The Growth of Kapur Tanduk (*Dryobalanops lanceolata* Burck.) on Different Levels of Canopy Opening and Fertilization

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**Abstract.** Critical land rehabilitation efforts in the forests areas are important activities to be undertaken. Dipterocarpaceae is a potential species to be developed in the restoration of degraded forest areas, one of which is Kapur Tanduk (*Dryobalanops lanceolata* Burck.). This study aims to determine the influence of canopy opening factor, dose of manure, and environmental conditions (temperature, humidity, slope, and soil conditions) to the growth of *D. lanceolata* in research plots (KHDTK Haurbentes, West Java). The results showed that the different levels of canopy opening (71.34%, 37.91%) and the dose of manure (0, 2, 4 kg / planting hole) have no significant effect either single or interaction both to the increase in diameter and height of *D. lanceolata*. The Different levels of canopy opening in both areas resulted that different responses in the early days of growth, the degree of opening of 71.34% (open area) had a good response to the diameter growth while at the level of opening of 37.91% (under the shade) had high growth rate of plants. Thus, until the age of 6 months *D. lanceolata* has a good adaptability to the degree of canopy opening in between 37-72%. The environmental conditions in the research plots in KHDTK Haurbentes are suitable with the characteristics of the growing species so it can support the growth of *D. lanceolata*.

1. **Introduction**

Indonesia's forest area has decreased compared to 25 years ago, this is indicated by the 20 million hectares of forest declared deforested due to various factors [1]. The decrease in forest area is also shown by the high rate of deforestation during 2012–2013 of 727,981.2 ha/year [2]. The impact caused by intensive exploitation of tropical forests in Indonesia is the emergence of critical land, decreased forest productivity also decreasing number and existence of species that have high commercial value, especially the dipterocarpaceae species group.

Critical land rehabilitation efforts in the forests areas are important activities to be undertaken. To rehabilitate forests area, it is very important to select species and know management techniques to determine methods that are appropriate with the environmental conditions. Species selection in accordance with the ecological characteristics of the place of growth will cause plants grow optimally. The type that is able to grow optimally on certain sites is one of the factors that determine the success rate of forest rehabilitation.

Dipterocarpaceae is a group of species that have excellent prospects to develop in rehabilitation of degraded forest areas. Cultivation of Dipterocarpaceae species such as *Dryobalanops lanceolata* Burck. can be an option because that is a potential species to be developed. *D. lanceolata* has the
advantage of wood that is resistant to destructive organisms because it contains extractive substances. Therefore, this species is classified as a type of wood that is durable and strong and has high economic value. The *D. lanceolata* is a species of the Dipterocarpaceae family which belongs to the endangered (EN) category [3].

Developing the *D. lanceolata* species in forest rehabilitation efforts will maintain the existence of these species from the extinction. This is demonstrated by the presence of *D. lanceolata* species in Indonesia which are still limited to several islands namely, Java on the arboretum dipterocarpaceae and Kalimantan in lowland rain forests [4], which are spread in northern and East Kalimantan (Sangkularang and West Kuta) [5]. The importance of this research related to planting *D. lanceolata* in different environmental conditions, to see the adaptability and growth in the context of planting activities on critical land. This study aims to determine the effect of canopy openness factors, dose of manure, and environmental physical conditions (temperature, humidity, slope, and soil conditions) on the growth of *D. lanceolata* in KHDTK Haurbentes, West Java.

2. Method

2.1. Study site
The research was conducted on February 2017 in the KHDTK Haurbentes area, Jasinga District, Bogor – West Java, Indonesia.

2.2. Tools and Materials
The tools used in this study were a work maps, measuring tapes, rulers, calipers, *spherical densimeters*, *thermohygroimeter*, rings sampo, *clinometer*, compass, label papers, plastics, cameras and a set of computers with some software such as *Microsoft Office* and SAS 9.1. The materials used in this study was *D. lanceolatta* in the KHDK Haurbentes and manure.

