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Effects of inundation height and peat swamp water treatment on the growth of Kalimantan swamp jelutung (*Dyera polyphilla*)

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Key words: Growth increment, Jelutung, Inundation, Empty fruit bunches of palm oil, Dolomite lime.

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Abstract

This study aimed to analyze the effect of inundation height with and without empty fruit bunches of palm oil (EFBPO) and dolomite lime on the growth of seedlings of swamp jelutung (*Dyera polyphilla*). The factors studied were factor A (inundation height) which consisted of the height of the polybag, the middle height between the tip of the polybag and the seedling shoot, and the height of the seedling shoot. Factor B consisted of peat swamp water without EFBPO and dolomite lime, peat swamp water with EFBPO, and peat swamp water with dolomite lime. The analytical method used was the Mann-Whitney U test to see the effect between each treatment. The results showed that the treatment of giving dolomite lime to peat swamp water could increase the height increment of jelutung seedlings at all levels of inundation, but the effect was not significant. This treatment could also significantly increase the survival percentage of jelutung seedlings, especially at deeper inundation heights, namely in inundation as high as the polybag height and as high as shoots of seedlings. The treatment of inundation height had a very significant effect on the increase in seedling height, where the higher the inundation, the higher the increase in the height of jelutung seedlings, but the survival percentage was decreasing. However, the decrease in the survival percentage could be reduced by applying dolomite lime to peat swamp water. In the present study, it is recommended to apply dolomite lime to the peat swamp water, while the use of EFBPO is not recommended unless there is an innovation to add oxygen to peat swamp water.

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Introduction

The destruction of Indonesia's forests and peatlands is in the international spotlight because of the importance of forest and peatland ecosystems for the future of the earth. Forest and land rehabilitation has been planned and carried out to overcome forest and peatland degradation. One of the programs that need to be done is to rehabilitate local species that are adaptive to living in forests and peatlands and can provide economic benefits for the surrounding community, one of which is swamp jelutung. Swamp jelutung (*Dyera polyphylla* (Miq.) Steenis) is a native plant species that grows in peat swamps, with natural distribution areas on the island of Sumatra, Peninsular Malaysia, and Kalimantan. Swamp jelutung is one of the species of the Apocynaceae tribe, genus *Dyera*.

Swamp jelutung can be developed with the pattern of Social Forestry (community forest), industrial tree plantations mixed with oil palm, or intercropping with agricultural crops and ponds (Agrosilvofishery) to obtain sap, timber, and restoration of ecological functions of an area. The use of marsh jelutung to rehabilitate peat swampland and to increase community income is also following the Research Master Plan of Lambung Mangkurat University, which was prepared as a policy direction to make the Lambung Mangkurat University a center for wetland development. Specifically, this research supports one of the focus areas of research, namely Natural Resources, Environment, and Disaster Management, which is to support the application of environmental rehabilitation technology for wetlands in the context of restoring and preventing damage to peatlands wetland vegetation and endangered animal species. However, if the peat swamp forest has been degraded, it is not easy to rehabilitate it. This is due to the high level of soil acidity, the presence of acid sulfate; in some areas, peat swamps have high inundation, so it is necessary to pay attention to the selection of the right type, hydrological regulation techniques, and avoid practices that accelerate peat compaction and increase emissions of greenhouse gases from peatlands.

According to Effendy (2010), planting jelutung in open areas after fires, land preparation is carried out with a lane system, lane width is 1.5 – 2.0 m and the distance between lanes is 5 m, planting distance is 5 m × 5 m. After making the path, stakes are installed and peat mounds are made. The goal is to collect soil mass for anchoring plant roots and raise the soil so that the seedlings are not submerged in water.

The height of the mound is at least 50% of the height of the inundation at the peak of the rainy season. Furthermore, according to Tata *et al.* (2015), jelutung nurseries with artificial inundation techniques as high as 30% of the polybag height are quite good, and water consumption is 28 times more efficient than manual nurseries.

