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SOIL SEED BANK GERMINATION IN PINE FORESTS AND SHRUBS, IN GUNUNG CIREMAI NATIONAL PARK

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A B S T R A C T

Problems that often occur in ecosystem restoration through planting are stem and root damage, plant death, and high costs. One possible solution is to trigger the germination of soil seed banks. The purpose of this study was to analyze the germination of soil seed banks in shrubs and pine stands, Gunung Ciremai National Park. The method used was soil sampling and sample plots. The results of the study provided evidence that pioneer tree germination did not occur, both in bushes and in pine stands. Germinated woody species was calliandra with densities 8.53 individuals/m^2 (bush) and 5.74 individuals/m^2 (pine stands) for sample plots and 3.15 individuals/tray (bush) and 4.03 individuals/tray (pine) for the soil sampling. The density of the calliandra between the two types of cover was not different ($p = 0.123$ for the sample plot method; and $p = 0.452$ for the soil sample method). The absence of pioneer species germination indicated that the restoration of ecosystems must be planted.

Key words: conservation, ecosystem, national park, restoration.

1. Introduction

Nowadays, ecosystem recovery is needed in many places, including in conservation areas. The most common method for restoring is planting. Planting activities certainly require a nursery for propagating plants that can be obtained from the adult trees or through extraction from forest stands. However, the supply of seedlings with extraction can damage the root system (Sarno & Ridho 2009) so that it often causes death to the plants (Dodo & Wawangningrum 2018). Plants originating from other places and far will be prone to contamination by harmful organisms, thereby reducing the success rate (Subandi 2015).

Furthermore, the seedlings ready for planting which are in the nursery require the process of transporting to the planting site. However, the process of transporting often reduces the seedlings quality (Fernandes 2014). Transporting plants in a conventional manner often results in failure mainly due to factors in field difficulties (Endom 2007). Seedlings transported can experience root damage, broken shoots and stems, and withering (Barkah 2009). Wilt on seedlings occurs due to high evaporation when the seedlings is moved from nursery (Wahyudi et al. 2014). Root system disorders can cause death in seedlings (Endom et al. 2007). In addition, transportation requires complex requirements, such as: watering the seedlings before transportation, the number of seedlings must be in accordance with the timing of the planting, transportation should be carried out at certain times (morning or evening), maintaining moisture during transportation, and necessary means for transportation which is a lot (Kurniaty & Danu 2012). Transporting by means of bearers can provide a risk of work safety, especially when transport distances are far from slippery road conditions (Endom et al. 2007).

To overcome the problems in transporting seedlings, the Management Unit of PT. Gunung Gajah Abadi has designed a seedling carrying bag with a capacity of 50 plants for one transport. Although the integrity of the plant is more maintained, the bag holds less comfort for workers so that the break time needed by workers becomes longer (Wahyudi et al. 2014). Previous researchers in overcoming the problem of the transporting have also developed elevated cable technology that drives diesel engines (Endom et al. 2007). However, this technology requires personnel who have special skills for the installation of cable networks and the number is limited (Wahyudi et al. 2014). In addition to requiring high costs, the tool also becomes less effective when the planting area is in the form of narrow areas rather than a wide expanse, the topography varies, and is far from the source of the seeds.

Another effort that can be done to overcome the above problems is to optimize the germination process of seeds contained in the soil in the locations to be rehabilitated. Some previous researchers have carried out research related to seeds stored in soil that can last for a considerable period of time (Dalling et al. 1997), or better known as soil seed bank (Pascoe 1994; Hossain & Begum 2015). In some studies, the seeds of pioneer species will germinate when land clearing occurs because sunlight can directly touch the surface of the soil or because of the warming of seeds (Fowler 2012). Therefore, there needs to be treatment to trigger seed germination in the soil.

One of locations that needs an ecosystem recovery effort is the Gunung Ciremai National Park, in an area of shrubs and pine stands. Replacing pine stands through logging is not possible in a conservation area because there are no supporting regulations so that more feasible activities are enriched. The research in the form of this experiment was aimed at analyzing the germination of soil seed banks in a) sample plots made in two different types of ecosystems, and b) trays containing soil samples from two different types of ecosystems placed in greenhouses. The variables recorded were the name of the type

and number of individuals of the type of tree that germinates. We hope that the results of this experiment can be implemented to the restoration of ecosystems, both inside and outside the conservation area.

