Sengon (*Falcataria moluccana*) prevention from gall rust through seed irradiation: field test in endemic location

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**Abstract.** The gall rust disease is the diseases of sengon plant (*Falcataria moluccana*), that it caused by *Uromycladium* spp. which can cause the decreased productivity. However, at this time not yet retrieved the right techniques to reduce attacks of gall rust disease on sengon plant. Efforts to control gall rust disease at the level of seeds can be through by seed irradiation technique. Irradiation techniques on seeds can be used to increase productivity through increased vigour and seed quality. The aim of the study was to determine the effectiveness of gamma rays irradiation techniques on sengon seeds its shown by the growth and percentage of damage caused gall rust at sengon plantation at Pandantoyo Sub Forest District (RPH), Pare Forest District (BKPH), Kediri Forest Management Unit (KPH), East Java. The research design used a randomized block design consisting of 3 blocks. Each block consists of 10 treatments based on irradiated doses (0, 5, 10, 15, 30, 60, 75, 90 and 105 Gy) and each treatment consist of 20 plants. The parameters observed were percentage of attacked plants that divided into four level of damage: healthy (0%); low (≤ 10%), moderate (≥ 11%–45%) and severe (≥ 46%) and growth of diameter and height. Generally, the health conditions of sengon plantation were affected by gall rust. At 18-months-old, the gamma rays irradiation at 75 Gy was the largest percentage of healthy plants (42.5%) and better than control (24%). At 25-months-old, the plants derived from seeds that were not irradiated (control) was the largest percentage of plants with severe damage. Gamma rays irradiation does not affect the growth of diameter and height. The highest percentage of healthy plants were at 1st block but the fastest growth of plant diameter was 2nd block.

1. Introduction

*Falcataria moluccana* (Sengon (MIQ.) is a timber-producing crop worth economically. In addition to the fulfilment of the needs in the country, the demand for sengon wood is increasing along with the need of plywood materials to be exported. The log wood production of sengon in Indonesia in the year of 2016 reached 2.56 million m³ that is the third-largest after acacia and meranti woods. The production of the largest sengon logwood (2.49 million m³) derived from Java Island or reached 59.95% of total production of sengon wood in Indonesia [1].

Currently the condition of sengon stands in Java is mostly affected by gall rust disease [2] [3], and several studies state that gall rust is caused by fungi *Uromycladium* spp. [4]. Specifically, several studies stated that the type of Uromycladium that attacked sengon in Java was initially identified as a *Uromycladium tepperianum* (Sacc.) McAlpine fungi [3]. *U. tepperianum* has also been reported attack various types of acacia [5] [6]. However, the results of the study by [7], successfully identified
that Uromycladium which in sengon has a difference with Uromycladium whose host is acacia, so specifically Uromycladium which hosts the sengon plant was proposed as U. falcatariium.

The gall rust attacks will degrade the quality of the wood so that it can reduce its economic value. The attack of gall rust that badly enough can cause death of the plant. This condition can affect the productivity of the forest and ultimately impact on the sengon-based lumber industry. Various prevention and control efforts have been carried out well, mechanically and biologically to prevent attacks and spread of fungus on sengon plants. One of the prevention efforts that can be done to overcome are using of superior seed quality and resistant to diseases, so that it can increase sengon crop productivity. Because seed pathogens can be carried up by the seeds and can further infect plants in the field [8].

The use of gamma rays irradiation is one of the breeding techniques used in the improvement of plants, such as increasing genetic diversity, increasing production, accelerating growth, and resistance to pest diseases [9]. In sengon, the technique of gamma rays irradiation at low doses has been shown increase the germination (DB) and speed of germination (KCT). DB and KCT values begin to appear at a dose of 5 Gy, and continue to increase until a dose of 90 Gy [10]. Gamma rays irradiation techniques are seed treatments carried out to improve seed vigor and quality [11]. Increased viability and vigor of the seeds can encourage seedling growth of sengon in the field, making it possible to survive in conditions that are not optimal as in the endemic location of the fungus.

