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Effectiveness of storage boxes and a simple greenhouse to revive *Shorea leprosula* wildlings

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Abstract

The *Shorea leprosula* wildlings needed a special storage box during transportation process in order that they still survive when planted in a nursery. In addition, they should be tended in a simple greenhouse to revive from stress because of extraction from original sites and transportation process. The aims of the research were to determine the longest time the wildlings can be kept in a storage box and the shortest time the wildlings should be tended in a simple greenhouse. The research applied two factors: duration of keeping the wildlings in a storage box and duration of tending the wildlings in a greenhouse. The two factors were tested with a factorial in a completely randomized design. The Least Significance Difference (LSD) test was used for testing the comparison effects among treatments of the two factors. The results showed that the growth of the wildlings was significantly affected by the two factors applied. The longest time the wildlings can be kept in a storage box was 3-5 days, while the shortest time the wildlings should be tended in a simple greenhouse was 15 days.

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Introduction

In planting the dipterocarp tree species such as *Shorea leprosula* in a large scale sometimes encounters obstacles such as silvicultural systems, particularly regarding seedling procurement. This is because the Dipterocarpaceae family sometimes bears fruit only once in four years, some even once in 13 years to bear fruit. One alternative to reduce this problem is utilization of natural/wild seedlings (wildlings) collected around mother trees.

Another issue is the reduction of natural forests as habitat of parent trees that make the distance between the source of wildlings and nurseries far away, and this takes time in transportation. To keep the wildlings fresh during transportation, they should be kept in a specific container such as storage boxes. The storage box was made of carton paper that was layered with sponge in the inner part of the box so it can keep moisture. Such condition will make the wildlings fresh for several days. In addition, to revive the wildlings from stress because of extraction from the original sites and transportation process, they need to be tended in a simple greenhouse. The simple green house was an imitated greenhouse that functioned to maintain high temperature and humidity that can trigger the growth of the wildlings.

Actually some studies about the effects of the simple greenhouse on wildlings' growth had been done by, for example, Sopandi (1992), Djers *et al.* (1998) and Achmad (2017), but they did not combine the effects of the storage box with the effect of the simple greenhouse on the wildlings' growth. The reason was that the mother trees as the source of wildlings and the nursery where the wildlings would be planted and tended were in the same location.

That situation will be different if the locations of mother trees and the nursery are far away. In the latter situation, the wildlings need transportation process for several days so that they need a specific container to keep them fresh. In this case, storage boxes were used. The storage box was made of a carton box that had been holed on all sides of the box except on the bottom side so that the wildlings ware able to respirate. In addition, the storage box was layered with sponge. After water spray, the sponge can keep the moisture in the box for several days so the wildlings would be in fresh condition.

The question was how many days the wildlings should be kept in the storage box so they still grow well in a nursery after being tended in a simple greenhouse. So the aims of the present research were (1) to determine duration of the wildlings should be kept in a storage box, and duration of the wildlings should be tended in a simple greenhouse, and (2) to determine the longest time the wildlings can be kept in the storage box, and the shortest time the wildlings can be tended in the simple greenhouse.

This would reflect that the longer the wildlings can be kept in the storage box, the more effective of the function of the storage box, and the shorter the wildlings to be tended in the simple greenhouse, the more efficient of utilization of the simple greenhouse in terms of costs, human energy, and time.

It was expected that the research would provide a technology package in seedling procurement through utilization of wildlings.

Materials and equipment

Materials used were wildlings collected around mother trees, topsoil underneath the mother trees, black polybags with a size of 10 cm × 15 cm that had been holed, storage boxes with a size of 40 cm × 25 cm × 20 cm of 4 boxes, sponge with 1 cm thick, transparent plastic sheet for covering the simple greenhouse, and woody poles for the simple greenhouse frames. Equipment used was a thermo-hygrometer for measuring temperature and relative humidity inside and outside the simple greenhouse, a ruler for measuring the height growth of the wildlings, a caliper for measuring diameter of the wildlings, a sprayer for watering the wildlings, and stationery. The research was conducted in the working areas of PT Antang Kalimantan, Barito Utara District, Central Kalimantan Province, Indonesia.

Experimental design

The research applied a factorial with completely randomized design with 3 replications. Each treatment consisted of 4 wildlings. Factors and treatments were explained below:

1) Factor A, duration of keeping the wildlings in the storage box that consisted of 5 levels:

A_0 = without keeping the wildling in the storage box (control)

A_1 = keeping the wildlings for 3 days

A_2 = keeping the wildlings for 6 days

A_3 = keeping the wildlings for 9 days

A_4 = keeping the wildlings for 12 days.

