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Characterization of seeds of *Peltophorum pterocarpum* (DC.)K. Heyne and *Spondias mombin* L. and effect of storage conditions on seed viability and seedling growth

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Knowledge of seed desiccation sensitivity is the beginning for seed storage which plays a decisive role in seed conservation. Experiments of two deciduous tree species (*P. pterocarpum* and *S. mombin*) have done to determine the type of seed, to apply the successful seed storage and determine their seedling behavior. The study was conducted in April 2016 until July 2017 at Purwodadi Botanic Garden. The seeds through the desiccation process and 2 types of storage : freezer (-16 ^{0}C) and at refrigerator (16 ^{0}C) during 7 months. One hundred eighty seeds of a species in each treatment were planted in pod filled with sand in a greenhouse. The germination traits were identified, including GP (Germination Precentage), GR (Germination Rate), RGR (Relative Growth Rate), VH (Velocity of plant height increase), VL (Velocity of leaves number increase. Those species are more classified as intermediate rather than orthodox seeds. Each treatment brought significant difference in growth parameters, except RGR. In general, storage treatments decrease the seedling growth. However, the seedling stored in cold temperature has better performance in growth than seeds stored in freezing temperature. Storage in higher temperature are more successful in the seed conservation of *P. pterocarpum* and *S. mombin.*

Keywords: ***P. pterocarpum* , *S. mombin*, intermediate, storage, viability**

INTRODUCTION

Peltophorum pterocarpum (DC.)K. Heyne is one of perrenial tree species belongs to Caesalpiniaceae family. *P. pterocarpum* is a deciduous tree usually reaching a height of 15 (-24) m, having a smooth and grey bark, with a dense and spreading crown. Called in Indonesia as Soga jambal (Orwa et al., 2009), *P. pterocarpum* is a rich source for phenols, flavonoids, tannins which have potential antioxidant and cytoprotective activity used as medicinal agents in traditional medicine (Pradeepkumar et al., 2017; Biswas et al., 2010).

Spondias is a genus of flowering plants belonging to the cashew family (Anacardiaceae). One species of this genera, *Spondias mombin* (yellow mombin) was considering as an important species because it is known to have many medicinal properties. In Indonesian, this species was names as kedongdong cina, kedongdong cucuk or kedongdong sabrang. Yellow mombin is an elegant, deciduous tree with a dense and spreading crown; it can reach an eventual height of 25 metres. Beside of a wide range of medicinal applications, it also provides various commodities as edible fruit, ornamental plant and to provide shade (Mitchell and Daly, 2015).Sameh et al., (2018) provides a comprehensive understanding of the chemistry and pharmacology of *S. mombin* and conclude that it contains of various type of phytochemicals compounds such as sterols, terpenoids, and phenolic. The fruits of *S. mombin* are used in Nigeria as a diuretic (Ayoka, *et al*. 2008). the leaves is used to treat diarrhoea and dysentery by populations in Nigeria, Benin(Adams, et al., 2007) while the gum is used in Belize as an expectorant and to expel tapeworms (Rodrigues and Samual, 1999 , Rodrigues, et al., 2000).

There is an increased demand worldwide for several high beneficial plants which are usefull for traditional medicine due to their beneficial effects including these two species, *P. pterocarpum* and *S. mombin*. Plant propagation takes very important roles both in ex-situ conservation and meeting the demand of plant for various purposes. The roles are related to the effort of increasing the number of individual or, for conservation are important to increase the population size in plants natural habitats which could be conducted through plants reintroduction and forest recovery programs. However, the propagations of plant species are oftenly faced many difficult obstacles and problems due to the lack information about the aspects of reproductive biology and initial growth including the propagation methods, seed characteristics, seed behaviour, and germination.

The propagation of two beneficial plant species, *P. pterocarpum* and *S. mombin* are reported could be done by seeds, however their seeds are dormant, because they are inhibited in their natural growth. The investigation to the nature and behavior of seeds is important for supporting conservation efforts and cultivation. Seeds can not survive for several years and even more, depending on the species (genetic life) and storage conditions. For conservation and cultivation supports, it is important to conduct successful storage for seeds to propagate plants of species target. A successful storage condition must ensure that seeds vigor and viability slightly injured from harvesting until planting.. The general effect of temperature on longevity is that longevity increases as temperature decreases (Linda et al*.,* 2000).

