Chapter

Seed Production and Handling of Two Important Conifers Grown in Kenya

Peter Murithi Angaine, Alice Adongo Onyango and Jesse Owino

Abstract

Pinus patula and *Cupressus lusitanica* are key commercial forestry plantation species introduced in Kenya. There are many uses for these species in industry creating a huge demand for their products. The demand has caused increased plantation establishment with seed as the major source of propagule. The many developments in the forestry sector have led to the need for low energy rapid extraction technique that improve seed quantity and quality from the available sources. There have been developments in improving extraction and quality which offer an opportunity for better seed collection and handling techniques for these conifers. This chapter will focus on improvement of seed production and handling of the two conifers that aids in the design of low energy-intensive methods that reduce the duration for extraction, optimize seed yield and enhance seed quality.

Keywords: *Pinus patula*, *Cupressus lusitanica*, cone and seed characteristics, seed extraction, seed yield, germination

1. Introduction

Pinus patula Schiede & Deppe belongs to the Pinaceae family, but *Cupressus lusitanica* Mill. belongs to the Cupressaceae family. Coniferous gymnosperms make up both species [1–3]. Mexican cypress, also known as *C. lusitanica*, was brought to Kenya in 1936, but it was not until the 1950s that it was widely planted to replace *Cupressus macrocarpa*, which had been introduced earlier but had developed a sensitivity to Cypress Canker [4, 5]. The two primary commercial forest plantation species utilized to supply saw-wood to Kenyan forest industries for the manufacturing of wood for furniture and construction, round wood for plywood, and fiber to produce pulp and paper are *C. lusitanica* and *P. patula* [6–8].

Kenya Forest Service (KFS) is a corporate body that provides for the development and sustainable management, including conservation and rational utilization of all forest resources for the socioeconomic development of Kenya [9]. Gazetted forest land consists of about two thirds of protected forest reserve that comprise indigenous tree species, and about 150,000 ha of exotic softwood plantations [5, 10] (**Figure 1**).

