Diversity of morphological characters and seed growth of \((\textit{Amorphaluus muelleri})\) plants based on sources of planting materials and growth media

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Abstract. \textit{Amorphalus muelleri} has been popular among farmers, with the high demand in the world market. However, the information and knowledge on the provision of seed sources, which is also one of the limiting factors in \textit{A. muelleri} cultivation technology. This research aimed to identify and characterize the morphological diversity and growth response of \textit{A. muelleri} plants in polybags with two treatments of growing media as seed sources. This research was conducted in Pakuwon experimental station, the IIBCRI, Sukabumi, from October 2020 – April 2021. The study was conducted in a factorial randomized block design with two factors; source of planting materials (seeds, bulbils, small tubers), and growing media, soil + organic manure (1:1), and soil+organic manure+husk charcoal (1:1:1). The results showed the variability of morphological characters in weight of 100 grains, shape of sources, stem height, age of fully open leaf plants, stem diameter, number of leaves, the emergence of second shoots, canopy diameter, and presence of bulbils. While the results on plant growth rates of the interaction between the factors only occurred on plant height, shoots number, and tuber weight. Planting material from bulbils and growing media with the addition of husk charcoal gave the best response to each variable.

Keywords: Diversity, morphological character, planting material, growing media, \textit{Amorphaluus muelleri}

1. Introduction

\textit{Amorphalus muelleri}, which we called in Indonesia porang plants, is still in the same family as Iles Iles. \textit{A. muelleri} is one of the famous industrial plants and favored by the community, especially farmers [1]. \textit{A. Muelleri} plants were usually planted by farmers using an agroforestry model, a combination of shading plants that function as shade and water binders. The development was carried out in various areas considering that there was not a need to make changes to the structure of the planting area, which could be developed as an intercrop. This type of farming model was one of the most interested farming models by farmers. It was adaptive and sustainable, not having to do repeated plantings [2].

Provision of \textit{A. Muelleri} seeds currently still comes from wild plant sources that grow and are taken from the forest, which was a diverse diversity of planting materials and difficult to distinguish. One example, farmers are still unable to recognize plant seeds from seeds, bulbils, or tubers and even the quality of tubers from the three seed sources. Currently, farmers, academics, and researchers are researching \textit{A. Muelleri} family (iles-iles) plants which were propagated using small bulbs, bulbils (called frog tubers or coplok in East Java), and tuber skins [3]. The opinion of the previous research results showed that plants from seed planting material were more practical with higher productivity. Therefore,
the diversity of *A. Muelleri* seeds that existed in farmers was one of the objects of interest in this study to characterize *A. Muelleri* seeds with different planting materials and planting media composition.

Planting *A. muelleria* field with different origins of planting material requires different cultivation techniques: spacing between harvesting cycles of 1-4 growth cycles depending on the goals of the farming business to be achieved. Santosa [4] recommends producing *A. Muelleri* seeds in large quantities with adequate quality can be planted by planting 3-year-old large tubers 5 cm deep at close spacing. Soil moisture conditions during cultivation did not affect the quality of the seeds produced, although there was a tendency for seeds from dry land to grow better than seeds from water-saturated land [5]. However, the best type of parent plant growth media has not been known descriptively.

Characterization of the diversity of sources planting materials also provides information and a database for the success of this plant breeding program. Improvement of the character of one type of cultivated plant is largely determined by the availability of genetic diversity sources obtained from collections or from wild in the forest [6].

This study aimed to identify and evaluate the morphological diversity and growth of *A. Muelleri* plants in polybags media as a good source of seeds.

2. Materials and method

The research was conducted at the Pakuwon Experimental station and laboratory of Indonesian Industrial Crops Research Institute Sukabumi from October 2020 – April 2021. Places to grow were provided with polybags of the same size as 20x20 cm. Different planting materials obtained with germination conditions (active tuber buds) can be depicted in (figure 1). Planting material was sorted according to relatively uniform material quality [7]. The different sources of planting materials were obtained from Ngawi Regency, East Java. The media used was the topsoil media with a depth of approximately 20 cm. Furthermore, Organic chicken manure fertilizers and the last ingredient is husk charcoal (biochar). The tools used were ballpoint pens, measuring tools, rulers, calipers, analytical scales, and documentation cameras.

| Growing media | pH     | C-Organik (%) | N-Total (%) | P2O5 (ppm) | K-dd (cmol+/kg) |
|---------------|--------|---------------|-------------|------------|----------------|
| Soil : organic manure (1 : 1) | 6.16   | 2.59          | 0.25        | 449.51     | 1.34           |
| Soil: organic manure :husk charcoal (1:1:1) | 6.37   | 2.60          | 0.13        | 361.84     | 1.28           |

Notes: Primary data of laboratory analysis

2.1. Experimental design and treatments

This research used Factorial Randomized Block Design (RBD) with two factors, sources of planting material and growing media. Factors of sources of planting material were divided into three groups, namely; seeds, bulbils, and tubers. Furthermore, the second factor was planting media with two planting media: soil media+fertilizer+raw husk and soil+fertilizer+husk charcoal.

