Agriculture

A review on Seed storage behavior of Schefflera abyssinica (Hochst. ex A. Rich.) Harms

Tura Bareke[1], Admassu Addi[2] and Tolera Kumsa[3]

[1-4] Oromia Agricultural Research Institute, Holeta Bee Research Center, Holeta, Ethiopia

Correspondence Author: Tura Bareke

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Abstract

The knowledge of the seed storage behavior is very crucial for the development of appropriate ex-situ conservation strategies. The main objective of this study was to determine seed storage behaviour of *Schefflera abyssinica.* To identify the seed storage behaviour of *Schefflera abyssinica* a factorial combination of three different values of temperature (-10, 0 and 22 °C), and 5 storage months were used. Seed moisture content and germination test were done every month until the majority of seeds stop germination. Accordingly, the highest average germination capacity of *Schefflera abyssinica* seeds was seen after two month of storage. On the other hand, the lowest germination capacity of *Schefflera abyssinica* was seen at the fifth month of seed storage. Seed germination capacity of *Schefflera abyssinica* has indirect relationship with seed storage period. This mean as the storage period increased the germination capacity of the seeds decreased. Seed storage period influences the germination capacity of *Schefflera abyssinica* by 47.8%. The germination capacities of *Schefflera abyssinica* seeds have showed the significance differences among the storage temperature. Seeds stored under -10^{0}C were showed the highest germination capacity in all storage months as compared to the two storage temperature. Generally, the highest germination capacity of *Schefflera abyssinica* seeds was found between 7 and 9% moisture content at the end of second and third months of storage. Thus, the seed storage behaviour of *Schefflera abyssinica* seeds shows the intermediate category.

Keywords: seed, storage behavior, germination capacity, moisture content

Introduction

Knowledge of the seed storage behavior is a key feature for determining the success of seed storage protocol that used for better conservation of plant species (Ganesh *et al*., 2019) [1]. Seed storage behavior varies from one species to another. Thus, the knowledge of the seed storage behavior of plant species is essential for the development of appropriate ex-situ conservation strategies (Hong and Ellis, 1996) [2]. Mositure content of the seed affect the age of the seed. An increase in seed moisture content by 1% wills double the rate at which germination declines (Harrington, 1960) [3]. In addition to this, the storage temperature affects the rate of aging, with an increase of 5ºC doubling the rate of aging. The impact of moisture content and temperature on seed quality has particular implication in tropical countries where ambient conditions will tend to lead to rapid loss in seed quality.

Seed storage behaviour is classified as Orthodox, intermediate or recalcitrant based on the responses to moisture content and storage temperature. Orthodox seeds are known as desiccation tolerant (up to 5%). On the other hand, recalcitrant seeds survive high moisture content >31% (Robert, 1973) [4]. Intermediate seed storage behaviour is found between orthodox and recalcitrant seed storage behaviour.

*Schefflera abyssinica (Hochst. ex A. Rich.) i*s an indigenous tree belonging to the family of Araliaceae, branched, small/medium to 30 m tall. It produces creamy-yellowish or creamy-white flowers from March to April. It grows in Afromontane forest, secondary forests and woodlands within the altitudinal range of 1450–2800 m a.s.l.; often occurs in association with *Hagenia abyssinica* (Bekele *et al*., 1993; Fichtl and Adi, 1994) [5, 6]. It is also usually found left as scattered tree in farmlands.

Schefflera abyssinica is one of the most important honey plants in Ethiopia (Bareke and Addi, 2019) [7]. It is a high producer of nectar and significantly contributed to honey production. One hectare of *S. abyssinica* plants has a potential to produce 895.5 kg of harvestable honey (Bareke *et al*., 2020) [8]. Due to its high potential, monofloral honey can be produced from this species which has high demand in the market and could generate high income (Bareke and Addi, 2018; Belay, 2005) [9, 10].

Schefflera abyssinica was considered as an epiphyte which grown on another tree species and finally overwhelms it and become an independent tree in highland areas. Currently, *Schefflera abyssinica* can be propagated by seed using aqueous smoke solution (Bareke *et al*., 2014) [11] and smoke treatment improve the capacity of the seedling to survive the effect of aphids. However, seed storage behaviour of this species is not known for maintenance. Therefore, the main objective of this study was to determine seed storage behaviour of *Schefflera abyssinica to* notify the scheme conservation strategies for the species.