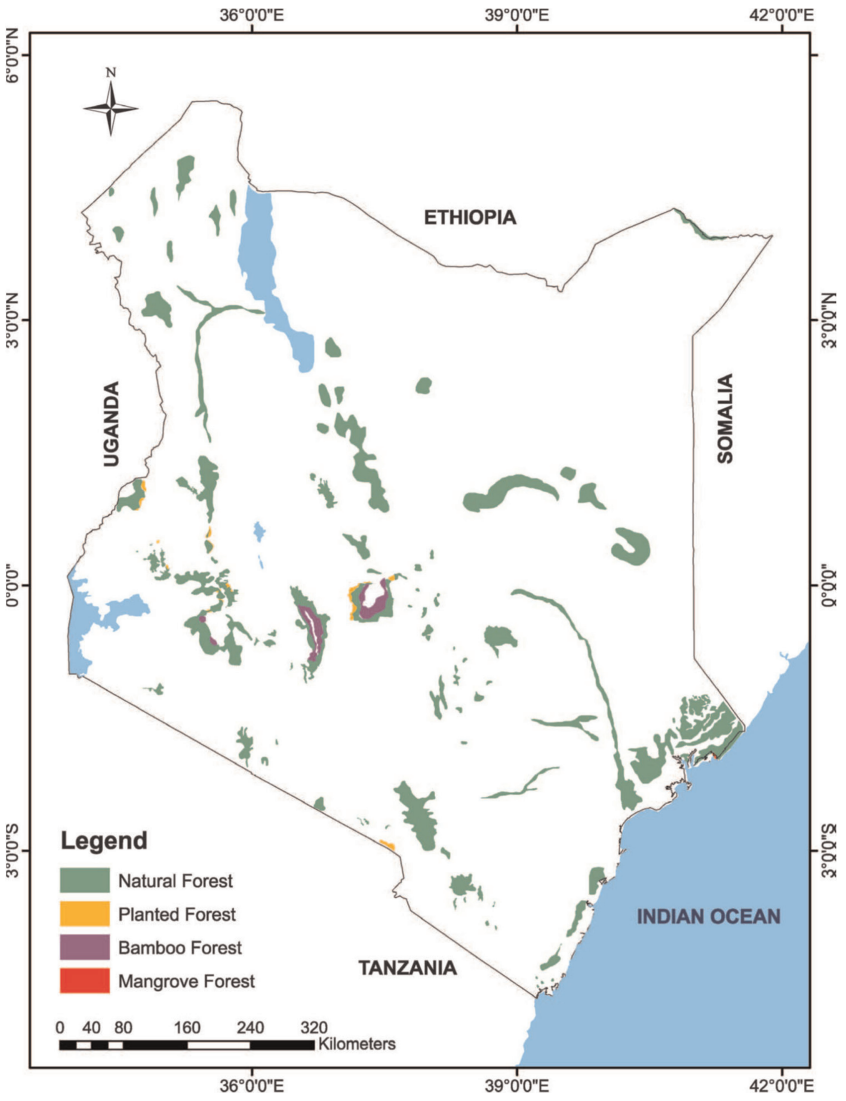

Figure 1.
Pine and cypress plantations fall under "Planted Forest" area [11].

C. lusitanica is the most widely planted species occupying about 55% of the plantation area, and *P. patula* taking 25% [12]. The agency that provides seeds for forest tree species is Kenya Forestry Research Institute (KEFRI) [13].

Despite sourcing seeds of *P. patula* and *C. lusitanica* from selected seed stands and seed orchards [14, 15], the demand for seed is not being met. Currently, the demand for *P. patula* seed in Kenya stands at 1000 kg, of which KEFRI can only supply 600 kg, while *C. lusitanica* seed is 1500 kg [16]. The bulk of this seed is taken by KFS for their annual planting programme, with the remainder going to private commercial nurseries and farmers. Taking into account the effects of climate change and the limited number of seed sources, it is essential to review seed collection and processing practices, to ensure improved quality and quantity of seed [17, 18]. Consequently, there are numerous opportunities to be explored in this regard. Therefore, opportunities

exist on quality improvement in terms of where to collect cones within the crown, the size of cones to be collected and how to improve seed yield through seed processing practices that will impact germination rate and packaging.

The gaps in the improvement of *P. patula* and *C. lusitanica* seed yield have been identified as the need to understand the influences of: (i) crown morphometry on seed production, (ii) cone characteristics on seed production, and (iii) extraction practices on seed yield and germination. To address these gaps, this chapter focuses on recent developments in collection and handling of *P. patula* and *C. lusitanica* seeds.

2. Materials and methods

2.1 Study site

The study materials were sourced from seed orchards in Londiani, Kenya. Londiani area is at an elevation of 2308 m.a.s.l. with an average temperature of 15.7°C (minimum of 8.6°C and maximum of 23.31°C). The area has two rainy seasons occurring in the months of March to May with an average rainfall of 750 mm and in October to December with average rainfall of 423 mm. The driest months are January to February and August to September [7, 19–21].

2.2 Sampling frame

2.2.1 Pinus patula

Crown morphometry and seed production: the sampling procedure was adopted from the method used by [21, 22]. The orchard was broken into three equal segments and 10 trees were picked and measured for their diameter at 130 cm (D130) and height from each area. One tree, which had produced the most fruit and had the greatest diameter (D130), was then selected and marked for cone collection from each of the three plots. Measurements were taken for D130 (cm), tree height (m), crown height (m) and crown radius (m) = D(m)/2 for the chosen trees (**Figure 2**). The crown of the tree was then divided into three equal parts; top (A), middle (B) and bottom (C). It was further split into two sections based on the distance from the stem (0–2 m = 1, >2 m = 2). Section 1 covered the part that was 2 m away from the stem (A1, B1, and C1), while Section 2 was made up of the part greater than 2 m from the stem (A2, B2, and C2) [15, 21]. From each crown section, 15 ripe cones were taken, amounting to 90 cones per tree. The gathered cones were put in individual bags for every section of the crown and then transported to the laboratory.

