Cone Maturation, Collection, Storage and Handling

Dave Kolotelo
Cones are the Vehicles to our Seed

- **Cone Maturation** – continuous process primarily heat unit driven
  - Talk will focus on post-fertilization events until collection
  - Pli specific falldowns not covered in this talk

- **Cone Collection** – a point in time designed to maximize seed yield and quality *(decision is influenced by other crops)*
  - What are our indicators *(review – emphasis on practicality and facility development of localized tools – no silver bullet)*

- **Cone Storage** – continuation of ‘maturation’, can impact seed quality, and yield
  - What is after-ripening? What conditions are required?

- **Cone Handling** – activities used to inform, maintain, or enhance cone condition, seed quality and yield
  - Everyone has a role in exercising due diligence

- **Tree Seed Centre - Upcoming Work**
  - Kilning trials, efficiency quantification, water activity
Cone and Seed Truisms

- Seed Quality (germination%) is thought to be maximal at time of natural dispersal - we want to collect at dispersal = **IMPRACTICAL**
  
  **Labour and Time Issues**

- Patterns of seed quality (germination) during development may be obscured by embryo dormancy which develops during maturation

- Goal is seeds mature enough to be extracted, and to germinate under optimal & suboptimal conditions, and which can be freezer stored for prolonged periods 😊

- Moisture content is directly related to damage potential
  - (moisture content ↑ then risk of damage ↑)

- The earlier the collection (relative to seed shedding) the more attention needs to be paid to post-collection handling!
Germination is not solely a population characteristic!

Germination = function of
- Cone Collection timing
- Cone Handling, Storage and Transport
- Cone and Seed Processing
- Seed Pretreatment

Seed Yield is influenced by the above factors and the Pollination and fertilization success for each crop

Most cone ‘maturation’ work (1950’s, 1980’s) aimed at wild stand seedlots – even there they found differences in seed maturity between
- Years (on any given day)
- Stands ~ differences between orchard clones
- Trees within stands
- Cones within a tree (location / aspect)
- Seeds within a cone
Cone Maturation

- Maximum cone dry weight achieved prior to full maturation
- Very high initial moisture content (60%+)
- Cone dehydration is accompanied by build-up of storage components in megagametophyte and embryo
  - Simple sugars $\rightarrow$ complex sugars, fats, proteins
- Megagametophyte changes from jelly-like to firm and white
- Conifer seeds are not vascularized
- Cones have one vascular strand into bract and two traces into the scale which branch
- Embryo nourishment is supplied primarily from embryonic fluid in the corrosion cavity secreted from the megagametophyte
- Mature Embryos have a well developed vascular system
- Female cones photosynthesize
Seed Maturity

- We are almost always dealing with needing to “after-ripen” crops (i.e. some degree of immaturity = collecting before seed shedding)

- **What is Possible** – 3 month early harvest in NZ with Radiata pine – Shaf (ProSeed) - feeding the genetic gain program immediate need
  - Limiting factor was not seed maturity, but seed extractability from cones!
  - No obvious anatomical changes occurred during this after-ripening period
  - Feasible for other species or lucky combination of an exotic and a new environment?

The more pre-mature the collection, the more exacting the cone storage conditions need to be to get continued development -

- Temperature
- Humidity levels both of which could be interior orchard challenges

- **What works one year shouldn’t become Standard Operating Procedures**
Collecting Timing
Impact on Germination

- Collections from early, mid and late clones bulked together
- Poor germination from earliest collections
  - Bias from bulk collections (late clones very bad in early picks)
  - How early can early clones be picked? Window-widening

Seeds must reach a stage at which they are independent of the tree for nutrition
Monitoring the condition of a crop prior to harvest is important to:

- **Determine size of crop**
  - Seed planning (budgeting / present + future needs)
  - Plan resource requirements (pick, interim storage, transport)

- **Determine maturity level**
  - More frequent monitoring closer to collection
  - Proper sampling of stand/orchard variability

- **Determine pest problems**
  - Pro-active or active control in orchard
Any result (i.e. fspc) is only as good as the sample taken!

Randomly drawn from the population

Representative of proportions in the population (i.e. clones)

Seed orchard seed represent much more variation than natural stands

- Removal of inbreeding depression
- Recombination of genotypes previously not in contact (although climatically similar)

Sample size determination has three components

1) Accuracy required (i.e. 1 fspc)
2) Variation present in trait of interest
3) Risk tolerance (often 95% confidence used)

We looked at seeds per half cone for wild interior spruce seedlots

- Provides indication of accuracy and risk = information (averages aren’t all created equal)
- Accuracy not linearly related to sample size

<table>
<thead>
<tr>
<th>Accuracy Level (# seeds/half cone)</th>
<th>Estimated sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32.3</td>
</tr>
<tr>
<td>2</td>
<td>8.0</td>
</tr>
<tr>
<td>3</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Accuracy not linearly related to sample size
Cone Maturation Indicators