Achmad and Bakri (2020) have proven that water from soaking empty fruit bunches of palm oil (EFBPO) and from dolomite lime can increase the pH of peat swamp water from 3.5 to 6 so that it can increase the growth of belangeran plant seedlings. To determine with certainty the sensitivity of marsh jelutung to inundation height about increasing pH through the treatment of oil palm empty fruit bunches and dolomite lime, it is necessary to conduct research. This study aimed to determine the sensitivity of the growth of swamp jelutung seedlings to inundation height with and without oil palm empty fruit bunches and dolomite lime. This growth will be represented by the increase in height, increase in diameter, and the survival percentage of swamp jelutung seedlings.

Materials and Methods

Materials

The materials used in this study were (1) Swamp jelutung (*Dyera polyphilla*) seedlings as an amount of 150 stems obtained from the Forest Plant Nursery of Central Kalimantan owned by the Watershed Management Institution in Tumbang Nusa, (2) black plastic bag with a size of 12 × 17 cm as many as 150 pieces that had been perforated, (3) water and peat swamp land from Liang Anggang, and (4) empty fruit bunches of fresh oil palm from the oil palm plantation of PT. Nusantara XIII Plantation (PERSERO) Pleihari Garden. The tools used were (1) a thermohygrometer to measure the temperature and humidity of the air inside and outside the greenhouse, (2) a ruler to measure the height of tillers, (3) a balance to weigh dolomite lime and oil palm empty fruit bunches, (4) a siegmat to measure the diameter of seedlings, (5) pH meter, (6) jeregens as a container of peat swamp water in transport, (7) glasses to measure the volume of water for watering, (8) large basins filled with water and seedlings as a medium for determining the height of inundation, (9) drums with a capacity of 220 liters 3 pieces, (10) machetes and saws for chopping empty bunches, and (11) stationery and camera for documentation.

Methods

The work procedure starts from (1) transporting the seedlings of Kalimantan swamp jelutung from Tumbang Nusa to Banjarbaru. The seeds were put in plastic bags containing 30 seedlings per bag to facilitate transportation, (2) after arriving in Banjarbaru; the seeds were stored in a shade house to adjust to the new conditions, (3) the original media was a mixture of peat compost and rice husks measuring too small for growth in the next four months, so the plastic bag was replaced with a larger size (16 cm high × 11 cm wide) so that peat soil was added to the polybag, (4) peat swamp water taken from the peat swamp in Liang Anggang was pH neutralized with empty fruit bunches of oil palm and dolomite lime. The peat swamp water was put in a basin and then added to one empty fruit bunches of oil palm that had been chopped. In another basin, dolomite lime was added to neutralize the pH of peat swamp water, which is 40 grams. In another basin without empty fruit bunches of oil palm and without dolomite lime or controls, (5) during the observation process, the seeds were placed in a greenhouse so that the treatment was not disturbed by rainwater, (6) measurements were made at the beginning and end of the study, and (7) maintenance during the experiment including the addition of peat swamp water with and without empty fruit bunches of oil palm and without dolomite lime so that the level of inundation remained by the treatment.

Factors studied: factor A (inundation height) consisting of A1 = as high as the polybag (16 cm), A2 = as high as the middle between the tip of the polybag and the seedling shoot, and A3 = the height of the seedling shoots (18.22 cm from the top of the polybag). Factor B (type of inundation water) consisting of B1 = Peat swamp water without empty fruit bunches of palm oil and dolomite lime/control, B2 = Peat swamp water with dolomite lime (20 g per basin), and B3 = Peat swamp water with empty fruit bunches of palm oil (1 piece empty fruit bunches of palm oil per basin with a capacity of 40 liters).

The treatments were combined so that 9 treatment combinations were obtained (A1B1, A2B1, A3B1, A1B2, A2B2, A3B2, A1B3, A2B3, and A3B3). Each treatment combination was compared in pairs.

