GROWTH COMPARISON BETWEEN LOCAL SENGON AND SOLOMON SENGON IN AGROFORESTRIC SYSTEMS

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Bogor, May 2019

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ABSTRAK

AMIN NUR IKHFAN. Perbandingan Pertumbuhan antara Sengon Lokal dan Sengon Solomon dalam Sistem Agroforestri. Dibimbing oleh NURHENI WIJAYANTO

Perkembangan industri perkayuan dan permintaan kayu di Indonesia yang terus meningkat harus diimbangi dengan peningkatan produksi kayu. Penggunaan jenis cepat tumbuh seperti sengon (*Falcataria moluccana*) menjadi salah satu cara untuk meningkatkan hasil produksi. Pemanfaatan lahan secara optimal dapat dilakukan dengan menerapkan sistem agroforestri. Penggunaan provenan dan teknik penanaman yang sesuai diharapkan dapat meningkatkan produksi kayu. Penelitian ini bertujuan membandingkan pertumbuhan antara sengon lokal dan sengon solomon dalam sistem agroforestri. Hasil penelitian ini menunjukkan bahwa penggunaan provenan berpengaruh nyata terhadap parameter diameter. Interaksi antara provenan dan teknik penanaman yang digunakan tidak berpengaruh nyata pada semua parameter seperti tinggi, diameter, luas tajuk, kedalaman akar, Panjang akar, dan diameter akar secara horizontal. Perlakuan sengon solomon F1 dengan perlakuan *polybag* dibuka memiliki rata-rata tertinggi pada parameter diameter. Kedalaman dan diameter rata-rata akar secara horizontal terbesar ditemukan pada perlakuan *polybag* ditutup, sedangkan nilai panjang rata-rata akar terbesar ditemukan pada perlakuan *polybag* dibuka.

Kata kunci: agroforestri, sengon lokal, sengon solomon, pertumbuhan

ABSTRACT

AMEN NUR IKHFAN. Growth Comparison between Local Sengon and Solomon Sengon in Agroforestry System. Supervised by NURHENI WIJAYANTO

The continued development of timber industry and demand for wood in Indonesia must be balanced with enhancement of timber production. Utilization of fast growing species such as sengon (Falcataria moluccana) becomes one way to increase production result. The using of land optimally can be done by applying agroforestry system. The compatibility of provenance and planting technique are wished to increase timber production. This research aims to compare the growth between local sengon and solomon sengon in agroforestry system. The result of this research showed that provenance is significantly influenced to the diameter. The interaction between provenance and planting technique do not affect to all parameters such as height, diameter, canopy area, depth of rooting system, root length, and root diameter horizontally. Solomon sengon F1 with opened polybag treatment has the highest average in diameter. The best average of depth and root diameter was found in closed polybag treatment, whereas the best average of root length was found in opened polybag treatment.

Keywords: agroforestry, local sengon, solomon sengon, growth

GROWTH COMPARISON BETWEEN LOCAL SENGON AND SOLOMON SENGON IN AGROFORESTRIC SYSTEMS

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An Undergraduate Thesis
to Acquire Bachelor's Degree
in Department of Silviculture

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PREFACE

Praise and gratitude the author prays to Allah Subhanahu wa Ta'ala for all His mercy and guidance, so that the author can complete a scientific work entitled "Comparison of Growth between Local Sengon and Solomon Sengon in Agroforestry Systems". This scientific work is one of the requirements for obtaining a Bachelor of Forestry degree at the Silviculture Department, Faculty of Forestry, Bogor Agricultural University.

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The author hopes for constructive criticism and suggestions for the improvement of this thesis. Hopefully the results of this research will be useful for the development of science and society.

Bogor, May 2019

Amin Nur Ikhfan

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INTRODUCTION

Background

The development of the timber industry and the increasing demand for wood in Indonesia must be balanced with efforts to increase wood production. Such improvement efforts can be carried out through the development of fast growing tree species. Several types of fast-growing trees that are often developed include Sengon (Falcataria moluccana), Acacia (Acacia sp.), White teak (Gmelina arborea), and Eucalyptus (Melaleuca leucadendron). Planting fast-growing tree species generally uses a monoculture system, but the use of this system is different from the wishes of farmers who expect by-products in the form of short-term seasonal crops (Hakim et al. 2009; Rachmad and Hani 2014).

According to Rachman and Hani (2014), farmers in Indonesia have the desire and habit to use land under stands. It aims to increase farmers' income, create diversity in yields, and obtain product yields in a short period of time. One alternative to increase wood production while maintaining the habits and desires of farmers in Indonesia is to use an extensification pattern, utilizing forest land with an agroforestry system.

Agroforestry is an optimal land use system by combining forestry and agricultural crops in the same land management unit. The agroforestry system was developed to improve the welfare of the people in and around forest areas while maintaining the sustainability of forest functions (Maryowani and Ashari 2011). Agroforestry systems also contribute to increasing farmers' income, providing employment, increasing food production, and preserving the cultural identity of the community or local institutions (Widianto et al. 2003). One of the agroforestry patterns that are currently being developed to meet the demand for wood and national food needs is agroforestry between sengon and upland rice (Senjaya et al. 2018).

Sengon (F. moluccana) is a fast-growing species that is widely cultivated by the community in the form of community forests or plantation forests. Sengon wood can be used for light construction wood, furniture, and raw material for pulp (Nuroniah and Putri 2013). Growth speed and resistance to sengon pests are important factors to meet the increasing demand for wood. According to Setiadi et al. (2014), one of the sengon provenances that has a faster growth than the local provenance is sengon provenance solomon.

Sengon solomon (Falcataria moluccana (L.) Nielsen Solomon) is a sengon native to the Solomon Islands. The solomon sengon at the age of two has a diameter of 16 cm, while the local sengon at the age of two has a diameter of 12 cm (Setiadi et al. 2014). More productivity sengon solomon is three times higher than local sengon which is currently being developed in Java. In Indonesia, sengon solomon is still rarely cultivated by the community. This is due to the high price of seeds and constrained by the presence of tumor rust disease which usually attacks sengon plants (Setiadi et al. 2014). Selection of appropriate species and provenances, and appropriate planting techniques in the agroforestry system between sengon and upland rice is one of the keys to increasing crop production.

Currently, there is no study comparing the growth of local sengon seedlings with sengon solomon in the treatment of opened polybags and closed polybags in sengon and upland rice agroforestry. Roots of sengon seeds in agroforestry systems are an indicator of competition for water and nutrients with combined upland rice plants. Therefore, it is necessary to conduct research on the growth of sengon plants from various provenances and with various planting techniques.

Problem Formulation

Exploitation of forest resources and land use change occur due to the increasing demand for wood and non-timber forest products in an effort to meet the availability of clothing, food and shelter. This can cause ecological damage if done in an unbalanced and excessive manner. The solution to overcome these problems is to develop a pattern of extensification by implementing an agroforestry system. Sengon agroforestry has the opportunity to overcome the problem of wood demand in Indonesia, because sengon is a fast-growing species that is widely cultivated and developed by the community.

Sengon planting by farmers is mostly developed in monoculture. It aims to increase the production of sengon wood to meet the demand for wood in Indonesia. Whereas sengon can be combined with agricultural crops while maintaining and even increasing the production of sengon wood. The selection of species, provenances, and techniques for planting sengon seedlings will later be considered in increasing sengon wood production in agroforestry systems.

Purpose of research

This study aims to compare the growth between local sengon and sengon solomon in agroforestry systems.

Benefits of research

The results of this study can provide knowledge to academics and the general public in the treatment of planting sengon seedlings and the best use of provenance in agroforestry systems.

METHODS

Time and places

This research was carried out for seven months, from August 2018 to February 2019. The research was carried out in Cikabayan Forest, IPB Dramaga Campus Bogor, West Java for planting locations and the Silviculture Department greenhouse for the germination process of sengon seeds.

Tools and materials

The tools used in this research are sewing meter, measuring tape, ring sampler, caliper, ground drill, rope, luxmeter to measure light intensity, thermohygrometer to measure humidity and air temperature, GPS, tally sheet, polybag with a size of 15 cm × 10 cm, hoe, scratchpad, stationery, camera, and laptop equipped with SAS 9.1.3 applications. The materials used in this study were soil, compost, husk charcoal, biological organic fertilizer (POH), manure, upland rice, local sengon seeds, sengon solomon F1 and sengon solomon F2.

Research procedures

The research activity began with a literature study on various provenances of sengon and techniques for planting sengon seedlings. The activity was continued by making preparations, planting in the field, maintaining plants, measuring and observing.

Sengon Seed and Seed Preparation

This research activity begins with preparing the administration, determining the location for seed germination and planting sengon seedlings, as well as providing the necessary materials. The preparation of sengon seedlings was carried out in the greenhouse of the Silviculture Department, Faculty of Forestry, IPB. Sengon seed germination as well as weaning was carried out in polybags containing planting media. The planting media used were soil, compost, and husk charcoal with a ratio of 1:1:1. The initial treatment of the seeds before germination in polybags was soaking them in hot water (90 °C) and letting them cool for ± 24 hours. This treatment can increase the absorption of water that enters the seeds so that the germination process can occur more quickly (Nuroniah and Putri 2013).