To study the succesfull storage method for conservation and cultivation purposes, the experiments should be conducted to determine the type of seed, which are applicative for suitable seed storage. The experiments should be usefull to determine their seedling behavior which is important for treating the early growth of trees. For this purpose, some parameters should be initially to identify such as their response to desiccation, including the process of seeds drying. To store the seed, seed must reach the certain dry conditions. Drying is a natural part of seed maturation. Some seeds should be dried to a minimum moisture content before they can germinate. Low water content of seeds is a prerequisite for long-term storage.

Seeds have been categorized into two main groups according to their desiccation response and storage physiology: orthodox (desiccation tolerant) and non-orthodox (desiccation sensitive). Orthodox seeds are desiccation-tolerance and more survival when stored in dry conditions for a predictable period under prescribed conditions. They are usually better able to maintain their viability from harvest until the next growing season (Berjak, 2005). Non orthodox seeds, which have high water contents can decrease the water content while desiccation. If we desiccate the seeds in silica gel, if seed weight is lose slowly we can define it as an orthodox seed, and otherwise we can define it as non-orthodox seed. Another type of seed grouping , namely intermediate seeds. These seeds have intermediate characteristic between orthodox seeds and recalcitrant (Hong *et al.* 1998). Intermediate seeds are seeds that can be dried with low water levels such as orthodox seeds, but are sensitive to low temperatures (Schmidt, 2000). Intermediate seeds, however, are quickly damaged after drying of less than 7-12% depending on the species.

Since the dryland is one of important ecosystem in the tropic areas, the conservation of plant species of drylands should be conducted as a part of tropical plant conservation, either locally and globally. Moreover, seed conservation is one of the program should be resulted in the planning of ex-situ conservation programs that deserve special attentions. Therefore, the prediction of the seed characters and seed storage behaviour will be useful to provide the successful storage treatment. Thus, we addressed the objectives of this study, 1) to study the seed characteristics of two deciduous species, *Peltophorum pterocarpum* and *Spondias mombin*. 2) to emphasize the benefit methods of seed storage related to temperature and seed humidity to seed viability and seedling growth of *Peltophorum pterocarpum* and *Spondias mombin* .

MATERIALS AND METHODS

The study was conducted in April 2016 until July 2017. *P. pterocarpum* and *S. mombin* were collected from plant collection in Purwodadi Botanic Garden in April 2017. We used the fresh seeds and stored seeds in the experiments. Seeds were obtained after extraction proccess. Extraction process is needed to release seeds from hard pericarp. Before storage, seeds are tested first by desiccation. Seeds are desiccated in a closed glass container (26 cm in diameter and 17 cm in height) which are filled by the active silica gel at temperature of 25 °C during 20 days. Everyday, the weight of seeds are measured to study the lose of seed weight. The response of seed to drying is shown in the trend of weight reduction and seed moisture content in graphics. When drying seed it is important to keep the container tightly closed (Hanson, 1985).

Control treatment used in the experiment is fresh seeds that were sown without storage treatment. Other treatments were seeds which were stored for 7 months at freezer (-16 ^{0}C) and at refrigerator (16 ^{0}C). Seeds stored during 7 months. Desiccation, moisture test, and storage conducted at Seed Bank of Purwodadi Botanic Garden. One hundred and eighty seeds of a species in each treatment were planted in pod filled with sand in a greenhouse at Purwodadi Botanical Garden. Air temperatures during the study averaged 29 ^{o}C with a low and high daily mean of 25 ^{o}C and 31 ^{o}C. In each species there are 9 replications which consist of 20 seeds per replication. During the experiment, seedlings were supplied with water. To describe the succsess of seed storage treatments, the germination traits were measured including GP (Germination Precentage), GR (Germination Rate), RGR (Relative Growth Rate), VH (Velocity of plant height increase), VL (Velocity of leaves number increase).