The number of seedlings used in this study was: 9 treatment combinations × 5 seedlings per treatment × 3 replications = 135 seedlings of Kalimantan swamp jelutung. The variables observed were the increase in seedling height, measured from a height of 1 cm above the root neck to where the young leaf stalks emerge, measurements were made at the beginning and end of the study, the increase in seedling diameter, measured at the height of 1 cm above the root neck, measurements were made at the beginning and the end of the study, the survival percentage of seedlings was obtained by counting the number of seedlings that survived until the end of the study divided by the number of seedlings weaned multiplied by 100%.

Analysis

The data that has been obtained were analyzed using non-parametric statistics, namely the Mann Whitney U test, to compare the effect between each treatment combination. Data processing used SPSS 19.0 program package. According to Soegiono, cited by Achmad (2017), the Mann-Whitney U test is the best test for testing two comparative independent samples if the data are ordinal.

Results

Height increment

The analysis results of the comparison of seedling height increase based on the presence or absence of dolomite lime in peat swamp water used with different inundation heights analyzed according to the Mann-Whitney U test can be seen in Table 1.

Based on Table 1, the combination treatment of inundation as high as the polybag with peat swamp water/control (A1B1) increased the height of jelutung seedlings by 1.53 cm, while the combination treatment of inundation as high as the polybag with peat swamp water given dolomite lime (A1B2) increased the height of jelutung seedlings of 1.82 cm.

Tabel 1. Comparison of seedling height increment based on treatment in peat swamp water.

Treatment	Inundation as high as the Polybag Height Increment (cm)	Mark
Peat Swamp Water/Control	1,53	a
Peat Swamp Water + Dolomite Lime	1,82	a
Peat Swamp Water + empty fruit bunches of palm oil	-	-
Inundation between the tip of the polybag and the seedling shoot		
Peat Swamp Water/Control	2,29	a
Peat Swamp Water + Dolomite Lime	2,94	a
Peat Swamp Water + empty fruit bunches of palm oil	-	-
Inundation up to the shoot of the seedling		
Peat Swamp Water/Control	5,30	a
Peat Swamp Water + Dolomite Lime	6,21	a
Peat Swamp Water + empty fruit bunches of palm oil	-	-

The combination of inundation treatment between the polybag tips and seedling shoots with peat swamp water/control (A2B1) increased the height of jelutung seedlings by 2.29 cm, while the combination of inundation treatment between the polybag tips and the seedling shoots with peat swamp water was added with dolomite lime (A2B2) increased the height of jelutung seedlings of 1.94 cm. Furthermore, the combination treatment of inundation to seedling shoots with peat swamp water/control (A2B1) increased the height of jelutung seedlings by 5.30 cm, while in combination treatment of inundation between the tip of the polybag and the shoots of the seedlings with peat swamp water given dolomite lime (A2B2) increased the height of jelutung seedlings of 6.21 cm.

Tabel 2. Comparison of seedling height increase based on inundation height.

Treatment	Peat swamp water/control Height increment (cm)	Mark
Inundation as high as the polybag	1,53	a
Inundation between the tip of the polybag and the seedling Shoot	2,29	b
Inundation reaches the shoot of the seedlings	5,30	c
Peat swamp water + dolomite lime		
Inundation as High as the Polybag	1,82	a
Inundation between the tip of the polybag and the seedling Shoot	2,94	b
Inundation reaches the shoot of the seedlings	6,21	c
Peat Swamp Water + empty fruit bunches of palm oil		
Inundation as High as the Polybag	-	-
Inundation between the tip of the polybag and the seedling Shoot	-	-
Inundation reaches the shoot of the seedlings	-	-

Based on the results of the analysis, it can be concluded that dolomite lime can increase the height increase of swamp jelutung seedlings, although based on the Mann Whitney U Test, the increase in height as a result of dolomite lime was not significantly different from the increase in the height of jelutung seedlings that were inundated with peat swamp water without treatment/control.

Tabel 3. Comparison of survival percentage of seedlings based on water treatment.