2) Factor B, duration of tending the wildlings in the simple greenhouse that consisted of 5 levels:

B_0 = without tending the wildlings in the simple greenhouse (control)

B_1 = tending the wildlings for 15 days

B_2 = tending the wildlings for 30 days

B_3 = tending the wildlings for 45 days

B_4 = tending the wildlings for 60 days.

The number of treatment interactions was 5 × 5 = 25 treatments, so that the number of seedlings used in the research was 25 treatments × 4 wildlings per treatment × 5 replications = 500 wildlings.

Procedures

1) Wildlings of *Shorea leprosula* were collected from underneath mother trees.
2) The wildlings were kept in the storage box based on the treatments, and at the third day, all wildlings of the A_1 treatment were taken out from the storage box, then they were tended in the simple greenhouse and so forth. The same procedures were done until the A_4 treatment (at the twelfth day, all wildlings of the A_4 treatment were taken out from the storage box, and then they were tended in the simple greenhouse).
3) After being kept in the storage box based on the treatments, the wildlings were tended in the simple greenhouse. At day 15, all wildlings from the B_1 treatment were taken out from the simple greenhouse, and then they were placed at a wildling bed. The same procedures were done at every next 15-day up to the B_4 treatment (the wildlings were taken out from the simple greenhouse at day 60).
4) Tending activities encompassed wildling watering 2 times a day (in the morning and afternoon), weed removal, and pest and disease spray.

Variables

1) Height growth of the wildlings was measured at 1 cm from the root collar up to the apical meristem. Measurement was done at the beginning and at the end of the research.
2) Diameter growth of the wildlings was measured at 1 cm from the root collar. Measurement was done at the beginning and at the end of the research.
3) Survival percentage was the comparison of the number of growing wildlings with the total of wildlings planted of each treatment multiplied by 100.

Analysis

Data were analyzed according to a factorial in a completely randomized design. Analysis of variance of the main factor effects and interactive effects of the two factors applied were tested with the F-test.

Furthermore, the multi-comparison test of treatment effects from the two factors was tested with the LSD test. The analysis was supported with the SPSS software.

Results and discussion

Height Growth

Analysis of variance of height growth showed that duration of keeping the wildlings in the storage box, and duration of tending the wildlings in the simple greenhouse significantly affected the height growth of the wildlings (p 0.00 < 0.05). Yet, the interaction of the two factors did not significantly affect the height growth of the wildlings (p 0.41 > 0.05).

Furthermore, the multi-comparison test of duration of keeping the wildlings in the storage box on height growth of the wildlings was described in Table 1.

Table 1. Height growth according to the treatments of duration of keeping the wildlings in the storage box.

Code	Duration (day)	Height Growth (cm)	Mark
A_0	0	3,25	a
A_1	3	2,78	ab
A_2	6	2,67	bc
A_3	9	2,38	bc
A_4	12	1,87	c

Table 1 showed that the wildlings that had the highest height growth were the wildlings that were not kept in the storage box (A_0/control) with height growth of 3.25cm. The result did not differ significantly from the height growth of the wildlings kept in the storage box for 3 days (A_1) with height growth of 2.78 cm. But the effect of the treatment (A_0) significantly differed from the effects of other treatments applied.

It was presumed that the wildlings that were not kept in the storage box and kept for 3 days had the highest height growth because their water condition was still favorable for growth, while the wildlings kept for 6 days, 9 days, and 12 days, had already experienced a shortage of water (dehydration) as a result of continuously transpiration and respiration without water supply through the roots, so the wildlings were not able to grow well; the wildlings lost much water so that the process of photosynthesis and other physiological processes disrupted.

Water is very fundamental in the physiological process of plant growth. Water is important because (1) it exists all over the protoplasm and cell wall, (2) it is the cell fluid contained in the vacuole cells and plays an important role in turgidity and growth, (3) it induces absorption, osmosis and transfer of material, (4) it is essential to the carbon assimilation and the process has become slow if the plant is not in a state of non-turgid and will cease if the plant is in a state of wilt, (5) it is needed in respiration, which stops when the water is at the minimum condition, (6) it is required for transpiration and (7) it is required for all movements caused by various disturbances (Toumey and Korstian, 1959). Meanwhile, according to Sambas (1979), dehydration not only inhibited the formation of chlorophyll, but also resulted in the destruction of chlorophyll and the leaves look yellow.