The planting material was graded based on size and was taken as medium-sized, which has an active bud [8]. Planting materials were planted in a seedling tank using soil, manure, and husk charcoal as a planting medium to produce shoots of approximately 2-5 cm than transplanting was carried out to polybag media measuring 20x 20 cm with soil media filling, raw husk manure, and another treatment with adding husk charcoal with portion ratio (1:1:1). The study was conducted in several sub-sections of the experiment. There are six experimental units with four replications.

2.2. Collecting data and statistical analysis

Observations had been measured since the completion of transplanting from the seedling tub to the media in polybags. The observed characters include qualitative and quantitative characters. The growth
rates of each quantitative character were observed three times on plant seeds aged 30, 90 and 150 days after planting (DAP). Qualitative character observations refer to previous research that had been carried out [9]. The observed morphological characters such as stem, leaves, bulbil, and tubers. The stem variables observed included diameter, height, color, texture, color pattern, and pattern shape. The leaf variables observed included leaf width, number of leaves, leaf length, canopy diameter, leaf color, and leaf shape. Bulbil variables observed include the presence of bulbil and bulbil shape. The tuber variables observed included tuber weight, tuber diameter, tuber surface color, tuber flesh color.

Furthermore, the other variables were observed on five samples of plant seeds for each experimental unit determined by systematic random sampling, four samples were taken from the fourth part of the plot, and one sample was taken from the center of the plot.

Data on the results of the diversity of morphological characters and growth diversity were presented in the form of group tables based on the treatment of sources of different planting materials. Furthermore, data analysis was carried out to see the interaction of the sources of the planting material on the diversity of the growth speed of *A. Muelleri* plants from different sources of planting materials.

![Figure 1](image)

Figure 1. Various sources planting materials; (a) seed, (b) bulbil (c) tubers

3. Results
The diversity of the morphological characteristics of porang from different sources of planting materials was found in many quantitative characters. Qualitative characters were not many found a field. Diversity was found in leaf, stem, and bulbil variables. Differences in planting material used *A. Muelleri* seedlings showed diversity in leaf color, stem height, age of leaf opening, stem diameter, number of leaves, age of second shoots, and canopy diameter.

The highest diversity was found in the sources of the planting material from seeds. Diversity was also seen in the qualitative characteristics of leaf morphology, leaf color, presence of bulbils, and stem pattern (figure 3). Observations were made on plants that had been transplanted from the seedbed to the media in polybags. The segregation theory supports the high diversity of plants from seed planting material in seeds of generative origin/seeds [10, 11]. The diversity in plant characters that appear can come from the combination of male pollen cells from other plants [10].

Based on the results are shown in (Figure 2 and Table 2) the qualitative variable of the shape of the seeds or tubers consists an oval, flat, and irregular shapes. While the bulbil tubers tend to be more uniform, oval, and irregular, then the tubers are round oval. Likewise, the leaf organ variables, namely leaf shape, leaf color, and leaf edge shape. In the variety of origin of plant material, the seeds have various leaf colors, namely, sharp green, light green, and dark purplish green. At the same time, the variety of planting materials from bulbil and tuber has leaf color from light green to sharp green. Diversity was also found in the shape of the leaf edges, variety of origin of the seeds has three variations of characters, namely, flat, grooved, and jagged. While the variety of origin of bulbil and tuber only has two variations of characters, namely, flat and curved.
Figure 2. Diversity of qualitative morphological characters in A. muelleri seed plants (A) shape of leaf, (B) color of leaf (C) Number of leaf (D, E, F) presence of bulbils, (G, H) shape of stem pattern.

Diversity was also found in stem morphology, including the shape of the pattern on the stem and bulbil at the tip. The character of the existence and shape of the stem pattern on the stems organ from the planting material, the seeds have a more uniform pattern on the stems than bulbils and tubers, which have linear and rhombus patterns. The character of the presence of bulbil at the tip of the stem was also more uniform in the absence of seed planting material, and this was different from the origin of bulbil and tuber planting material which had bulbil at each end of the stem.