2.3. Research Plot Conditions and Design
The study was conducted on *D. lanceolata* plants whose seeds were obtained from the District of North Barito, Central Kalimantan and were planted at the KHDTK Haurbentes in August 2016. The *D. lanceolata* were divided into two groups, based on the level of canopy openness 1) under the stand and 2) in the open area. In each group there is a difference in the dose of fertilizer (manure) which is 0 kg/planting hole (as a control), 2 kg/planting hole and 4 kg/planting hole.

This study uses a split plot design which arranged in a Latin Cage Longitude (RBSL) environmental design. The treatment consists of two factors: 1) two levels for canopy openness and 2) three different levels of the dose of organic fertilizer (manure) given. That factors are arranged in 6 treatment combinations which is repeated 3 times, so there are 18 experimental units with 9 observation units per experimental unit. The main plot is the differences of canopy openness (under the shade and open area). For the subplot is dose of manure (0 kg / planting hole, 2 kg / planting hole, and 4 kg / planting hole).

2.4. Method
The data used in this study are primary and secondary data. Primary data is collected by taking data on the growth of *D. lanceolata* such as height, diameter and physical condition of the environment (soil, temperature, humidity, topography). Secondary data used are initial data (T0) diameter and height of *D. lanceolata* when planting in the research plot, as well as other research supporting data needed.

2.4.1. Height and diameter
Height and diameter measurements were carried out on all *D. lanceolata* individuals in the research plot. Height measurements are measured using a tape meter starting from the base of the stem to the apical shoot growth point. Diameter measurements are carried out using digital calipers at a height of 10 cm above the ground level.
2.4.2. Percentage of canopy openness
Measurement of canopy openness was carried out in the research plot using a *spherical densiometer* at 5 points with azimuths of 360°, 90°, 180°, 270°, and center point. At each point, the *spherical densiometer* is directed towards North, East, South, and West.

2.4.3. Environmental conditions
Environmental conditions data that used in the research plot are temperature, humidity and slope. Temperature and humidity measurements were carried out using a *thermohygrometer* for three consecutive days without rainy days, measured in the morning (07.00 – 08.00), afternoon (12.00 – 13.00) and evening (16.00 – 17.00) [6]. Slope level measurements are measured using a *clinometer*.

2.4.4. Soil Characteristic
Soil condition data is used as supporting information on the growth of *D. lanceolata*. Data collection on soil conditions (chemical and physical properties) is done by taking soil samples in two land conditions, namely treatment plots under shade and in open areas.

2.5. Data Analysis
Data analysis of measurement results was carried out using analysis of variance (ANOVA) with the F test, this analysis was conducted to determine the effect of treatment on the growth of *D. lanceolata*. Data processing is performed using *Microsoft Excel* and *SAS software 9.1.3*

3. Result and discussion
The influence of different treatment on level of canopy opening and dose of manure on observed parameters in the form of diameter growth and height of *D. lanceolata* can be determined by performing variance analysis. Results of analysis of variance at 95% confidence intervals can be seen in Table 1.

| Treatment                        | Parameter | Height  | Diameter |
|----------------------------------|-----------|---------|----------|
| Canopy openness                  |           | 0.1307<sup>ns</sup> | 0.3645<sup>ns</sup> |
| Dose of fertilizer (manure)      |           | 0.4221<sup>ns</sup> | 0.8738<sup>ns</sup> |
| Canopy openness x fertilizer (manure) interaction | | 0.6721<sup>ns</sup> | 0.9416<sup>ns</sup> |

Note: The numbers in the Table are significant values, <sup>ns</sup> = treatment has no significant effect at the 95% confidence interval (> α (0.05))