Germination percentage is an estimation of the viability of a population of seeds. The equation to calculate germination percentage is: GP = seeds germinated/total seeds x 100 (Throneberry & Smith ,1955)

Germination Velocity or also called Germination Rate index:

GR (Germination Rate) :

GR= G1/1 + G2/2 +· · ·+ Gx/x (%/day)

G1= Germination percentage × 100 at the first day after sowing,

G2= Germination percentage × 100 at the second day after sowing

(Throneberry & Smith ,1955)

VH (Velocity of plant height increase), VL (Velocity of leaves number increase):

$V_{H/L}$= G1/1 + G2/2 +· · ·+ Gx/x (%/day)

G1= increase in plant height or leaf number× 100 at the first day after sowing, G2= increase in plant height or leaf number × 100 at the second day after sowing

Modified of Throneberry & Smith (1955)

RGR (Relative Grow Rate) was calculated using the following equation (Hoffmann and Poorter, 2002) :

RGR = (ln W2-ln W1)/(t2-t1)

Where:

ln= natural logaritm

t1 = time one

t2 = time two

W1 = dry weight of plant in time 1

W2 = dry weight of plant in time 2

The experimental design used One-way ANOVA which was followed by Duncan test was used to assess whether there were significant differences in germination traits between three storage treatment in 2 species.To assess the moisture content (MC) of seeds throughout the study, the seeds were weighed before and after drying at 103°C for 17h (ISTA, 2008)

RESULTS

The fresh seeds of two species, which are *P. pterocarpum* and *S. mombin* have been desiccated. The seeds of these two species showed different responses to desication. The seed's weight response because desiccation shown in Figure 1

We observed the weight of seeds and water content everyday during 20 days. The average results of our 3 replications showed that *P. pterocarpum* and *S. mombin* both experienced a pattern of decreased weight and water content were gradually decrease, not sharp decline. Our temporary observation showed that they were orthodox seeds.

Initial water content was not high, they were 6.32% for *S. mombin* and 9.23% for *P. Pterocarpum*, showed in Table 1

Table 1. The Average of Moisture Content of Control and Stored Seed of *P. pterocarpum* dan *S. Mombin*

Treatment	*P.pterocarpum*	*S. Mombin*
	Moisture Content (%)	
Control	9.23	6.32
Stored at 16^{o}C (cold temperature)	10.34	8.9
Stored at – 16^{o}C (Freezer)	11.25	9.12

The effect of storage conditions on Germination Percentage, Germination Rate, Velocity of plant height increase, RGR and

Velocity of leaves number increase in seeds of *P. pterocarpum* and *S. mombin* are presented in table 2 to table 4.

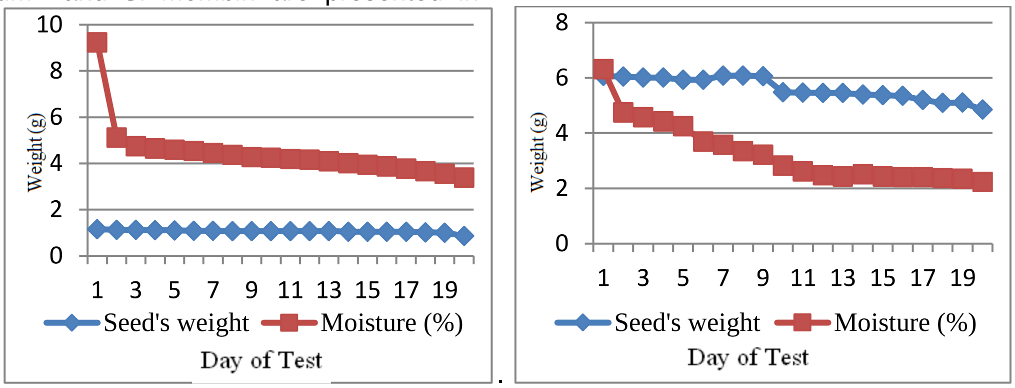

Figure 1. Desiccation Response of *P. pterocarpum* and *S. mombin* in Silica Gel

Table 2. The P Value of *Peltophorum pterocarpum* and *Spondias mombin* Germination Percentage, Germination Rate, Velocity of plant height increase, RGR and Velocity of leaves number increase based on ANOVA Test (P<0.05) in Each Treatment

