The effect of planting media composition and provision of liquid organic fertilizer on the growth of *Casuarina junghuhniana* seedlings

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Abstract. The purposes of this study were to determine the effect of planting media composition and liquid organic fertilizer concentration as well as their interactions on the growth and quality of *Casuarina junghuhniana* seedlings. The experimental design used a completely randomized design (CRD) factorial experiment with five replications. The first factor was the planting media with the composition of topsoil (control), topsoil:sand:husk charcoal (1:1:1), topsoil:sand:husk charcoal (1:2:1), topsoil:sand:husk charcoal (1:1:2), topsoil:sand:husk charcoal (2:1:1). The second factor was liquid organic fertilizer with a concentration of 0 ml (control), 100 ml/10 liters of water, 200 ml/10 liters of water, 300 ml/10 liters of water, 400 ml/10 liters of water. Growth variables observed were height, trunk diameter, number of leaves, top root ratio, and seedling quality index. Then, data were analyzed with the HSD at a 5% confidence level. The results showed that the treatment of planting media combination with topsoil:sand:husk charcoal (2:1:1) and liquid organic fertilizer concentration of 400 ml/10 liters of water had the best responses.

1. Introduction

*Casuarina junghuhniana* is a protective tree that able to absorb rainwater and to prevent landslides. This tree has many benefits for humans, which can be used as an ornamental plant because of its beautiful shape, the trunk of the mountain pine tree can also be used as firewood because of its strong and durable wood-burning properties. This tree called mountain ru because it is able to survive in a place with an altitude of about 400-3000 meters above sea level [1].

The development and production of mountain ru seedlings in providing the needs of sufficient and good quality seedlings need to pay attention to nursery silvicultural techniques that can support the initial preparation of seedlings, such as fertilizing and determining the types of composition for planting media [1].

The planting medium is an essential aspect of supporting plant growth. The media help plants to stand upright and to meet the needs of water and nutrients, which absorbed by their roots. The planting media used are topsoil, husk charcoal, sand, gravel, rice husks, coconut belts, and others. The production of better planting media, combining three different types of media, is needed.

The quality of seedlings in the nursery can also be improved by fertilizing. Using various types of liquid organic fertilizer doses for forest trees has been conducted previously, such as a study by Saranga (2017) [2] on mahogany seedlings, with 100 ml/10 liters of water, 200 ml/10
liters of water, and 300 ml/10 liters of water concentrations. The results showed that the provision of Liquid Organic Fertilizer (LOF) had a significant influence on plant height growth. The higher the dose of LOF given, the higher the increase in the average height of the plant.

For supporting the development of forest tree plantations, such as mountain ru, silvicultural strategies need to be taken to stimulate the growth of the tree. Furthermore, it is necessary to add fertilizer to planting media in order to meet the needs of nutrients for plant growth. Therefore, research on the effect of planting media composition and the provision of liquid organic fertilizer on the growth of mountain ru seedlings need to be conducted.

2. Methodology

2.1. Research Time and Location
This research was carried out for ten weeks in the Permanent Nursery of Watershed Management Office at Saddang Lembang Marindind, Mengkendek District, Tana Toraja, and Laboratory of Silviculture and Tree Physiology of Faculty of Forestry, Universitas Hasanuddin, Makassar.

2.2. Research Materials
The materials used were 125 mountain ru seedlings. Planting media consisted of topsoil, sand, and husk charcoal in the ratio of 1:1:1, 1:2:1, 1:1:2, 2:1:1, as contents of mixture polybags, and liquid organic fertilizer as treatments.

2.3. Research Method
The experimental design used was a completely randomized design factorial experiment with 5 replications. The model of this experiment was:

\[ Y_{ij} = \mu + i + Bj + (abij + \epsilon_{ijk}) \]

\[ i = 1, \ldots, 3 \]

\[ j = 1, \ldots, 3 \]

\[ k = 1, \ldots, 3 \]

This research was conducted using two factors tested. The first factor was the planting media with the symbol 'm'. The second factor was fertilization by using liquid organic fertilizer (LOF) with the symbol 'p'.

