Determination of Seed Density of Several Forest Trees Species to Improve the Successful Seed Germination

N Yuniarti1*, Nurhasybi
1Forest Tree Seed Technology Research and Development Centre, Jl Pakuan Ciheuleut PO BOX 105U Bogor 16001, Indonesia

*email: naningbtp@yahoo.co.id

Abstract. The success of tree seed germination for planting programme depends on several factors including tree seed density for seed sowing. The purpose of this study was to determine the seed density based on the level of seed aging to increase the success of seed germination of several forest tree species, namely white jabon (Anthocephalus cadamba (Roxb) Miq.), bambang lanang (Magnolia champaca Linn.), jelutung (Dyera polyphylla Miq.), kayu bawang (Azadirachta excelsa (Jack) Jacobs), and trema (Trema orientalis Linn. Blume). The seed density treatments covered 5 phases (d0, d1, d2, d3, d4) based on the germination percentage (GP). Seedlots variation was derived from 5 seed aging treatments (0, 48, 96, 144, and 192 hours). The determination of seed density was based on Kartika’s formula (1994). The results showed: (1) seed density of white jabon was 0.1 g of seed /300 cm$^2$ with pure live seeds (PLS) of 1140 seedlings / 0.1 g of seed; (2) seed density of bambang lanang was 100 seeds /300 cm$^2$ with GP of 58%; (3) seed density of jelutung seeds with 85% of GP was 50 seeds /600 cm$^2$; (4) seed density of kayu bawang with 83% of GP was 50 seeds /600 cm$^2$ and (5) seed density of trema with 78% of GP was 100 seeds /600 cm$^2$. The longer the time of seed aging, the lower the value of germination percentage. Therefore, the lower the germination percentage, the seed density will be more tight.

Key words: seed density, seed germination, tree species

1. Introduction

The wood industry raw material needs are increasing while material availability in natural forests shows a very drastic decline caused by the massive forest exploitation [1]. In order to fulfill the needs of the timber industry the government promotes the development of plantations and community forests [2]. Several species have potential to be developed to support the timber industry, including white jabon (Anthocephalus cadamba (Roxb) Miq.), bambang lanang (Magnolia champaca Linn.), Jelutung (Dyera polyphylla Miq.), kayu bawang (Azadirachta excelsa (Jack) Jacobs), and trema (Trema orientalis Linn. Blume).

White jabon produces wood utilized as plywood, construction, pulp, fiberboard and particle board [2]. White jabon wood is generally used for core layers or veneer surface layers (plywood) and is also suitable for particle board materials, cement boards and block boards [3]. Bambang lanang wood -known to the community as a type of wood carpentry with good quality- is used as material to build houses, raw materials for making doors, frames, windows and furniture such as wardrobes, decorative cabinets, chairs and tables [4]. Generally, the use of jelutung wood is for drawing tables, carvings, furniture,
pencils, plywood, crates, canoes, and shingles. Besides, jelutung wood can also be used as a component for making guitars and violins [5]. One of non-timber forest products that has the potential to be developed and has high economic value is jelutung sap. The jelutung sap is the result of an exudate from the jelutung tree [6]. Other economic values of jelutung are leaves and skin that can be used as a treatment ingredient to deal with inflammation, fever and pain [7]. Kayu bawang is one of the local types of woodworking producers [8], whereas the trema tree is a versatile plant because all parts of the tree can be used. The wood quality is class III, not very durable, smooth and easy to burn when dry. The wood contains a calorie of 4576 cal/g [9].

One of the obstacles in cultivating the species of white jabon, bambang lanang, jelutung, kayu bawang, and trema is the provision of high-quality seeds as they are often difficult to obtain and the seed germination technique is unknown. Therefore, to support the success of planting these species, proper seed handling techniques are needed, one of which is the aspect of seed germination. Germination is an activation of the embryo which results in the opening of seedcoat and the appearance of young seedlings. Seed germination is also one indicator related to the seed quality. The seed germination or seed viability generally describes potential seedlings, more over will reflect the expected results of the seedling in the nursery [10-11]. Seed germination provides information to seed users on the ability of normal seedling to grow into plants produced naturally in a highly optimum biophysical state [12-13].