Furthermore, according to Soedijanto *et al.* (1982), seedling supply through a wildling extraction system is sometimes stagnant so it is likely difficult to "get up" so that growth is rather late.

The multi-comparison test of duration of tending the wildlings in the simple greenhouse on height growth of the wildlings was described in Table 2.

Table 2. Height growth according to the treatments of duration of tending the wildlings in the simple greenhouse.

Code	Duration (day)	Height Growth (cm)	Mark
B_2	30	3,00	a
B_1	15	2,73	ab
B_3	45	2,69	ab
B_4	60	2,45	bc
B_0	0	2,00	c

Table 2 showed that the wildlings that had the highest height growth were the wildlings tended in the simple green house for 30 days (B_2) with mean height growth of 3.00 cm. This result was significantly different from the height growth of the wildlings tended for 60 days (B_4). Yet, this height growth did not differ significantly from the height growth of the wildlings tended for 15 days (B_1) and 45 days (B_3). This meant that the optimum duration of tending the wildlings in the simple greenhouse was 30 days. Tending the wildlings in the simple greenhouse for more than 30 days decreased height growth of the wildlings.

Leppe and Smits (1988) explained that wildlings that have been extracted should be placed under shade and in a greenhouse in order that they are in a humid condition of 80-90% and temperature not exceed 28°C. In keeping the high humidity, the wildlings in the greenhouse should be watered every day because low humidity can decrease survival percentage of the wildlings and soil temperature that exceed 29°C can kill the mycorrhizae that live on the wildling roots. If the research was associated with the temperature and humidity in the simple greenhouse especially at day time, the temperature reached 32°C and humidity reached 83%, it was

possible that the mycorrhizae were unable to grow more than 30 days in the simple greenhouse resulting in the decrease of the wildling growth.

This was consistent with the research results of Sopandi (1992) which concluded that tending the seedlings in the simple green house could be done for 30 days, but he did not keep the wildlings in the storage box previously. According to Leppe and Smits (1988), after transplanting the wildlings from the forest, they were able to place at humid room like in a simple greenhouse. After a few days, the simple greenhouse can be opened gradually and in general has been opened completely after three weeks and after two weeks later the wildlings can be planted in the field. It showed that the seedling tended for 30 days in the simple greenhouse got environmental factors that were in accordance with seedling growth, especially regarding the availability of moisture and temperature suitable for growth. Similarly, in keeping the wildlings in the storage box for 3 days with tending for 15 days (A_3B_1), although their yields were lower compared to the treatment without keeping the wildlings (A_0) with tending for 30 days (A_0B_2), but the results were not significantly different from the result of the best treatment (A_0B_2). Conversely, keeping the wildlings too long (12 days) without any tending (A_4B_0) resulted in a very stunted wildling growth.

According to Daniel *et al.* (1979), physiologically, water is very important as an essential element of protoplasm and vacuole fluid, as solvent gases and as supporting the transport of minerals and maintains turgidity. Water is also essential for the growth and elongation of cells, maintaining the plant form and regulate stomatal opening and regulate movements of the petiole and flower parts. So it was suspected that the wildlings kept for 12 days in the storage box might be encountered drought because the transpiration and respiration took place continuously without the supply of water through the roots, so that the wildlings were not able to pass up a perfect physiological process that interfere with growth. Moreover with no tending in the simple greenhouse, there was no trigger to solve physiological problems because of longer duration of keeping the wildlings in the storage box.

Diameter growth

Analysis variance of diameter growth showed that the factor of keeping the wildlings in storage boxes (p 0.00 < 0.05) and the factor of tending the wildlings in a simple greenhouse (p 0.00 < 0.05) significantly affected the diameter growth, but interactions of the two factors did not affect the diameter growth of the wildlings (p 0.63 > 0.05). Furthermore, the multi-comparison test of duration of keeping the wildlings in the storage box on diameter growth of the wildlings was described in Table 3.

Table 3. Diameter growth based on duration of keeping the wildlings in the storage box.

Code	Duration (day)	Diameter Growth (cm)	Mark
A_3	9	0.061	a
A_0	0	0,058	ab
A_2	6	0.043	bc
A_4	12	0,041	bc
A_1	3	0,038	c

Table 3 showed that the highest diameter growth was reached by the wildlings kept in the storage box for 9 days (A_3) with diameter growth of 0.061 cm. This result was higher than the result of the wildlings that were not kept in the storage box (A_0). The diameter growth then decreased when they were kept for 6 days (A_2), 12 days (A_4), 3 days (A_1).