2.3.1. Factor I was planting media consisted of topsoil media:sand:husk charcoal. It consisted of five levels with the symbol 'm'

- m0 = Topsoil
- m1 = 1 : 1 : 1
- m2 = 1 : 2 : 1
- m3 = 1 : 1 : 2
- m4 = 2 : 1 : 1

2.3.2. Factor II was fertilization by using Liquid organic fertilizer (LOF) consisting of five doses with the symbol 'p'

- p0 = Control
- p1 = 100 ml + 10 liters of water
- p2 = 200 ml + 10 liters of water
- p3 = 300 ml + 10 liters of water
- p4 = 400 ml + 10 liters of water

Total combination treatment was 25 combinations and repeated five times; thus, the total of the research units was 125 polybags. The treatment combinations are presented in table 1.
Table 1. Combinations of Treatments Between Media Topsoil:Sand:Husk Charcoal and Liquid Organic Fertilizer

| Planting media | The doses of Liquid Organic Fertilizer |
|----------------|---------------------------------------|
|                | p0 | p1 | p2 | p3 | p4 |
| m0             | m0p0 | m0p1 | m0p2 | m0p3 | m0p4 |
| m1             | m1p0 | m1p1 | m1p2 | m1p3 | m1p4 |
| m2             | m2p0 | m2p1 | m2p2 | m2p3 | m2p4 |
| m3             | m3p0 | m3p1 | m3p2 | m3p3 | m3p4 |
| m4             | m4p0 | m4p1 | m4p2 | m4p3 | m4p4 |

2.4. Research Procedure

2.4.1. Media Preparation. The media used for planting were topsoil, sand, husk charcoal. The mixtures of topsoil, sand, husk charcoal (1:1:1), (1:2:1), (1:1:2), and (2:1:1) were stirred until evenly mixed, then transferred to a polybag (12 x 17) cm and watered until saturated.

2.4.2. Weaning Seedling. The 3-months-old seedlings were weaned (moved) into polybags filled with media compositions according to the experimental design. The weaning was done in the morning. After the seedlings became solid, about five days after weaning, the seedlings height, diameter, and the number of leaves were measured as preliminary data.

2.4.3. Fertilization. Fertilization was done by giving various concentrations of LOF, namely p0 = without fertilizer (control), p1 = 100 ml + 10 liters of water, p2 = 200 ml + 10 liters of water, p3 = 300 ml + 10 liters of water, p4 = 400 ml + 10 liters of water. The mountain ru seedlings were sprayed for ten weeks with an interval of seven days and done in the morning.

2.4.4. Maintenance. Maintenance included watering and weeding. Watering was done twice a day, in the morning and evening. Weeding was done by pulling weeds that grew inside and outside of the polybag.

2.4.5. Observation and measurement. Observations and measurements were performed once a week during the study.

2.5. Observation variables

Observations and measurements were made once a week during the study. The observation variables were:

1. Plant height (cm). Measurement was carried out from the base of the trunk that had been marked up to the growing point using a ruler once every week.
2. Trunk diameter (mm). The measurement was done at about 2 cm above the base of the trunk using a caliper once every week.
3. The number of leaves. The fully open leaves were counted once every week.
4. Top Root Ratio (TRR), which was the ratio between the dry weight of plant top to the roots limit, and dry weight of the roots at the end of the study, calculated using the following formula:

\[
TRR = \frac{DWR (g)}{DWT (g)}
\]

5. The seedling quality index was calculated after completing the observation of plant height, trunk diameter, and the number of leaves at the end of the study. Three out of five seedlings for each treatment were selected to calculate the seedling quality index. Seventy-five mountain ru seedlings were selected. The formula of Seeding Quality Index is:

\[
QI = \frac{S}{(h/d) + (t/r)}
\]
Seed quality is classified as a good category if the Seedling quality index is greater than 0.09 [3].

2.6. Data Analysis
The difference in height growth, diameter, and the number of leaves obtained between the last measurement and initial measurements were analyzed. The top root ratio was obtained from the ratio between the dry weight of the upper side of the seedling and dry weight of roots.