2. Methods

2.1. Location

The study was conducted in two types of ecosystems in Gunung Ciremai National Park, which are shrubs of Rehabilitation Zone and pine stands of Utilization Zone. The Rehabilitation Zone is overgrown with grass, understorey, shrubs, and kaliandra; pine trees are found in several places with a fairly low density. Before becoming a national park, the shrub ecosystem was a community cultivated land planted with vegetables. Pine forests located in the Utilization Zone are old pine stands and some of them are used as campsites managed by community groups around the forest. Forest floors in pine stands are covered with various types of shrubs and Caliandra. However, the forest floor at the location used as the campground was open; the surface of the land was visible.

2.2. Soil Seed Bank Sampling Design

To determine the density of woody plant seeds in the soil seed bank, soil samples with 15 x 15 x 15 centimeters have been taken using a mini shovel (Tierney & Fahey 1998). Four soil samples were taken randomly from each sample plot of 10 m2 (Tierney & Fahey 1998). The plots be made on pine stands and shrubs. The number of sample plots under pine stands and shrubs were 10 plots or 40 sample units respectively so that the total sample of the two types of cover is 80 units. The interval between sample plots was 100 meters.

2.3. Pioneer Growth Sampling Design

To find out the species of pioneers that grow, 1 x 1 m of sample plots have been made. The plots were distributed in two types of cover: pine stands and shrubs. The sample plots were 30 units in the shrubs and 35 units in the pine stands. The interval between sample plots was 5 meters. Thus, the total sample plots of two ecosystem types were 60 plots. All species and individuals of plants, except for tree species, in the sample plots were cleaned. Observations carried out on the fourth month. The types of data recorded were the name of the species and number of individuals.

2.4. Testing of Soil Seed Bank

To find out the seedling species growing from the seed bank, the soil obtained from the field was stirred by hand and transferred into a plastic tray measuring 24 x 52 x 6 cm, then placed in a greenhouse. The soil every day watered if experiencing drought. Observations were carried out for 16 weeks since the soil seed bank was stored in the greenhouse. Data collected during observations were the length of day needed to germinate, pioneer species name, and the number of individuals.

2.4. Data Analysis

Data analysis was carried out descriptively and inferently. Descriptive analysis was used to explain woody plant species that germinate and density in samples obtained from two types of cover. Inference analysis was carried out to determine the level of difference in density of woody plants. The analysis used was the middle value difference test. This analysis used the help of SPSS 21 Software. The formula used manually is:

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Note:

$\bar{X}_i$ = *average of i-type ecosystem density (individuals)*
S_i^2 = *variance of the i-type ecosystem*
n_i = *the number of samples of the i-type ecosystem (individuals)*

Hipotesis:

Ho: *The density of plants between ecosystem types that are compared is not different*
H1: *The density of plants between the types of ecosystems that are compared is different*

Conclusion

– If Z counts > 1.96 then accept H1
– If Z counts ≤ 1.96 then accept Ho

3. Result and Discussion

3.1. Result

3.1.1. Germination of soil seed banks in sample plots

The first objective of the study was to analyze the germination of soil seed banks in sample plots made in the field. Research has been carried out on 65 sample plots: 30 units in shrubs and 35 units in pine stands. The research obtained results that pioneer species germination did not occur, both in sample plots made in shrubs and pine stands. Woody plant that germinate was calliandra. Research has recorded an average density of the calliandra as much as 8.53 individuals/m2 (n = 30; S = 8.15) in shrubs and 5.74 individuals/m2 (n = 35; S = 5.79) in pine stands. By using a middle value difference test, the density of the calliandra between the two types of cover was not different (t = 1.567; df = 51; p = 0.123).

3.1.2. Germination of soil seed banks in greenhouses

In addition to making sample plots in the field, this research has also taken soil samples from the field which were inserted into a plastic tray, then placed in a greenhouse. The experiment was carried out for 4 months. This experiment obtained the results that there were no germination of pioneer tree species from soil stored in trays taken from shrubs and pine stands. As the results of experiments on sample plots, woody plants that germinate in trays are calliandra. This species is also a type of plant that first grows in trays, then followed by non-wood species.

The study obtained an average density of calliandra seedlings of 3.15 individuals/tray (n = 40; S = 5.26) for soil samples taken from shrubs and 4.03 individuals/tray (n = 40; S = 5, 10) for soil samples taken from under pine stands. Through the middle value difference test, the density of calliandra between the two types of cover was not significantly different (t = -0.755; df = 78; p = 0.452).

3.2. Discussion

Research has been conducted to obtain empirical evidence of seed germination of pioneer tree species from soil seed banks taken from under pine stands and shrubs. The study found that seed germination of pioneer tree species did not occur, both in soil samples stored in green house and in sample plots made under pine stands and shrubs. In this study, woody

plants that were able to germinate in the two experimental models were calliandra which was an invasive type (Mustika 2012).