Based on these expectations, the planting of sengon seeds that have been irradiated with gamma rays at a dose of 0-105 Gy and has been planted at Pandantoyo Sub Forest District (RPH Pandantoyo), Pare Forest District (BKPH Pare), Kediri Forest Management Unit (KPH Kediri) (East Java) which is an endemic area of gall rust, will be survive. The purpose of this study was to determine the effectiveness of gamma rays irradiation techniques on sengon seeds (F. moluccana) in suppressing the attack of gall rust on sengon plantation and their growth at the endemic location of the gall rust.

2. Materials and Methods

2.1. Time and location
The study was conducted in June 2017 and February 2018, at Pandantoyo Sub Forest District (RPH Pandantoyo), Pare Forest District (BKPH Pare), Kediri Forest Management Unit (KPH Kediri) Perhutani Enterprise, East Java, Indonesia. Irradiation gamma rays were conducted in Agency of National Nuclear Energy (BATAN).

2.2. Material and instrument
The research material that used was the sengon plantation (planted in January 2016 at RPH Pandantoyo). The cropping pattern is mixed planting with red jabon, the planting distance used is 4 x 4 m. The sengon plant comes from the seeds produced by gamma irradiation at a dose of 0, 5, 10, 15, 30, 45, 60, 75, 90 and 105 Gy which are emitted through the gamma cell 200A irradiator with a Cobalt 60 radiation source. The equipment used is 200A gamma cell irradiator, gauge, calliper, height measuring instrument, stationary and camera.

2.3. Research procedure
The research design was a randomized block design consists of 3 blocks; each block consists of 10 irradiation dose treatments (0, 5, 10, 15, 30, 45, 60, 75, 90 and 105 Gy). Each treatment was repeated for 3 replications and 20 replications per plant. Health observations of sengon stands were carried out by observing the response of the rate of gall rust attack. Gall rust attacks level are divided into four categories, namely: healthy (0%); mild (≤ 10%), moderate (≥11% - 49%) and severe (≥49%) [12]. In addition to the observation and measurement of the gall rust attacks level, also observed and measured diameter and height growth.
2.4. Data analysis
The data obtained were analyzed by ANOVA, and if it was significant, it would be continued using Duncan's advanced test at the level of 5%.

3. Results and Discussion

3.1. Results
Generally, the health conditions of sengon plantation were attacked by fungi. The condition of the 18-month-old plant was mostly (38.5%) attacked by gall rust with moderate attack intensity, while plants that were not attacked (healthy) only reached 21.9%. At the age of 25 months, 56.6% of the plants were infected with fungus with a mild intensity of attack (Figure 1)

![Figure 1. The intensity of gall rust attack on sengon plants aged 18 and 25 months in Pandanroyo RPH.](image)

The results of variance analysis (Table 1) showed that at the age of 18 months, gamma rays irradiation treatment on sengon seeds significantly affected the percentage of plants that were not infected with fungi (healthy), but did not significantly affect the percentage of plants attacked by fungi with mild attack intensity, medium and severe. At the age of 25 months, gamma rays irradiation treatment on sengon seeds only significantly affected the percentage of severely affected plants. Block conditions significantly affected the percentage of healthy plants and the mild attacked by fungus, moderate and severe attacks on 18-month-old sengon plantation. Whereas for plants aged 25 months, block conditions only significantly affect the percentage of healthy plants and plants attacked with mild intensity.