Spesies	Parameter				
	Germination Percentage (%)	Germination Rate ($\% day^{-1}$)	VH ($\% day^{-1}$)	RGR ($g^{-1}g^{-1}day^{-1}$)	VL ($\% day^{-1}$)
Peltophorum pterocarpum	0.000	0.000	0.000	0.094	0.000
Spondias mombin	0.000	0.000	0.000	0.007	0.000

P>0.05 showing there is no significant difference

Table 3. The average of *Peltophorum pterocarpum* Germination Percentage, Germination Rate, Growth Velocity, RGR and Leaf Velocity on different storage treatments

Storage treatments	Germination Percentage (%)	Germination Rate ($\% day^{-1}$)	VH ($\% day^{-1}$)	RGR ($g^{-1}g^{-1}day^{-1}$)	VL ($\% day^{-1}$)
Control	68.33^{a}	6.57^{a}	3.73^{a}	0.06^{a}	3.46^{a}
Stored at –16°C (Freezer)	10.00^{c}	0.96^{c}	0.92^{b}	0.02^{a}	1.59^{b}
Stored at 16°C (Cold Temperature)	20.00^{b}	1.92^{b}	0.91^{b}	0.02^{a}	1.52^{b}

Values followed by different letter are significantly different at 95 % confidence level using Duncan test

Table 4. The average of *S. mombin* Germination Percentage, Germination Rate, Growth Velocity, RGR and Leaf Velocity on different storage treatments

Storage treatments	Germination Percentage (%)	Germination Rate ($\% day^{-1}$)	Growth Velocity ($\% day^{-1}$)	RGR ($g^{-1}g^{-1}day^{-1}$)	Leaf Velocity ($\% day^{-1}$)
Control	61.67^{a}	5.93^{a}	2.67^{a}	0.024^{a}	2.81^{a}
Stored at –16°C (Freezer)	7.78^{c}	0.75^{c}	1.26^{b}	0.018^{b}	1.25^{b}
Stored at 16°C (Cold Temperature)	39.44^{b}	3.79^{b}	1.26^{b}	0.016^{b}	1.37^{b}

Values followed by different letter are significantly different at 95 % of confidence level using Duncan test

DISCUSSION

Seed Characterization

Seeds have been categorized into two main groups according to their desiccation response and storage physiology: orthodox (desiccation tolerant) and non-orthodox (desiccation sensitive). So if we desiccate the seeds in desicator with some of silica gel, the seeds can appreciate in decrease the weight slowly or suddenly. If seed's weight is lose slowly we can define it as an orthodox seed , and otherwise we can define it as non-orthodox seed (Berjak, 2005).

Based on the the initial water content (Table 1) and the seed response to drying in silica gel, the seeds are considered as the orthodox. Roberts and King's (1980) stated about the relationship between plant ecology and seed storage behavior. The study results were reinforced by Von Teichman and van Wyk, (1994); Hong and Ellis, (1996); Pritchard et al., (2004) who conducted the research on association between the level of drying sensitivity and typology of natural habitats (eg tropic or sub tropic) and their characteristics.

Association between Seed Ecology, Seed Characteristics and Response to Desiccation

Based on its ecology, *P. pterocarpum* is native to Australia (native Bismarck Archipelago), Brunei, Burma, Cambodia, Indonesia, Jawa (Sulawesi, Sumatra, Kalimantan), Malaysia, Peninsular Malaysia, Philippines, Sabah, and Vietnam (Global Species, 2018). Most of the region is tropical areas. *P. pterocarpum* is a lowland species, rarely occurring above an altitude of 100 m (Orwa et al., 2009) . While, *S. mombin* tree is native and common in most lowland forests, and indigenous to tropical Africa (Adepoju, 2009). The tree *has* been naturalized in India, Bangladesh, Sri Lanka, The Bahamas, Indonesia, and other Caribbean islands (Wikipedia, 2018). *S. mombin* occurs in a great variety of humid tropical climates, often in secondary vegetation derived from evergreen lowland forest or semi-deciduous forest (Orwa et al., 2009). *P. pterocarpum* flowering occurs from March-May, although sporadic flowering may occur throughout the year and *S. Mombin* flowering occurs during the dry season; some ripe fruit can be found on the tree most of the year (Orwa et al., 2009).