With no emergence of germination on pioneer tree species, this study shows that the density of tree seeds at the bottom of pine stands and shrubs is low. This condition also implies that the restoration of ecosystems in shrubs and enrichment of tree species in pine stands requires intensive management intervention or planting. With the amount of germination of calliandra, these results indicate that the species is a threat to ecosystem and local species. Calliandra will dominate the area and local species will be excluded when the area experiences land cover opening. As it is well known, calliandra is a foreign and invasive species (Sunaryo et al. 2012) so it is difficult to control or destroy it from within a conservation area.

The results showed that the germination of pioneer tree species did not occur almost the same as the results of Utomo (2013) study: germination of pioneer tree species in soil seed banks originating from disturbed forest areas in Gunung Gede Pangrango National Park was not found except for Villebrunea rubescens. The Simbolon (2018) study in Protected Forests in the Lake Toba catchment area also obtained similar results where pioneer tree germination did not occur except Pinus merkusii which began to germinate in the tenth week. Furthermore, the results of the study show that kaliandra has the potential to become the dominant plant because it is the only woody species that can germinate in line with the results of the study of Sunaryo et al. (2012) in Gunung Halimun-Salak National Park which stated that calliandra has become one of the types of plants that dominate in several places.

There are several possibilities that can explain why the germination of pioneer tree species did not occur in both types of experiments in both types of land cover. The first possibility is thought to be related to the distance of the research location to natural forest. The research location is far from natural forest. This long distance is thought to have hampered the spread of seeds of tree species, especially pioneer species. In other words, seeds with natural help (wind and animals) cannot reach the research location. Thus, the soil under the stands of pine and shrubs is poor against the seeds of the tree species. The density of seed content in the soil is related to or influenced by many factors, such as the presence of the adult tree and vertical position in the soil (Cseresnyes & Csontos 2012). The second possibility is thought to be related to the size of the sample taken and the size of the sample plots made. In this study, the size of the soil sample taken was 15 x 15 x 15 cm which was probably too small for research on germination of tree species, although for grass research this size was widely used. For sample plots, the size made was 1 m x 1 m, possibly too small. The size is thought to be too small so that the sunlight that reaches the surface of the ground is not enough to trigger germination. Another cause, germination was not found in sample plots allegedly because sample plots were made before the dry season so that the location was less moist and inhibits seed germination: dormant seeds can germinate when growth factors such as water, gas, temperature and light are met (Triharso 1996).

Calliandra has dominated germination because these adult trees were often found in research sites, both in the shrubs and pine stands. Calliandra was planted when the area was still functioning as a production forest (Aen, personal.com.) with the aim of limiting arable land, rehabilitating land, providing firewood for land tenants (Herdiawan et al. 2012), animal feed, a firebreak, and suppress weed growth (Stewart et al. 2001).

In the beginning, this study was expected to provide information about the tree species seeds that can be grown from soil seed banks in shrubs and pine stands. However, the study found no germination of pioneer tree species. This study has provided empirical evidence about the condition of soil seed banks in areas that have undergone modification of vegetation within a conservation area. Information obtained from the results of this study is very useful for ecosystem recovery activities or enrichment of tree species in both types of land cover.

3.2.1. Limitation

This study has not been able to conclude that the seeds of pioneer species in the soil cannot germinate. The study also could not provide an explanation of whether germination did not occur because the seeds of the pioneer species in the soil in both types of cover were not present. However, this study has provided an illustration that the germination of soil seed banks in shrubs and pine stands for woody plants is dominated by calliandra, which is an invasive species.

The samples used in this study was little in number and small in size. In addition, samples were taken from one longitudinal pathway. In fact, the area of pine stands and shrubs is not in the form of longitudinal paths. This research will be even better if the number of lines made is more than what has been done. Therefore, it is necessary to do research with a larger sample size and more number of paths. Line placement needs to be spread evenly at many points so that it can represent all conditions in both types of land cover.

3.2.2. Implication for management

Information obtained from the results of this study is very useful for recovery and enrichment activities in ecosystems that have changed far from natural forests. The results of this study indicate that ecosystem enrichment and restoration activities must involve human intervention, namely by planting. Research with the results that the calliandra dominated germination at an early stage has shown that uncontrolled and large land clearing needs to be avoided to prevent uncontrolled growth of calliandra.

4. Conclusion

The results of this study can be concluded that the seeds of the pioneer tree species contained in the soil are low, both in shrubs and pine stands. Therefore, ecosystem recovery activities must be carried out through planting activities.

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