P. patula cones were assigned a particular identity based on the tree and crown sector they were taken from, with a maximum of 10 cones per sector. Before they were extracted, the characteristics of each cone were observed, including shape (straight or curved), length (in cm), diameter at the widest point (in cm), and weight (in g). The cones were placed on glass petri dishes and heated in an oven at 65°C for 24 hours. The seeds were extracted by gently tapping the cones 15 times on a flat wooden bench. The weight of the cones without the seeds and the total number of seeds per cone were recorded. The percentage of cones that opened after heat treatment for seed extraction was also measured.

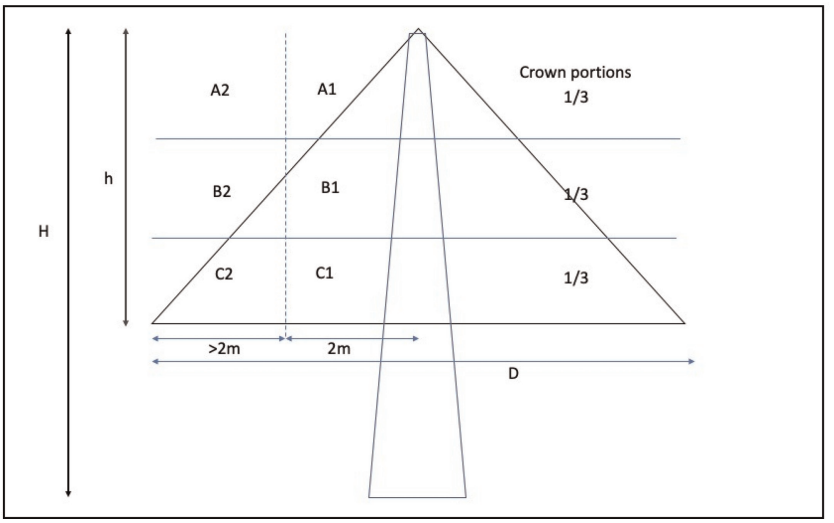

Figure 2.
Schematic diagram on crown compartmentalization for sampling area of Pinus patula *cones.*

2.2.2 Cupressus lusitanica

The study materials were taken from a 14-year-old clonal seed orchard of *Cupressus lusitanica* in the Londiani region. Thirty trees that were producing seeds were randomly chosen and fifty mature cones were taken from each, giving a total of 1500 cones. Cones that were brown and shut at the time of collection were judged to be mature [23]. The cones were bundled together and put in gunny bags before being brought to the laboratory for seed extraction, screening and weighing.

2.3 Experimental design

2.3.1 Pinus patula

Cone characterization was based on the method described by [21]. This involves categorizing mature cones according to their shape (straight or curved) (**Figure 3**), length (L1) (cm), diameter at widest part (cm) and weight (g). The cones were then placed on uncovered glass Petri dishes and heated in an oven (Yamato DS411) at 65°C for 24 hours [19]. After drying, the cones were removed and seeds extracted by tapping 15 times on a flat wooden bench. Measurements of the length of the part of the cone that opened (L2) (cm) (**Figure 4**), the weight of the cone without seed (g) and the total seed count from each cone were taken. The percentage of the cone that opens after drying for seed extraction (p) was calculated using Eq. (1); this p is used to compare the opening length of the cone in relation to its shape [19, 21, 24].

$$p = \frac{L2(cm)}{L1(cm)} * 100 \quad (1)$$

Cone pretreatment and seed extraction: the cones were identified and measured for length, diameter and weight, then put in hot (100°C) and room temperature

Figure 3.
Pinus patula *cones ranked based on shape (straight-top and curved-bottom, with a 30 cm ruler on the side showing scale).*

Figure 4.
Pinus patula *cones showing stages of cone opening.*

(25°C) water for 10 minutes, 24 hours and a control (not soaked) to examine the impact of humidity [19, 25]. The cones were arranged in labeled glass Petri dishes with sufficient distance between them to avoid cross-contamination of the seeds, and then exposed to artificial heating for seed extraction. Eight temperatures (30, 40, 50, 65, 70, 75 and 85°C) [26] and a DB condition (drying bed to simulate real-life seed

extraction with a temperature of 44.8 ± 6.00°C) were tested for 4, 24 and 48 hours together with the control (no soaking).