There are several methods for increasing the germination success, one of which is by setting the seed density in the germination box. The use of seed density is basically to provide good seedling space and plants without experiencing competition between plants [14]. Density of seeds sown in sowing beds or germination box is very closely related to the normal seedling produced. Testing the growth of seedling in sowing beds is testing the seeds under sub-optimum conditions which aims to predict the ability of seeds to grow in conditions that are close to the actual conditions in the field, with observations on the initial and final counts [15].

The success of forest tree seed germination for planting activities is determined, among others, by the seed density at the sowing time. Seed density provides information about the number of seeds needed for planting activities. Effective use of tree seeds for sowing in nurseries can be increased by using germination percentage to determine the level of seed sowing. To find out the number of seeds needed in planting activities, research is needed on seed density. Seed density research can generally be done by regulating the number of seeds in planting, tree populations or spacing arrangements. Seed density can be done by arranging the number of seeds per cm² or the weight of seeds per cm² in a germination box or sowing bed, before seedlings are transferred to the nursery.

Another problem that often arises in tree seed procurement is low seed viability because seed had been stored for a long time. According to [16], the decline of germination percentage is one of the physiological changes in seed. Germination percentage declines due to the treatment given to the seed(seed aging), where the longer time of the seed aging the lower the seed germination. The results of the study showed that the lower the germination percentage, the more dense seed density per germination box. It is expected that a decrease in the germination percentage can be overcome by increasing the seed density which will eventually increase the number of normal seedlings that will be used for further planting activities.

From the above problems, the purpose of this study is to determine the seed density based on the level of seed aging to increase the success of seed germination of several forest trees species, namely white jabon, bambang lanang, jelutung, kayu bawang, and trema.
2. Materials and methods

2.1. Materials

The white Jabon seeds used in this study originated from South Sulawesi. The jelutung seeds were from Central Kalimantan, the seeds of bambang lanang from West Java, kayu bawang seeds came from Banten, and the trema seeds were taken from Bali. Seed testing were carried out in a laboratory and greenhouse of Forest Tree Seed Technology Research and Development Institute in Bogor. The duration of research for each species were 3 (three) months.

Other materials and tools used in this study were alcohol, sand and sterilized soil media, tools for staining, gauze, 300 cm² germination box, strimines, transparent boxes, incubators, germinators and sprayers.

2.2. Methods

Replications and treatments
The number of replications used in this study were 4 replications in each treatment. The treatment consisting of 5 levels of seed aging, namely 0, 48, 96, 144 and 192 hours. For white jabon seeds, each replicate was as much as 0.1 gram of seeds. For bambang lanang and trema, each replicate are 100 seeds, but for the jelutung and kayu bawang seeds, each replicate contains of 50 seeds.

Seed aging
Seed aging treatments were aimed to get a variety of seedlot. The method of seed aging is as follows: seeds were placed on wire netting and put in a plastic container filled with 150 mL of water, with the position of the seeds on wire netting above the water. The container was then placed in an incubator at 40°C. The time of seed aging consists of 5 levels, namely 0, 48, 96, 144 and 192 hours. The seeds were then sown on a mixture of soil and sand (1: 1 (v/v)) in a germination box. Seed germination percentage (N) was calculated for each replication level of seed aging. Four (4) replications were used in each treatment.

Parameter
The parameters observed were germination percentage and pure live seed. Observation of seed germination was carried out every day until there were no more growing seedling. Each treatment used in this study contains 4 replications.

