves (Helai) of Agarwood Seedlings (*Aquilaria malaccensis* Lamk) Age 11 Weeks After Planting

Treatment	Average Value	LSD 5%
M0 = No mulch (control)	4.83a	
M1 = Straw Mulch	8.00c	
M2 = Sawdust Mulch	6.50b	0.58
M3 = Bamboo Leaf Litter Mulch	6.33b	
M4 = Rice Husk Mulch	9.00d	

Notes: Numbers Followed by the Same Letter Notation Show Different Not Significant at 5% BNT Test

Table 6 shows that the average increase in the number of leaves of Gaharu seedlings in the treatment of M4 Rice Husk Mulch (100 g) with an average increase in the number of leaves of 9.00 strands is not significantly different from M3 Mulch Bamboo Leaf Litter (100 g) with an average increase in the number of leaves 6,33 strands were not significantly different from M2 Sawdust Mulch (100 g) with an increase in the number of leaves averaging 6.50 strands, significantly different from treatment M1 Straw Mulch (100 g) with an increase in the number of leaves 8.00 strands, significantly different from treatment M0 as a control with an increase in the number of seedling leaves averaging 4.83 strands. The average increase in the number of leaves of Gaharu seedlings (Aquilaria malaccensis Lamk) is significantly different between the 5 treatments above, organic rice husk mulch has the most diameter increase in treatment (M4).

3.2 Discussion

The results showed that the provision of rice husk mulch was the best because of its good water storage capacity, the provision of various organic mulches on the growth of Gaharu (*Aquilaria malaccensis* Lamk) seedlings gave better results compared to the treatment without organic mulch. Statistically, organic mulch has a significant effect on seedling height, seedling diameter, and number of leaves, Gaharu seedlings (*Aquilaria malaccensis* Lamk) where from all observation parameters that have the highest average value, namely in the M4 treatment of 100 g rice husk mulch, then the M1 treatment of 100 g straw mulch and M2 treatment of 100 g sawdust mulch and M3 treatment of 100 g bamboo leaf litter mulch then M0 treatment or no treatment (control).

The use of organic mulch can improve the physical, chemical and biological properties of the soil which will facilitate the provision of nutrients needed by plants for fruit formation and development. (Chopra & Koul, 2020; Iqbal et al., 2020; Limonu et al., 2021) . The application of straw mulch significantly increased available phosphorus and potassium in the soil (Harman & Zulkaidhah, 2019). The results of decomposition of organic matter can increase the elements of N, P, K which can increase carbohydrates in the photosynthesis process, because the element N to form chlorophyll and which serves to absorb sunlight and as a place for the photosynthesis process to take place while the element K increases the absorption of CO2 associated with the opening and closing of leaf stomata then the carbohydrates after the plant enters the reproductive phase are stored in the fruit. (Zulkaidhah, Wardah, et al., 2022). Thus, increasing nutrient uptake can increase the number of fruits (Blesh & Ying, 2020; Mayer et al., 2023).

Organic mulch lowers soil temperature, causing faster plant growth and fruit formation time. (Sumarni et al., 2006). The use of organic mulch gives good results because in addition to supplying P needs for plants, it can also supply other nutrients. In addition, it can maintain soil moisture so that water needs for plants can be available compared to without mulch. (Mayer et al., 2023)

Plant height is a measure that is often observed both as an indicator of growth and as a parameter used to measure the effect of the environment or treatment applied. This is based on the fact that plant height is the easiest measure of growth to observe. The increase in plant height is a result of plant metabolism in the form of an increase in the size of growing cells both in cell size and length. The increase in plant height is also the result of the activity of meristem tissues that are actively dividing so that the number of cells increases. Agarwood plant height is measured from the base of the root to the top of the stem. In addition to the influence of the environment, plant height is also an indicator of growth to measure the effect of a given treatment. (Wasis & Sandrasari, 2011). Plant growth is strongly influenced by the availability of nutrients in the soil such as Nitrogen (N), Phosphorus (P), and Potassium (K). these three types of nutrients are the most needed by plants, because each nutrient has a very important function for plant growth (Rehling et al., 2021) Seedling diameter is an important morphological trait to be used as an observation parameter in determining seedling quality, because the size of the seedling diameter affects seedling resistance. Diameter increase is caused by the increase in xylem and phloem networks contained in the stem due to nutrients absorbed by plants such as Ca which functions to stimulate the growth of root hairs, plays a role in making proteins or active parts of plants, hardens plant stems and at the same time stimulates seed growth, neutralises organic acids produced during calcium metabolism contained in stems and leaves can neutralise compounds or soil acidity atmosphere (Sumarni et al., 2006). Leaves are a place for plants to synthesise food for plant needs and as food reserves, leaves have chlorophyll which plays a role in photosynthesis, the more the number of leaves, the place to carry out photosynthesis is more and the results are more as well. (Aji et al., 2018; Blesh & Ying, 2020)..

