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Effect of Inundation Depth, Dosage of Sago Bagasse and Husk Charcoal on Sago Palm Seedling (*Metroxylon sagu*) Grown in Polybags

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Abstract Various attempts have been made to increase the survival rate (SR) of sago plants (*Metroxylon sagu* Rottb), especially the treatment of growing media and irrigation. The purpose of this study was to calculate the effect of (i) the depth of inundation on the survival rate of the seedling of Tana Luwu sago palm variety; (ii) dosage of ameliorant of sago bagasse and husk charcoal on the survival rate of the seedling of Tana Luwu sago palm variety. The research was conducted in Waelawi Village, West Malangke District, North Luwu Regency; South Sulawesi, Indonesia, April to June 2023. The study used a two-factor factorial design with a split plot design field design. The first factor is the depth of the stagnant water that flows continuously on the side of the polybag as the main plot, consisting of 3 levels: 3 cm, 6 cm and 9 cm. While the second subplot factor is the planting media factor consisting of 5 levels: without ameliorant, soil only (A0S6); a mixture of sago bagasse and soil with a ratio of 1:2 (B2S4); a mixture of soil and sago bagasse and soil 1:1 (B3S3); a mixture of husk charcoal and soil with 1:2 (C2S4), and a mixture of husk charcoal with 1:1 (C3S3) respectively based on volume. The seedlings used are relatively small, weighing between 168-728 grams (after trimming the leaves, leaving a midrib of 60 cm). The variable measured was the survival rate of the seedlings up to 50 days old. The results showed that the depth of inundation, the dose of bagasse and rice husk charcoal, had a significant effect on the survival rate of the Tana Luwu sago palm variety seedlings.

Keywords Sago, Inundation, Flood Tolerant, Bagasse, Biochar

1. Introduction

Food and Agriculture Organization (FAO) predicts, in 2050, the world will need to increase food production up to 60 percent, while at the same time there will be a scarcity of agricultural resources, especially land / land and water. Therefore, the use of marginal land, especially flooded land, with waterlogging tolerant plants needs to be developed. Sago is a crop that is suitable for these conditions [1]; but its seedling is steel, which is a problem. Indonesia has 50-60 percent of the world's sago potential [2].

Low survival rate (SR) in sago seedling is a very urgent problem in developing sago palm. Although the fact that sago palm seedlings cultivated on flooded land produce fewer carbohydrates than those grown on non-flooded land [3]. A substantial body of research indicates that soaking sago palm seedlings, particularly in water that flows through a raft system, increased survival rate [4]. By integrating immersion with flowing water around a pot containing a suitable volume of media which involved a composition of fertile materials, it is possible to achieve optimal seedling growth and a favorable survival rate. Survival rate is the percent of living tree seedlings against total tree seedlings planted [5], [6].

Inundation and Media of Sago Palm Seedlings

Multiple research findings have established that the presence of water on land, particularly in the form of inundation, significantly impacts the productivity of fully-grown plants as well as the survival rate and morphological growth of small plants or seedlings. In a study conducted by A. Azhar et al. [7], it was shown that sago plants grown on flooded ground exhibited reduced or diminished yield in comparison to plants cultivated on non-flooded land. Plants that undergo waterlogging exhibit elevated qNmax and NPQmax values, as elucidated. Prolonged waterlogging also results in a substantial reduction in leaf water potential (ψleaf) and photosynthetic pigment concentration. Optimal soil conditions, combined with adequate water supply, are essential for the plant to achieve a heightened photosynthetic potential and ensure consistent sago production.

However, it seems that several other research results, especially nurseries, show different results. Nursery acclimatization through immersion (flooding) has been shown to give good (positive) results in many parameters. The effect of the immersion treatment was found from some factual information from various research findings, which included: (i) the saplings (saplings) that had just been released from the stem of the parent tree were soaked in aerobic water (running water) for 3-4 weeks and then planted [8], [9]; (ii) it is recommended to carry out nurseries using a raft nursery system [10]; and (iii) nursery with a raft system is proven to produce a longer average shoot length than the polybag system alone [11].