Data obtained were analyzed by ANOVA using SPSS software. If there was a difference in the treatments given, a further test would be carried out by using an Honest Significant Difference (HSD) test. According to Gaspersz (1999), the formula is as follows:

\[ W = Qa (p,fe). \]

3. Results and discussion

3.1. Results of Study

3.1.1. Seedling Height. The results of measurements on seedling height carried out for ten weeks showed an increase every week. The best height growth of the seedlings was observed on \( m_4p_4 \), 15.0 cm, which was a combination of topsoil, sand, and husk charcoal with a ratio of 2:1:1 and the application of 400 ml LOF + 10 liters of water.

The increase in the average of seedlings height varied from 2.16 cm to 9.48 cm. That of the highest was \( m_4p_4 \) while the treatment with the lowest one was control (\( m_0p_0 \)). The increase in the average height of seedlings is depicted in Figure 1.

![Figure 1](image-url)

**Figure 1.** The increase of the average height of Mountain Ru Seedlings

The results of the analysis showed that a combination of planting media and LOF had a very significant effect, while the interaction between the two treatments had no significant effect on the increase of seedlings height. HSD tests for planting media and LOF solely on an average increase of seedling height are presented in Tables 2 and 3.
Table 2. The HSD Test of Planting Media Combinations on The increase of the average height of Mountain Ru Seedlings

| Planting media | Median | HSD test ($\alpha = 5\%$) |
|----------------|--------|---------------------------|
| m3             | 9.11   | a                         |
| m4             | 9.02   | a                         |
| m2             | 7.79   | b                         |
| m1             | 6.42   | c                         |
| m0             | 6.25   | c                         |

Note: Different letters mean significantly different in HSD test 5% of $\alpha$ level

The HSD test showed that $m_3$ was significantly different from $m_2$, $m_1$, and $m_0$. It indicated that the composition $m_3$ gave the best effect on the increase in the average height of seedlings compared to other treatments.

Table 3. HSD test of Liquid Organic Fertilizer on The increase of the average height of Mountain Ru Seedlings

| Liquid Organic Fertilizer (LOF) | Median | HSD test ($\alpha = 5\%$) |
|--------------------------------|--------|---------------------------|
| p4                             | 8.71   | a                         |
| p3                             | 7.89   | b                         |
| p2                             | 7.61   | bc                        |
| p0                             | 7.37   | bc                        |
| p1                             | 7.01   | c                         |

Note: Different letters mean significantly different in HSD test 5% of $\alpha$ level

The HSD test in Table 3 presents $p_4$ was significantly different from $p_3$, $p_1$, and $p_0$. The concentration of $p_4$ obtained the best response to the height increase of the seedlings compared with other treatments.

3.1.2. Seedling Diameter. Observations on mountain ru seedlings growth for ten weeks exhibited that the growth response increased every week. The results of measurements carried out for ten weeks showed that the best seedlings diameter was $m_4p_4$ with 400 ml of LOF + 10 liters of water compared to other treatments.

The average increase in the diameter of the seedlings for ten weeks was varied from 1.14 mm to 2.42 mm. $m_4p_4$ had the best seedling diameter, and the lowest one was $m_0p_0$. The overall diameter increase of mountain ru seedlings is presented in Figure 2.

![Figure 2. The increase of the average diameter of Mountain Ru Seedlings](image_url)
The HSD test of planting media and LOF sorely on seedlings diameter is displayed in Tables 4 and 5.

**Table 4. The HSD Test of Planting Media Combinations on The increase of the average diameter of Mountain Ru Seedlings**

| Planting media | Median | HSD test (α = 5%) |
|----------------|--------|-------------------|
| m4             | 1.74   | a                 |
| m3             | 1.48   | b                 |
| m1             | 1.47   | b                 |
| m2             | 1.41   | b                 |
| m0             | 1.41   | b                 |

Note: Different letters mean significantly different in HSD test 5% of α level.

The HSD test in Table 4 shows that m4 was significantly different from m3, m2, m1, and m0. It indicates that m4 gave the best effect on the increase in seedlings diameter compared to other treatments.

**Table 5. HSD test of Liquid Organic Fertilizer on The increase of the average diameter of Mountain Ru Seedlings**

| Liquid Organic Fertilizer (LOF) | Median | HSD test (α = 5%) |
|---------------------------------|--------|-------------------|
| p4                              | 1.59   | a                 |
| p3                              | 1.54   | ab                |
| p2                              | 1.48   | b                 |
| p0                              | 1.46   | b                 |
| p1                              | 1.44   | b                 |

Note: Different letters mean significantly different in HSD test 5% of α level.

