This article was listed in Forest Nursery Notes, Winter 2008

135. Conifer cone and seed processing. Kolotelo, D. International Plant Propagators' Society, combined proceedings 2006, 56:474-478. 2007.

Conifer Cone and Seed Processing©

Dave Kolotelo
British Columbia Tree Seed Centre, Surrey, British Columbia, Canada V4P 1 M5
E-mail: Dave.Kolotelo@gov.bc.ca

INTRODUCTION

The cone and seed processing of conifers is presented as a part of the Seed Handling System defined as all activities between cone collection and sowing in the nursery (Fig. 1). This presentation covers the activities of: (1) Post-collection handling of cones, (2) Cone processing, and (3) Seed processing with a general aim of increasing knowledge about conifer cone and seed biology and processing.

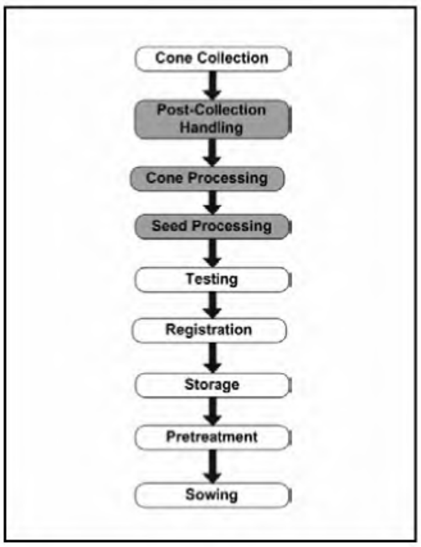

Figure 1. The seed handling system.

Conifers are a very diverse group of organisms and have been shown to be among the most heterozygous plants (Hamrick et al., 1979). This is not surprising given their long life spans and wide species distributions. This variation is important to maintain and although we continually are improving our processes it is not simply a matter of reducing variability in our product as this variability has an important role to play in our forests. There is a great deal of cone and seed biology behind cone and seed processing, but it is also subjective at times and requires highly competent and dedicated technicians to combine the art and the science into successful cone and seed processing.

There currently are three conifer cone and seed processing facilities in British Columbia (B.C.) which have averaged approximately 6000 hectoliter (hl) of cones over the past 10 years. In 2006 there was a very large increase in cone collections, primarily in response to the mountain pine beetle (*Dendroctonus ponderosae* Hopk.) epidemic, with a total of 12,000 Hl of cones processed in B.C.

The primary descriptors of cone and seed processing are yield and germination. Yield can be thought of as a measure of efficiency measured as kilograms of seed per Hl of cones and varies from approximately 0.27 in lodgepole pine (*Pinus contorta* Dougl.) to above 2.0 in amabilis fir [*Abies amabilis* (Dougl.)Forbes]. Differences in yield are the result of many factors including; species, seed size, cone size, reproductive success of that crop, proper timing of collection, and appropriate post-collection handling of the cones. The second descriptor is germination and represents the germinable proportion of seed in a seedlot. The primary reforestation species in B.C. generally have good germination capacities: lodgepole pine (95%); interior spruce [*Picea glauca* (Moench) Voss], *P. engelmannii* Parry ex. Engelm. and hybrids (90%);

Douglas-fir [*Pseudotsuga menziesii* (Mirb.)Franco] (92%), and western red cedar (*Thuja plicata* Donn ex. D.Don) (85%). During final cleaning these two variables, yield and germination, are balanced to try and derive the greatest numbers of potential seedlings from a seedlot.

Cones are obtained from both natural stands and seed orchards for those species and seed zones in which tree improvement programs exist. An effective monitoring and pre-collection evaluation system is important in both areas to (1) determine crop size (and plan for needed resources), (2) determine if any pest problems exist, and (3) determine maturity level and try and match collection timing to full seed maturity without losing seed to natural dispersal. Sampling should become more frequent as cones and seeds are approaching full maturity (generally August to September).