In 2017 in the area of a sago plantation in Meranti Regency, an experiment was carried out aiming to find out the effect of immersing sago palm seedlings using the lid and raft method on the growth of young sago plants in the adaptation phase. The experimental results showed that soaking sago palm seedlings had a significant effect on the number of live plants (SR), number of leaf midribs, leaf color index, plant height, number of leaflets, width of plant midribs and number of dead leaf midribs, but had no effect on the increase in the number of leaf midribs [12]. In addition, it was also explained that the change in the water content of the raft seedlings indicated that there was a maximum time for the transfer process from the nursery to the field, namely 120 minutes with a moisture content value of 81%. However, there have been no experiments regarding the effect of immersion water depth on the survival rate and growth of sago palm seedlings.

Sago Plant Nursery Pot Media

Sago palms are tolerant of very acidic conditions (low pH) coupled with high concentrations of metals in the soil such as aluminum, iron and manganese, which inhibit the growth of other plant species. It has an ability to thrive in heavy clay soils, which inhibits the growth of other plant species [13]. Sago will grow more optimally on soils with a fairly-high organic content. The organic content in this soil is usually related to the element calcium, phosphate, potassium and magnesium [14]. One source of organic material which is an important agricultural waste because it is quite abundant in sago growing areas is sago waste in the form of sago waste (sago bagasse, SB) itself. Various research findings indicate that this waste is very potential (bagasse) to be developed into a plant medium. These findings, among others, come from Kumar et al. [15].

The recommended use of organic materials is not only in the form of compost, but also in the form of charcoal or biochar. It was further explained that the combination of the use of rice husk biochar and Glomeromycota mushroom inoculation is recommended to increase Cherry tomato yields and improve fruit quality through the production of bioactive compounds. Singh [16] suggested that rice husk biochar is an option for sustainable crop residue waste management to improve nutritional status, microbial biomass and plant productivity. Increasing the concentration of biochar according to Abdelhafez et al. [17] allows significant improvement of various parameters by increasing the pH which can be a useful strategy to further increase the rate of organic loading.

In addition, the application of biochar from peanut shells and date seeds also increased chlorophyll pigment in the leaves and increased plant growth parameters in its application up to 2.5%, better than concentrations of 1, 5 and 10%. The results of other studies are in line, which show that the addition of biochar to soil can increase pH, increase organic carbon content, increase nutrient retention, encourage porosity, increase water holding capacity, and increase microbial biomass. As a result, biochar can contribute to soil fertility, increase crop yields, help close nutrient cycles [18]. A research results [19] showed that the composition of 75% sago dregs + 25% two-month decomposition compost was able to increase the growth and productivity of dwarf pepper while fresh sago waste

(75 - 100%) resulting from one month's decomposition is effective in reducing weed populations.

2. Research Objectives

The aim of the study was to analyze the effect of the depth of inundation water, and the composition of the media for sago nursery polybags in North Luwu Regency, South Sulawesi, Indonesia. The details are presented as follows:

(i) To analyze the effect of the depth of inundation on the survival rate of the Tana Luwu sago variety;

(ii) To analyze the effect of dosages of sago bagasse and husk charcoal on the survival rate of Tana Luwu sago palm seedlings.

3. Material and Method

Research Design and Location

This research was carried out in Waelawi Village, West Malangke District, North Luwu Regency, a most famous village as a central of sago production in South Sulawesi (Fig. 1). North Luwu Regency is a regency sited in northern of South Sulawesi as a region that is known as a central of sago production in South Sulawesi Indonesia. Besides that, the region has a variety of sago palm, called sago variety Tana Luwu.