Variations in morphological characters at the sources of A. Muelleri planting materials tend to be strongly influenced by genetics and the growing environment [12]. Genetic influences that were passed on to offspring have inherent traits in each individual, but it was also influenced by the environment, such as the climate in which the environment grows or abiotic and the different media from which the initial adaptation grows. The nature of free pollination of A. Muelleri plants inland or forest made the seeds had a high level of diversity of morphological characters compared to the sources of bulbil and tuber planting material. Thus, diversity was an expression of the character possessed by each individual, the influence of the merging of the two traits of male and female elders. The combination of several characters possessed by individuals has a different portion or percentage from one individual to another.

The percentage of germination or seed viability for each variety of plant materials was also different. The highest germination occurred from the source of the seed plant material, with a value of 97%. Furthermore, bulbil and tubers with a value of 93% and 84%, respectively. The high percentage of growth in plants from seed planting material is thought to be affected by the maturity level of the seeds obtained from a plant. In contrast, it was different from the planting material from bulbils and tuber which were obtained from various plants and adaptive land.
Tabel 2. The results of quantitative and qualitative morphological characterization A. Muelleri seed plants.

| Variables                        | Sources planting materials |
|----------------------------------|-----------------------------|
|                                  | Seed           | Bulbil          | Tuber           |
| Weight of 100 grain (gr)         | 45-70          | 120-370         | 230-380         |
| Shape                            | Oval, flat and irregular | Oval, and irregular | Oval           |
| Viability seed (%)               | 97% (11736/12000) | 93% (1864/2000) | 84% (671/800)  |
| Leaf opened (days after transplanting) | 6-12          | 8-14            | 14-23           |
| Second of the shoot (Hst)        | 22-36          | 26-36           | 52              |
| Leaf color                       | Dark green, light green, sharp green | Dark green, light green | Dark green, light green |
| Leaf shapes                      | Lancet, Oval   | Lancet          | Lancet          |
| The shape of stem pattern        | Vertikal line  | Vertikal line   | irregular       |
| Presence of bulbil               | absent         | exist           | exist           |
| Leaf edge                        | Flat, notched, and jagged | Flat, notched | Flat, notched |

3.1. The diversity of A. muelleri plant growth rates due to differences in planting media

The growth of A. muelleri seeds in polybags with different treatments of planting media resulted in differences in the variety of planting materials. Based on the variant analysis results, it turns out that from the five observed variables, two variables are not affected by any or both of the treatments. Variables that were not significantly affected by the treatment of the composition of the planting media included the number of leaves and the number of shoots. That was suspected that the number of leaves and shoots was not influenced by the speed of growth based on the treatment of (abiotic) growing media but it was biotic factors such as genetic or hormone. In contrast, the variables that were not affected by the sources of planting material treatment were found in the number of shoots. It was presumed that the large and medium planting materials size supplies more food reserves at the beginning of growth, resulting in faster growth with the plant height than small size [13]. Furthermore, the variables affected by the interaction of planting media composition with the sources of planting material included stem diameter, canopy diameter, and the number of leaves (Table 3).

The results showed the quantitative characters on the variables of stem diameter, plant height, and canopy diameter were influenced by the sources of planting material and the treatment of the growing media composition. The sources of planting materials from bulbil and tuber tend to have a high value compared to the origin of planting seeds. While the interaction treatment of the two treatments from the sources of planting material and the composition of the planting media affected the observed variables of plant height, the number of shoots, and weight of harvested tubers. This happens due to two reasons. The first was influenced by the size of the seeds, which was the smallest size of sources planting materials. The second reason was the poor porosity of the media caused by no addition of husk charcoal[13, 14, 15].
Table 3. The results of the variance analysis for quantitative characters observed.

| Source                        | Stem diameter (mm) | Plant height (cm) | Canopy diameter (cm) | Number of Leaves (sheet) | Number of shoots |
|-------------------------------|-------------------|-------------------|----------------------|--------------------------|-----------------|
| Growth Media                  | 0.004**           | 0.001**           | 0.000**              | 0.110                    | 0.08            |
| Sources planting materials    | 0.000**           | 0.000**           | 0.004**              | 0.000**                  | 0.000**         |
| Growth Media*various planting material | 0.198             | 0.001**           | 0.464                | 0.345                    | 0.001**         |

30 days after planting

| Sources planting materials    | 0.000**           | 0.000**           | 0.000**              | 0.000**                  | 0.000**         |
| Growth Media*various planting material | 0.372             | 0.000**           | 0.053                | 0.368                    | 0.002**         |