Data analyze
Determination of seed density was based on observational data at the stage of investigation. If data on the germination percentage (N0, N1, N2, N3, N4) is obtained, then the seed density information will be counted. Determination of seed density is calculated based on multiples of the seedling ratio that grows normally in each lot (N) of the control. Seedling density treatment of white Jabon used as much as 0.1g seeds for the size of 300cm² germination box, therefore the initial seed density (d0) = 0.1g seed/300cm². The density treatment for bambang lanang used 100 seeds for 300cm2 germination box, hence the initial seed density (d0) = 100 seeds/300cm². The density treatment for jelutung and kayu bawang used as many as 50 seeds for the 600cm² germination box, therefore the initial seed density (d0) = 50 grains/600cm². Meanwhile, treatment trema seed using the seed of 100 seeds with a size of 20 cm x 30 cm of germination box (area = 600 cm²), then the initial seed density (d) or d0 = 100 grains / 600 cm².

Seed density after seed aging in this study is [15]:

\[ d1 = \frac{N0}{N1} \times d0 \]
d2 = \frac{\text{N0}}{\text{N2}} \times d0

d3 = \frac{\text{N0}}{\text{N3}} \times d0

d4 = \frac{\text{N0}}{\text{N4}} \times d0

3. Results and discussion

3.1. Results

3.1.1 White Jabon (Anthocephalus cadamba (Roxb) Miq.)

The results of the average value of pure live seeds (PLS) of white Jabon based on the level of seed aging were shown in Figure 1 [17] while the seed density of white jabon based on the level of seed density was listed in Table 1.

![Figure 1](image)

**Figure 1.** The average of pure live seed (PLS) of white jabon based on the level of seed aging

While the seed density of white jabon based on the level of seed aging was as follows (Table 1).

| Level of seed aging | Seed density          |
|---------------------|-----------------------|
| D0 (0 hour)         | 0.1000 grams/300 cm² |
| D1 (48 hours)       | 0.1161 grams/300 cm² |
| D2 (96 hours)       | 0.1279 grams/300 cm² |
| D3 (144 hours)      | 0.1972 grams/300 cm² |
| D4 (192 hours)      | 0.2581 grams/300 cm² |

**Source:** [17]

Based on the results obtained (Figure 1 and Table 1), it was known that in the control treatment (0 hour seed aging) the pure live seed of the white jabon was 1140 seedlings/0.1g seeds. Seed sowing was carried out on a germination box with size of 15 cm x 20 cm (300 cm² area) with the number of seeds sown as...
much as 0.1 grams. The seed density of white jabon (d0) was 0.1g of seed/300 cm$^2$. At 48 hours of seed aging with pure live seed of 920 seedlings/0.1g of seed required seed sowing density of 0.1161g of seed/300 cm$^2$. At 96 hours of seed aging (PLS = 961 seedlings/0.1g) the sowing density required seeds of 0.1279g/300cm$^2$. A 144 hours seed aging (PLS = 873 seedlings/0.1g) required seed sowing density of 0.1972g/300cm$^2$, and a 192 hours seed aging (PLS = 826 seedlings/0.1g) required seed sowing density of 0.2581g/300 cm$^2$ [17].

3.1.2 Bambang lanang (Magnolia champaca Linn.)
The average of germination percentage (GP) of bambang lanang based on the level of seed aging treatments was illustrated in Figure 2, while the seed density of bambang lanang based on the level of seed aging was shown in Tabel 2.

![Figure 2](image-url)

**Figure 2.** The average of germination percentage (GP) of bambang lanang based on the level of seed aging treatments

| Level of seed aging | Seed density          |
|---------------------|-----------------------|
| D0 (0 hour)         | 100 seeds/300 cm$^2$  |
| D1 (48 hours)       | 264 seeds/300 cm$^2$  |
| D2 (96 hours)       | 305 seeds/300 cm$^2$  |
| D3 (144 hours)      | 322 seeds/300 cm$^2$  |
| D4 (192 hours)      | 341 seeds/300 cm$^2$  |