3.1.3. Number of Leaves. m4 was the highest number of leaves on mountain ru seedlings compared to other treatments (34.6). The average increase in the number of leaves for ten weeks was varied results from 11.4 to 26.0. The lowest number of leaves was obtained on control media, while that of the highest one was obtained by planting media composition at a ratio of 2:1:1 and LOF with a concentration of 400 ml + 10 liters of water. The average increase in the number of leaves can be seen in Figure 3.

![Average numbers of seedlings leaves](image)

**Figure 3. The increase of the average numbers of Mountain Ru seedlings leaves**

The ANOVA showed that the combination of planting media and the LOF had a significant effect, while the interaction between both treatments had no significant effect on the increase leave number of the seedling; thus further test was needed. Table 6 and Table 7 provide the
HSD test results of planting media, and LOF on the average increase of seedlings leaves a number.

**Table 6. HSD test of Planting Media Composition on The increase of the average number of Mountain Ru Seedlings leaves**

| Planting media | Median  | HSD test (α = 5%) |
|----------------|---------|------------------|
| m4             | 20.64   | a                |
| m3             | 18.48   | b                |
| m1             | 17.75   | bc               |
| m2             | 17.31   | c                |
| m0             | 15.67   | d                |

Note: Different letters mean significantly different in HSD test 5% of α level

The HSD test results in Table 6 show that m4 was significantly different from the m3, m2, m1, and m0. It shows that the composition of m4 gave the best effect on the increase of mountain ru seedling’s leaves number compared to other treatments.

**Table 7. HSD test of Liquid Organic Fertilizer on The increase of the average number of Mountain Ru Seedlings leaves**

| Liquid Organic Fertilizer (LOF) | Median  | HSD test (α = 5%) |
|---------------------------------|---------|------------------|
| P4                              | 20.38   | a                |
| P3                              | 18.28   | b                |
| P2                              | 17.99   | bc               |
| P1                              | 17.39   | c                |
| P0                              | 15.81   | d                |

Note: Different letters mean significantly different in HSD test 5% of α level

The HSD test results in Table 7 show that p4 was significantly different from the p3, p2, p1, and p0. It indicates that p4 gave the best effect on the increasing number of mountain ru seedlings leaves compared with other treatments.

**3.1.4 Top Root Ratio.** The top root ratios of the seedlings were varied. The average of the mountain top root ratio can be seen in Table 8.

**Table 8. The Top Root Ratio of Mountain Ru seedlings**

| Treatment | Average of Top Root Ratio |
|-----------|---------------------------|
| M4P0      | 2.14                      |
| M2P4      | 1.97                      |
| M3P4      | 1.85                      |
| M3P1      | 1.81                      |
| M0P0      | 1.81                      |
| M4P3      | 1.70                      |
| M2P1      | 1.60                      |
| M3P0      | 1.57                      |
| M3P2      | 1.49                      |
| M0P1      | 1.46                      |
| M4P2      | 1.38                      |
| M2P2      | 1.38                      |
| M1P1      | 1.30                      |
M2P0       1.29
M4P1       1.23
M3P3       1.23
M1P0       1.22
MOP2       1.20
M1P4       1.20
M2P3       1.17
M1P2       1.09
M0P4       1.07
M0P3       1.05
M4P4       1.04
M1P3       0.94

ANOVA showed that the combination of planting media and LOF had a very significant effect, while the interaction between the two treatments did not affect the top root ratio. The results of the further test on the combination of planting media and LOF can be seen in Tables 9 and 10.

Table 9. HSD test of Planting Media Composition on The Top Root Ratio of the Mountain Ru Seedlings

| Planting media | Median | HSD test (α = 5%) |
|----------------|--------|-------------------|
| m3             | 1.58   | a                 |
| m4             | 1.50   | ab                |
| m2             | 1.48   | ab                |
| m0             | 1.32   | bc                |
| m1             | 1.15   | c                 |

Note: Different letters mean significantly different in HSD test 5% of α level

The HSD test in Table 9 presents that m3 was significantly different from m1, while m2 and m0 were not. It indicates that the combination of m3 gave the best influence on the top root ratio compared with other treatments.