Treatment	Inundation as high as the polybag	Mark
	Survival percentage of seedlings (%)	
Peat swamp water/control	100,00	a
Peat swamp water + dolomite lime	100,00	a
Peat swamp water + empty fruit bunches of palm oil	-	-
Inundation between the tip of the polybag and seedling shoots		
Peat swamp water /control	66,70	a
Peat swamp water + dolomite lime	73,30	a
Peat swamp water + empty fruit bunches of palm oil	-	-
Inundation up to seedling shoots		
Peat swamp water /control	20,00	a
Peat swamp water + dolomite lime	53,30	b
Peat swamp water + empty fruit bunches of palm oil	-	-

The Increase in Seedling Height based on Inundation Height

The results of the analysis of the comparison of the increase in seedling height without paying attention to the presence or absence of dolomite lime in the peat swamp water used at each inundation height of jelutung seedlings analyzed according to the Mann-Whitney U test can be seen in Table 2.

Based on Table 2, the combination of peat swamp/control inundation treatment with the polybag high inundation height (A1B1) increased the height of jelutung seedlings by 1.53 cm, the combination treatment of peat swamp/control inundation treatment as high as the polybag height with the seedling shoots (A1B2) increased jelutung seedling height of 2.29 cm. And the combination of peat swamp/control inundation treatment with a height of up to seedling shoots (A2B1) increased the height of jelutung seedlings by 5.30 cm. Furthermore, the combination treatment of inundation water in peat swamp with dolomite lime with inundation height as high as the polybag (A2B1) increased the height of jelutung seedlings by 1.82 cm, the combination of peat swamp inundation treatment which was given dolomite lime with the top polybag inundation height with seedling shoots (A2B2) increased the height of jelutung seedlings of 2.94 cm. And the combination treatment of inundation water from peat swamp plus dolomite lime with an inundation height up to seedling shoots (A2B3) increased the height of jelutung seedlings by 6.21 cm.

Based on the results of the analysis, it can be concluded that the higher the inundation, the greater the increase in the height of jelutung seedlings. This was evidenced by the Mann Whitney U Test, that the increase in height as the effect of inundation height was significantly different at each level of inundation.

Survival percentage of seedlings

Survival percentage of seedlings with and without Dolomite Lime

The results of the comparative analysis of the survival percentage of jelutung seedlings based on the presence or absence of dolomite lime in the peat swamp water used at each inundation height of jelutung seedlings were analyzed according to the Mann Whitney U test as shown in Table 3.

Based on Table 3, the combination treatment of polybag-high inundation with peat swamp water/control (A1B1) achieved a survival percentage of 100%, and the combination of polybag-high inundation treatment with peat swamp water treated with dolomite lime (A1B2) achieved a survival percentage of 100%. The combination of inundation treatment between the polybag tips and seedling shoots with peat swamp water/control (A2B1) reached a percentage of 66.70%, while the combination of inundation treatment between the polybag tips and seedling shoots with peat swamp water added with dolomite lime (A2B2) reached the percentage of life is 73.30%. Furthermore, the combination of treatment with inundation up to seedling shoots with peat swamp water/control (A2B1) only reached 20%, whereas in combination treatment with inundation up to seedling shoots with peat swamp water given dolomite lime (A2B2), the percentage of life was 53, 30%.

Tabel 4. Comparison of survival percentage of seedlings based on Inundation Height.

Treatment	Peat Swamp Water/Control	Mark
	Survival Percentage of Seedlings (%)	
Inundation as high as the polybag	100	a
Inundation between the tip of the polybag and seedling shoots	66,7	b
Inundation up to seedling shoots	20	c
Peat swamp water + dolomite lime		
Inundation as high as the polybag	100	a
Inundation between the tip of the polybag and seedling shoots	73,3	b
Inundation up to seedling shoots	53,3	b
Peat swamp water + empty fruit bunches of palm oil		
Inundation as high as the polybag	-	-
Inundation between the tip of the polybag and seedling shoots	-	-
Inundation up to seedling shoots	-	-

Based on the results of the analysis, it can be concluded that dolomite lime can increase the survival percentage of seedlings. Based on the Mann Whitney U Test, the survival percentage of swamp jelutung seedlings can be increased by applying dolomite lime to peat swamp water. Dolomite lime significantly increased the survival percentage of swamp jelutung seedlings, especially at the height of inundation to seedling shoots, from 20% to 53.3%.