Results of variance analysis (Table 1) shows that canopy opening treatment, manure dose, and interaction between canopy opening and manure dose did not have a significant influence on average growth height and diameter of *D. lanceolata* seedlings at 6 months after planting. This result can be seen from the observed parameter values (height and diameter) or P-value is greater than 0.05 for each given treatment combination. The results of measurements and calculations of canopy opening level was performed using a *Spherical densiometer* in the opened areas and under the shaded areas showed values of 71.34% and 37.91%, respectively. Factors that cause growth response (diameter and height) do not significantly affect the treatment given are thought to be due to the influence of other factors simultaneously in the research plot such as temperature, humidity, topography, soil characteristics and the amount of light intensity which were not measured.
3.1 Influence of Canopy opening and Fertilization on Height Growth

In this study the treatment given did not have a significant effect on the average growth rate of *D. lanceolata* seedlings. The average height growth shown in Figure 1.

![Graph showing the effect of canopy openness and fertilizer on height growth of *D. lanceolata* 6 months after planting](image)

**Figure 1.** Effect of canopy openness and fertilizer on height growth of *D. lanceolata* 6 months after planting

Plant height is an indicator of growth that is often observed to determine the influence of the environment and the treatments applied [7]. Figure 1 shows that the level of canopy opening (71.34% and 37.91%) and the dose of manure (0, 2, 4 kg / planting hole) gave a response to an increase in the average height growth of *D. Lanceolata* seedlings but based on the results of variance analysis not showed significant differences, because the average range of seedlings height growth of those treatments did not show a significant difference.

The average height growth of *D. lanceolata* at 6 months in both areas ranged from 29.33 cm - 52.96 cm. Another study related to the growth of *D. lanceolata* was carried out by Omon [8] about the growth of *D. lanceolata* on Imperata grasslands which was performed by techniques preparing planting land in East Kalimantan, known the average growth rate of *D. lanceolata* was one year after planting were showed in range from 33.10 cm - 56.29 cm. This study shows that the average height growth of *D. lanceolata* in the six month HHDTK Haurbentes study plot had relatively faster height growth.

According to the diagram of the average height growth in Figure 1 indicates that *D. lanceolata* planted in areas with an opened level of 37.91% or under the shade experienced a response to an increase in height growth that was faster than seedlings planted in areas with an open level of 71.34%. The diagram (Figure 1) also shows the tendency of 2 kg manure dose / planting hole gives a faster growth response compared to 0 and 4 kg fertilizer dose/planting hole in areas with low or high openness levels, although the results of statistical analysis between fertilizer doses do not significantly different.

Canopy openness is an external factor that greatly influences the growth of *D. lanceolata*. The degree of canopy openness will affect the amount of light intensity received by plants. Each plant or tree species has a different tolerance to sunlight. The *Dryobalanops* spp. is type of plant species with characteristics resistant to shade at the first stage of its growth [9]. Shade resistant species have lower light compensation points than intolerant plants [10], so that in the early stages of growth, *D.
lanceolata seedlings planted with a low level of canopy openness (37.91%) tend to grow faster vertically (high) to get enough sunlight according to the point of light compensation it needs to carry out photosynthesis.

In addition to the canopy openness, other external factors that affect the height growth of D. lanceolata is the treatment of different doses of fertilizer used. The type of fertilizer used in this study was manure from goat manure. The addition of manure into the soil is very necessary to increase the activity of soil microorganisms, improve soil physical properties and fulfill the plant nutrients that cannot be fulfilled from the soil to support root development and absorb more nutrients in order to increase metabolic process of plants [11].

Figure 1 shows the application of manure can increase the average growth rate of D. lanceolata in areas with canopy opening level of 71.34% and 37.91%. The application of goat manure will affect the increase of nutrients N and K in the soil. This result is in accordance with the statement of Hardjowigeno [11] which states that manure from goat manure contains nutrients N and K twice as large as cow manure. Based on the diagram of average height of growth (Figure 1) also shows that the greater dose of manure given results in lower growth rates, this is presumably because manure from goat manure contains more nutrients N than other types of manure. Thus, the use of this type of fertilizer without using the right dosage will result in excess of element N in the soil and can cause soil pollution that disrupts the metabolic process of plants.