Table 10. HSD test of Liquid Organic Fertilizer on Top Root Ratio of Mountain Ru Seedlings

| Liquid organic fertilizer (LOF) | Median | HSD test (α = 5%) |
|---------------------------------|--------|-------------------|
| p0                              | 1.60   | a                 |
| p1                              | 1.48   | ab                |
| p4                              | 1.43   | abc               |
| p2                              | 1.31   | bc                |
| p3                              | 1.22   | c                 |

Note: Different letters mean significantly different in HSD test 5% of α level

The HSD test results in Table 10 show that the p0 was very significantly different from p1, p2, p3, and p4. This result shows that the combination of p0 gave the best effect on the top root ratio compared to other treatments.

3.1.5. Seedling quality index. The observation result of the seedling quality index on mountain ru seedlings showed that seedlings had good quality. Data on seedling quality index measurement can be seen in Appendix 5. The ANOVA showed that the composition of the planting media and LOF gave a very significant effect, but the interaction between these two
treatments gave no effect on the mountain ru seedling quality index. The average of a seedling quality index can be seen in Table 11.

| Treatment | Average of Seedling quality index |
|-----------|----------------------------------|
| m4p4      | 0.23                             |
| m1p4      | 0.16                             |
| m4p3      | 0.15                             |
| m1p3      | 0.14                             |
| m2p1      | 0.13                             |
| m4p0      | 0.13                             |
| m4p1      | 0.13                             |
| m4p2      | 0.13                             |
| m0p3      | 0.12                             |
| m0p4      | 0.12                             |
| m1p0      | 0.12                             |
| m1p1      | 0.12                             |
| m2p3      | 0.12                             |
| m2p4      | 0.12                             |
| m3p0      | 0.12                             |
| m3p2      | 0.12                             |
| m3p4      | 0.12                             |
| m0p1      | 0.11                             |
| m1p2      | 0.11                             |
| m2p2      | 0.11                             |
| m3p1      | 0.11                             |
| m3p2      | 0.11                             |
| mop2      | 0.10                             |
| m2p0      | 0.10                             |
| m0p0      | 0.08                             |

The results of the analysis presented that the combination of planting media and LOF gave a very significant effect, while the interaction between the two treatments gave no significant effect on the seedling quality index of mountain ru seedlings. The results of the further tests of the combination of planting media and LOF can be seen in Tables 12 and 13.

| Planting media | Median | HSD test (α = 5%) |
|----------------|--------|------------------|
| m3             | 0.15   | a                |
| m4             | 0.13   | a                |
| m2             | 0.12   | b                |
| m0             | 0.11   | b                |
| m1             | 0.11   | b                |

Note: Different letters mean significantly different in HSD test 5% of α level
The HSD test results in Table 12 show that \( m_3 \) and \( m_4 \) were significantly different from \( m_2 \), \( m_1 \), and \( m_0 \). It depicts that \( m_3 \) gave the best effect on the seedling quality index compared to other treatments.

**Table 13. HSD test of Liquid Organic Fertilizer on Seedling quality index of Mountain Ru Seedlings**

| Liquid organic fertilizer (LOF) | Median | HSD test (\( \alpha = 5\% \)) |
|--------------------------------|--------|-------------------------------|
| p4                             | 0.15   | A                             |
| p3                             | 0.13   | B                             |
| p1                             | 0.12   | Bc                            |
| p2                             | 0.11   | Bc                            |
| p0                             | 0.11   | C                             |

Note: Different letters mean significantly different in HSD test 5% of \( \alpha \) level

The HSD test results in Table 13 show that \( p_4 \) significantly different from \( p_3 \) and \( p_0 \). These results show that the combination of \( p_0 \) gave the best effect on the seedling quality index compared to other treatments.