It can be seen (from Figure 2 and Table 2) that in the control treatment (0 hour seed aging) the germination percentage of bambang lanang seed was 58%. Seed sowing was carried out on a germination box in size of 15cm x 20cm (area of 300cm$^2$) with the number of seeds sown as many as 100 seeds. So, the seed density of bambang lanang (d0) was 100 seeds/300cm$^2$. At the 48 hours seed aging there was a drastically decrease in germination percentage to 22%, thus requiring a seed sowing density of 264 seeds/300cm$^2$. For 96 hours of seed aging (GP = 19%) the sowing density required 305 seeds/300cm$^2$ seed. A 144-hours seed aging (GP = 18%) required seed sowing density of 322 seeds/300cm$^2$, and a 192 hours of seed aging with germination percentage of 17% required seed sowing density of 341 seeds/300cm$^2$. 

3.1.3. Jelutung (Dyera polyphylla Miq.)

The value on germination percentage (GP) average of jelutung based on the seed aging treatments was presented in Figure 3, and seed density of jelutung based on the seed aging treatments was shown in Table 3.

![Figure 3](image)

**Figure 3.** The average of germination percentage (GP) of jelutung seed based on the level of seed aging treatments

**Table 3.** Seed density of jelutung after seed aging treatments

| Level of seed aging | Seed density          |
|---------------------|-----------------------|
| D0 (0 hour)         | 50 seeds/600 cm²      |
| D1 (48 hours)       | 58 seeds/600 cm²      |
| D2 (96 hours)       | 72 seeds/600 cm²      |
| D3 (144 hours)      | 97 seeds/600 cm²      |
| D4 (192 hours)      | 129 seeds/600 cm²     |

In Figure 3 and Table 3, it was known that in the control treatment (0 hour seed aging) the germination of the jelutung seeds was 85%. Seed sowing was carried out on a germination box in size of 30cm x 20cm (area of 600cm²) with a number of sown seeds of 50 seeds. So the seed density of jelutung for the control treatment (d0) was 50 seeds/600cm². At 48 hours of seed aging treatments (GP = 73%), the seed density was 58 seeds/600cm². For 96 hours of seed aging (GP = 59%) the sowing density required 72 seeds/600cm². A 144 hours of seed aging (GP = 44%) required seed sowing density of 97 seeds/600cm², and at 192 hours of seed aging with GP 33%, the seed sowing density was 129 seeds/600cm².

3.1.4. Kayu bawang (Azadirachta excelsa (Jack) Jacobs)

Based on the level of seed aging, the average GP of kayu bawang was shown in Figure 4, while the seed density of kayu bawang based on the level of seed aging was presented at Table 4.
Figure 4. The average of germination percentage (GP) of kayu bawang seed based on the level of seed aging treatments

Table 4. Seed density of kayu bawang after seed aging treatments

| Level of seed aging | Seed density       |
|---------------------|--------------------|
| D0 (0 hour)         | 50 seeds/600 cm^2 |
| D1 (48 hours)       | 63 seeds/600 cm^2 |
| D2 (96 hours)       | 94 seeds/600 cm^2 |
| D3 (144 hours)      | 101 seeds/600 cm^2|
| D4 (192 hours)      | 189 seeds/600 cm^2|

It was shown in Figure 4 and Table 4 that in the control treatment (0-hour seed aging) the germination rate of kayu bawang seeds was 83%. Seed sowing was carried out on a germination box in size of 30 cm x 20 cm (area of 600 cm^2) with a number of sown seeds of 50 seeds. So the seed density of kayu bawang for the control treatment (d0) was 50 seeds/600 cm^2. At 48 hours of seed aging treatments (GP = 66%), the seed density was 63 seeds/600 cm^2. For 96 hours of seed aging (GP = 44%) the sowing density required 94 seeds/600 cm^2. A 144 hours of seed aging (GP = 41%) required seed sowing density of 101 seeds/600 cm^2, and at 192 hours of seed aging with GP 22%, the seed sowing density was 189 seeds/600 cm^2.