90 days after planting

| Growth Media                  | 0.014**           | 0.000**           | 0.004**              | 0.102                    | 0.007**         |
| Sources planting materials    | 0.000**           | 0.000**           | 0.000**              | 0.000**                  | 0.000**         |
| Growth Media*various planting material | 0.372             | 0.000**           | 0.053                | 0.368                    | 0.002**         |

150 days after planting

| Growth Media                  | 0.018**           | 0.298             | 0.181                | 0.049*                   | 0.52            |
| Sources planting materials    | 0.000**           | 0.000**           | 0.99                 | 0.000**                  | 0.005**         |
| Growth Media*various planting material | 0.001**           | 0.487             | 0.99                 | 0.301                    | 0.664           |

Notes: * and ** significant at 5% and 1% level respectively

Planting media has a role in supplying water and food reserves stored in starch or commonly known as tubers in root crops. Tubers are starch plants stored in plant roots, and its development is largely determined by the proportion of soil and husk charcoal, which has functions as a water retainer and provides high water porosity so that it does not cause stagnant water and does not quickly solidify. That was shown in the data (Table 3) the effect of soil growing media, manure that has been added with husk charcoal with a portion ratio (1:1:1) has a higher value than that without husk charcoal on the observation parameter (character) stem diameter, plant height, canopy diameter respectively. Meanwhile, the growing media containing soil and chicken manure (1:1) lacked porosity and permeability for root and tuber development. Thus was reinforced at the time of harvesting tubers at the end of destructive observations, harvesting was done that the growing media of soil, manure, and husk charcoal were easier to harvest than media without husk charcoal [14, 15].

3.2. The diversity of A. muelleri plant growth rates due to different sources of planting materials

The diversity of growth performance from different sources of planting materials can be seen in (Table 4), the four quantitative characters of A. Muelleri plant growth, including stem diameter, plant height, canopy diameter, and a number of leaves, were significantly affected by the variety of different planting materials. This was expected, which it was caused by the difference in size between each selected planting material (Table 2) on the weight variable of 100 grains (gr). Seed size and weight, tubers weight, and bulbil weight increased sequentially. The larger the tuber size, the larger the shoots and stem diameter of each plant. This was in line with previous research conducted that bulbil weight size significantly affected the viability and growth of A. muelleriseeds[16, 17]. The greater the planting material used, the better the viability of the seeds, the plant height, and the weight of the tubers produced.
### Table 4. Effect of planting media on A. Muelleri seed growth performance

| Growth media                                               | Variable of quantitative characters |   |   |   |
|------------------------------------------------------------|-------------------------------------|---|---|---|
|                                                            | Stem diameter (mm)                  | Plant height (cm) | Canopy diameter (cm) | Number of leaves (sheet) |
| **30 day after planting**                                  |                                     |               |                |                      |
| Soil+Organic manure (1:1)                                  | 5.52 b                              | 10.40 b       | 17.84 b         | 6.21 a               |
| Soil+Organic manure+ husk charcoal (1:1:1)                 | 7.14 a                              | 16.30 a       | 22.39 a         | 6.68 a               |
| **90 Day after planting**                                  |                                     |               |                |                      |
| Soil+Organic manure (1:1)                                  | 8.89 b                              | 25.42 b       | 30.02 b         | 7.28 a               |
| Soil+Organic manure+ husk charcoal (1:1:1)                 | 10.38 a                             | 31.57 a       | 33.08 a         | 7.68 a               |
| **150 Day after planting**                                 |                                     |               |                |                      |
| Soil+Organic manure (1:1)                                  | 16.77 b                             | 33.64 b       | 36.18 b         | 6.83 b               |
| Soil+Organic manure+ husk charcoal (1:1:1)                 | 19.01 a                             | 52.56 a       | 37.40 a         | 7.73 a               |

Notes: Numbers followed by the same letters are not significantly different according to Duncan’s test at 5% level