POST-COLLECTION HANDLING

Post-collection handling, including temporary storage, monitoring, and transport of cones, is a key step in the production of high quality seeds. Unfortunately it is a stage that too often receives inadequate attention. Freshly picked cones are very moist, and this moisture must be removed gradually to mimic the natural maturation process and to prevent overheating and/or case hardening of the cones. Collecting immature cones or picking them during wet weather will compound moisture problems. For moist cones reduce the volume per sack to promote uniform drying.

It is generally recommended that the cones of most species should be field-stored for approximately 4 weeks prior to shipping to the extractory to reduce moisture content and risk of damage. However, exceptions to this rule include western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] and western red cedar, which have shallow seed dormancy and should be shipped to the seed processing facility directly upon picking. Store cones in sacks under shelters with exposure to freely circulating cool air to gradually remove moisture. The weave of the cone sack should not allow released seed to be lost. It is important that sacks are not stored in direct sunlight because overheating can damage cones, but they also should not be allowed to remain wet for excessively long periods since this will encourage the growth and spread of fungi. Air movement is more beneficial to drying than light or heat.

Transportation of cones from interim storage to the extractor is an important aspect of post-collection handling as seed quality can be degraded by improper transport. The keys to proper transport are to provide good circulation around the cone sacks, maintain a cool temperature, and limit the time in the transport vehicle. Proper circulation can be accomplished by using pallets to separate cone sacks. For most species cone sacks should be two-deep followed by another pallet.

Upon arrival at the extractor the cones are placed into cone storage areas until processing is initiated. An initial random sample of cones will be evaluated for basic morphological features, degree of insect or pest activity, estimates of seed yield through half-cone counts, and detailed examination of internal seed condition through cutting tests. The details of a longitudinal section of a typical conifer seed are illustrated in Fig. 2.

CONE PROCESSING

Cone processing generally involves a kilning process and a tumbling process to separate the seed from the cones. Kilning refers to drying cones in a controlled,

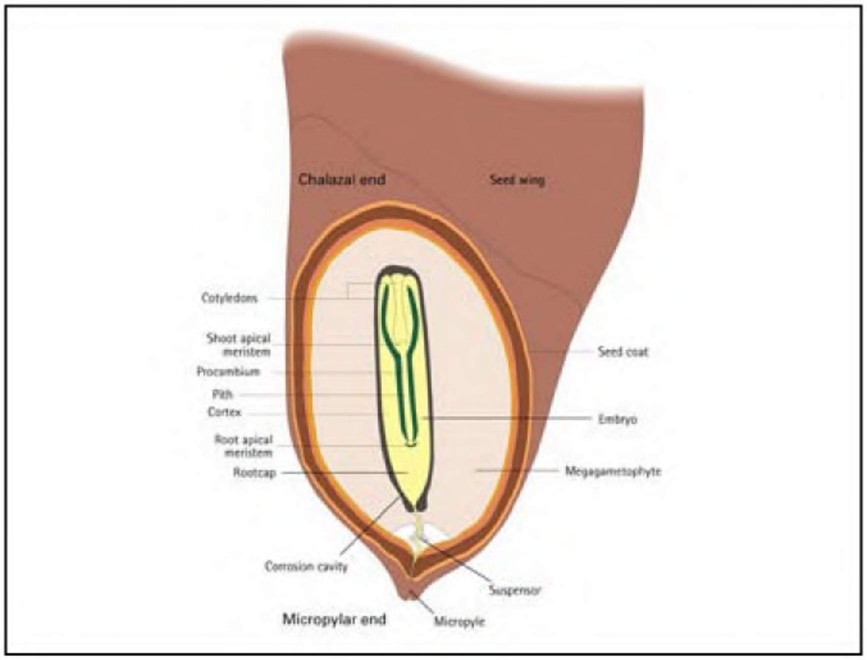

Figure 2. The anatomical details of a generalized conifer seed in longitudinal section.