Germination and weaning of sengon seedlings in polybags measuring 15 cm × 10 cm are carried out for 2-4 months or after the seedling height reaches 20-25 cm, the roots develop well, and the stems are woody. During the weaning period, watering, weed removal, and fertilization activities must be carried out to accelerate seedling growth. The addition of biological organic fertilizer is given once a week during the germination process. This treatment can bind nitrogen from the air and stimulate seedling growth (Nuroniah and Putri 2013).

Land Preparation

a. Land clearing

Land preparation begins with clearing an area of 756 m2 of trees, shrubs, and undergrowth manually or mechanically. Land clearing is done at the end of the dry season. Next, plowing and plowing are carried out on the land, especially on dense soil to destroy the chunks of land. Land clearing is not only carried out on the top of the soil surface, but also cleaning the roots of trees and undergrowth so that the roots of sengon seeds to be planted are not disturbed by their growth and development (Nuroniah and Putri 2013).

b. Adding basic fertilizers and dolomite to the land

The basic fertilizer given is in the form of cow manure and biological organic fertilizer. The addition of dolomite is done by spreading fine and coarse dolomite over the entire land area evenly. According to Juarsah (2016), the application of dolomite aims to increase soil CEC, increase phosphorus availability, neutralize soil pH, and improve soil physical properties such as soil structure and soil holding capacity to water. This can happen because dolomite has a network of negatively charged pores that can prevent leaching of nutrients out of the root area.

Sengon and Upland Rice Seeds Planting

a. Making planting holes

Making planting holes measuring 30×30×30 cm is done manually using a hoe. The distance between the planting holes of 1.5×1.5 m and 1.5×3 m was made in 12 lanes with each lane consisting of 20 planting holes. The planting hole is made at the same time by cleaning the remaining tree roots and undergrowth that are still left behind. After the planting hole is formed, then one kilogram of cow manure is added to each planting hole. The layout for planting sengon seedlings can be seen in Appendix 6.

b. Polybag treatment when planting

Sengon seedlings were planted with two kinds of treatment. First, the planting of seedlings is carried out as usual by removing polybags from the weaning media. Second, the planting of seeds is carried out simultaneously with polybags that are still attached to the planting media with the bottom surface of the polybags being torn or removed. Sengon seedlings were planted in each planting line based on provenance and polybag treatment.

c. Upland rice planting

Upland rice is planted after the sengon is four months old in the field and is carried out between the sengon plant paths. Planting was carried out using the tugalan technique with each hole filled with five upland rice seeds. The spacing between upland rice and sengon plants is 50 cm, while the spacing between upland rice is 25×25 cm (Nazirah and Damanik 2015).

Plant Maintenance

a. Stitching

This activity is carried out after 2-3 weeks from the beginning of planting sengon seedlings in the field. If the seeds experience abnormal growth, such as wilting, pressure, and disease, replanting is carried out immediately.

b. Sprinkling

Watering is done every day in the morning and evening, especially in the dry season or without rain in one week. When it rains watering is not done.

c. Weeding

Sengon seedlings were manually weeded twice a month during observations. Weeding is done by hand, scraper and hoe. This weeding aims so that the growth of sengon seedlings is not hampered or grows stunted due to the presence of wild weeds that can interfere with the growth of these sengon seedlings (Nuroniah and Putri 2013).

d. Fertilization

Fertilizer application is done by using manure as basic fertilizer at the beginning of planting. Furthermore, at three months after planting, POH was added to sengon and at 10 days after planting, inorganic fertilizer was added to upland rice plants.

e. pruning

Pruning activities are carried out when the plants are 3-6 months old. Pruning is carried out periodically or periodically with the aim of obtaining straight quality stems and removing parts that are attacked by pests and diseases.

Pest and Disease Control

Pest and disease control activities are carried out mechanically by cutting directly the plant parts that are attacked by pests and diseases. This is intended to prevent the wider spread of pests and diseases. In addition, the use of chemical pesticides to control pests and diseases is carried out after the plants are severely affected by spraying them directly on the affected plants. The use of mechanical or chemical methods is carried out based on pests and diseases that attack sengon and upland rice plants.

Sengon Seed Measurement and Observation

The characteristics or parameters observed in sengon seedlings for six months (September 2018–February 2019) included:

a. Height measurement

Height measurements were carried out using a sewing meter and a pole. Plant height was measured from the base of the stem adjacent to the soil surface to the tip of the stem growth point.

b. Rod diameter measurement

Stem diameter is measured at a point one cm above the ground in centimeters (Sukarman et al. 2012). This measurement was carried out on three samples of sengon seedlings for each treatment replicate using a caliper.

c. Measuring header area

The width of the canopy was measured using a sewing meter. The area of the crown is measured in centimeters based on the length of the crown which is parallel and perpendicular to the direction of the array and then averaged to determine the radius of the crown.

d. Root dimension measurement

The root dimensions of the sengon seedlings were measured manually by digging the soil to a depth of 10–30 cm or until the first primary root was found that was perpendicular to the direction of the array and was carried out in each treatment replication. This excavation is carried out carefully to prevent breaking of the roots. Root dimensions observed included root depth, root length, and root diameter horizontally. Root length was measured from the root neck (primary root) to the tip of the root (tertiary root), while root depth was measured from the soil surface to the top of the root neck (primary root).

Environmental Data Collection

a. Light intensity

Measurement of light intensity was carried out using a luxmeter for three days a week. Measurements were made in the morning, afternoon, and evening during observations. If it rains, data collection cannot be carried out and is replaced with the next day.

b. Temperature and humidity

Temperature and humidity data were collected three days in a month, namely at the beginning, middle, and end of the month. Sampling was carried out in the morning, afternoon, and evening using a thermohygrometer. If it rains, data collection cannot be done and is replaced on the next day.

c. Rainfall

Daily rainfall data in August 2018–February 2019 was downloaded from the BMKG (Meteorological, Climatological and Geophysical Agency) website for the Citeko Meteorological Station, Cisarua District, Bogor, West Java. Furthermore, the daily rainfall data is averaged to determine the monthly rainfall at the research location.

d. Soil sample

Soil sampling was done by purposive sampling. Soil samples were taken according to the boundaries of certain purposes that were representative of the land. Soil samples were taken at five points and taken in a composite manner to represent the soil conditions at the research site (Wicaksono et al. 2015). Soil samples were taken and laboratory tests were carried out to determine the physical and chemical properties of the soil. Sampling was carried out at the beginning of land preparation, after giving dolomite and planting sengon and upland rice, and after harvesting upland rice or completing observations.

Data analysis

The variance test was carried out using ANOVA to determine the effect of treatment in this study. The data is processed using the SAS 9.1.3 application, if:

a) P-value > (0.05), then the treatment did not have a significant effect on diameter, height, canopy area, root depth, root length, and root diameter horizontally.
b) P-value < (0.05), then the treatment gave a significant effect on diameter, height, canopy area, root depth, root length, and root diameter horizontally. If the results of the analysis were significantly different between treatments, further tests were carried out using Duncan's test.

RESULTS AND DISCUSSION

General Condition of Research Site

Figure 1 Map of the research location of Cikabayan Forest IPB

IPB's Cikabayan Forest is administratively located within the IPB Dramaga Campus, Bogor, West Java. Astronomically, the research location (Figure 1) is located at coordinates 06° 43'02.4” South Latitude and 06° 32'48.8” East Longitude. The research area used is 756 m2 with a slope of 0% and is located at an altitude of 162 masl. Rainfall from August 2018 to February 2019 at the study site (Appendix 3) ranged from 20.5–428 mm/month with a sunlight intensity of 14608 lux (BMKG 2018). The average temperature between August 2018 and February 2019 is 28 °C with an average humidity of 70%. The pH content in the research area was 5.48, C-Organic content was 2.05%, N-Total was 0.18%, and Cation Exchange Capacity was 15.99 cmol/kg (Appendix 2).

Biophysical environmental conditions are one of the most influential factors on plant growth, including sengon plants. These environmental conditions include soil, temperature, humidity, sunlight intensity, and rainfall. According to Krisnawati et al. (2011), sengon plants will grow optimally at a temperature of 22 °C to 29 °C with a minimum rainfall of 291 mm/month or 15 rainy days in the driest four months. Soil conditions are also an important factor in influencing plant growth. This relates to the macro and micro nutrients needed by plants. The addition of compost at the beginning of planting aims to have a positive impact on the growth of sengon dimensions. This can happen because plants can get one of the important nutrient supplies for plants growth, namely nitrogen nutrients. Nitrogen is a macro nutrient and plays a role in cell growth (Senjaya 2017).

Based on the conditions at the research site, sengon plants can grow and develop well. This can happen because the sengon plant is a fast-growing species with a tree habit from the Leguminosae family which is widely developed by the community and can grow in various environmental conditions and does not require high growth requirements. The ever-increasing demand for wood has also resulted in people preferring species that grow fast and have a short harvest life. This condition makes the development of sengon plants currently the prima donna in community plantation forests on the island of Java (Nuroniah and Putri 2013).