The study was designed with a split plot design with two factors. The first factor is the depth of the puddle which continuously flowed around of the polybag media. The second factor is the media that is filled into the polybags. The first factor is the depth of the puddle consisting of 3 levels: 3 cm, 6 cm and 9 cm. The second factor is the composition of the mixture of ameliorant of sago bagasse and husk charcoal and soil in polybag with five levels: without ameliorant, mixture of bagasse and soil with ratio 1:2, bagasse and soil with ratio 1:1, husk charcoal and soil with ratio 1:2, and husk charcoal and soil with ratio 1:1. The media volume is 6 L and height 20 cm. It is repeated five times so that there are 75 units. The treatment combinations are shown as follows:

G1A0S6: inundated 3 cm, media without ameliorants sago bagasse or rice husk charcoal, soil only 6 L

G1B2S4: inundated 3 cm, mixed media of sago bagasse 2 L and soil 4 L, ratio 1:2 based on volume

G1B3S3: inundated 3 cm, mixed media of sago bagasse 3 L and soil 3 L, ratio 1:1 based on volume

G1C2S4: inundated 3 cm, mixed media of husk charcoal 2 L and soil 4 L, ratio 1:2 based on volume

G1C3S3: inundated 3 cm, mixed media of husk charcoal 3 L and soil 3 L, ratio 1:1 based on volume

G2A0S6: inundated 6 cm, media without ameliorants sago bagasse or rice husk charcoal, soil only 6 L

G2B2S4: inundated 6 cm, mixed media of sago bagasse 2 L and soil 4 L, ratio 1:2 based on volume

G2B3S3: inundated 6 cm, mixed media of sago bagasse 3 L and soil 3 L, ratio 1:1 based on volume

G2C2S4: inundated 6 cm, mixed media of husk charcoal 2 L and soil 4 L, ratio 1:2 based on volume

G2C3S3: inundated 6 cm, mixed media of husk charcoal 3 L and soil 3 L, ratio 1:1 based on volume

G3A0S6: inundated 9 cm, media without ameliorants sago bagasse or rice husk charcoal, soil only 6 L

G3B2S4: inundated 9 cm, mixed media of sago bagasse 2 L and soil 4 L, ratio 1:2 based on volume

G3B3S3: inundated 9 cm, mixed media of sago bagasse 3 L and soil 3 L, ratio 1:1 based on volume

G3C2S4: inundated 9 cm, mixed media of husk charcoal 2 L and soil 4 L, ratio 1:2 based on volume

G3C3S3: inundated 9 cm, mixed media of husk charcoal 3 L and soil 3 L, ratio 1:1 based on volume