Based on Purwodadi Seed Bank data, the data of *S. mombin* is always available in the dry months, while *P. pterocarpum* can be harvested throughout the year eventhough the big harvest occurs in the dry season. As stated by Pritchard, et al., (2004) the dessicant-tolerant seeds are usually shed during the dry season and grow in dry environments (such as savanna) and other tropical lands. On the contrary dessicant-sensitive seeds cannot be found on the savanna and shed in the rainy season because if they shed in the dry season can cause the death of an entire annual cohort of seeds.

Orthodox seed storage behaviour is shown by species which produce achenes, many-seeded berries, many-seeded dehiscent capsules, many dry-seeded pods (but not arillate), many dryseeded follicles, schizocarps and utricles (Hong and Ellis , 1996). *P. pterocarpum* fruits 1-4 seeded pods, flat, thin, winged, 5-10 cm long, dark red when ripe, then turning black. Fruit of *S. Mombin* is an ovoid or ellipsoid drupe, 3-4 x 2-2.5 cm in diameter; dull light orange to yellow or brown; in clusters of 1-20; epicarp thin, enclosing a juicy orange or yellow mesocarp 3-6 mm thick; endocarp large, with a soft, fibrous, grooved coat surrounding 4-5 small seeds (Orwa et al., 2009). Hong , et al. (1996) stated that plant, fruit, or seed characters (achene, acorn, berry, capsule, caryopsis, nut, drupe, pod, and the other of fruit type) associated with their storage behavior. *P. pterocarpum* has pod type of fruit which consist of many small seeds. Hong, et al. (1996) stated that this type was orthodox. *S. mombin* has drupe type of fruit and consist of 1-5 seeds. This seed type was considered as orthodox or recalcitrant. Seed size alone does not determine seed storage behavior. Nevertheless, typically recalcitrant seeds do tend to be larger than intermediate seeds, which in turn do tend to be larger than orthodox seeds.

Association between seed moisture content at maturity (harvest maturity in crops) and seed storage behavior

According to Hong and Ellis, (1996), the seed moisture content at maturity or at sheeding are the factors associated with the seed storage behaviour. The seed with the water content distributed between 36% and 90% will considered as recalcitrant. The seed with the water content between 23% and 55% will be considered as intermediate. Moreover, for orthodox seed, the water content was approximated between 0% and 20%. The initial water content of seeds before storage of *P. pterocarpum* and *S. mombin* are described in Table 1. The initial water content of seeds before storage was 9,23 % for *P. pterocarpum* and 6,32 % for *S. mombin*. Based on these results, the seeds of two species studied are estimated as orthodox seeds.

Temporary observation from desiccation response showed that the seeds of two species studied were orthodox, which also supported by their initial water content. But Table 2 shows the P values of each species indicate that each treatment in *P. pterocarpum* and *S. mombin* brought significant difference to each parameter, except RGR. They show a significant decrease between fresh seeds and stored seed during 7 months at the refrigerator and freezer temperature. In this condition they were sensitive to low temperature especially temperatures below 0^{o}C, they can be classified as intermediate (Yang et al., 2008). Gemene and Eriksen, 2004 noticed that storage conditions at 4°C were more detrimental for *K. senegalensis* seeds than at -20°C or 15°C. The seeds can be dried to moisture contents as low as 5%, but are sensitive to cold temperatures, which limits the possibilities for long term storage. As happened in *S. bierra* (Ouédraogo and Verwey, 1987 and Kamra, 1990). A physiological study also conducted on the causes of the difficult storage behaviour of neem tree seed (Sacandé, 2000). Sacandé et al., 1998 find out that the drier the seeds, the more sensitive the seed to imbibition stress, especially when rehydration occurs in cold temperature. Because of these considerations, the two seeds can be classified as intermediate.