Sengon plants have beneficial properties compared to other types of plants. According to Setiadi et al. (2014), sengon plants, both local provenance and solomon, can be developed in tropical areas, from coastal forests to areas with an altitude of 1600 m above sea level (asl), and can grow optimally at an altitude of 0–1000 m asl. Sengon plants can also grow in a wide distribution of climates and include multipurpose plants. Based on these conditions, sengon plants can be applied in an agroforestry pattern combined with agricultural crops such as upland rice, so as to increase production yields in the form of sustainable food, animal feed, firewood, and carpentry needs (Amin et al. 2016).

Print Results Variety

Observations on the growth of local sengon seeds and sengon solomon in agroforestry systems between sengon and upland rice were carried out for six months using several parameters, namely diameter, height, and canopy area. Recapitulation of the results of the variance of the influence of the provenance, planting technique, and their interaction on the parameters of diameter, height, and canopy area (Table 1).

Table 1 Recapitulation of the results of the variance of the effect of provenance and planting techniques on the growth parameters of sengon seedlings

Parameter	Treatment		
	Provenant	Planting Technique	Proven x Planting Techniques
Diameter	< 0.0001*	0.5650tn	0.3718tn
Tall	0.1422tn	0.8071tn	0.7902tn
Header Area	0.4161tn	0.5194tn	0.8005tn

Description: The numbers in the table is a significant value. * = the treatment has a significant effect on the 95% confidence interval with a significant value (Pr<F) 0.05 (α) tn = the treatment has no significant effect on the 95% confidence interval with a significant value (Pr>F) 0.05 (α).

The results of variance (Table 1) showed that the provenance of sengon seedlings had a significant effect on diameter growth, but had no significant effect on growth in height and canopy area at a 95% confidence interval. The planting technique used and the interaction between the provenance and the planting technique used also did not significantly affect the parameters growth in diameter, height, and canopy area at a 95% confidence interval (Appendix 1).

Diameter Growth

Growth can be defined as a quantitative change in the plant life cycle that is irreversible or irreversible. Plant growth is the process of increasing the number and size of leaves and stems due to structural changes and the addition of new structural elements due to cell division and enlargement, for example the division of meristem tissue in a plant where meristematic cells develop. Growth occurs not only at the top (top) of the plant, but also occurs at the bottom (root) of the plant (Maretina 2010).

Diameter growth is also known as secondary growth or sideways growth and is one of the parameters that can be calculated quantitatively. The diameter of the plant will continue to increase along with the growth and development of the plant. The increase in the diameter of a plant will affect the increment and productivity of the tree at the time of harvesting. Duncan's further test results (Table 2) the effect of local sengon and sengon solomon provenances and the planting technique used on the growth of sengon seedling diameter.

Table 2 Result Duncan test effect of provenance and cultivation technique on growth of seedling diameter sengon

Treatment	Average growth diameter (cm)
F1T2	4.44 a
F1T1	4.18 ab
F2T1	3.50 b
F0T2	3.38 b
F2T2	3.30 b
F0T1	3.18 b

Note: Numbers followed by the same letter indicate that the treatment is not significantly different at a 95% confidence interval.

The results of the growth of the average diameter of sengon seedlings (Table 2) showed that sengon provenance solomon F1 treated with opened polybags (F1T2) had the highest average diameter growth value of 4.44 cm. Furthermore, the Solomon F1 provenance with closed polybags (F1T1) also has a fairly large average diameter of 4.18 cm. The lowest average diameter growth was owned by local provenance sengon and sengon solomon F2 in the treatment of polybags opened and polybags closed with an average diameter of 3.50, respectively; 3.38; 3.30; 3.18 cm.

The rapid growth of plant diameter can be used as an indicator of the high production of a plant. This can be obtained by selecting the right type and setting the appropriate spacing (Kosasih and Mindawati 2011). Based on the results of the average diameter obtained, the selection of sengon provenance Solomon has the largest diameter growth, both in polybags and polybags opened and closed polybags compared to local provenance sengon. This is in accordance with the statement of Setiadi et al. (2014) which stated that the provenance of sengon from the Solomon Islands had a faster growth than local sengon. At the age of 12 months sengon solomon has an average diameter growth of 5.7 cm and at the age of 20 months it can reach 12 cm. Sengon solomon also has three times higher productivity compared to local sengon. These differences can occur due to genetic diversity in each provenance of sengon plants.

According to Baskorowati et al. (2005), genetic diversity is the difference in genes contained in an individual and is related to the ability to adapt through changes that occur during the development process. One of these adaptation abilities can be observed using plant phenotype parameters, namely growth. Based on the results of the average diameter obtained by sengon solomon has a greater growth than local sengon at the age of seven months. This can happen because the genetic diversity of the individuals making up the solomon provenance stands has a relatively low genetic basis, because it comes from seed stands that only come from one provenance, so it can be assumed to have the same adaptability (Setiadi et al. 2014).

The results of variance at 95% confidence intervals obtained on the diameter parameter have a significant effect on the sengon provenance used. The growth of the average diameter of sengon seedlings every two weeks of observation in each treatment presented (Figure 1) is the best and lowest treatment on diameter parameters based on Duncan's test.

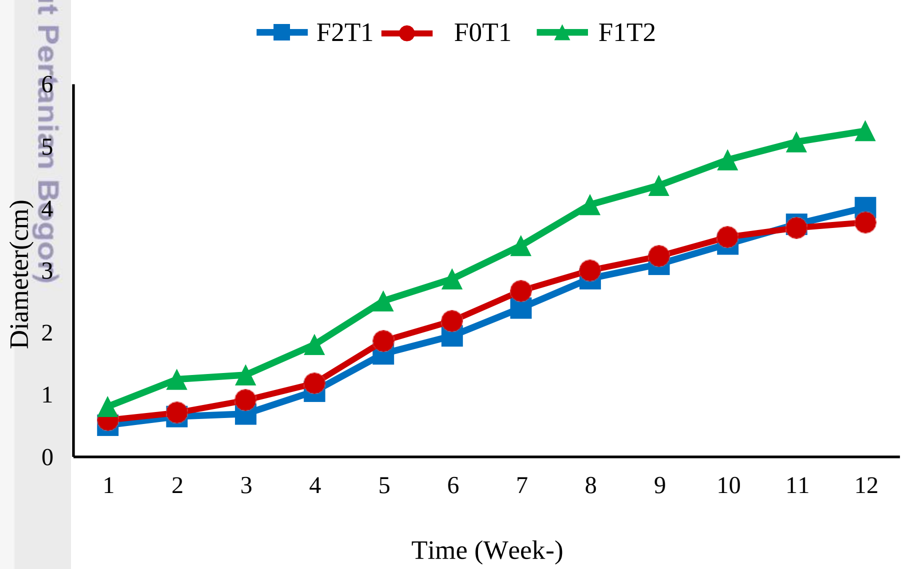

Figure 2 The growth of the average diameter of sengon seedlings in various treatments

The diameter of the sengon plant can increase due to several factors, including soil and environmental conditions. According to Nusantara (2000), the diameter of sengon can increase due to sufficient nutrient supply and a supportive environment. More intensive land management in agroforestry systems compared to monoculture lands will affect better nutrient supply and environmental conditions for plant growth. This is supported by the statement of Senjaya et al. (2018), that land management in an agroforestry system can increase growth in height and a larger diameter compared to land management in monoculture, this is related to growing conditions that are more supportive for plant growth.

The results of measuring the diameter of sengon seedlings obtained at week 1 to week 4 of observation (Figure 2), diameter growth in the three treatments did not provide a significant difference, but at week 5 to week 12 of observation, growth of sengon seedlings provenance solomon F1 in the treatment of opened polybags had a significantly increasing diameter growth. This can happen because in the 3rd month, biological organic fertilizer is applied to sengon and at 10 days after planting, inorganic fertilizer is applied in the form of urea, SP 36, and KCl on upland rice. According to Sudradjat and Komarayati (1992), the application of inorganic fertilizers can stimulate overall plant growth and is an important aid in the formation of green leaves.

According to Rusdiana et al. (2000), increasing plant age will increase the number of roots, diameter, and root surface area, thus affecting the greater nutrient uptake. Inorganic fertilizers given to upland rice plants are thought to be absorbed by the roots of sengon seeds, especially in the treatment of opened polybags, so as to increase the growth of the average diameter of sengon seedlings. This is in accordance with the statement of Gumilar (2014) which states that the root direction of a plant will follow the location of water and nutrients in the soil. The treatment of opened polybags was thought to have lower horizontal root penetration barriers than closed polybags in finding nutrients in the soil. These conditions can affect the growth of roots horizontally better,

The average growth in diameter of local sengon seedlings with closed polybag treatment had the lowest growth compared to other treatments. This can occur due to root growth that is not optimal due to polybags that are still attached to the previous planting media for sengon seeds. According to Rusdiana et al. (2000), the density of the structure of the planting medium greatly affects the growth rate of root penetration. The denser a root medium causes the area of root elongation to be shorter, thus affecting the nutrients absorbed by plants.