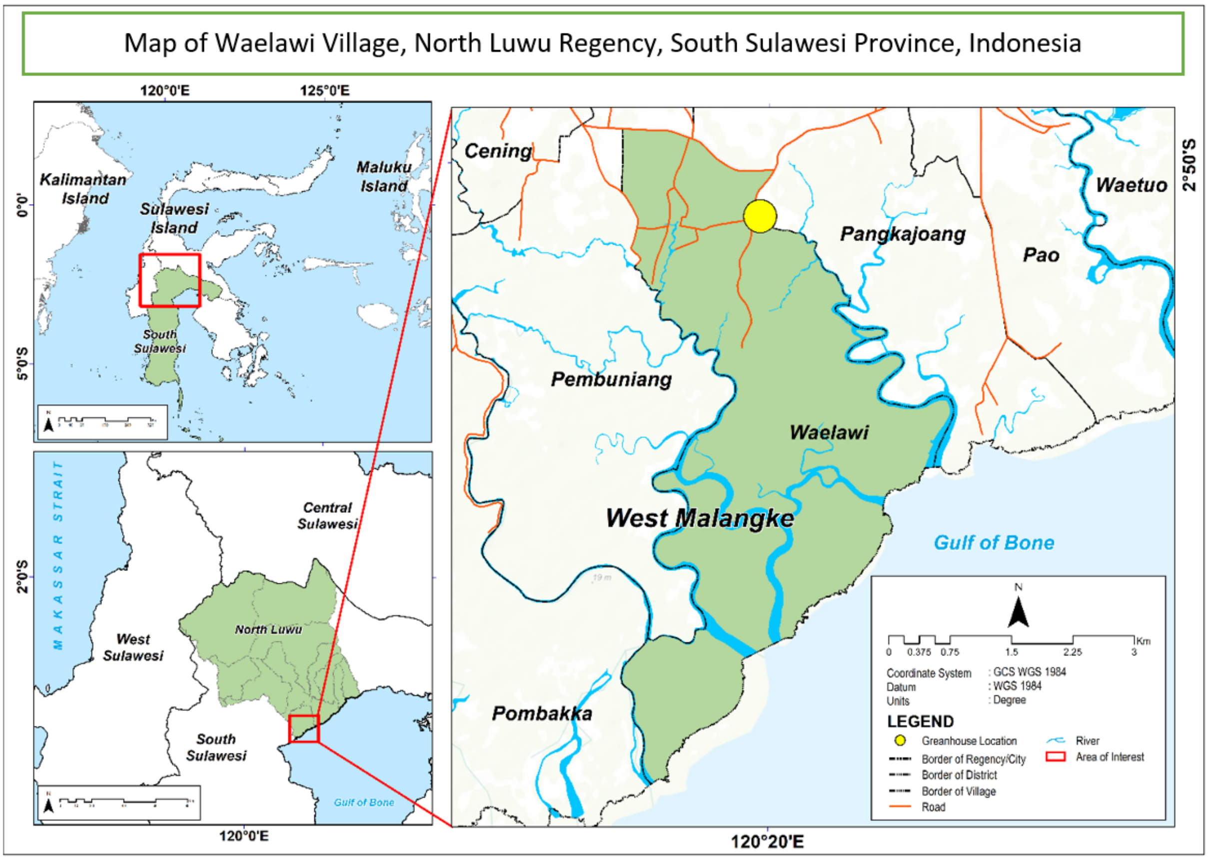

Figure 1. The site of the research, Waelawi Village, West Malangke, North Luwu, South Sulawesi, Indonesia

Materials

- Sago palm seedlings (*dangkel*) with 3-4 leafy fronds have just been weaned from their mothers, measuring 162-722 grams of plants with leaves removed and leaving only 60 cm long fronds. The roots are also cleaned, followed by soaking for 12 hours with a mixture of shallot: garlic extract 2:1 which fsunctions as a root growth stimulant and organic pesticide. Actually small seeds (<999 g) are not recommended; The recommended ones are those weighing between 1000-1499 g because they provide better growth of the rachis and primary roots, as well as a survival rate that is no different from large seedlings, namely between 66.3-71.0% [20]. However, researchers consider it important to examine the possibility of using small sized seeds for ease (efficiency) in mobilizing seeds in the context of expanding sago plantations.
- Air-dried soil (not paddy soil), which has been refined by filtering through a 5-mesh sieve.
- Weathered air-dried sago bagasse, at least two years after processing and disposal in open land as waste with a bulk density of 270 g/cm^3.
- Husk charcoal (charcoal) with a bulk density of 210 g/cm^3.
- Shallots and garlic with a ratio of 2:1 as a source of extracts to be used as growth regulator and natural pesticides with an extract concentration of 1 kg/50 L of water.
- Chemicals for soil and tissue analysis in laboratories
- Scales, meter, sliding bar.
- Mini-green house with UV plastic roof and 75-percent screen.
- PVC pipe for irrigation installation.
- Seedling planted before three days, recommended before 7 days after being released from its mother [21].

Parameters

- Survival rate up to the age of 50 days (in %). The survival rate was calculated by the formula [5], [6]

$$\text{Survival rate} = \frac{\text{Number of living seedling}}{\text{Number of total seedling planted}} \times 100\%$$

Procedure

Starting with the preparation of a mini-green house measuring 5 m x 4 m; preparation of bagasse ameliorant and rice husk charcoal; preparing gutters to form puddles as deep as 3, 6 and 9 cm; mixing soil with ameliorant; poly bag filling; planting seeds by immersing all parts of the hump until the position of the growing point is about 3-5 cm depth below the surface of the media in a polybag; maintenance and measurement of variables/parameters.

Bagasse materials are taken from the sago processing waste disposal site, air-dried (until the weight is constant), and then sieved with a 5-mesh sieve. Husk charcoal is made by burning according to the method of farmers or rice processors in most rice producing areas and in general in Indonesia. These materials are then measured in 2 or 3 L to be mixed with air-dry soil prepared according to the treatment. The soil used is inceptisol (alluvial) soil taken from the environment where sago plants grow in Waelawi Village. It is also air-dried then sifted with a 5-mesh sieve. The media mixture with a volume of 6 L each is put into polybags until the soil level in the polybag is 20 cm. Thus the media is ready to be planted.