Seed Viability and Seedling Growth

Fresh seeds or control treatment of *P. pterocarpum* germinated only 68.33% (Table 1) can be caused by low quality or dormant properties. *P. pterocarpum* is a *Fabaceae* family which has a thin seed coat but suspected it is not permeable enough for water to penetrate and hypocotyl extension. However, no one has reported about the dormancy of *P. pterocarpum*. From the germination experiments, there were only few seeds that could germinate. As reported by Kristiati and Putri (2008), *Parkia javanica* seed which has hard coat is phisycally dormant, as well as some other Fabaceae seeds (Copeland and McDonald, 1995, and Schmidt, 2000). If the seeds are physically dormant, the scarification treatment should be done before germination.

Spondias mombin belongs to the family of Anacardiaceae. Some Anacardiaceae have seed coat that are not permeable to water (Baskin and Baskin, 1998; Li et al., 1999a; 1999b). Moreover, no one has reported the dormancy of *S. mombin* seeds. Neya (2006) stated that in the seed germination test of *Lannea microcarpa* (Anacardiaceae) in various levels of seed harvesting, there are not differences in the germination percentage. This indicates that some Anacardiaceae seeds experienced a physical dormancy. But unlike in *Sclerocarya birrea* (Anacardiaceae), the seeds must undergo physiological maturation first after being picked to improve the germination process. Therefore, the seed is classified as physiologically dormant. Therefore, there are 2 possible dormancy properties in *S. mombin,* or combination of both. So that to grow *S. mombin* seeds must be given preliminary treatment.

Table 3 showed that the percentage of germination of stored *P. pterocarpum* seed experienced a significant decrease (10% in freezer and 20% in cold temperatures). The seed germination of *S. mombin* also experienced a significant decrease after being stored (7.78% in the freezer and 39.44% in cold temperatures) in Table 4. A very low germination percentage of seedling of *P. pterocarpum* and *S. mombin* indicated that the storage treatments in freezer may damage the seed. The storage methods of freezing temperature are not suitable for these two species, and better to be stored in higher temperature.

Low temperature storage could prevent seeds from ageing and drying. At low water contents and temperatures the cytoplasm turns into a glassy state, in which molecular motion is slow and, consequently, ageing is slowed (Buitink et al., 2000). However, the patern is not entirely perfect. There is some water content that can become frozen. There is a process of freezing injury. Where the water content in seeds can be a form of intracellular ice when stored in frozen conditions, it can cause freezing damage in tissues. This can explain the decline in seed quality at freezing storage. There was a decrease of germination in *P. pterocarpum* and *S. mombin.*(Table 3 and 4). Storage in cold temperatures also has some not good effect for sensitive species. There was a decrease of germination until 48% in *P. pterocarpum* and about 22% *in S. mombin*. (Table 3 and 4). Quality loss also can be caused due to stress imbibition. Tropical tree seeds are thought to be particularly sensitive to low imbibitions temperatures because of the relatively high gel-to-liquid crystalline phase transition temperature of their membranes as compared to the relatively low temperature membranes of temperate zone seeds. (Sacande, et al., 1996)

Besides viability, seedling growth is also something that we examine in these two seeds. The Germination Rate, Velocity of plant height increase, and the Velocity of leaves number increase indicate the level of seedling growth of a seed.

The germination type of *P. Pterocarpum* is epigeal. Cotyledon in epigeal germination is usually raised above the ground, changes its color to green, and can do photosynthesis, but its age is not long. The leaves then fall , meanwhile on the sprouts already normal leaves can form do photosynthesis. *P. pterocarpum* germination does not occur simultaneously. Within 3 days there are seeds that germinate, and the percentage of sprouts increases every day is 6.57%, that means that, to reach a maximum number of sprouts of 68% there are 10 days that must be passed. In freezer and refrigerator storage, the speed of seed germination also decreases significantly. This could be because the physical and enzymatic processes that occur in stored seeds experience several obstacles.

The species of Spondias all have hypogeal germination. The seedlings are cryptocotylar (the cotyledons enclosed in the germinating seed); the hypocotyl emerges, curved at first, then carries cotyledons aloft; the cotyledons are opposite, linear, and green. *S.mombin* germination does not occur simultaneously. Within 3 days there are seeds that germinate, and the percentage of sprouts increases every day is 5,93 %, that means to reach a maximum number of sprouts of 61,63% there are 11 days that must be passed. In freezer and refrigerator storage, the speed of seed germination also decreases significantly.