Percentage of seedling survival based on inundation height

The results of the comparison of the survival percentage of seedlings without paying attention to the presence or absence of dolomite lime in the peat swamp water used, but based on the inundation height analyzed according to the Mann-Whitney U test, can be seen in Table 4.

Based on Table 4, the combination of peat swamp/control inundation treatment with inundation height as high as the polybag (A1B1) achieved a survival percentage of 100%, the combination treatment with peat swamp/control water inundation as high as between the polybag and seedling shoots (A1B2) achieved a survival percentage of 66.7%, and the combination of inundation oh peat swamp/control treatment with a height to shoots of seedlings (A2B1) resulted in a percentage of seedling survival of 20%. Furthermore, the combination of peat swamp inundation treatment with dolomite lime with inundation height as high as the polybag (A2B1) resulted in a 100% survival rate of seedlings, the combination of peat swamp inundation treatment which was given dolomite lime with the height inundation was between the polybag and seedling shoots (A2B2) resulted in a survival percentage of seedlings of 73.3%, and the combination of treatment of peat swamp inundation plus dolomite lime with inundation height to seedling shoots (A2B3) resulted in the percentage of survival of seedlings of 53.3%. Based on the results of the analysis, it can be concluded that the higher the inundation, the lower the survival percentage of seedlings, and the difference was categorized as significant according to the Mann-Whitney U test, but the decrease in the percentage of survival can be reduced by adding dolomite lime to peat swamp water.

Discussion

Liming is the application of lime to the soil not because the soil lacks Calcium elements but because the soil is acidic. Therefore, soil pH needs to be increased, so those nutrient elements such as Phosphate are easily absorbed by plants and Alminium poisoning can be avoided (Hardjowigeno, 2003). Furthermore, Kuswandi (1993) argues that applying lime to acid soils with materials containing Calcium or Magnesium will change or shift the position of H+ on the colloidal surface, thereby neutralizing soil acidity. Dolomite lime has a content or percentage of calcium (Ca) 30% and magnesium (Mg) 18 - 22%. The benefits of dolomite lime for soil are to neutralize acidic soil, increase Ca and Mg elements, reduce Fe, Mn, and Al poisoning, as well as improve micro-organism life and improve the formation of root nodules. Plant growth is strongly influenced by soil pH, either directly or indirectly. At low pH, Ca, Mg, and P are less available, while microelements are available, but Al is very high. Soils with low pH (pH < 6) are classified as acidic soils. Acid soils in the world are almost entirely concentrated in the wet tropics (Hakim *et al.*, 1986).

Some researchers have proven that dolomite lime can increase plant growth because it can increase soil pH. According to Hastuti (2013), the doses of dolomite lime (8 tons/ha) were the optimum dose for the growth of mustard greens. Furthermore, Prayitno (2015) concluded that there was a very significant interaction effect between the treatment of giving dolomite lime and modern granule organic fertilizer on the growth of shallots. The interaction treatment of giving dolomite lime at a dose of 9 tons/ha (29.220 g/polybag) and modern granule organic fertilizer at a dose of 150 kg/ha (4.870 g/polybag) gave the best results on the growth of shallots. Furthermore, according to Dianti (2015), the interaction of giving dolomite lime and EM4 has a significant effect on the growth of sweet corn plants. The average growth of sweet corn plant height was 68 cm in the treatment with concentrations of (Lime 40 g) and (EM4 40 cc/l water), while the average number of leaves was 10 leaves with concentrations of (Lime 30 g) and EM4 (40 cc/l of water). Based on the results of previous studies, dolomite lime alone or in combination with other factors was all targeted at the growth media. For this reason, it is necessary to try using splash water which is neutralized by soaking empty fruit bunches of oil palm and dolomite lime.