3.2 Influence of Canopy Openness and Fertilization on Diameter Growth

The second parameter used to see the growth of seedlings is plant diameter. The results of variance analysis carried out to see the effect of treatment on the addition of diameter (Table 1), showed results that did not significantly affect all treatments and their interactions. The average response of diameter growth to the treatment given is presented in Figure 2.

Figure 2. Effect of canopy opening and fertilizer on diameter growth of D. lanceolate 6 months after planting

Crop productivity can be measured through several parameters, one of which is diameter growth because it has high accuracy and consistency and is easy to implement [12]. Based on Figure 4, it can be seen that D. lanceolata experienced a relatively stable increase in diameter growth in both opening levels (71.34% and 37.91%), although with insignificant difference in values for each given treatment combination. The average diameter growth of D. lanceolata at 6 months ranged from 5.94 mm to 7.24 mm. Research with the similar methods was carried out by Omon [8] on Imperata grasslands with
planting land preparation techniques in East Kalimantan, the results of the study showed the average diameter of one year age *D. lanceolata* ranged from 0.30 cm to 0.61 cm. Based on those explanation, it shows that *D. lanceolata* at 6 months of age in KHDTK Haurbentes study has relatively faster in diameter growth rate.

Overall, the best diameter growth was demonstrated by a combination of treatments in areas with canopy opening rate of 71.34%. Diameter growth is secondary growth that occurs when the need for photosynthesis results for respiration, leaf turnover, roots and height growth are fulfilled [10]. This shows that *D. lanceolata* seedlings have the ability to obtain and utilize light effectively for diameter growth in areas with a canopy opening rate of 71.34% which allows sunlight to enter optimally so that the plant's need for photosynthesis can be fulfilled. In addition to the level of canopy openness, fertilization also takes role in the growth of *D. lanceolata* seedlings.

Based on Figure 4, the average diameter growth of *D. lanceolata* shows an insignificant difference in the dose of manure given (0, 2, and 4 kg / planting hole), where the difference in the average diameter of each dose of the fertilizer is 0.17 mm - 0.68 mm. The amount of fertilizer applied is related to plant needs for nutrients. Increasing the amount of fertilizer given to plants does not guarantee the plants to grow better, especially if other factors in the soil are less supportive.

Many factors that can affect to the effectiveness of fertilization in the field such as soil fertility, such as fertilizer positioning in plant holes, fertilizer time, type of fertilizer used on fertilized soil and other limiting factors. Most soils only contain 2% -10% soil organic matter [13], so the addition of organic matter in the form of manure will have a direct or indirect influence on the availability of plant nutrients in supporting plant growth. The nutrient content in manure is not too high but this type of fertilizer can improve soil physical properties such as soil permeability, porosity, soil structure, water holding capacity and cations contain in soil. Good soil physical properties will benefit plants because root growth can perform optimally, thereby increasing the ability of plants to absorb water and nutrients [14].

### 3.3 Environmental conditions in research plot

| Table 2. Measurement of environmental factors was carried out on several parameters: slope, temperature, and humidity |
|---------------------------------------------------------------|
| **Parameter** | **Opened area** | **Shaded area** |
| Slope (°) | 15-30 | 20-35 |
| Temperature (°C) | 26.6 | 25.1 |
| Humidity (%) | 54.3 | 63.4 |

Environmental factors affecting plant growth are grouped into environmental factors, there are soil compositor and above ground factors [7]. The environmental conditions in the study plots (Table 5) show that the slope level in the opened area is 15-30°C while under the shade is 20-35°C. In addition, the general conditions at the KHDTK Haurbentes are located at the altitude of ± 250 meters above sea level (asl) [15]. *Dryobalanops* spp. is a plant that is suitable for growing in areas that have a flat and wavy topography and at the altitude of 60-400 m.asl [16].

The other parameter measured was temperature and humidity at both levels of opening in the study plot. In general, air temperature and humidity have values that are inversely proportional where with increasing air temperature will cause lower humidity and in reverse, because air temperature and humidity have correlation with the intensity of received sunlight. Humidity will be lower if the temperature of the air rises and the opposite, humidity gets higher when the air temperature is lower [6].