Data Collection and Data Processing

Data collection is carried out by counting and recording the number of plants indicated to be alive (not dead).

Data Tabulation

Primary data collected are verified then tabulated and grouped using MS-EXCEL.

Data Analysis

Data that have been tabulated and grouped are then analyzed using a qualitative-quantitative descriptive analysis.

4. Results and Discussion

Result

Effect of Inundation Depth

The depth of the inundation statistically gives a real effect. The minimum depth (3 cm) is better than the 6 cm depth treatment, but not significantly different from 9 cm depth. Thus, the treatment depth of 9 cm is significantly different from 6 cm. Even so, the results of the linear regression test show the low strength of the relationship, it can even be said that it cannot be explained by the water depth variable (Table 1 and Figure 2).

Table 1. Survival rate of sago palm seedlings according to inundation depth at 50 days old

Inundation depth	percentage of viable seeds, %					Average
	I	II	III	IV	V	
3 cm	100	90	50	70	70	76[b]
6 cm	60	50	90	90	60	78[b]
9 cm	100	50	90	70	60	82[a]

Numbers followed by different letters mean differences at the 0.05 level

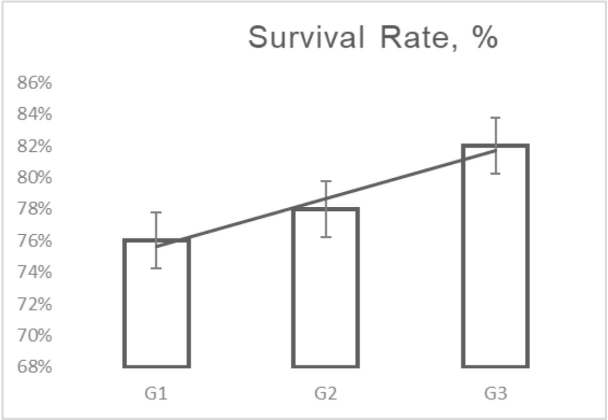

Figure 2. Correlation between polybag immersion depth and survival rate (SR) of sago palm seedlings

This finding is an indication that a relatively deep immersion depth to maintain a saturated or near-saturated soil water content is better; no voids in the soil are void of water. Aeration is thought to occur in the presence of an O_2 solution which is accompanied by flowing water by the provision of continuous flowing water. This can be a method that has the same effect as the initial seed growing method using a raft system which has so far been considered the most capable of providing the highest success rate of seedling survival [12]. Or it could be caused by the characteristics of the sago plants which are resistant to inundation, especially in the first 50 days. Previous studies have shown that deeper immersion heights have a good effect, although only up to the first two months (60 days) and thereafter the effect is worse than at other depths [3], [7]. There is a strong indication that additional water depth can still be recommended to reach its optimum.

Media Composition

Organic matter, both sago bagasse and husk charcoal, has a significant effect on survival rates. The higher the level, the better. When compared to the two organic materials, husk charcoal is significantly better than sago bagasse for both levels (Table 2 and Figure 3). This is thought to be caused by adding organic matter to increase the porosity of the media while the water level is also guaranteed or meets the requirements continuously. The advantage of rice husk charcoal compared to bagasse until 50 days after planting is due to its greater sterility, while the advantage that bagasse has due to its higher nutritional content has not contributed to the seedlings at the beginning of their growth. It cannot be recommended yet, because it is possible that bagasse can be better at an advanced stage when bagasse is able to support it with nutrients compared to husk charcoal which is only rich in carbon and poor in other nutrients. Another research found, the combination of granule compost and inorganic fertilizer may improve the results of dry corn grain production of 30-47 % compared with inorganic fertilizer or granule compost alone [22]. The increasing production related to the significantly affected the physical characteristics of soil including soil bulk density, soil porosity, soil macropore, mesopore, and micropore.