Table 1. F-value of the sengon seed irradiation effect on the percentage of healthy plants and attacked by puru fungus in RPH Pandanroyo.

| Age (month) | Variance | Percentage of healthy plant | Percentage of plants with level of damage |
|-------------|----------|-----------------------------|-----------------------------------------|
|             |          |                             | low          | medium        | severe      |
| 18          | Treatment| 1.02*                       | 0.45         | 0.92          | 0.71        |
|             | Block    | 16.48**                     | 2.98*        | 13.66**       | 8.98**      |
| 25          | Treatment| 0.56                        | 0.74         | 1.21          | 4.65*       |
|             | Block    | 8.90**                      | 7.39**       | 0.38          | 0.57        |

**significantly different at 99% confidence interval, * significantly different at 95% confidence interval
At the age of 18 months, gamma ray irradiation 75 Gy was proven to produce the largest percentage of healthy plants (42.5%) and better than control (24%) (Figure 2). For 25-year-old sengon plants, plants derived from seeds were not irradiated (control) shows the percentage of trees infected with fungus with the highest severe intensity (15%). The sengon plant with irradiated seeds of 5 Gy was not attacked by fungus with severe intensity (Figure 3).

The highest percentage of healthy sengon plants were at 1st block, which are 41% (18 months) and 32.3% (25 months) respectively. At the age of 18 months, the highest percentage of plants was at the 2nd and 3rd block with medium damage, but at the age of 25 months were the highest percentage of plants was at the 2nd and 3rd block with low damage (Figures 4 and 5).

**Figure 2.** Percentage of 18-month-old sengon plants that were not attacked by puru fungus (healthy).

**Figure 3.** Percentage of 25-month-old sengon plants attacked by fungus with severe attack rates.

**Figure 4.** The percentage of sengon plant was attacked by fungus in the three planting blocks in RPH Pandantoyo at the age of 18 months.

**Figure 5.** The percentage of sengon plant was attacked by fungus in the three planting blocks in RPH Pandantoyo at the age of 25 months.
The irradiation treatment on sengon seed did not give a significant effect on diameter growth, height and percentage of life of sengon plants aged 18 and 25 months. Block conditions significantly affect diameter and height growth. Block conditions did not significantly affect the percentage of life of sengon plants aged 18 and 25 months (Table 2).

### Table 2. F-value of the sengon seed irradiation effect on the growth of sengon plants in RPH Pandantoyo.

| Age (month) | Source of diversity | Diameter | Height | Percentage of life |
|-------------|---------------------|----------|--------|-------------------|
| 18          | Treatment           | 0.76     | 0.88   | 0.74              |
|             | Block               | 5.79*    | 3.55*  | 0.93              |
| 25          | Treatment           | 0.45     | 0.58   | 0.57              |
|             | Block               | 4.56*    | 21.18**| 0.59              |

**significantly different at 99% confidence interval,*significantly different at 95% confidence interval

Based on the results of further tests (Table 3) it is known that block 2 produces the fastest diameter and height growth of the sengon plant. Block 3 produces low growth and high diameter. This is in line with the number of plants attacked by fungus with heavy intensity found in this block (17.78%; 3%).

### Table 3. The sengon growth average and percentage of life in the three planting blocks in RPH Pandantoyo.

| Block | Diameter (cm) | Height (cm) | Percentage of life |
|-------|---------------|-------------|-------------------|
|       | 18 month      | 25 month    | 18 month          | 25 month         | 18 month          | 25 month         |
| 1     | 18.24ab       | 25.79 ab    | 442.76ab         | 833.01 a         | 87.17 a           | 81.00 a          |
| 2     | 19.94 a       | 27.76 a     | 494.78 a         | 831.60 a         | 89.33 a           | 83.83 a          |
| 3     | 16.09b        | 23.14 b     | 425.40 b         | 703.60 b         | 84.67 a           | 79.83 a          |

Remarks: the value followed by the same letter in the same column shows no significant difference at 99% confidence interval

Although seed irradiation did not affect diameter growth, sengon plants that seeds were not irradiated tended to produce the highest average stem diameter growth of 21.04 cm at the age of 18 months and 28.64 cm at the age of 25 months (Figure 6).