Having regard to the tendency of such data, it did not mean that the longer the storage in the storage box, the more decreased the diameter growth. This might be related to the survival percentage of the wildlings studied, namely the wildlings with low survival percentage got space to grow better, and competition among the wildlings was relatively low, so they accepted full light (the light did not become a limiting factor) and thus they were able to make photosynthesis process well. In contrast, the wildlings in treatments that had high growth percentage had spacing between seedlings too close, and caused sunlight competition (the light became a limiting factor), so that it pushed the height growth of the wildlings.

Jensen *et al.* (1998) stated that the important external factor influencing the growth and development of plants is the light, and auxin is one of the major hormones regulating the plant growth and development. Neff *et al.* (2006) explained that hypocotyl cells exposed to light at the soil/air interface stopped elongating whereas the apical meristems and cotyledons expanded, became photosynthetic, and developed as juvenile plants competing for optimal light conditions.

According Harjadi (1983), both height and diameter growth is mostly determined by the sunlight. Plants that lack of light has high growth is much faster than the plants enough light. This is related to the synthesis of auxin. Auxin will be more and more active on plants or parts of plants that are less light, so sometimes the plants less light showed an abnormally high growth. Furthermore, according to Kramer and Kozlowski (1960), when the seedlings get full light, the auxin that has been located and active in the apical meristem, tends to come down to stems and stimulate the lateral growth (diameter). Thus, it is suspected that wildlings kept in the storage box for 9 days (B3) had the higher increase in diameter because they had a small survival percentage (58%) compared with the growth percentage of the wildlings that were not kept in the storage box (90%), so they had space to grow better, and got the full light. The wildlings kept for 12 days in the storage box, despite having the smallest growth percentage (41%), but most likely already dehydrated resulting in the shrinking of the diameter growth. Furthermore, according to Kramer and Kozlowski (1960), plants that lack of water can lead to shrinking diameter growth and narrowing the annual rings.

In addition, condition of the wildlings in the storage box was different between the wildlings on the top and on the base positions. The wildlings on the top might be drier that the wildlings on the base so that the wildlings on the base were fresher and grow better than the wildlings on the top. The multi-comparison test of duration of tending the wildlings in the simple greenhouse on diameter growth of the wildlings was described in Table 4.

Table 4. Diameter growth based on duration of tending the wildlings in the simple greenhouse.

Code	Duration (day)	Diameter Growth (cm)	Mark
B_2	30	0.059	a
B_1	15	0,053	ab
B_3	45	0.046	bc
B_4	60	0,045	bc
B_0	0	0,038	c

Table 4 showed that the diameter growth of the wildlings had increased with the tending duration in the simple greenhouse, and after reaching a certain time the increase in diameter began to decline. The highest diameter increment was obtained from the wildlings tended for 30 days (A_2) with increasing average diameter of 0.059 cm, and then began to decline. Similarly, the highest height growth was occurred on the wildlings tended for 30 days (A_2). This illustrated that the environmental conditions of tending the wildlings for 30 days (A_2) was very suitable for wildling growth. As had been stated by Sopandi (1992) that tending seedling in the simple greenhouse could be done for 30 days. And Leppe and Smits (1988) suggested that tending the seedlings in the simple greenhouse will increase seedling growth typically ranged about three weeks.

Survival percentage

Analysis of variance of survival percentage of the wildlings showed that factors of keeping the wildlings in the storage box (p 0.00 < 0.05) and tending the wildlings in the simple greenhouse (p 0.00 < 0.05) significantly affected the survival percentage of the wildlings, but the interactions of the two factors did not affect the survival percentage of the wildlings (p 0.98 > 0.05). The multi-comparison test of duration of keeping the wildlings in the storage box on survival percentage of the wildlings was described in Table 5.

Table 5. Survival percentage based on duration of keeping the wildlings in the storage box.