3.1.5. Trema (Trema orientalis Linn. Blume)
The average of germination percentage (GP) of trema seed based on the level of seed aging treatments was shown in Figure 5 whereas Table 5 illustrated the seed density of trema based on the level of seed aging treatments.
Figure 5. The average of germination percentage (GP) of trema seed based on the level of seed aging treatments

Table 5. Seed density of trema after seed aging treatments

| Level of seed aging | Seed density         |
|---------------------|----------------------|
| D0 (0 hour)         | 100 seeds/600 cm$^2$|
| D1 (48 hours)       | 137 seeds/600 cm$^2$|
| D2 (96 hours)       | 193 seeds/600 cm$^2$|
| D3 (144 hours)      | 197 seeds/600 cm$^2$|
| D4 (192 hours)      | 226 seeds/600 cm$^2$|

From Figure 5 and Table 5, it was shown that in the control treatment (0 hour seed aging) the germination percentage of trema seeds aging was 78%. Seed sowing was carried out on a germination box in size of 30cm x 20cm (area of 600cm$^2$) with a number of sown seeds of 100 seeds. So the seed density of trema for the control treatment (d0) was 100 seeds/600 cm$^2$. At 48 hours of seed aging treatments (GP = 57%), the seed density was 137 seeds/600 cm$^2$. For 96 hours of seed aging (GP = 40.5%) the sowing density required 193 seeds/600cm$^2$. 144 hours of seed aging (GP = 39.5%) required seed sowing density of 197 seeds/600cm$^2$. At 192 hours of seed aging with GP 34.5%, the seed sowing density was 226 seeds/600cm$^2$.

3.2. Discussion

Seed density testing can be done, among others, by arranging the number of seeds per cm$^2$ or based on the weight basis of seeds per cm$^2$ in a germination box or sowing bed, before the seedlings are transferred to the nursery. Seed density testing can be carried out on a germination box in size of 20 x 30cm or other sizes with a mixture media of sand and soil (1: 1) with the number of seeds sown according to the size of the seed. The density of seeds sown in sowing beds was very closely related to the seedling produced. Testing the growth strength of seedlings in sowing beds is testing the seeds under sub-optimum conditions which aims to predict the ability to grow seeds in conditions that are close to the actual conditions in the field, with observations on the count of the beginning and end [15].
Based on the results of the study, it was shown that the seed aging treatments affected the seed germination rate of white jabon, bambang lanang, jelutung, kayu bawang and trema. The longer the time of seed aging, the lower the value of germination percentage. For white jabon seeds, at the level of 48 hours seed aging, the pure live seed decreased by 160 seedlings/0.1 g seeds from the control (without seed aging treatments). Seed aging levels of 96 hours, 144 hours, and 192 hours caused a decrease in PLS to 179, 267, and 314 seedlings/0.1 g of seed, respectively.

At the same level of seed aging treatments, bambang lanang seed experienced a decrease in germination by 36%, 26%, 41% and 47% respectively. For kayu bawang seeds decreased the germination percentage in each level of seed aging, which was 17%, 39%, 42% and 61%. As for trema seed, the germination percentage decreased by 20%, 37%, 38% and 43% respectively. Decreasing seed germination rate is one of the physiological changes in seed decline. Seed decline in the seed test occurs due to the treatments given to the seed, where the longer the seed aging the lower the germination percentage [10].

From the density value of each seed (white jabon, bambang lanang, jelutung, kayu bawang, and trema), it is known that the lower the germination percentage, the more dense the seed density for sowing, so the number of seeds needed will be higher. Effective use of seeds for sowing on containers in nurseries can be increased by considering germination percentage to determine the level of seed sowing. According to [18], the longer the time for seed aging treatments, the lower the viability of the seeds, which causes the seeds to deteriorate. Seeds that have experienced a decline in seed germination will affect the amount of seed density. It is stated by [10] that the addition of seeds e.g. by increasing seed density during sowing to overcome seed decline at all levels of testing can still be done.