![Figure 6](image_url)  
**Figure 6.** The diameter growth average of sengon plants aged 18 and 25 months in Pandantoyo RPH at various irradiation doses
3.2. Discussion

On site of RPH Pandantoyo, BKPH Pare, KPH Kediri, the plants originating from sengon seed which had been irradiated with gamma rays is still mostly attacked by fungi on the leaves, twigs and/or stems. Sengon plants that were not affected by fungus (healthy) were 21.9% at the age of 18 months and 20.8% at the age of 25 months. This condition is due to the Pandantoyo area being an endemic area of puru fungi, where most of the sengon plants are attacked by pests and diseases, especially puru fungi. The presence of fungi spores in the region is estimated occur in all parts of the plant from the top, stem to roots even on the forest floor. The accumulation of high puru fungi spores allows the environment in the Pandantoyo area to be covered by spore fog. With such environmental conditions, the sengon that planted in this area if they do not have high resistance are most likely to be attacked by pests and diseases. Gamma rays irradiation is a seed treatment that is expected to improve the resistance capability of sengon plants to attack fungus. As for the Ambonese bananas, 1000 rad gamma rays irradiation has been shown to increase the resistance of ambon bananas to Fusarium wilt [12].

In this study, at the age of 18 months, sengon plants whose seeds were irradiated 75 Gy were more tolerance to fungi attack than sengon plants without irradiation treatment (control). Percentage of healthy sengon plants whose seeds were irradiated 75 Gy reached 42.5%. But with the increasing of the age, the ability of plants to survive from the attack of the puru fungus decreases and is relatively the same for all treatments with the percentage of healthy trees at the age of 25 months ranging from 10.8% - 30.7%. Plant tolerance puru will change along with the increase of the age and the change of the environmental conditions of the plant. As in the Solomon sengon plant, at the age of 6 months, some Solomon sengon families are still relatively resistant to attack by gall rust, but along with the increasing of age, all off the families are attacked by gall rust disease [13]. The percentage of 18-month-old plants attacked by puru fungus was relatively the same between the treatment of irradiation doses for the three levels of attack intensity, namely mild, moderate and severe. Whereas at the age of 25 years, the sengon plant whose seeds were irradiated 5 Gy no one was attacked with a severe intensity level. This is probably due to the pruning of the branches of plants that are attacked by puru fungi. This silvicultuare technique is one of the efforts to control the attack of the fungus [14]. Other silvicultural techniques that can be applied as a preventive effort in controlling the density and intensity of fungi attack include the application of agroforestry systems with the right combination of plants, proper spacing and the use of balanced fertilizer [15] [2]. Fertilization using additional essential micro nutrients, such as Silica (Si) is highly recommended to be able to build natural plant resistance to diseases caused by fungi [16] ; [17]. Otherwise, [4] stated that there was a significant relationship between six cultivation factors with the incidence of gall rust, namely the age of plants, use of organic fertilizers, chemical control of gall rust, pruning of plants that were rusty, mixing plants, and slope of land. Growth is one of the measured parameters of plant physiological processes. Control of citrus rust fungi through the technique of gamma ray irradiation at the seed level has not affected the diameter growth, height and percentage of plant life planted in the endemic location of the fungi. However, sengon plants without irradiation treatment (control) tend to have faster stem diameter growth compared to sengon plants with gamma ray treatment up to 105 Gy.

The effect of blocks affected the growth of sengon plants because of the grouping of seeds was used, in block 1 the seeds used were from Papua, while block 2 and 3 seeds were from Java. The native of sengon from Papua is a type of sengon which is more resistant to gall rust disease because it shows a lower area and intensity of attack [18] [19]. This shows that the origin of the seeds used to build plantation forests must be considered especially for sengon plants.

4. Conclusion

The irradiation treatment on sengon seeds as an effort to control the gall rust disease which was subsequently planted at the location of the gall rust endemic (RPH Pandantoyo, BKPH Pare, KPH Kediri, East Java, Indonesia), showed that the irradiation treatment of seeds at a dose of 75 Gy was observed at 18 months have plants with the highest healthy category of 21.9%, but decreased at 25
months to 20.8%. This condition is not only of the treatment of the seed, but also the applied of silviculture intensive such as pruning and the mixture of planting system with other species (red Jabon).

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