2.3.2 Cupressus lusitanica

Cone and seed characterization: the cones were divided into two categories, large (CB) and small (CS), based on sieving with a 20 mm sieve. After assessing for maturity and any defects, 240 defect-free mature cones were chosen from each category. The diameter and weight of each cone was measured. Then, the cones were heated artificially at 65°C for 48 hours to extract the seeds [19]. The seeds were then sorted by sieving using a 2 mm sieve to create small (SS) and large (BS) category. To further categorize the seeds, they were floated in water for 5 minutes, and divided into floaters (FF) and sinkers (SS) (**Figure 5**). Finally, the seeds were germinated according to their categorization.

Cone pretreatment and seed extraction: In order to conduct an experiment, 540 cones were randomly divided into three groups of 180 cones each. The first group acted as the control and was not soaked in any liquid. The second and third groups were submerged in cold and hot water, respectively, for 10 minutes [19, 25, 27]. The three groups were further broken down into 6 different temperature categories (GH, DB, 40, 50, 65, and 85°C) of 30 cones each and labeled. The categories of 'greenhouse' (GH) and 'seed drying bed' (DB) refer to two infrastructures used for seed extraction in Londiani, Kenya.

Observations for seed release and seed counts per cone were done at 24 hours and at 48 hours. Seeds that had not been released from open cones were forcefully removed manually using forceps to account for seeds that were retained in a cone and labeled as 48F (48 hours forced).

Germination tests were conducted based on the extraction treatments. Radicle emergence was taken as the criterion for germinability [28].

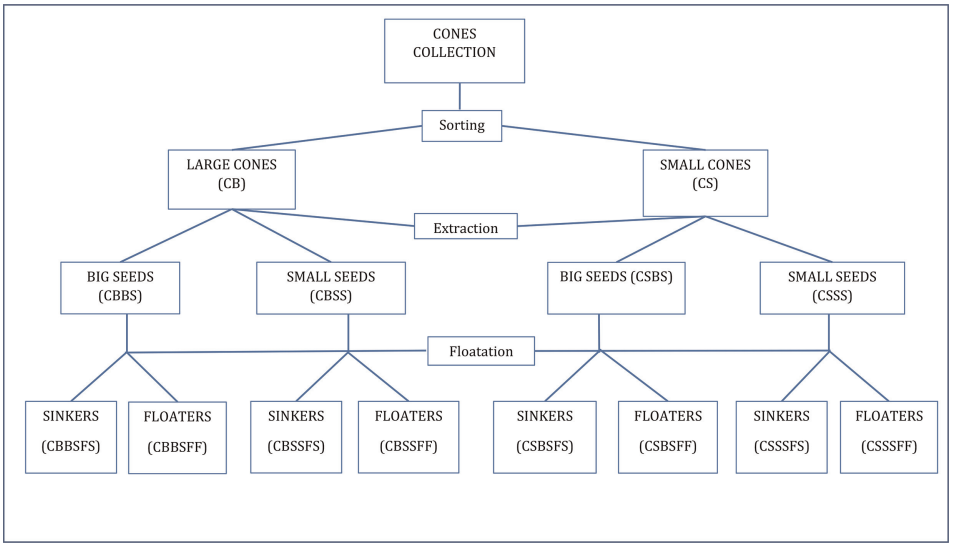

Figure 5.
Experimental layout for Cupressus lusitanica *cones and seed categorization [20].*

3. Results and discussion

3.1 *Pinus patula*

The different sections of the crown had varied seed yield, with compartment A2 missing from the crown due to the conical shape of *P. patula* crown. Compartment A1 had the highest number of seeds (33.3 ± 4.91) from the cones, while C2 had the lowest (14.4 ± 2.76). This is in agreement with research done on another species, *Pinus densiflora* [29]. Compartment C2 had the highest percentage of opening (46.6 ± 1.98%), yet this did not result in a high seed yield (**Figure 6**). This study found that neither cone shape nor percent opening had an effect on seed yield [21]. Mathematical modeling was used to analyze the results, which showed that the length of the cone had the greatest influence on seed yield [24].