4. CONCLUSIONS

The provision of organic mulch has a significant effect on all growth parameters of Gaharu (Aquilaria malaccensis Lamk) seedlings. Rice husk organic mulch gives the best effect shown in the average value, namely the average increase in seedling height of 8.67 cm, the average increase in seedling diameter of 1.46 mm, and the average increase in the number of leaves of 9.5 strands, which is higher than the treatments, M3, M2, M1 and M0.

Acknowledgements

Research Funded by BLU Funds Faculty of Forestry, Tadulako University Fiscal Year 2024 In accordance with the Research Program Implementation Assignment Agreement Number: 2653/UN28/KU/2024 Dated May 22, therefore our gratitude goes to the Rector of Tadulako University, Chairperson of the Institute for Research and Community Service of Tadulako University, Dean of the Faculty of Forestry, Tadulako University.

References

Ador, M. A. H., Farabi, F., Ahmed, R., Khatun, R., & Haque, M. M. U. (2021). Agar (Aquilaria agallocha Roxb.) based small-scale enterprises in Bangladesh: Management, production, marketing and role in socio-economic development. *Trees, Forests and People*, *6*, 100141.

Aji, I. M. L., Sutriono, R., & Hayati, M. (2018). Pengaruh media simpan dan lama penyimpanan terhadap viabilitas benih dan pertumbuhan semai mahoni (Swietenia Mahagoni (L.) Jacq). Jurnal Belantara, 1(1), 225264.

Auri, A., Faridah, E., & Hardiwinoto, S. (2021). Agarwood tree characteristics based on different growing habitat and ecophysiological attributes in the Papuan tropical forests. Jurnal Sylva Lestari, 9(3), 444–453.

Blesh, J., & Ying, T. (2020). Soil fertility status controls the decomposition of litter mixture residues. Ecosphere, 11(8). https://doi.org/10.1002/ecs2.3237

Chopra, M., & Koul, B. (2020). Comparative assessment of different types of mulching in various crops: A review. Plant Arch, 20, 1620–1626.

Harman, H., & Zulkaidhah, Z. (2019). Pertumbuhan Semai Eboni (Diospyros celebica Bakh.) Pada Berbagai Intensitas Cahaya dan Jenis Mulsa. Jurnal Warta Rimba, 7(2).

Hasibuan, S., Sumihar, S., & Mardiana, S. (2022). Pengaruh Pengolahan Tanah dan Pemberian Mulsa Organik Terhadap Kesuburan Tanah dan Hasil Produksi Jagung Manis (Zea mays saccaharata Strut L). Jurnal Ilmiah Pertanian (JIPERTA), 4(2), 111–123.

Iqbal, R., Raza, M. A. S., Valipour, M., Saleem, M. F., Zaheer, M. S., Ahmad, S., Toleikiene, M., Haider, I., Aslam, M. U., & Nazar, M. A. (2020). Potential agricultural and environmental benefits of mulches—a review. Bulletin of the National Research Centre, 44, 1–16.

Limonu, A., Pembengo, W., & Musa, N. (2021). Kajian Penggunaan Berbagai Mulsa Organik dan Teknik Aplikasi Pupuk Terhadap Pertumbuhan dan Produksi Tanaman Jagung Manis (Zea mays Saccharata Sturt). Jurnal Agroteknotropika, 10(2), 43–49.