Achmad and Bakri (2021) have proven that soaking water of empty fruit bunches of palm oil (EFBOP) and dolomite lime can increase the growth of belangeran seedlings through the study of the Obligatory Research Lecturer program of Lambung Mangkurat University in 2020. The reason was the EFBOP and dolomite lime was able to increase the water pH from 3.5 to 6. For this reason, the treatment will be tried again in the study of the compulsory lecturer research program in 2021 with a different technique. In the 2020 study, water from empty fruit bunches of oil palm and dolomite lime was sprinkled onto the plants, but in the 20201 programs, it was through inundation, because of the habitat of the swamp jelutung seedlings in the field is mostly inundated by tidal water.

Based on the literature above, it can be concluded that dolomite lime is very helpful for plant growth. This has to do with the availability of nutrients directly from the lime itself, and also with the addition of lime can increase the pH of water and soil pH. With this increase in pH, elements of the growing media can become available, especially macro-nutrients, and reduce the availability of micro-nutrients that can poison plants.

A new thing that was found from the results of this study was the increase in the height of the seedlings which was quite sharp with the increasing height of the inundation. This has something to do with the plant's response to inundation, where the plant wants to be free from inundation quickly. Similarly, if there are other plants around the plant, the competing plant will work on the sensor that there are plants around it that will compete with its growth so that it tries to accelerate its height growth so that it can win the competition for light (Sasidharan *et al.* 2014).

In the case of the increase in the height of the seedlings which was quite sharp with the increasing height of the inundation, according to Visser (2003), stress on plants is much magnified when floodwater deepens sufficiently to inundate the shoots and roots. This is because the influx of aerial carbon dioxide for photosynthesis is largely impeded. One strategy of the plants to escape from the problem is to shorten the period of total submergence through a strong increase in the shoot elongation rate that reunites the shoot with air. In most cases, this strategy needs oxygen, is regulated by a build-up of the plant hormone ethylene, and is mediated via the expression of expansion genes (Voesenek *et al.* 2003; Vriezen *et al.* 2003). Conversely, according to Visser (2003), some species such as (*Potamegeton pectinatus*) are also able to escape with accelerating vertical extension without oxygen and independently of ethylene.

In particular, the application of empty fruit bunches of palm oil to peat swamp water at various inundation heights is not recommended because it causes plant death. This may be due to the presence of the empty fruit bunches of palm oil in the peat swamp water; the breakdown of organic matter by bacteria (decomposers) is still ongoing. These bacteria require considerable energy in the process of overhauling organic matter so that in the inundation there is a lack of dissolved oxygen. According to Hasymi (1986) quoted by Yunita (2002), in the process where bacteria and decomposing organisms require large amounts of energy, they consume large amounts of oxygen; this results in reduced oxygen dissolved in water. The amount of energy expended causes an increase in respiration results followed by an increase in excretion such as temperature, carbon dioxide, and ammonia levels in the water so that the pH decreased which caused the water to become acidic and hydrogen sulfide (H_2S) compounds were formed which caused a foul odor. In this situation, the water quality decreased drastically. This was exacerbated by the absence of oxygen supply from the water stream or aerator, causing plant death.

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Conclusions
Dolomite lime treatment could increase the height growth and survival rate of seedlings of Kalimantan swamp jelutung. In addition, the treatment of inundation height greatly affected the increase in height and the survival percentage of seedlings, namely, the higher the inundation, the higher the growth of seedling height, but the survival rate decreased drastically. However, the application of lime to peat swamp water can slow down the rate of decline in the rate of survival of jelutung seedlings. In particular, the application of empty fruit bunches of palm oil to peat swamp water at various inundation heights is not recommended because they caused a lack of dissolved oxygen in the peat swamp water resulted in plant death.

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