Based on the results of measurements taken, the average daily temperature in the opened area was 26.6°C with 54.3% air humidity while in the shaded area the average temperature was lower that was 25.1°C with higher air humidity 63.4%. The provision of shade trees has an impact on the intensity of
received sunlight in the lower layer of trees so that it affects the photosynthetic activity [17]. The optimum temperature for plants to carry out metabolism processes ranges from 10–30°C, above or below that temperature, rate of plant metabolism will decrease [14].

Based on the above statement, temperature in the two areas are suitable for plant growth with the optimum temperature ranging from 25.1°C-26.6°C, the temperature can support plant growth even though it does not show a significant difference in each combination treatments. The requirements to grow Dryobalanops spp in order to grow optimally is in the temperature range between 20–32°C [6].

The response of plants to the optimum temperature varies depending on the type of plant species, type of organ or tissue and the stage of plant growth. This study shows, with different levels of area canopy opening produce different responses in the early growth period of D. lanceolata seedlings, due to differences in the received light intensity that can affects the temperature and humidity in each area [19]. D. lanceolata planted at an opening level of 71.24% has good growth response on diameter growth, while at an opening level of 37.91% increase in plant height growth. These differences on canopy opening may stimulate different growth orientation in D. lanceolata at seedling stages. Such kind of phenomenon is commonly found in Dipterocarpaceae seedlings.

3.4 Soil characteristics in study plot

Analysis of soil physical and chemical properties was carried out to determine the soil nutrient content in the research plot. Soil samples were analyzed at Soil and Plant Laboratory of the SEAMEO BIOTROP. Data on soil physical and chemical properties is presented in Table 3.

Table 3. Physical and chemical soil properties at study site

| Parameter                  | Opened area (0cm – 20cm)* | Shaded area (20cm- 40cm)* | Physical properties | Shaded area (20cm- 40cm)* |
|----------------------------|---------------------------|---------------------------|---------------------|--------------------------|
| Weight (g/cm³)             | 0.82                      | 0.87                      | Porosity (%)        | 67.19                    |
| Porosity (%)               |                           |                           | Texture             |                          |
| Sand (%)                   | 12.80                     | 14.30                     | Silt (%)            | 38.80                    |
| Silt (%)                   | 38.80                     | 36.10                     | Clay (%)            | 48.80                    |
| Clay (%)                   | 48.80                     | 49.60                     | pH (M)              | 5.10                     |
| pH (M)                     |                            |                           | C-Org (%)           | 2.14                     |
| C-Org (%)                  |                            |                           | N total (%)         | 0.20                     |
| N total (%)                |                            |                           | C/N Ratio           | 10.7                      |
| C/N Ratio                  |                            |                           | P-content (ppm)     | 9.4SR                    |
| P-content (ppm)            |                            |                           | Cations             |                          |
| Ca(meq/100g)               | 6.08SR                    | 5.62SR                    | Mg (meq/100g)       | 2.74T                    |
| Mg (meq/100g)              |                            |                           | K (meq/100g)        | 0.17R                    |
| K (meq/100g)               |                            |                           | Na                  | 0.24R                    |
| Na                         |                            |                           | CEC (meq/100g)      | 19.15S                   |
| CEC (meq/100g)             |                            |                           | Base saturation (%) | 51.0S                    |
| Base saturation (%)        |                            |                           |                     |                          |

Note: M = Acid, S = Medium, R = Low, SR = Very low, T = High, * = soil depth [11]