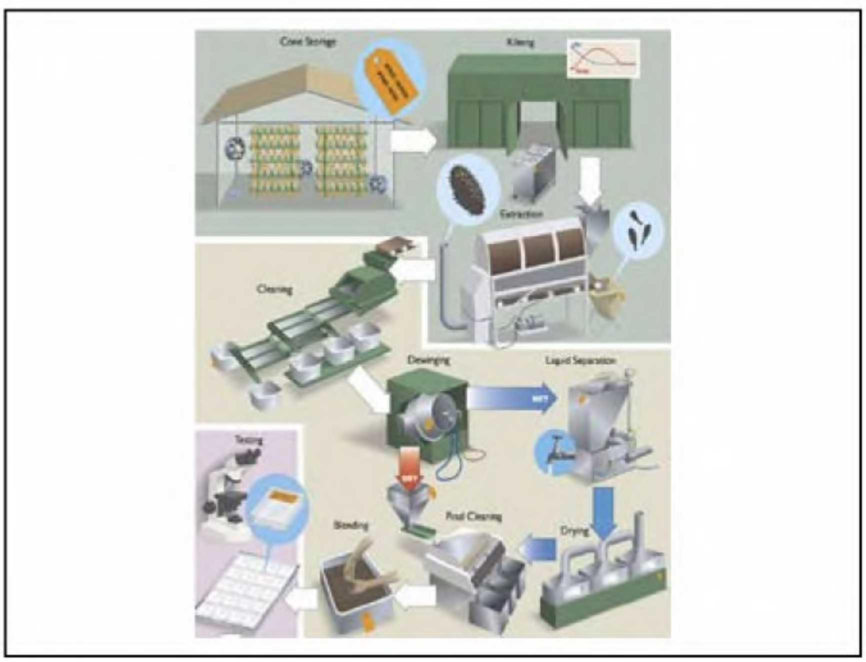

Figure 3. A generalized view of conifer cone and seed-processing steps.

warm, dry environment to flex the cone scales and allow seeds to be extracted. An overview of cone and seed processing steps are illustrated in Fig. 3. The *Abies* sp. are the exception and are usually not kilned or tumbled because their cones natually disintegrate with additional conditioning.

Following kilning, the seeds are extracted from the cones in a large mesh cylinder referred to as a tumbler. The speed of rotation and angle of the cylinder are adjustable to allow for optimization by species. Seeds will fall through the mesh screen and onto a conveyor belt that will collect seeds and debris in a plastic bag. Spent cones traverse the length of the mesh cylinder and for small-coned species they are vacuumed out of the processing plant to an outside holding area. For large-coned species, cones are manually removed from the extraction area.

Extraction is a critical point in processing and monitoring unextracted seeds per cone is very important. If all viable seeds are not removed from the cones at this point in time it can have a large impact on yield, and there is no second chance. It is important to determine through cutting tests whether unextracted seeds are viable, since many "empty" seeds are routinely retained in the cone. If it is determined that sufficient viable seeds still remain in the cones and are extractable, the seedlot, or a portion of it, may be rekilned to improve cone opening and extraction efficiency. Excessive tumbling should also be avoided; it introduces additional debris to the seedlot, reducing processing efficiency and possibly damaging seeds.

The *Abies* taxa are not kilned or tumbled, making their cone processing unique. Upon receipt, cones are de-sacked onto plastic trays and placed into a pre-conditioning area that is maintained at a temperature of 10 to 15 °C with fan ventilation provided. The cones will remain in this area until the cones have disintegrated (generally at about 15% moisture content) and are then put over a vibrating screening machine to remove cone axis and scales and fine debris particles.

SEED PROCESSING

Seed processing involves the removal of debris, removal of nonviable seeds, and reduction of seed moisture content to prepare the seeds for long-term storage. Many different processes and pieces of equipment may be used in seed processing, and different species have different requirements. For example, all *Pinaceae* species have their seed wing removed during processing. However, the seed wing is not removed in the Cupressaceae species since it would significantly damage the seeds.