### Table 5. The effect of sources planting materials on the growth of A. Muelleri seeds

| Source planting material | Variable of quantitative characters |   |   |   |
|--------------------------|-------------------------------------|---|---|---|
|                          | Stem diameter (mm)                  | Plant height (cm) | Canopy diameter (cm) | Number of leaves (sheet) |
| **30 days after planting**|                                     |               |                |                      |
| Seed                     | 3.33 c                              | 5.17 b        | 9.12 b         | 5 c                  |
| Bulbil                   | 7.45 b                              | 18.50 a       | 24.50 a        | 7.28 b               |
| Tuber                    | 8.21 a                              | 16.38 a       | 26.73 a        | 8.78 a               |
| **90 days after planting**|                                     |               |                |                      |
| Seed                     | 6.92 c                              | 13.50 c       | 18.57 c        | 5.08 c               |
| Bulbil                   | 8.74 b                              | 25.42 b       | 34.70 b        | 7.28 b               |
| Tuber                    | 13.25 a                             | 37.65 a       | 41.38 a        | 8.78 a               |
| **150 days after planting**|                                     |               |                |                      |
| Seed                     | 7.29 c                              | 33.64c        | 36.18a         | 5.08 c               |
| Bulbil                   | 16.77 b                             | 52.56b        | 39.42 a        | 7.42 b               |
| Tuber                    | 22.82 a                             | 60.52 a       | 42.57 a        | 9.35 a               |

Notes: Numbers followed by the same letters are not significantly different according to Duncan’s test at 5% level

Growth rates due to different sources of planting materials were different for each parameter. Tubers that have the highest value of each parameter than seed and bulbil sources planting materials figure 3. The growth rate of plant height for each source planting material was very consistent from 30 days after planting to the end of its life cycle.
Figure 3. The effect of sources planting materials on the growth rates of (A) plant height (cm), and (B) canopy diameter (cm)

In contrast, the data of (figure 4) showed the growth rates of canopy diameter increase dramatically from 30 days after planting to 90 days, then after that did not change values on the bulbil and tuber of sources planting materials. That was affected by the shoot ages, which it was old enough or ready to be dormant plants[18].

3.3. The effect of the interaction of composition media and various planting materials on the number of shoots, plant height, and weight of harvested tubers.

The interaction between composition media and sources of planting materials occurred in some observed variables such as the number of shoots, plant height, and weight of tubers. The type, size, and weight of sources planting materials which has treated soil and husk charcoal media had the highest value of the number of shoots, plant height, and weight of the tubers. In contrast, sources of planting material from seeds treated with soil and manure have the lowest value of the number of shoots, plant height, and weight tubers. This happens due to two reasons. The first was influenced by the size of the seeds, which was the smallest size of sources planting materials. The second reason was the poor porosity of the media caused by no addition of husk charcoal [13, 14, 15].

Tabel 6. The effect of the interaction of planting media with various planting materials on the number of shoots, plant height, and tubers weight.

| Groth Media                                      | Number of shoots (30 days) | Plant height 30 days (cm) | Tubers weight (gr) |
|--------------------------------------------------|----------------------------|---------------------------|-------------------|
|                                                  | Seed Bulbil Tubers         | Seed Bulbil Tubers        | Seed Bulbil Tubers |
| Soil+Organic manure (1:1)                        | 2.25 b                     | 2 a b                     | 13.50 b           |
|                                                  | 2 a b                      | 25.42 b                   | 37.65 b           |
|                                                  | 2 a b                      | 17.85 b                   | 54.37 a           |
|                                                  |                            | 61.74 b                   |                   |
| Soil+Organic manure + husk charcoal (1:1:1)      | 2.5 a                      | 2 a                        | 14.95 a           |
|                                                  |                            | 31.57 a                    | 40.73 a           |
|                                                  |                            | 30.18 a                    | 61.88 a           |
|                                                  |                            |                            | 99.83 a           |

Notes: Numbers followed by the same letters are not significantly different according to Duncan’s test at 5% level

The bigger the sources of planting material used, the higher the growth rate of the seeds obtained. This was due to a large amount of starch used as food reserves to grow seed vigor from tuber vegetative propagation. This was in accordance with the function of husk charcoal (biochar), as a soil enhancer and
as a form of carbon sequestration (tethering). Empirical evidence has proven that biochar could increase fertility, aeration, porosity, and soil organic C [14, 15].

4. Conclusion
Based on the results of the observation data and discussion, it can be concluded from this research; (1) The diversity of qualitative morphological characters had many found on seed sources planting material compared a bulbil, and tubers. (2) Diversity quantitative morphological characters such as plant growth rates due to differences in planting media had found in stem diameter, height plant, canopy diameter, and a number of leaves. (3) The effect of interaction between composition media and sources planting materials occurred in some observed variables such as the number of shoots, plant height, and weight tubers (4) The effect of soil growing media, manure that has been added with husk charcoal with a portion ratio (1:1:1) has a higher value of each variable. The addition of biochar or similar organic matter is highly recommended for the development of A. muelleri production in the field.

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