High Growth

Growth can be interpreted as an increase in the number and dimensions of plants, both diameter and height in a stand. One aspect of growth that can be measured quantitatively in plant development is height. Plant height is the growth of the plant vertically and is included in the primary growth (initial growth) which can be undergoes changes every day. The height growth of each plant can be influenced by soil and environmental conditions. Soil conditions are related to the nutrients needed by plants, while environmental conditions are related to temperature, humidity, and rainfall that are suitable for plants (Senjaya 2017).

The simplest growth observation parameter is the height parameter, because it can determine the effect of the environment or the treatment given. The growth of plant height is related to the active growth of cells that occur at the tip of the plant or called the promeristem (Maretina 2010). The results of variance at 95% confidence intervals obtained at high parameters, which gave results did not significantly affect the provenance of sengon, the planting technique used, as well as the interaction between the provenance and the planting technique.

The results of the average height growth of sengon seedlings every two weeks of observation in each treatment presented (Figure 3) were the highest, medium, and lowest treatments on the height parameter.

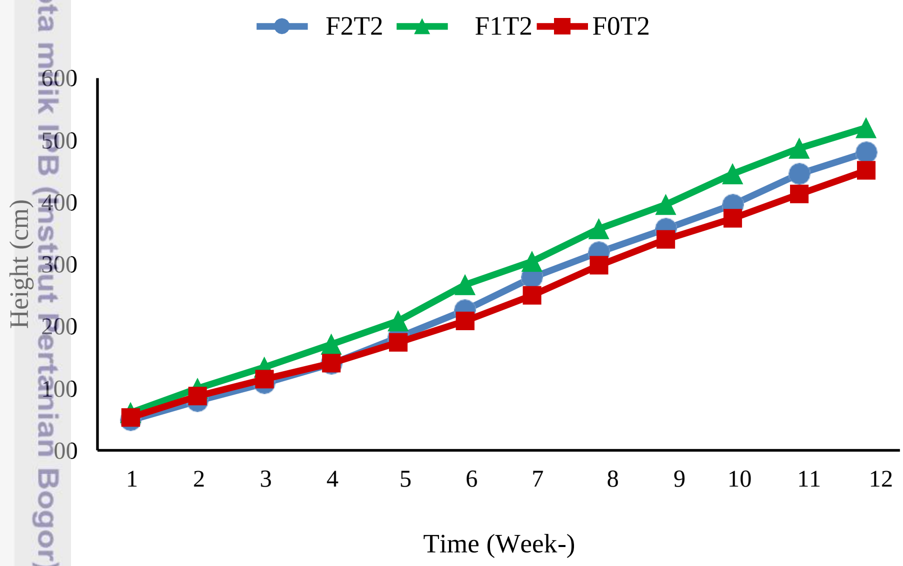

Figure 3 Growth of the average height of sengon seedlings in various treatments

The average height growth results from the provenance treatment of Solomon F1 with opened polybags (F1T2) on the height parameter had the highest average height compared to other treatments every two weeks for 24 weeks of observation (Figure 3). The F0T2 treatment had the lowest average height growth value compared to the other treatments. Based on the variance, the results showed that the treatment given did not significantly affect the height parameter. This could happen because the average height growth of sengon seedlings every two weeks in various treatments did not show a significant difference in results.

The growth parameters of sengon can be seen based on the growth dimensions, such as height, diameter, and roots. Based on Figure 3. the best average height growth is shown by sengon provenance solomon compared to local provenance. This is in accordance with the statement of Setiadi et al. (2014), which stated that the growth of sengon provenance solomon faster than local provenance sengon. Sengon solomon at the age of 12 months has an average height growth of 5 m and at the age of 20 months has an average height of 12 m, while at the local provenance sengon the average height growth at the age of 20 months is only 10 m. This is supported by the statement of Krisnawati et al. (2011), that the local sengon aged 5–10 years has a height ranging from 9.9–27.9 m, while the solomon sengon at the age of 5–10 years can reach a height of up to 40 m. The comparison of the height growth of sengon seedlings can be seen in Appendix 4.

The different mean height growth in the two provenances may occur because the genetic diversity in each provenance is also different. Genetic diversity is related to the adaptability of an individual in experiencing changes during the development process and adapting to the environment in which it grows. The main cause of diversity can occur, namely due to environmental variations (environmental variation) and differences in genetic composition passed down from parents to their offspring (genetic variation) (Dwiyanti 2009). Provenant solomon has a low genetic base and is assumed to have uniform adaptability compared to local sengon. This can happen because the Solomon Islands are small islands which are very close to each other.

Sengon plant growth is also strongly influenced by the silvicultural technique used. Silvicultural techniques used in the maintenance of young plants include spacing, replanting, fertilizing, weeding, and pruning (Mindawati and Heryati 2006). One of the plant maintenance activities that can increase growth and includes mechanical pest control is pruning. Pruning is a maintenance action that can encourage high growth and can produce stems without knot defects so that good and straight stem quality is produced (Sudomo et al. 2007; Susanto and Baskorowati 2018).

The difference in average height growth which was not too significant in each treatment was thought to be due to pruning of the shoots of the sengon stems. Pruning of sengon stem shoots in some individual plants can affect the overall height growth rate. Shoot pruning is a mechanical control that is carried out to overcome stem borer pests (Xystrocera festiva) that attack sengon seedlings, both in local provenances and solomon provenances (Nuban 2010).

Xystrosera festival or also called boktor pests, including the order Coleoptera from the family Cerambycidae and usually attacks various types of trees belonging to the Leguminosae family, including sengon plants. According to Darwiati and Anggraeni (2018), early symptoms of boktor pest attack on sengon plants can be seen from the presence of slightly fine and fresh sawdust with a whitish color attached to the tree bark. The powder is the result of larval activity that eats skin tissue by grinding around the larvae.

The life cycle of boktor pests begins with the laying of eggs by adult beetles in groups on former branches or wounds of sengon trees. After the 15–20 day stage, the eggs will hatch and the X. festiva larvae will drill the skin to enter the inside of the sengon stem. In young sengon plants, the larvae will enter and attack the young wood from the top to the bottom. During the larval stage to imago, the life span of X. festiva remains in the wood or trunk of sengon, so that it can inhibit the growth and quality of sengon wood (Tuhumury 2007).

Header Area Growth

Sengon plant growth is strongly influenced by genetic diversity factors and environmental influences. Environmental factors that can affect growth are soil fertility, water availability, and light intensity. The intensity of light that can be received by plants is very influential on growth and plays an important role in the process of photosynthesis. In addition to environmental factors, genetic diversity factors can also affect the diversity of sengon dimensional growth. Both of these factors can change every year as a result of climate change that continues to occur (Susanto and Baskorowati 2018).

One of the dimensional variables of sengon plants observed was canopy area. The canopy area of sengon was obtained based on the length of the crown from the four sides of the plant, namely, in the direction of the array (East-West) and perpendicular to the direction of the array (South-North). The length of the canopy from the four sides was then averaged to determine the area of the canopy (Gumilar 2014). The results of variance at 95% confidence intervals obtained on the canopy area parameter did not significantly affect the sengon provenance, planting technique, or the interaction between the provenance and the planting technique used.

The results of the growth of the average canopy area of sengon seedlings every two weeks of observation in each treatment presented (Figure 4) were the widest, medium, and lowest treatments on the parameter of canopy area.

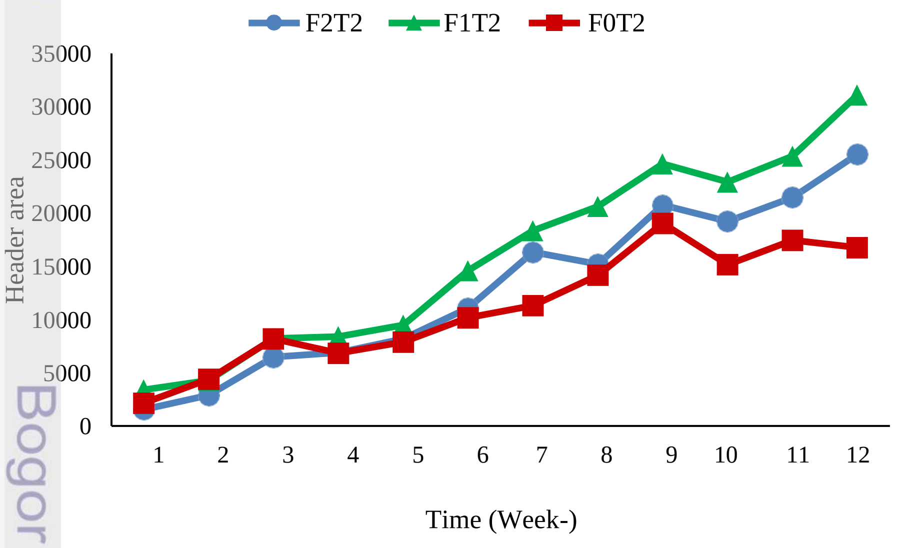

Figure 4 Growth of the average crown area of sengon seedlings in various treatments

The results of the growth of the average canopy area of sengon seedlings (Figure 4) showed that sengon provenance solomon F1 with opened polybag treatment had the largest canopy area of 31109.0 cm2. The provenance of sengon solomon F2 with opened polybag treatment had a crown area of 25539.0 cm2, while local sengon with opened polybag treatment had the lowest canopy area value of 16755.4 cm2. The size of the crown of a plant can describe the competition between plants. This is related to space competition for light which will affect the shape, canopy area, and growth of the plant. Thick crown growth or infrequent crown growth can affect growth rates due to responses to unfavorable growth sites, competition or disease (Raharjo and Sadono 2008).