Initial cleaning is the first step in seed processing and is primarily concerned with the removal of debris from a seedlot. This debris may add moisture or pathogens or may mechanically damage the seeds, and therefore its early removal is a priority. A "scalper" or multi-screened vibrational seed cleaner uses metal screens of varying opening sizes, shapes, and arrangements to separate seed from debris. Choice and order of screens as well as vibrational speed are based on the species and type of debris in each seedlot and are important decisions for efficient and successful seed cleaning.

The seeds separated during initial cleaning will then be dewinged to remove the seed wing from its attachment to the seed coat. Dewinging generally occurs in a rotary drum or cement mixer in which rotation speed and angle can be controlled and water can be added if required. The seed wings are blown off in the dewinger and/or removed during final cleaning. Species that are wet dewinged also subsequently undergo a very brief water bath, which helps to separate particles denser than water (i.e., rocks and pitch), which sink to the bottom of the liquid separation tank. Wet dewinging results in much "cleaner" looking seeds that will not release more debris (wing remnants) over time, but not all species respond to wet dewinging. Dewinging is a stage in which the probability of seed damage is higher, and it is important that the activity be as brief as possible to accomplish the required product.

Final cleaning is the final removal of debris particles, which should have been minimized through previous processing, and the removal of empty, immature, and nonviable seeds. Two pieces of equipment can be used for final cleaning: aspirators or the gravity table. The aspirator or pneumatic separator uses an adjustable air column to separate seeds based on terminal velocity, which is influenced, by specific gravity, size, shape, and surface texture (Edwards, 1979). Aspirators may have several, usually three, outlets for seed discharge. These are commonly referred to as light, mid, and heavy seed fractions. Cutting tests are used to calibrate airflow settings and determine if acceptable separations are occurring. The machine is set up to separate the heavy seeds considered filled and viable from the light fraction consisting of "empty" seeds and debris. The mid fraction is usually a combination and commonly has to be re-run, with adjusted settings, to separate out the viable seed. Various configurations on this central concept have been constructed and the "aspirator" is a common piece of equipment found in most seed-processing facilities.

The gravity table, originally used in the mining industry, is the primary tool used for final cleaning at the B.C. Ministry of Forests Tree Seed Centre. Seeds are separated across an inclined deck that moves in two directions — up and down, and backwards and forwards. An air current is also present from below the deck. Although it requires a great deal of dedication on the part of the technician, it can produce excellent separations. The gravity table is initially overwhelming because the operator has many variables to control.

The air current blown through the gravity table deck is strong enough to lift the light seeds slightly off the surface. These light seeds, not in contact with the deck, will run to the lower end of the deck due to the force of gravity. The heavier seeds, in contact with the deck, will be moved upwards with the reciprocating motion of the deck. The outcome of light seeds running down the deck and heavier seeds running up the deck initially seems counter-intuitive until one recognizes that different forces are used to move these fractions in their respective directions. Separations are performed on the gravity table by placing dividers on the discharge end of the deck separating the seeds into heavy, mid, and light fractions similar to the aspirators. The placement of dividers is determined through cutting tests, and it is common that more than one "run" is required for each seedlot. Separate runs on the gravity table may include changes to settings and adjustment of dividers based on additional cutting tests.

Following final cleaning the seedlot will be blended to ensure it is homogeneous prior to sampling for testing and placement in long-term storage at -18 °C

LITTERATURE CITED

Edwards, D.G.W. 1979. An improved air seed-sorter for laboratory use. Environ. Can., Can. For. Serv., Pac. For. Res. Cent., Victoria, BNC. Info. Rep. BC-X-188.

Hamrick, J.L., M.J. Linhart, and **J.B. Mitton.** 1979. Relationships between life history characteristics and electrophoretically-detectable genetic variation in plants. Ann. Rev. Ecol. Syst. 10:173-200.