Research has indicated that cone soaking does not have a major influence on cone opening. Temperature of extraction was seen to have a major effect on cone opening and the subsequent seed yield, with higher temperatures favoring both cone opening

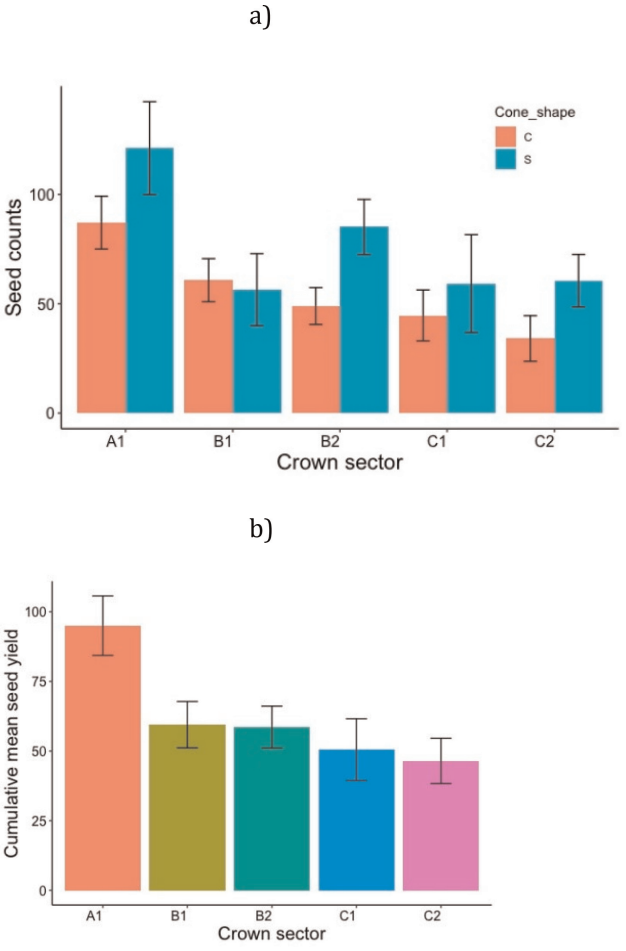

Figure 6.
a) Seed yield by cone shape and crown compartment and b) Cumulative mean seed yield by compartment.

and seed yield [19]. Soaking of cones increases the moisture content of the cone, which can hinder the swift opening of the cones [19, 30, 31].

3.2 *Cupressus lusitanica*

Sieving of cones and seeds was found to be a helpful tool when it comes to predicting seed yield and quality. It was observed that bigger seeds from both small and big cones had better germination performance. Floatation was found to be an effective method of predicting germination, where denser (sinkers) seeds yielded better results than floaters. Big seeds yielded 95,000–105,000 seeds per kilogram, with a germination rate of 51%. This is a big improvement from the previous rate of 25% and 160,000–290,000 seeds per kilogram [20, 32, 33]. Different from pines, soaking cones in cold water prior to seed extraction was found to have a significant effect on cone opening and seed release, with 77% of seeds released within the first 24 hours, 90% within 48 hours and 10% having to be forced out [2, 34]. Temperature was also seen to affect seed release, with higher temperatures leading to higher seed yield than lower temperatures [35, 36]. After 30 days of assessment, it was observed that germination performance was highest for seeds extracted from cones that had been soaked in cold water. Several studies have been conducted on the effects of soaking media on seed germination, with the present study focusing on soaking cypress cones in cold and hot water and their influences on germination [37–40].

4. Conclusions

The upper sections of *P. patula,* crown should be targeted during seed collection for higher seed yield. Larger cones for both *P. patula and C. lusitanica* have highest seed yield. Combined effect of soaking and higher temperature exposure of *P. patula* and *C. lusitanica* cones have a positive effect on seed yield without adverse effects on seed germination.

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Conflict of interest

The authors declare no conflict of interest.

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