4. Discussion

4.1. Planting Media

The results of the HSD test in Table 5 show that \( m_4 \) with a comparison of 2 topsoil:1 sand:1 husk charcoal on the growth of mountain ru seedlings diameter produced the best response in this study. Furthermore, the results of this study were following a study by Rao (1994) [4] that soil is a natural medium for plants to grow that provides physical support needed to hold the root system and has a function as a reservoir of air, water, and nutrients, which essential for plant growth. The results of the HSD test in Table 7 show that the best growth of mountain ru seedlings leaves number was the interaction between the concentration of LOF and planting media composition with two topsoil:1 sand:1 husk charcoal (\( m_4 p_4 \)). The interaction between those two treatments with nutrients contained in LOF and planting media presumably able to provide supplies to stimulate the development of mountain ru seedlings. Foth (1994) [5] stated that nitrogen contained in fertilizer increases growth and produce greater development in dark green trunks and leaves.

The lowest diameter growth was obtained on \( m_0 \) and \( p_0 \), which were the controls of treatments. It is better to conduct a combination of treatment between 400 ml LOF + 10 liters of water and composition of 2 topsoil:1 sand:1 charcoal husk to obtain the optimal mountain ru seedling diameter growth. The results of ANOVA showed that the combination of planting media and the LOF gave a very significant effect, but the interaction between those two treatments had no significant effect on the increase of mountain ru seedling leaves a number.

4.2. Liquid Organic Fertilizer

The provision of LOF with a concentration of 400 ml LOF + 10 liters of water gave the best effect on the height increase of mountain ru seedlings. The concentration of 400 ml + 10 liters of water was the highest LOF concentration used in this study; thus, it gave the best effect on the growth of mountain ru seedlings. According to [6] one of the most critical factors that support plant growth to grow and produce optimally is the availability of nutrients in the soil at sufficient quantities.

The phosphorus content of LOF in mountain ru seedling’s primary function is cell division to trigger plant height growth.
In this study, the highest number of leaves produced by p₄, with a concentration of 400 ml LOF + 10 liters of water, which was the highest concentration of fertilizer. A high number of leaves produces due to the nitrogen content in LOF, where one of its functions is to stimulate leaf growth in a plant.

4.3. Top Root Ratio
The top root ratio shows the ability of roots to absorb water and nutrients from the soil to balance the rate of photosynthesis and transpiration of shoots. The smaller ratio indicates the readiness of seedlings to be moved to the field because it means that seeds have sufficient roots to support further growth in the field [8]. Barnett (1983) in Bramasto et al. (2011) [9] showed that the ratio of good root shoots is in the range of 1 - 3. The results of this study showed that the top root ratio ranged from 0.94 to 2.14.

These results indicated that the influence of planting media composition and LOF had a significant effect, but the interaction between these two treatments had no significant effect on the top root ratio. Only the treatment with top root ratio that meets the physical quality criteria of the seedlings that can be transferred to the field.

4.4. Seedling quality index
Based on the study by Yuniarti (2008) [8], the seedling quality index can be used to determine the best treatment tested and as an illustration of seedlings' ability to adapt to the new environment. The results of ANOVA showed that the treatment of planting media and LOF obtained a very significant effect, but the interaction between those two did not affect the seedling quality index of mountain ru seedlings. Roller (1977) in Martin et al. (2004) [10] showed that plants that are ready to be planted in the field have a seedling quality index above 0.09, which means that the seeds have a better ability to grow in the field [11]. Furthermore, the seedling quality index of this study ranged from 0.08 to 0.23. The average of the seedling quality index in the m₀p₀ treatment was 0.08, which meant that the seedlings were not ready to be planted in the field. However, in this study, it had been considered as successful research because the higher seedling quality index is more dominant. It can be seen from Table 10 that the averages quality index of mountain ru seedlings were good, and indicated that the seedlings are ready to be planted in the field.

5. Conclusion
The conclusions of this study were:
1. The concentration of 400 ml LOF + 10 liters of water obtained the best effect on the growth of mountain ru seedlings.
2. The composition of the planting media that given the best effect on the growth of mountain ru seedlings was topsoil, sand, and husk charcoal with a ratio of 2: 1: 1.
3. The interaction of LOF concentration and composition of planting media that obtained the best effect was topsoil, sand, husk charcoal with the ratio of 2: 1: 1, and concentration of 400 ml LOF + 10 liters of water.
4. The quality index of mountain ru seedlings was good, ranging from 0.10 to 0.23.

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