Materials and Methods

Study site

Seeds were collected from Munessa forest which was recommended as a good provenance for multiplication *Schefflera abyssinica* by seedling (Bareke *et al*., 2014) [11]. The experiment was conducted at Holeta Bee Research Center with an elevation of 2450 masl and with bimodal rainfall pattern. June to September is the main rainy season for the study area

with a mean annual precipitation of 1150 mm (Bareke *et al*., 2018) [12].

Collection fruits/seeds and processing

After the mother trees were randomly selected, the mature seeds/fruits were collected from the elite 5 to 10 trees in each collection from the top, middle and lower parts of the crown of mother trees (ISTA, 2007) [13]. To ensure maximum genetic variation within the population, the selected trees were kept at least 100 m apart from each other (FAO, 1975) [14]. The mixture of fruits and seeds were packed in perforated sacks and transported to Holeta Bee Research Center and placed on the laboratory bench at room temperature for about a week. Seeds from dehiscing fruits were extracted manually/by hand and allowed to dry further for 1 day on the same bench.

Fig 1: Seeds of *Schefflera abyssinica* during collection

Seeds moisture content estimation

To determine the seed moisture content (MC) 5 g of seeds were taken with three replications (Hong and Ellis, 1996). The weighted sample was kept in oven dry for 2 hrs at 120 ^{0}C and then put in desiccator for cooling. Dry weight was measured and calculation was done for MC determination based on a fresh weight basis (ISTA, 2005; Schmidt, 2007) [15, 16], as following equation;

$$Mc\ (\%) = \left(\frac{W2-W3}{W2-W1}\right)x100$$

Where, Mc is moisture content, w_1 is the weight of the container, w_2 is the weight of the container with seed sample before oven drying, and w_3 is the weight of the container with seed sample after oven drying.

Seed storage behaviour testing

Seed storage behaviour was tested, following the protocol developed by Hong and Ellis (1996) [2]. Seeds were dried to 9-10% moisture content pre-storage at room temperature and their germination tested. Since most of the seeds survive desiccation of this moisture content, the seed storage behaviour of *Schefflera abyssinica* was not recalcitrant. Thus, to differentiate whether storage behaviour of this plant species is intermediate or orthodox a factorial combination of three different values of temperature (-10, 0 and 22 °C), and 5 storage periods were used to determine the germination capacity and storage behaviour of the collected seeds. Seed moisture content and germination test again were done every month until the germination capacities become less than 20%. Germination test was conducted using the top of the paper method using petridish (12 diameters) with Whatman germination papers. One hundred (100) seeds were counted and divided into four replications were arranged on the surface of the paper (Hong and Ellis, 1996) [2]. All seeds are allocated randomly and all exogenous factors will assume constant.

Fig 2: Seed counter and germination experiment

Data collection methods

For the entire experiments, seed germination counts were made every three days after the commencement of seed germination. To facilitate future counts, germinated seeds were removed after recording. The experiment was continued until at least

90% of the replication from each treatment shows no new germination for 3 consecutive counts. A seed is considered as germinated at the time when the protrusion of the radicle occurs to the surface of the petridish.

Estimation of germination capacity of seeds

Germination percentage was calculated according to the following formula:

$$1.\ Germination\ Percentage = (\frac{n}{N}) \times 100\%$$

where:

n = Total number of germinated seeds;

N = Total number of seeds in the sample (Labouriau and Agudo, 1987) [17].

Data analysis

The interaction effect of storage period and storage temperature has no significance effect ($p>0.05$) on the germination capacity of *Schefflera abyssinica*. Therefore, the effect of each factor was analyzed independently using One Way ANOVA and regression analysis to see their effect on germination capacity of seeds. The storage behavior of *S. abyssinica* was determined using seeds germination percentage before and after storage using the protocol developed by Hong and Ellis (1996) [2].

Results and Discussion

Seed storage behaviour

The highest germination capacity of *Schefflera abyssinica* seeds were seen between 7 and 9% of seeds moisture content (Figure 3). This indicates that most of the seeds tolerate desiccation to about 7-9% moisture content. Further desiccations lower the moisture contents and it reduces germination capacity of *Schefflera abyssinica* seeds. Therefore, this shows intermediate seed storage behaviour.

Seed moisture content is a key factor to determine the seed storage behaviour of plant species. Parimala *et al*. (2013) [18] is also reported that the moisture content of the seeds is the most important factor influencing the germination capacity of the seeds during storage. Seeds with low moisture content is damaging to the quality of seeds whereas, seeds with more than 14% of moisture content deteriorate rapidly. Seed storage behaviour is the way to identify whether the seeds of plant species can be maintained successfully over the long, the medium, or only for the short period of time (Hong and Ellis, 1996) [2]. This is essential for the development of appropriate ex-situ conservation strategies (Hong *et al*., 1996) [19].