Code	Duration (day)	Survival percentage (%)	Mark
A_0	0	90	a
A_1	3	87	ab
A_2	6	76	b
A_3	9	58	c
A_4	12	41	d

Table 5 showed that the wildlings that had the highest survival percentage were the ones that were not kept in the storage box (A_0/control) with a survival percentage of 90%, which was significantly different from the survival percentage of the wildlings kept for 6 days (A_2), 9 days (A_3) and 12 days (A_4). But those results were not significantly different from the results of the wildlings kept in the storage box for 3 days (A_1). This meant that if the wildlings should be kept in the storage box because of long-distance transportation from the forest to the nursery, they can be kept in the storage box for 3 days because this result was not significantly different from the result of the wildlings that were not kept at all in the storage box. It was presumed that the wildlings kept for 3 days in the storage box still in good conditions for growth. The storage box that was layered with sponge on all sides as a store of water, it provided a good condition for seedling growth; still able to maintain the freshness of the wildlings so that the majority of the wildlings still grew well. In contrast, the wildlings kept for 6 days, 9 days and 12 days in the storage box, they might suffer from a lot of dehydration because of ongoing transpiration without water supplied through the roots, so that the wildlings no longer grew well. According Harjadi (1983), the function of water for plants is a solvent system of cells and provides a medium for transportation in the soil. Water can maintain turgor very necessary in the complexities of transpiration and plant growth. In addition, the water itself is also needed as a nutrient for the formation of new compounds. Water loss can cause the cessation of growth and continuous water deficiency causes irreversible changes in plants resulting in death. Furthermore, the multi-comparison test of duration of tending the wildlings in the simple greenhouse on survival percentage of the wildlings was described in Table 6.

Table 6. Effects of duration of tending the wildlings in the simple greenhouse on survival percentage of the wildlings.

Code	Duration (day)	Survival percentage (%)	Mark
B_2	30	81	a
B_1	15	75	ab
B_3	45	71	abc
B_4	60	63	bc
B_0	0	62	c

Table 6 showed that the wildlings that had the highest effect on survival percentage were the wildlings tended in the simple greenhouse for 30 days (B_2), which was significantly different from the effect of the wildlings tended in the simple greenhouse for 60 days (B_4) and not tended at all (B_0). But those effects were not significantly different from the effect of the wildlings tended in the simple greenhouse for 15 days (B_1) and 45 days (B_3).

Leppe and Smits (1988) explained that the wildlings that have been extracted should be placed under shade and in the greenhouse in order that they are in a humid condition of 80-90% and temperature not exceed 28°C. In keeping the high humidity, the wildlings in the greenhouse should be watered every day because low humidity can decrease survival percentage of the wildlings and soil temperature that exceed 29°C can kill the mycorrhizae that live on the wildling roots. If the research was associated with the temperature and humidity in the simple greenhouse especially at day time, the temperature reached 32°C and humidity reached 83%, it was possible that the mycorrhizae were unable to grow more than 30 days in the simple greenhouse so the wildling growth decreased. Besides, it was possible that humidity and temperature in the simple greenhouse were related each other, that is, when the air temperature increased, the maximum capacity of air to hold water vapor also increased. When there is no addition of water vapor, the relative humidity will decrease even if the temperature is raised.

Conclusions and suggestions

Utilization of wildlings in planting *Shorea leprosula* species is a good alternative because the species bear fruit irregularly. The problem is locations of mother trees as a source of *Shorea leprosula* wildlings are getting farther from the nursery because of forest destruction. As a result, the transportation of wildlings from the mother tree locations to the nursery takes several days. Therefore, the wildlings need a specific container during transport process in order that they still grow well when planted in the nursery. The present research studied about the utilization of storage boxes and a simple greenhouse to revive the wildlings' growth.

The study concluded that duration of keeping the wildlings in a storage box and duration of tending the wildlings in a simple greenhouse significantly affected the growth of the wildlings particularly on the height and diameter growth, and the survival percentage of the wildlings. The wildlings that had the best growth were the wildlings that were not kept in the storage box and were tended for 30 days in the simple greenhouse. The longest duration of the wildlings can be kept in the storage box was 3-5 days, and the shortest duration of the wildlings can be tended in the simple greenhouse was 15 days. The two factors tested in the research did not have interactive effects, so they can be applied separately. If the wildling source is close enough to the nursery so they do not take several days during transportation, the wildlings should directly be tended in a simple green house for 30 days without keeping the wildings in a storage box. If the wildlings need several days for transportation process, they should be kept in a storage box up to 3 days, and then they are tended in a simple greenhouse for 30 days. Positions of the wildlings in a storage box during the research should be arranged regularly between the wildlings on the top and on the base positions so that they have the same moisture. Similarly, the spaces among wildlings in a simple greenhouse should also be arranged regularly so that they have the same space. The wildlings that have different humidity and different spaces will have different height and diameter growth.

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