The growth of the crown area of a plant is an important component in influencing the process of growth in height and diameter, because it directly affects the photosynthesis process and is positively correlated with the attainment of roots to obtain minerals in the soil. The wider tree canopy will enlarge the photosynthesis process, thus causing plant growth to be faster (Raharjo and Sadono 2008; Gumilar 2014). Based on the results obtained, the canopy area of Solomon proven sengon has a greater value than that of local sengon. These results are directly proportional to the growth of diameter and height in sengon provenance solomon which has a greater value than local sengon. This can happen because sengon provenance Solomon has a faster growth,

In the agroforestry system between sengon and upland rice, upland rice yields are strongly influenced by environmental factors and the rice varieties used. One of the environmental factors that affect crop yields is light intensity. These factors can be influenced by the presence of sengon plants in combined agroforestry cropping patterns. The higher sengon crown density with increasing age of the plant will affect the intensity of light that enters the upland rice field, so that it can affect the upland rice harvest (Senjaya 2017).

One way to minimize the effect of shade on sengon plants on upland rice is by periodic pruning. Periodic pruning can have a positive impact on upland rice and the sengon plant itself. According to Hamid (2008), pruning and planting intercrops can increase the dimensional growth of sengon plants. This can happen because the results of pruning leaves and woody tissue on sengon can reduce the barriers to the entry of the intensity of sunlight into the soil surface. These conditions will increase the activity of soil organisms, thereby accelerating the decomposition process and increasing soil fertility.

The fluctuating growth of canopy area or changing every two weeks of observation was also caused by the attack of Eurema spp. which damaged the leaves of local sengon seedlings and sengon solomon in the field (Appendix 5). Pests Eurema spp. or yellow butterfly belongs to the order Lepidoptera from the family Pteridae which usually attacks leaves on young plants in the field and attacks sengon seedlings in nurseries (Tuhumury 2007).

An attack by Eurema spp. on sengon seeds can cause plant denudation. These conditions can cause the number of leaves and canopy area to decrease, so that it affects growth and can even cause death in the sengon seedlings (Aprilia 2011).

Sengon Root Dimensions

Roots are part of the physiological processes of trees that are important for the entry of water and nutrients from the soil. Providing good growing space and minimizing the occurrence of competition for nutrients in the soil can affect root growth optimally. This can be done through spacing and treatment of the planting system (Rusdiana et al. 2000). According to Rao and Ito (1998), root systems can be classified based on the level of branching consisting of main roots, primary roots, secondary roots, and tertiary roots (Figure 5).

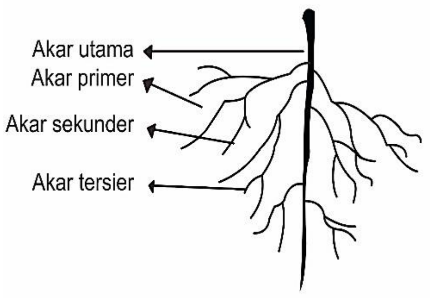

Figure 5 Root system in Leguminosae (Rao and Ito 1998)

Sengon plant (F. moluccana) is one type of forestry plant that is widely developed and cultivated by the community for the development of community forests and community plantation forests. Sengon plantation forest development currently has good market prospects and economic value. In addition to being profitable from the economic value, sengon plants can also be used and developed as plants in reforestation and forest rehabilitation programs to increase soil fertility on critical land or soil with few nutrients (Baskorowati 2014).

According to Khalif et al. (2014), on land planted with sengon species, an increase in the quality of soil fertility can be indicated by an increase in the input of organic matter, soil organic content, total N, and available N. Planting sengon using an agroforestry system has higher pH, C-Organic, total N, and available N values compared to monoculture sengon. This condition can occur because the ability of the roots of sengon plants in symbiosis with Rhizobium bacteria and more intensive maintenance in agroforestry systems can make a positive contribution to the root system and soil fertility (Khalif et al. 2014).

Sengon plant roots and upland rice roots as intercrops in the application of agroforestry systems must be considered. This is related to the aim of minimizing the occurrence of root competition between sengon plants and combined upland rice plants. Dimensions of the root.

observed in this study included horizontal root depth, horizontal root length, and horizontal root diameter. Recapitulation of the results of the variance of the influence of the provenance, planting techniques, and their interactions on the root dimension parameters of sengon seedlings (Table 3).

Table 3 Recapitulation of the results of the variance of the effect of provenance and planting techniques on root dimension parameters

Parameter	Treatment		
	Provenant	Planting Technique	Proven x Planting Techniques
Root depth	0.9246tn	0.1667tn	0.2640tn
Root length	0.0631tn	0.4122tn	0.7781tn
Root diameter	0.7256tn	0.8739tn	0.9807tn

Description: The numbers in the table is a significant value. * = the treatment has a significant effect on the 95% confidence interval with a significant value (Pr<F) 0.05 (α) tn = the treatment has no significant effect on the 95% confidence interval with a significant value (Pr>F) 0.05 (α).

The results of the variance (Table 3) show that the provenance treatment and the planting technique used as well as the interaction between the two have no significant effect on the parameters of root depth, root length, and root diameter horizontally.

Horizontal Root Depth

Horizontal root depth was measured at the end of the observation along with horizontal root length and root diameter measurements. Root depth was measured by digging the soil by hand and scraping on both sides of the plant, namely the North and South (perpendicular to the direction of the array). Measurements were made using a sewing meter from the soil surface to the top primary root of the plant, so that the average depth of the roots of sengon seedlings was obtained (Table 4).

Table 4. The average depth of horizontal roots of sengon seedlings in each treatment

Planting technique	Sengon Proven	Average root depth (cm)
polybag closed	Local	21.33
	Solomon F1	17.06
	Solomon F2	15.13
The average depth of the roots of closed polybags		17.84
polybag opened	Local	11.67
	Solomon F1	13.31
	Solomon F2	16.76

The average root depth of polybags opened	13.91

Horizontal Root Length

North and The root length of the sengon plant was measured at the end of the observation using a sewing meter. Root length was measured from the primary root to the tertiary root tip. Measurements were carried out on both sides of the plant, namely. South (perpendicular to the direction of the run). The lengths of both sides were then averaged, so that the average root length of the sengon seedlings was obtained (Table 5).

Table 5 Average length of horizontal roots of sengon seedlings in each treatment

Planting technique	Sengon Proven	Average root length (cm)
polybag closed	Local	118.25
	Solomon F1	111.68
	Solomon F2	36.53
The average length of the roots of the closed polybags		88.74
polybag opened	Local	119.00
	Solomon F1	127.55
	Solomon F2	77.55
The average length of the roots of polybags opened		108.03

Horizontal Root Diameter

Measurement of the horizontal root diameter of sengon was carried out at the end of the observation using a caliper. Diameter was measured at the base, middle, and tip of the root. Measurements were made on both sides of the sengon seedlings and the results were then averaged, so that the average diameter of each treatment was obtained (Table 6).

Table 6 The average horizontal root diameter of sengon seedlings in each treatment

Planting technique	Sengon Proven	Average root diameter (cm)
polybag closed	Local	0.44
	Solomon F1	0.53
	Solomon F2	0.46
The average diameter of the roots of closed polybags		0.48
polybag opened	Local	0.45
	Solomon F1	0.50
	Solomon F2	0.44
The average diameter of the roots of polybags opened		0.46

Analysis result The variance (Table 3) showed that the provenance treatment, planting technique, and their interaction did not significantly affect the parameters of root depth, root length, and root diameter horizontally. Root development is strongly influenced by the physical and chemical conditions of the soil (Gumilar 2014). Soil has an important role in providing nutrients for plant growth, a place for growth and holding of roots, as well as a storage area for groundwater which is very important for the survival of a plant. Soil fertility and density also greatly affect root development, both in number and level of root penetration. The more fertile the soil, the better the root development and the higher root penetration (Hidayat 2000).

Root depth is one of the variables that can affect plant growth, because it is closely related to root activity in finding water and nutrients. The movement of plant roots will follow the location of water and nutrients in the soil (Wijayanto and Rhahmi 2013). Based on Table 4, the average root depth in the closed polybag treatment had a greater depth than the opened polybag. The closed polybag treatment had an average root depth of 17.84 cm, while the opened polybag had an average depth of 13.91 cm.

Based on the results obtained, the value of root depth perpendicular to the array was greatest in the closed polybag treatment. This is presumably due to the planting technique used. According to Hidayat (2000), root development is strongly influenced by temperature, oxygen, soil fertility, mechanical obstacles, and applied cultivation techniques. The closed polybag treatment that was applied was thought to be able to inhibit the movement of roots horizontally, because of the polybags that were still attached to the previous planting medium, so that this condition resulted in the movement of roots penetrating more into the soil.