Mayer, M., Matthews, B., Sandén, H., Katzensteiner, K., Hagedorn, F., Gorfer, M., Berger, H., Berger, T. W., Godbold, D. L., & Rewald, B. (2023). Soil fertility determines whether ectomycorrhizal fungi accelerate or decelerate decomposition in a temperate forest. New Phytologist, 239(1). https://doi.org/10.1111/nph.18930

Nath, P. C., Nath, A. J., Sileshi, G. W., & Das, A. K. (2023). Growth and coppicing ability of the critically endangered agarwood (aquilaria malaccensis lam.) tree in monoculture and polyculture in North East India. Journal of Sustainable Forestry, 42(9), 947–959.

Noviolla, L., & Suparjo, S. (2018). Pertumbuhan Stek Aquilaria malaccensis Lamk. dengan Pemberian Biourine Sapi. BIO-SITE| Biologi Dan Sains Terapan, 4(2), 68–77.

Rehling, F., Sandner, T. M., & Matthies, D. (2021). Biomass partitioning in response to intraspecific competition depends on nutrients and species characteristics: A study of 43 plant species. Journal of Ecology, 109(5). https://doi.org/10.1111/1365-2745.13635

Rindyastuti, R., Yulistyarini, T., & Darmayanti, A. S. (2019). Population and ecological study of agarwood producing tree (Gyrinops versteegii) in Manggarai District, Flores Island, Indonesia. Biodiversitas Journal of Biological Diversity, 20(4), 1180–1191.

Sari, D. E. (2022). Pengaruh Jenis Mulsa Organik dan Pupuk Kandang Kambing terhadap Pertumbuhan dan Produksi Bawang Putih. Jurnal Agrotan, 8(1), 4–7.

Satria, B., Gustian, G., Swasti, E., Kasim, M., & Darnetti, D. (2008). Karakteristik Morfologi dan Genetik Tanaman Penghasil Gaharu (Aquilaria spp) Endemik Sumatera Barat. Sainstek, 11(1), 43–52.

Shivanand, P., Arbie, N. F., Krishnamoorthy, S., & Ahmad, N. (2022). Agarwood—the fragrant molecules of a wounded tree. Molecules, 27(11), 3386.

Sumarni, N., Hidayat, A., & Sumiati, E. (2006). Pengaruh tanaman penutup tanah dan mulsa organik terhadap produksi cabai dan erosi tanah. Jurnal Hortikultura, 16(3), 83244.

Tamyiz, M., Prayoga, L., Prasetyo, R., Murchie, E. H., & Sugiyono. (2022). Improving Agarwood (Aquilaria malaccensis Lamk.) Plantlet Formation Using Various Types and Concentrations of Auxins. Caraka Tani: Journal of Sustainable Agriculture, 37(1). https://doi.org/10.20961/carakatani.v37i1.58370

Wasis, B., & Sandrasari, A. (2011). Pengaruh pemberian pupuk kompos terhadap pertumbuhan semai mahoni (Swietenia macrophylla King.) pada media tanah bekas tambang emas (Tailing). Jurnal Silvikultur Tropika, 3(1), 109–112.

Ye, L., Xu, Y., Zhu, G., Zhang, W., & Jiao, Y. (2023). Effects of Different Mulch Types on Farmland Soil Moisture in an Artificial Oasis Area. Land, 13(1), 34.

Zulkaidhah, Z., Rahma, M., Wardah, W., Wahyun, D., & Hapid, A. (2022). Respon Pertumbuhan Semai Tanjung (Mimusops elengi Linn.) terhadap Intensitas Cahaya di Arboretum Fakultas Kehutanan Universtas Tadulako. Jurnal Penelitian Hutan Tanaman, 19(2), 137–148.

Zulkaidhah, Z., Wardah, W., Saleh, S., Satriawan, W., Hapid, A., Wulandari, R., Wahyuni, D., Taiyeb, A., Rukmi, R., Rahmawati, R., & Hamka, H. (2022). Soil Macrofauna Diversity and Litter Decomposition Rate in the Buffer Zone of Lore Lindu Biosphere Reserve Indonesia. International Journal of Design and Nature and Ecodynamics, 17(5). https://doi.org/10.18280/ijdne.170513