Table 2 shows the P values of each species indicate that each treatment in *P. pterocarpum* and *S. mombin* brought significant difference to each parameter, except RGR. They show a significant decrease between fresh seeds and stored seed during 7 months at the refrigerator and freezer temperature. The decrease occurs in the value of germination percentage (%), germination rate (% day-1), VH (Velocity of plant height increase,% day-1, and VL (Velocity of leaves number increase,% day-1). But not significantly different in *P. pterocarpum* 's RGR (g-1g-1day-1).

The storage treatments both had impact of Velocity of leaves increase that was significantly different from the seeds without treatment (control). The functions of cotyledons are to do photosynthesis during the epigeal growth to absorb, and to transport nutrients from endosperm to the growing sprouts. if the function of tissues were good, the leaves formation process will be fast. When leaves were formed, photosynthesis the leaves were thought to be helped by the presence of energy derived from cotyledons in the form of residual starch. This was what drives grana to absorb more light energy to do photosynthesis, so that the respiration results can be used to optimize stem and leaf meristem cell division. So why leaf growth is hampered can affect the plant's height. If there is inhibition in leaf growth, the stem growth is also inhibited. Quality decline at stored seed can be caused due to the process of freezing injury on seeds. Freezing injury or damage due to crystallization of water in seeds occurs because the water content in the seeds is stored at temperatures below minus zero degrees. The water content forms ice crystals bound between cells and cell components in the seeds (Hong et al. 1998). This can explain what is presented in tables 3 and 4.

Analysis of plant growth is a way to describe photosynthetic processes measured by leaf area and dry matter production. The variable analysis of plant growth differs not only at the species level, but also at the variety level (Sitompul and Guritno, 1995). One of the variables commonly used in the analysis of plant growth is the Relative Growth Rate (RGR) is the dry weight gain of plants in a certain time interval that is closely related to the initial dry weight of plants. RGR is used to measure the productivity efficiency of plant biomass. Differences in RGR can occur between species due to differences in photosynthetic rates and biomass efficiency. Plants that contain a lot of protein per unit of biomass such as beans will form biomass that is less per unit substrate (carbohydrate) than plants that contain less protein such as cereals. When plants get taller and the number of leaves increases but are small and thick, plants are more efficient at photosynthesis by storing photosynthate (carbohydrates) into biomass and not using photosynthates to expand the leaf surface.

In this study, RGR measurements for seedlings from seeds that were treated with seed storage and without seed storage treatment (control) were carried out. The results showed that the treatment of seed storage both at the freezing temperature and cold temperature caused a decrease in RGR compared to the control treatment. Based on the results of statistical tests, in the species of *Peltophorum pterocarpum* , decrease in RGR is not significant while in the species of *Spondias mombin* , the decrease is significant. The results showed that seed storage treatment caused a slowdown in biomass storage on seedling growth. However, the slowdown of biomass storage also corelates to the germination initiation of the seed as the effects of seed storage treatments. The later the germination initiated, the lower RGR will be obtained. In *Spondias mombin* , the storage treatment using freezing and cold temperature decrease the RGR significantly. It means that two storage methods in this study may damage the seed and is not suitable for storing the seed of this species.

CONCLUSION

The study on the effects of storage condition to the seed of *P. pterocarpum* and *S. mombin* conclude that the seeds of two deciduous species are more classified as intermediate rather than orthodox seeds based on the desiccation response and type of storage. Storage treatments, both cold and freezing temperature, decrease the seedling growth of two species studied. However, the seedling stored in cold temperature has better growth than seeds stored in freezing temperature. Storage in higher temperature is more successful in the seed conservation of *P. pterocarpum* and *S. mombin.* The more successful storage method should be developed for both species for seed conservation purposes.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

ASD designed the experiment, control the progress of experiment, problem solving related to experiment, and was responsible for submission, correction and correspondence. RR performed seed treatments and experiment. FAS performed data and statistic analysis.

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