Root depth in agroforestry systems is closely related to the competition for space, water and nutrients (Wijayanto and Rhahmi 2013). The deeper the roots of the sengon plant will affect the competition and competition for water and nutrients with upland rice roots in the soil. According to Torey et al. (2013), the average root length of upland rice ranges from 6–15 cm. Based on these conditions, treatment of closed polybags on sengon seedlings can minimize root competition between sengon seeds and upland rice which can affect the final yield of sengon wood production and productivity in upland rice. This is also supported by the statement of Dewi et al. (2018), that deep or shallow root systems in agroforestry systems are closely related to the ability of root ranges to absorb water and nutrients,

Root development is closely related to the growth of the crown of the main plant. One of the variables in the root dimension that affects the growth of sengon is root length. The average length of horizontal roots perpendicular to the array in the opened polybag treatment was 108.03 cm, while in the closed polybag treatment it was 88.74 cm. According to the basic concept of physiology, root growth is based on the morphogenic balance between roots and plant crowns, in other words, the wider the distribution of the canopy and the height of the tree will determine the depth and breadth of the distribution of tree roots. This condition affects the length and number of roots that are getting bigger which results in better canopy growth (Suryanto et al. 2005). Based on the root length data obtained, these results are positively correlated with the data obtained from the height and width of the canopy. The longer the roots and the greater the number of roots, the higher the plant height and canopy area. This condition is closely related to the amount of nutrients and water that can be absorbed by plant roots, as well as the symbiosis between sengon roots and Rhizobium bacteria which can increase nutrient uptake in the plant.
land (Sari and Prayudyaningsih 2018).

Optimal root development is strongly influenced by the presence of nutrients in the soil. Increased root development can occur in the most fertile soil layers and usually around the placement of fertilizer application (Hidayat 2000). Variable dimensions of root development that can be measured is root diameter. Based on the analysis of the variance of the provenance effect, the technique planting, and their interaction had no significant effect on the horizontal root diameter parameter. The results of measuring the diameter of sengon seedlings (Table 6) showed that the average root diameter in the closed polybag treatment was greater than that in the opened polybag. The average root diameter in closed polybags was 0.48 cm, while in polybags opened it was 0.46 cm.

The difference in root diameter is thought to be due to barriers to root spread and penetration in the soil (Rusdiana et al. 2000). The resistance to root spread can be affected by the treatment at the beginning of planting. The planting technique with closed polybags is thought to be able to inhibit the spread and penetration of roots due to the planting media in compacted polybags. According to Hidayat (2000), self-defense in plant roots when there are obstacles in the form of dense soil or lack of water, the plant roots will increase the diameter and increase the branching. This can happen because the root cells will lose turgor and do not do much cell division, so the cell walls become thicker.

Knowledge of plant species, plant provenances, and planting techniques is needed in combining various crops in an agroforestry system. The use of superior provenances and the right combination of intercropping can increase crop yields optimally. Knowledge of roots in agroforestry systems is also needed to minimize and avoid competition for space for root growth, struggle for nutrients, and water in the soil. Main plants with deep root systems can be combined with intercrops with shallow roots.

CONCLUSIONS AND SUGGESTIONS

Conclusion

The provenance of local sengon and sengon solomon used only had a significant effect on diameter parameters, while planting techniques and interactions between provenances and planting techniques used did not significantly affect all parameters, namely diameter, height, canopy area, root depth, root length and root diameter. horizontally. The treatment of sengon solomon F1 with opened polybag treatment had the highest average diameter parameter of 4.44 cm. The closed polybag treatment had a greater root depth and diameter than the opened polybag, but the opened polybag treatment had a greater root length value than the closed polybag.

Suggestion

Sengon seeds planted in agroforestry systems should be treated with closed polybags. The recommended prevalence of sengon in agroforestry systems is sengon solomon F1. Research on the root dimensions of sengon plants needs to be done vertically and horizontally in all root directions.

REFERENCES

Amin N, Rachman I, Ramlan R. 2016. Types of agroforestry and land use orientation in Simoro Village, Gumbasa District, Sigi Regency. Warta Jungle 4(1):97–104.

Aprilia NT. 2011. Literature study of sengon pests (Paraserianthes falcataria (L.) Nielsen) [thesis]. Bogor (ID): Bogor Agricultural University.

Baskorowati L. 2014. Cultivation of Superior Sengon (Falcataria moluccana) for Community Forest Development. Bogor(ID): IPB Press.

Baskorowati L, Bush D, Setiadi D, Susanto M. 2017. Genetic variation of growth and disease resistance traits in open-pollinated provenance-progeny trials of Falcataria moluccana growing on two rust-affected sites at age-18 months. Journal of Tropical Forest Management 23(1):1–7.

[BMKG] Meteorology, Climatology and Geophysics Agency. 2018. Daily climate report. [Internet]. [Downloaded 2019 March 17]. Available at: https:///www.dataonline.bmkg.go.id.

Darwiati W and Anggraeni I. Attack of boktor (Xystrocera festifa Pascoe) and tumor rust (Uromycladium tepperianum (Sacc.) McAlpine) on sengon (Falcataria mollucana) (Miq.) in Ciater tea plantation. Journal of Natural Science, University of Nusa Bangsa 8(2):59–69.

Dwiyanti FG. 2009. Diversity of sengon solomon (Paraserianthes falcataria (L.) Nielsen) in progeny testing in the Cirangsad experimental forest [thesis]. Bogor (ID): Bogor Agricultural University.

Gumilar RA. 2014. Dimensions of the root system of sengon (Paraserianthes falcataria (L.) Nielsen) in Cikarawang Village, Dramaga District, Bogor Regency [thesis]. Bogor (ID): Bogor Agricultural University.

Judge I, Indartik, Suryandari EY. 2009. Analysis of the trade system and market for sengon wood in Wonosobo Regency and Temanggung Regency, Central Java. J Social Research and Forestry Economics 6(2):99–115.

Hamid A. 2008. Effect of sengon pruning on intercrop performance in sengon agroforestry systems. World of Science 8(2):189–202.

Hidayat Y. 2000. Root growth response of sengon (Paraserianthes falcataria) on density and water content of red-yellow podzolic soil [thesis]. Bogor (ID): Bogor Agricultural University.

Inkasari LAC, Baskorowati L, Damayanti A. 2016. Differences in the xylem structure of sengon (Falcataria moluccana) stems from Solomon and Wamena provenances. Journal of Plant Breeding 10(1):1–11.

Juarsah I. 2016. The use of zeolite and dolomite as a repairer to increase the efficiency of fertilization in paddy fields. Journal of Agro 3(1):10– 19.

Khalif U, Utami SR, Kusuma Z. 2014. Effect of planting sengon (Paraserianthes falcataria) on C and N content of soil in Slamparejo Village, Habung, Malang. Journal of Soil and Land Resources 1(1):9– 10.

Kosasih AS, Mindawati N. 2011. Effect of spacing on the growth of three types of meranti in the Haurbentes Research Forest. Journal of Dipterocarp Research 5(2):1–10.

Krisnawati H, Varis E, Kallio M, Kanninen M. 2011. Paraserianthes falcataria (L.) Nielsen: Ecology, Silviculture and Productivity. Bogor (ID): CIFOR.

Maretina T. 2010. Effect of application of NPK fertilizer and compost on gold mine tailings media on the growth of sengon buto seedlings [thesis]. Bogor (ID): Bogor Agricultural University.

Maryowani H, Ashari. 2011. Development of agroforestry to support food security and empowerment of farmers around the forest. Agro-Economic Research Forum 29(2):83–96.

Mindawati N, Heryati Y. 2006. Effect of frequency of maintenance of young plants on meranti growth in the field. Journal of Plantation Forest Research 3(2):63–71.

Nazirah L, Damanik BSJ. 2015. Growth and yield of three upland rice varieties on fertilization treatment. J Floratek 10:54–60.

Nuban SR. 2010. Development of Boktor (Xystrocera festifa Pascoe) larvae in artificial food (Artificial Diet) using sengon (Paraserianthes falcataria) powder [thesis]. Bogor (ID): Bogor Agricultural University.

Nuroniah HS, Putri KP. 2013. Cultivation Manual of Sengon (Falcataria moluccana Miq.). Bogor (ID): Research and Development Center for Forest Productivity Improvement, Forestry Development Research Agency.

Archipelago AD. 2002. Response of sengon (Paraserianthes falcataria (L.) Nielsen) seedlings to double inoculation of arbuscular mycorrhizal fungi and Rhizobium sp. Indonesian Journal of Agricultural Sciences 4(2):62–70.

Rachman E, Hani A. 2014. Agroforestry patterns of sengon (Falcataria moluccana L.) and curly red chili in the highlands of Ciamis, West Java. Journal of Agroforestry Research 2(1):35–44.

Raharjo JT, Sadono R. 2008. Teak canopy model (Tectona grandsi LF) from various families in a 9-year-old progeny test. Journal of Forestry Science 2(2):89–95.

Rao TP, Ito O. 1998. Differences in root system morphology and root respiration in relation to nitrogen uptake among six crop species. Japan Agriculture Research Quartery 32:97–103.

Rusdiana O, Fakuara Y, Kusmana C, Hidayat Y. 2000. Root growth response of sengon (Paraserianthes falcataria) on density and water content of red-yellow podzolic soil. Journal of Tropical Forest Management 6(2):45–53.