The right planting density will have to depend on seed quality. One of the factors that influence the differences in seed viability is the environmental conditions during the development of seeds in the field. Other environmental factors influencing the seed viability are the availability of nutrients, light, temperature and water. The differences in planting density will directly lead to competition for plants in using the existing environmental factors [19].

4. Conclusion and suggestion
4.1. Conclusions
The seed density of white jabon was 0.1 g of seed/300 cm² with pure live seeds of 1140 seedlings/0.1 g of seed. Seed density of bambang lanang was 100 seeds/300 cm² with GP of 58%. Seed density of jelutung seeds with 85% of GP was 50 seeds/600 cm². Seed density of kayu bawang with 83% of GP was 50 seeds/600 cm² and seed density of trema with 78% of GP was 100 seeds/600 cm². The longer the time of seed aging, the lower the value of germination percentage so the seed density will need to be higher, hence the number of seeds needed will be much more.

4.2. Suggestion
The need for high quality seed and the adjustment of seed density is very important to produce more vigorous seedlings that will impact to the vigor of the whole seedlings in the nursery. In establishing forest plantations, the government institutions and private sectors should pay attention to improving the seed germination rate in order to produce more vigorous seedlings in the nursery.
6. References

[1] Ditjen Bina Usaha Kehutanan 2014 *Statistik kehutanan tahun 2013* (Jakarta : Kementerian Kehutanan Republik Indonesia) (in Indonesia Language)

[2] Sudrajat DJ 2015 *Disertasi* (Bogor : Sekolah Pascasarjana Institut Pertanian Bogor) (in Indonesia Language)

[3] Krisnawati H, Kallio M and Kanninem M 2011 *Anthocephalus cadamba* Miq. Ekologi, Silvikultur dan Produktivitas (Bogor : CIFOR) (in Indonesia Language)

[4] Lestari S, Winarno B and Premono BTP 2015 *JPSEK* 12 89-97 (in Indonesia Language)

[5] Yahya S, Hamdan S, Jusoh I and Hasan M 2010 *J. Nondestruct Eva* 29 38-42

[6] Waluyo TK, Wahyudi I and Santos G 2012 *JPHH* 30 301-313 (in Indonesia Language)

[7] Wong SK, Lim YY, Noor RA and Fariza JN 2011 *BMC Complementary an Alternative Medicine* 11 3

[8] Premono BT and Lestari S 2014 *JPHT* 11 185-197 (in Indonesia Language)

[9] Rostiwati T, Heryati Y and Bustomi S 2006 *Review hasil litbang kayu energi dan turunannya* (Bogor : Pusat Penelitian Dan Pengembangan Hutan Tanaman) (in Indonesia Language)

[10] Rohandi A and Widyani N 2009 *JPHT* 6261-271

[11] Saupe SG 2009 *Testing for Seed Viability* (Collegeville : Plant Physiology (Biology 327) College of St. Benedict/St. John’s University Biology Department)

[12] Sutopo L 2010 *Teknologi Benih* (Jakarta : PT. Raja Grafindo Persada)

[13] Pramono E 2009 *Penuntun Praktikum Teknologi Benih* (Bandarlampung: Universitas Lampung)

[14] Fatchullah D 2017 *J. Agrosains* 5 15-22

[15] Kartika E 1994 *Disertasi* (Bogor : Program Pascasarjana IPB)

[16] Rohandi A and Widyani N 2007 *JPHT* 13-26

[17] Yuniarti N, Kurniati R and Nurhasybi 2015 *Bunga Rampai Teknologi Pembibitan Jabon Puth* (Neolamarckia cadamba (Roxb.) Bosser) (Bogor : Forda Press)

[18] Imaniar 2012 *Skripsi* (Bogor : IPB)

[19] Purnamasari L, Pramono E and Kamal M 2015 *JPPT* 15 107-114