Soil fertility is correlated strongly with the nature of soil (physical, chemical, biological) that affects to the increase of the nutrient availability in the soil. Soil fertility has an important role in supporting plant growth. Soil physical properties, especially texture, weight and porosity have role in
the plant root development and system. A good root system will increase the ability of plants to absorb nutrient and water. Soil texture is inherent and relatively static. Proportion ratio of sand, silt and clay fractions in the two areas (Table 3) shows no significant difference between shaded and opened areas [12]. Based on the results of the analysis it can be seen that the soil texture is dominated by 50% clay, 40% silt, and 10% sand, so that the texture of the soil is included in the silty clay. Similar to soil texture, the results of analysis of soil weight and porosity (Table 3) show differences in values that are not too significant in the two study plots. The value of content weights in two study plot ranged from 0.82 to 0.87 g / cm3 while porosity > 60%. The weight of soil content has a value inversely proportional to the level of porosity of the soil. The smaller the weight of the soil content, the greater porosity will be produced, thereby supporting the ability of roots to penetrate the soil and carry on water. Good soil will improve the soil porosity, aeration (air content in soil) is sufficiently available and the absorption of nutrients can performed optimally [14].

The results of the chemical properties analysis indicated that the soil conditions in the study plots have not too different percentage in nutrients content; this can be seen from the content of macro and micro nutrients both in opened and shaded areas. The results of the analysis of the soil chemical properties presented in Table 3 show that macro nutrient content in the form of P was very low, as well as N was also low in both areas, with an average acidity level (pH) of soil in both areas of 5–5.3 (acid). Acid soil conditions causing P elements could not be absorbed by plants because of its binding with Al. Low N content can be caused by many factors such as acid soil conditions that can decrease organic matter decomposition and high levels of rainfall causing the element N in the form of nitrates easily leached [11].

One of the properties of organic matter that is important for increasing soil organic matter content is carbon content (C) and nitrogen (N) or often called C/N ratio [13]. The C / N ratio value is related to the effect of the material on the availability of N for plants and the rate of decomposition. The analysis showed that the C/N ratio in the study plot was classified in medium category. The current C / N ratio indicates that the material contains relatively similar C/N, decomposition rate is inhibited and affects the C-organic content in the soil.

Other soil chemical properties such as CEC and base saturation in both areas indicate that CEC value is 16.22-19.15 (moderate), while the base saturation value in opened areas ranges between 49.6-51.0 (moderate) and under the shade of 55.2–55.4 (high). Base saturation shows ratio between the number of base cations (Ca, Mg, K, Na) and soil CEC [11]. Base cations are generally susceptible to leaching so that soils with moderate to high base saturation indicate that the soil has not been leached a lot. CEC has a very close correlation with the level of soil fertility, because it is related to the ability of the soil to absorb and to provide nutrients.

The assessment of soil fertility status is analyzed using the criteria of soil fertility assessment from the Soil Research Center (PPT) referring to the CEC status of the soil, base saturation value, organic matter content, and P-content [20]. The results of soil chemical analysis (Table 3) carried out and related to the criteria for assessing the fertility status of soil chemical properties indicate that the status of soil chemical fertility in the study plot both in open areas and under shade is classified as low. However, based on the results of research conducted, soil characteristics in the study plot at KHDTK Haurbentes allegedly in accordance with the characteristics of soil type of D. lanceolata to grow optimally. Soil for Dryobalanops spp. to grow optimally, well-drained soil conditions with light-heavy texture, and acidic-neutral soil pH [18]. In general, the Dipterocarpaceae group does not require high growth requirements because it is able to grow in soil conditions that have well to low moderate drainage as well as in nutrient-poor soils [4], however, this species is also prefer to grow in soil that react acid, has deep solute and contains a lot of clay [21].

4. Conclusion
The treatment of differences in canopy opening level (71.34%, 37.91%) and the dose of manure (0, 2, 4 kg/planting hole) did not have a significant effect either in single treatment or in combination treatments on the diameter and height growth of D. lanceolata seedlings. Thus, until the age of 6
months. D. lanceolata seedlings are able to adapt to the level of canopy opening between 37-72%. The environmental conditions in the research plot at KHDTK Haurbentes are suitable with D. lanceolate characteristic and support the seedlings to grow optimally.

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