Sari R, Prayudyaningsih R. 2018. Development of root nodules on sea sengon (Paraserianthes falcataria (L.) Nielsen) seedlings. EBONI Technical Info 15(2):105–119. Senjaya N. 2017. Evaluation of sengon (Paraserianthes falcataria (L.) Nielsen) agroforestry systems with upland rice (Oryza sativa L.) [thesis]. Bogor (ID): Institute Bogor Agriculture.

Senjaya N, Wijayanto N, Wirnas D, Achmad. 2018. Evaluation of the sengon agroforestry system with upland rice against the fungus Rhizoctonia sp. Journal of Tropical Silviculture 9(02):120–126.

Setiadi D, Baskorowati L, Susanto M. 2014. Growth of sengon solomon and its response to tumor rust disease in Bondowoso, East Java. Journal of Tree Plant Breeding 8(2):121–136.

Sudomo A, Permadi E, Rachman E. 2007. Study of plantation forest silvicultural control on pulpwood quality. Technical Info 5(2):1–10.

Sudradjat R, Komarayati S. 1992. The effect of using a mixture of organic and inorganic fertilizers on the growth of sengon (Paraserianthes falcataria) tillers. Journal of Forest Products Research 10(5):150–155.

Sukarman R, Kainde R, Thomas A. 2012. Growth of sengon (Paraserianthes falcataria) seedlings on various growing media. Eugenia 18(3):215–220.

Suryanto P, Tohari, Sabarnurdin MS. 2005. System dynamics of various resources (resources sharing) in agroforestry: basic considerations for silvicultural strategists. Agricultural Science 12(2):165–178.

Susanto M, Baskorowati L. 2018. Genetic and environmental influences on the growth of sengon (Falcataria moluccana) the Javanese land race. Bioexperiment 4(2):35–41.

Torey PC, Ai NS, Siahaan P, Mambu SM. 2013. Morphological characters of roots as an indicator of water shortage in Superwin local rice. Journal of Bios Logos 3(2):58–64.

Tuhumury A. 2007. Inventory of pests on sengon (Paraserianthes falcataria) at the Waaesamu Community Forest, Kairatu District, West Seram Regency. Journal of Agroforestry 2(1):13–18.

Wicakono H, Putra ETS, Muhartini S. 2015. The suitability of canna (Canna indica L.), suweg (Amorphopallus paeoniifolius (Dennst.) Nicolson), and cassava (Manihot esculenta Crantz) agroforestry in the Manoreh Hills. Vegetalika 2(1):87–101.

Widianto, Hairiah K, Suharjito D, Sardjono MA. 2003. Functions and Roles of Agroforestry. Bogor (ID): World Agroforestry Center (ICRAF) Southeast Asia Regional Office.

Wijayanto N, Rhahmi I. 2013. Length and depth of lateral roots of Jabon (Anthocephalus cadamba (Roxb.) Miq.) in Cibening Village, Pamijahan District, Bogor Regency, West Java. Journal of Tropical Silviculture 4(1):23–29.

APPENDICES

Appendix 1 Results of various parameters of sengon seedling growth in various treatments

The results of the various parameters of the diameter of sengon seedlings

Source	DF	JK	KT	F Value	Pr>F
Provenant	2.00	5.06	2.53	20.88	<.0001
Planting technique	1.00	0.04	0.04	0.34	0.5650
Proven and technique planting	2.00	0.25	0.12	1.05	0.3718

The results of the variance of the parameters of the height of sengon seedlings

Source	DF	JK	KT	F Value	Pr>F
Provenant	2.00	8534.81	4267.40	2.18	0.1422
Planting technique	1.00	120.31	120.31	0.06	0.8071
Proven and technique planting	2.00	935.21	467.60	0.24	0.7902

The results of the various parameters of the canopy area of sengon seedlings

Source	DF	JK	KT	F Value	Pr>F
Provenant	2.00	95782780.40	47891390.20	0.92	0.4161
Planting technique	1.00	22455438.00	22455438.00	0.43	0.5194
Proven and planting technique	2.00	302462379.20	151231189.60	2.91	0.8005

The results of the parameter variance of root depth of sengon seedlings horizontally

Source	DF	JK	KT	F Value	Pr>F
Provenant	2.00	7.01	3.50	0.08	0.9246
Planting technique	1.00	92.43	92.43	2.08	0.1667
Proven and technique planting	2.00	127.78	63.89	1.44	0.2640

The results of the parameter variance of the root length of sengon seedlings horizontally

Source	DF	JK	KT	F Value	Pr>F
Provenant	2.00	20627.92	10313.96	3.23	0.0631
Planting technique	1.00	2247.50	2247.50	0.70	0.4122
Proven and technique planting	2.00	1622.60	811.30	0.25	0.7781

The results of the parameter variance of the root diameter of sengon seedlings horizontally

Source	DF	JK	KT	F Value	Pr>F
Provenant	2.00	0.02	0.01	0.33	0.7256
Planting technique	1.00	0.0009	0.0009	0.03	0.8738
Proven and technique planting	2.00	0.001	0.0007	0.02	0.9807

Appendix 2 Results of the analysis of the physical and chemical properties of the soil at the research site

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http://www.icbb.or.id

No: 28.1/FP/ICBB
Revision: 1

TEST RESULT REPORT

Result of Analysis

No.: ICBB.LHP.III.2019.0238

1. Number
   1.1. No Order / Order No : ICBB. Mark KP.II/2019/0098
   1.2. No. Invoice / Invoice No : Inv-0088/ICBB/II/2019
2. Customer / Principal
   2.1. Name / Name : Department of Silviculture, Faculty of Forestry
   2.2. Address / Address : Bogor Agricultural Institute
3. Test Results / Result No.: ICBB.LHP.III.2019.0238

No.	Parameter		Method	Unit	**Results/*Result*** End 1902.01965
1.	C-Organic		Walkley & Black	%	2.05
2.	N-Total		Kjeldahl	%	0.18
3.	C/N Ratio		Counting	-	11.00
4.	P_2O_5 Available		Bray I	ppm	1.50
5.	P_2O_5 Potential		HCl 25%	mg/100g	61.76
6.	K_2O Potential		HCl 25%	mg/100g	10.03
7.	Cation Exchangeable	K^+	*N* NH_4Oac	cmol(+)/kg	0.08
		Na^+			0.05
		Ca^{++}			2.67
		Mg^{++}			0.80
8.	Exchangeable Packaging	Al-dd	*N* KCl	cmol(+)/kg	2.44
		H-dd			0.46
9.	Cation Exchange Capacity		*N* NH_4Oac	cmol(+)/kg	15.99
10.	Base Saturation		Calculation	%	22.50
11.	Water content		Gravimetry	%	9.55
12.	pH	H_2O	Potentiometry	-	5.48
		KCl *N*			3.95
13.	Texture of 3 Fractions	Sand	Pipette	%	18.00
		Dust			25.00
		Klei			57.00

This analysis result represents only the content of the delivered sample.
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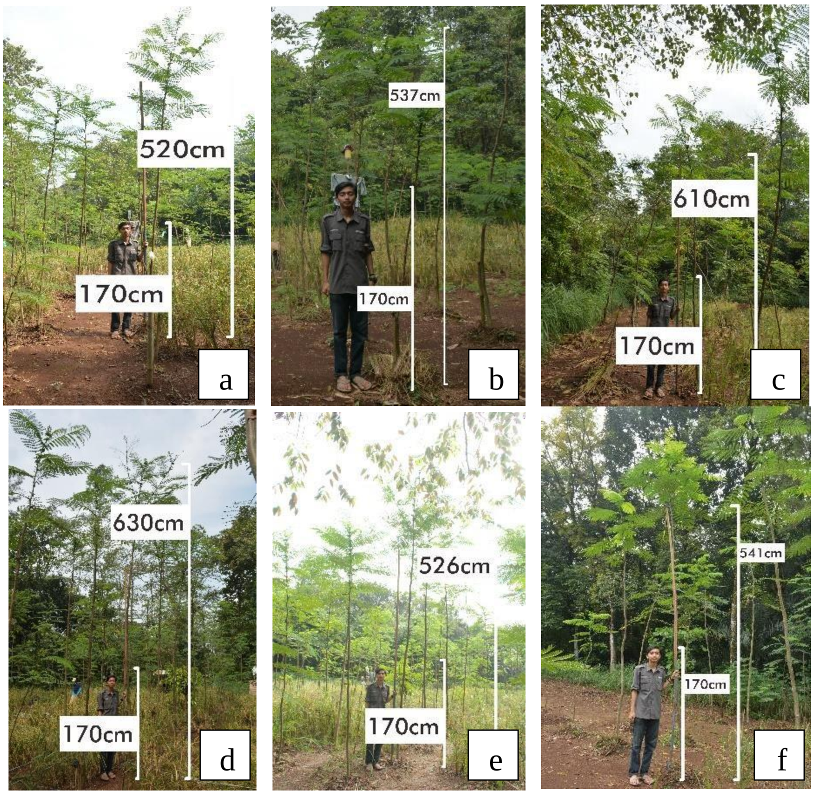
Appendix 3 Daily rainfall data for Dramaga Bogor area in August 2018–February 2019