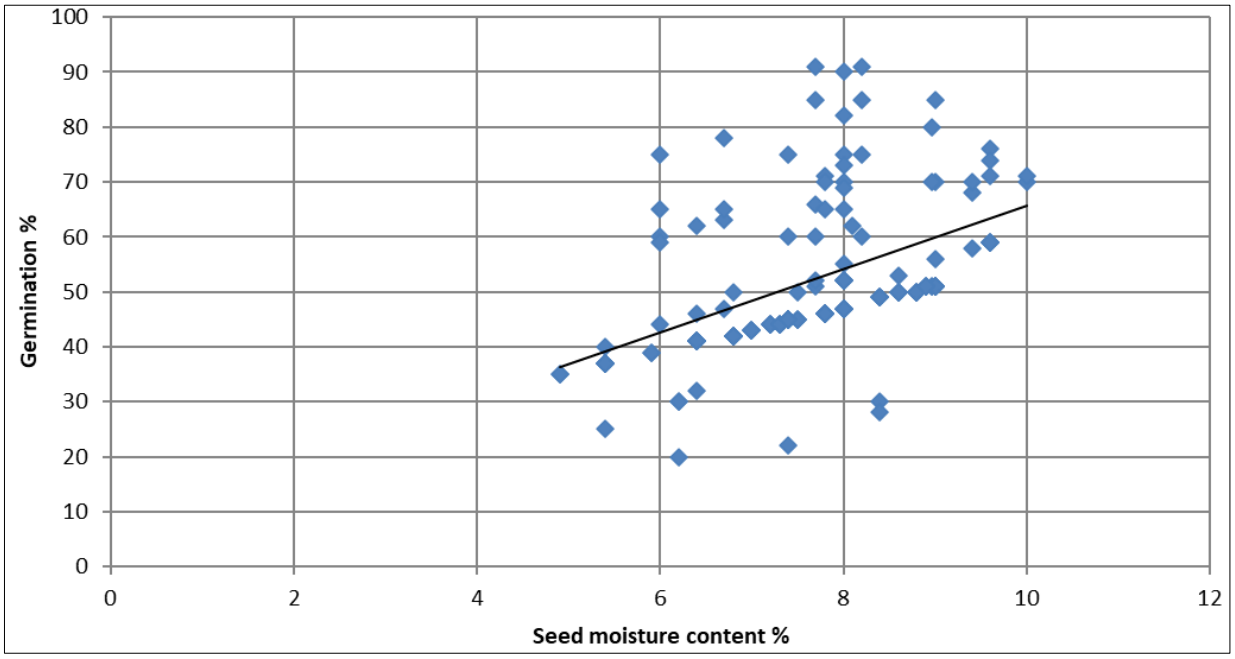

Fig 3: The relationship between seed moisture content and germination capacity of *Schefflera abyssinica*

The moisture content of *Schefflera abyssinica* seeds were an average of 9.5%, after the air dry at room temperature for a week. At the end of fifth month of storage, seed moisture content decreases to an average of 6.75%. Similar study conducted by Zheng *et al*. (2016) [20] on Kapok was also indicates that the moisture content was 11.1% at the initial measurement and decreased to 4.98% after five days of desiccation. As seed storage period increased, seed moisture content of *Schefflera abyssinica* was decreased as well as germination capacity increased to somewhat and become decreased after reached a peak germination.

The highest average germination capacity of *Schefflera abyssinica* seeds were seen after two month of storage at 8.37% average moisture content of seeds. On the other hand, the lowest germination capacity of *Schefflera abyssinica* was seen at the fifth month of seed storage (Table 1). After fifth month of storage the germination capacity was less than 15%. The maximum germination capacities of the seeds were seen from first to third months of storage with 7.58 to 8.58% of average seed moisture content. This indicates that seeds storage behaviour of *Schefflera abyssinica* is intermediate. After fifth month of seed storage, the values of moisture content as well as germination capacity of *Schefflera abyssinica* seeds decreased. Study conducted by Joshi *et al*. (2019) [21] on seed germination and seed storage behavior of *Pittosporum eriocarpum* Banks. ex Gaertn is also indicates that the moisture content and germination capacity of stored seeds were gradually decreased with increase of storage period.