Table 2. Survival rates according to the composition of the media

Media Composition	percentage of viable seeds, %					Average
	I	II	III	IV	V	
A0S6	67	67	100	83	67	77 b
B2S4	83	67	83	67	67	73 c
C2S4	67	83	83	67	83	77 b
B3S3	83	83	67	83	67	77b
C3S3	100	67	83	83	67	80a

Numbers followed by different letters mean differences at the 0.05 level

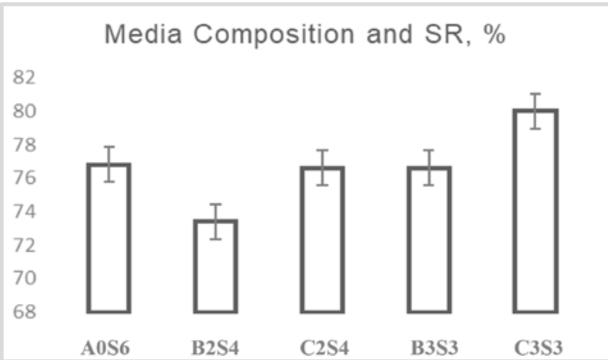

Figure 3. The relationship between the type and dosage of ameliorant and the seedling survival rate of up to 50 days

Due to their findings, Kumar et al. [15] strongly recommend that sago bagasse hydrolysate (SBH) be used for planting media. SBH with plant growth promoting properties should be used for agricultural productivity as an inexpensive, environmentally friendly biofertilizer. In line with that, Tando & Asaad [23] explained that SBH apart from triggering seed germination due to hormone production also significantly increases the expression of carbon assimilation enzymes such as malate. Sago bagasse biochar is proven to have low nutrient content, but could retain important plant nutrients, and there is an increase in N, P, K and C nutrient absorption in the Talam one peanut variety and nutrient status in ultisol soil. Also Ch’ng et al. [24] found that the seed germination index in the phytotoxicity test was above 80% of the final compost.

It was further explained that co-compost products with balanced nutritional content can be produced by composting sago bagasse and chicken manure slurry. From the results of a 1994 experiment, it was concluded that applying 25% sago bagasse compost was better than 0.50 and 70 percent for albisia seedlings [25]. However, in the shallot experiment, even though the dose of sago bagasse compost did not significantly affect various parameters, it did have a significant effect on tuber production, increasing according to the dose. The highest tuber production of 11.56 t ha^{-1} was obtained from a dose of 105 t ha^{-1} compared to 9.61 t ha^{-1} at a dose of 70 t ha^{-1} [26]. Research results showed that the composition of 75% sago dregs + 25% two-month decomposition compost was able to increase the growth and productivity of dwarf pepper [19].

Most researchers report positive effects of biochar application on soil physical and chemical properties, soil microbial activity, biomass and plant yields [27]. Rice husk charcoal (rice husk biochar, RHB) for example. Biochar contains soluble and leached potassium. The amount of potassium leached from the soil given 30 t ha^{-1} biochar was no different from that given 200 kg KCl ha^{-1}. The research also found that biochar produced significantly reduced soil pH [28]. Apart from that, biochar also reduced soil salinity and increased soil organic matter. Additionally, application of biochar to the soil affected the changes in both physical and chemical soil properties such as BD, WHC, pH, and cation exchange capacity [15]. The addition of biochar to the media increases C-organic, which is thought to be the cause of the increased survival rate, because C-organic is positively correlated with pH (KCl), Calcium, CEC, Magnesium and Potassium. C-organic is positively correlated with pH (KCl), calcium, CEC, magnesium, and potassium; also decreases Fe [29]. Prihastanti [30] found, sago waste block compost is better for seedling growth, so that sago waste block compost can be considered as an environmentally friendly alternative to polybags.

5. Conclusions

1) The depth of inundation has a significant effect on the survival rate of sago palm seedlings up to 50 days old. Up to a depth of nine centimeters the deeper the puddle, the better.
2) Bagasse and/or rice husk charcoal and their dosages have a significant effect on the survival rate of sago palm seedlings up to 50 days of age.
3) Until the age of 50 days, husk charcoal at the two dosages level (ratio 1:2 and 1:1) has a better effect than sago bagasse at the same concentration.
4) These findings show the importance of continuing research by increasing the high level of inundation and dosage of sago bagasse and husk charcoal.

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