WMO ID	: 96751
Station Name	: Citeko Meteor Meteorological Station
Latitude	: -6.70000
longitude	: 106.85000

date	Rainfall (mm)						
	2018					year 2019	
	August	September	October	November	December	January	February
1	0	4.3	0	2.0	2.8	23.5	10
2	0	0	0	15.6	0.7	23.3	21.5
3	0	14.9	0	5	3	8.8	TTU
4	0	0	2.1	8.9	16	0	1.4
5	0	0	0.1	3.9	24.5	2.2	0
6	0	0	0	2.4	11.5	TTU	0.1
7	0	0.1	0	10.9	10.8	0	35.3
8	0	50	0	12.7	4.3	30.8	TTU
9	0	0.2	0	9.5	1.4	9.3	TTU
10	0	0	0	2.4	TTU	0.7	TTU
11	0	0	0.4	26	TTU	9.2	8
12	0	0	0	35.6	TTU	31.2	32.9
13	11.5	0.1	TTU	6.5	8.3	20.2	TTU
14	0	0	0	10.2	20.6	29.1	TTU
15	0	0	TTU	0.3	23	2.3	65.9
16	0	0	0.9	0.9	27.7	1.4	87.4
17	0	0	0.5	0	3.5	0.1	7.5
18	0	0	TTU	3.1	0	4.6	11.1
19	0	0	25	0	TTU	15.7	TTU
20	0	0.4	0.8	13	3.5	5.4	30.8
21	0	20.8	19.6	5.6	0	80.3	37
22	0	3.9	0	52.6	TTU	6.3	4.4
23	0.1	0.5	50.1	0	TTU	18.2	0.7
24	0.2	29.6	6.1	6.2	0	3	17.6
25	0	0	2.9	41.2	0	46.9	3.4
26	0	0	7.4	9.8	31	11.4	29.5
27	0	0.9	2.5	38.3	0.9	0.8	0
28	0	36	3.7	28.3	TTU	1	0
29	0	0	5.6	TTU	0	11.4	
30	0	0	TTU	31.2	2.1	6.7	
31	8.7		2.7		0.1	4.5	

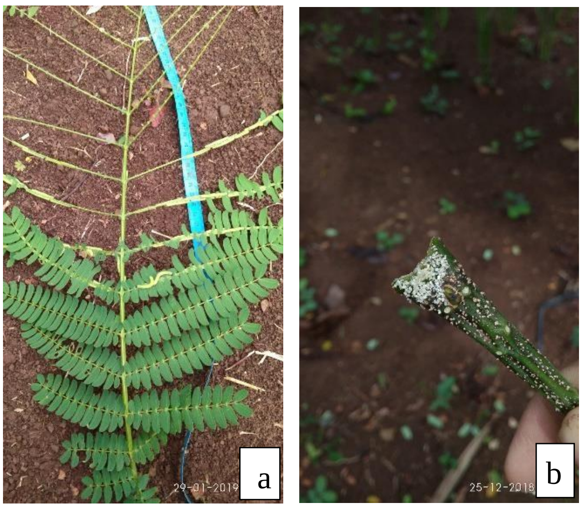
Note: TTU/ Not Measured = Rain less than 0.1 mm

Appendix 4 Comparison of dimensions of height growth in each treatment



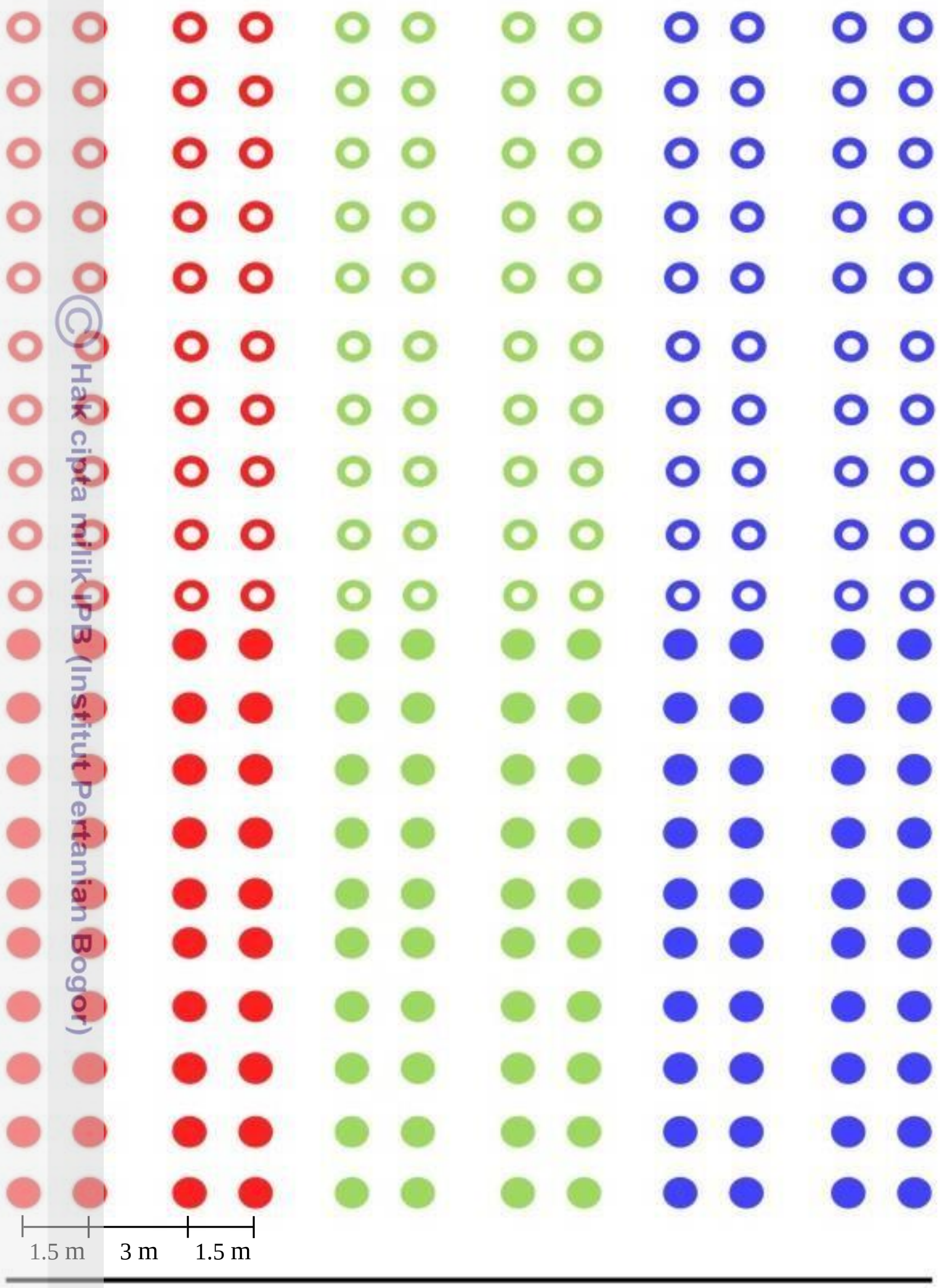
Description: Appearance of sengon seed height in each treatment a) F0T1 (local sengon + closed polybag); b) F0T2 (local sengon + polybag opened); c) F1T1 (solomon F1 + closed polybag); d) F1T2 (solomon F1 + polybag opened); e) F2T1 (Solomon F1 + closed polybag); f) F2T2 (solomon F2 + polybag opened)

Appendix 5 Pests Xystrocera festiva and Eurema spp. which attacks local sengon seedlings and solomon sengon



Description: Attacks of leaf and stem pests of sengon seedlings in each treatment a) Eurema pests spp. b) Pest Xystrocera festiva

Appendix 6 Layout of double lane planting of sengon in agroforestry systems



Description:

: Polybag closed

: Polybag opened

: local sengon

: Sengon solomon F1

: Sengon solomon F2

BIOGRAPHY

The author was born in Banyumas, Central Java on May 14, 1998 as the eldest of two children of Mr. Tarsim and Mrs. Artiyati. The author completed his high school education at SMA Negeri 1 Sampang, Cilacap Regency in 2015. In the same year the author passed the selection to enter the Bogor Agricultural Institute through the SNMPTN route and was accepted at the Silviculture Department, Faculty of Forestry, Bogor Agricultural University.

became a finalist in the Scientific Writing Competition (LKTI) Ganesha Bali University of Education, and won 1st place in the Fish Writing Essay competition (KATIkan) at Diponegoro University, Semarang in 2018. In 2017, the author carried out General Forestry Practice (PUK) in Gunung Sawal, Pangandaran, and Gunung Walat Educational Forest. The author also conducted a Real Work Lecture (KKN) in Cikembang Village, Kertasari District, Bandung Regency, West Java in July–August 2018.

To obtain a Bachelor of Forestry degree from IPB, the author completed a thesis entitled "Comparison of Growth between Local Sengon and Solomon Sengon in Agroforestry Systems" under the guidance of Prof. Dr. Ir Nurheni Wijayanto, MS.