Table 1: The moisture content and germination capacity of *Schefflera abyssinica* seeds in different storage period

Storage period	Moisture content	Germination % ± SE	Minimum	Maximum
Control	9.5 ± 0.29^{a}	56 ± 3.7^{bc}	45	65
First month	8.58 ± 0.10^{ab}	56 ± 2.3^{bc}	45	91
Second Month	8.37± 0.21^{b}	70 ± 2.4^{a}	46	91
Fourth month	7.65 ± 0.15^{bc}	48 ± 1.3^{cd}	43	73
Third Month	7.58 ± 0.31^{bc}	65 ± 2.5^{ab}	44	85
Fifth month	6.75 ± 0.15^{c}	40 ± 1.2^{d}	20	71

Seed storage duration influence the germination capacity of *Schefflera abyssinica* seeds by 47.8%. The peak germination time was at first and second months of storage period. Seed germination capacity of *Schefflera abyssinica* has indirect relationship with seed storage period. This mean as the storage period increased the germination capacity of the seeds decreased.

Duration of seed storage length and storage temperature is very important to determine the seed storage behaviour associated with moisture content. For instance, seeds of *Cattleya aurantiaca* tolerated desiccation to 3.7 and 2.2% moisture content with 94 germination percentage, however only 10% germinated after storage of 90 days at –18°C with 3.7% moisture content (Pritchard and Seaton, 1993) [22].

The germination percentages of seeds stored under -10^{0}C were above 50 at the first, second and third months of storage period. This statistically similar with the seeds stored at room temperature. On the other hand, the seeds stored at 0^{0}C have shown the highest germination capacity only at the second and third months of storage period. At the end of the fifth month of storage period, the lowest germination capacity was seen for the seeds stored at the room temperature. In all months of storage the germination capacity of seeds stored under -10^{0}C were the highest as compared to other two storage temperature. Many authors have been mentioned that the seed storage longevity is affected by many factors. Some of them are seeds maturation; ways to harvesting, time and weather of harvesting as well as pre-harvesting handling are the factors that affect seed storage longevity (Hong and Ellis, 1996; Bareke, 2018; Ellis *et al*., 2018; Hay and Probert, 2011; Hay *et al*., 2013) [2, 23, 24, 25, 26]. If matured seeds are not collected from mother trees, they have drastic consequences on the quality of seeds. As a result, when seeds exposed to less favorable environmental conditions, they are rapidly deteriorated (Bareke, 2018) [23]. Visual identification of physiological maturity of seeds is used to identify the maturity of seeds. Hong and Ellis (1996) [2] were also reported that the response of seed storage behavior is also influenced by storage environment. According to Harringtom's thumb rule, the seeds with the range of 5-14% of moisture content will double the germination potential of the seeds when moisture content of the seeds decreased by1% (Parimala *et al*., 2013) [18]. Moisture content above 14% prone seed to insect and mold attach, whereas, below 5% causes changes to physiochemical changes in the seeds.

Seed storage temperatures influence the germination capacity of *Schefflera abyssinica* seeds by 52%. Storage temperature and germination capacity of *Schefflera abyssinica* seeds have indirect relationships. As the temperature increased the germination capacity of *Schefflera abyssinica* seeds were decreased.

Conclusion

The moisture content of *Schefflera abyssinica* seeds were an average of 9.5%, after the air dry at room temperature for a week. At the end of fifth month of storage, seed moisture content decreases to an average of 6.75%. The seed germination capacity of *Schefflera abyssinica* has indirect relationship with seed storage period and moisture content. Seed storage period influences the germination capacity of *Schefflera abyssinica* by 47.8%. The germination capacities of *Schefflera abyssinica* seeds have showed the significance differences among the storage temperature. Seeds stored under -10^{0}C were showed the highest germination capacity in all storage months as compared to the other storage temperature. Generally, the highest germination capacity of *Schefflera abyssinica* seeds was found between 7 and 9% moisture content at the end of second and third months of storage. Orthodox seeds can be dried to low moisture contents (up to 5%) without damage; if most or all seeds tolerate desiccation to about 10-12.5% moisture content, they are known as intermediate seed storage behaviour. On the other hand, if most or all seeds are killed by desiccation to 15-20% moisture content, they are known as recalcitrant seed storage behaviour (Hong and Ellis, 1996) [2]. Therefore, based on the definition of seed storage behaviour given by Hong and Ellis (1996) [2], we conclude that the seeds storage behaviour of *Schefflera abyssinica* shows the intermediate category.

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Conflict of Interest

The authors do not have conflict of interest.

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