Emphasis on site-specific method development - What works for your site, species and employees
Cone Morphological Observations

- Cone maturity is tied to a reduction in moisture and lignification of tissues (woody structure)
- Extremes in appearance are obvious – the earliest we can pick cones is not so obvious from cone morphology
- Cone colour, bract colour, firmness - degree of scale flexing (1953)
- Seed or seed wing colour are not great indicators, especially with seed orchard crops – large variability between clones
- Seed wing release from cone scale is HIGHLY RECOMMENDED
  - Separation of seed from ovuliferous scale
Half-Cone Cuts
(not recommended for lodgepole pine)

• Originally designed to help determine whether to collect a natural stand crop (Y/N) – megagametophyte presence
• Seed orchard crops are almost always collected
  • Pest observations / axis test
• FRDA 55 – correlations between filled seeds in ½ cone and whole cones:
  • Douglas-fir : \( r^2 = 0.71 \)
  • Interior Spruce : \( r^2 = 0.81 \)
  • Subalpine fir : \( r^2 = 0.77 \)

FRDA 055 minimum collection standard for lodgepole pine is 20 filled seeds per cone!
Cone “Axis Test”

- KAL credit Kudo’s (Chris and Gary)
- Assessment of moisture level / cone independence
- Quick and easy to perform in the field!
- Useful for western larch, interior spruce and Douglas-fir
- Cut cone longitudinally – does axis appear brown and dry? Indicating link with tree has been severed
- Or does it still contain moisture (Gary suggest running knife blade on axis – look for water droplets)
Cutting Tests

- ‘seed anatomy tests’
- Seed cut longitudinally
- **embryo length in relation to corrosion cavity (> 90%)** *(1982 still using 75%)*
- Megagametophyte = white with a firm, solid consistency
- Used extensively in cone and seed processing – viable / non-viable seed estimation
- Lack of overnight megagametophyte shrinkage used by some to indicate maturity
- Green embryos are a ‘warning’ → germination
Embryo Cavity Ratio

August 17

- Embryo cavity ratio has been a good maturation indicator
- Physiological maturity continues after this stage
- Reason for proper post-collection handling procedures = After-ripening
Other Methods Used

- **Liquid Floatation** - cones will dry and will reach a certain specific gravity at maturation – consistent measurement – clonal variation?
  - Direct specific gravity assessment cumbersome
  - Liquids (kerosene, various oils) have been used to assess maturity (1950’s)
  - When some % (80-90) of cones float then , cones are considered mature
  - Is there something we can use to make water less dense?

- **Degree Days** – maturation is primarily degree day driven
  - Lower and upper threshold temperatures?  5 and 35 °C used at KAL
    - At high temperatures, ‘reactions’ may cease or slow-down
  - Can provide a good guide to crop progression vs. other years

- **Indicator plants** – integrates other environmental variables (light, precipitation …)
  - For white spruce, fireweed capsule bursting was found to be superior to degree-days

- **Biochemical indicators** – generally not field methods
  - Amount of reducing sugars shown to be an accurate method
  - Leachate conductivity – decreases during maturation
ONE TIME ACTIVITIES

- Collection, post-collection handling & transport
- Care, organization and $ invested at these stages will be ‘captured’ for the entire life of a seedlot
- Do you only quality assure your cones until they are in the sacks? Investments in QA
- Do you know what conditions your harvested cones experienced
  - Yesterday at noon
  - Last night
  - Do you open your cones sacks during storage

“Risk Management” requires a real appreciation of when risks are greatest
And what the costs of failure are
Cone Collection Due Diligence

- Use new sacks or properly sterilized sacks (steam/hot water)
- Limit amount of debris included (mc / fungi / abrasive)
- Move sacks daily from collection site to interim storage
- Correct Identification (Outside and inside sacks)
- Fill sacks ½ to ⅓ full to minimize heat build-up / cone expansion
- Keep sacks off ground / on sides to reduce weight
- Place sacks in shady, cool environment protected from the elements and pests with good air circulation (fans help!)
- Turn sacks to encourage uniformity, discourage clumping
  - Frequency depends on cone moisture content
- Examine cones during cone storage –
  - Know how your cones look at shipping, not just at picking
Cone Storage

- Goal is to slowly dry the cones and complete maturation process maximizing seed extractability and germination
- Physiological changes continue after anatomical maturity has been reached
  - Protection / Aeration / humidity levels?
  - Weight distribution / restricting opening

Serotinous Pli can be stacked
Coneworms (*Dioryctria* spp.)

- Insect continues feeding after cone harvest! Distinctive dark head
- Complicated life cycle = overlapping generations makes control difficult
- Identification during seedlot evaluation crucial – prioritize extraction // cooling slows feeding
- COMMUNICATION
Fungal Problems

• Uncommon, but do occur
• Easy to correct if identified early
  • change environment
• Lack of due diligence with post-collection handling

• Communication!
Cone Storage Impact on Germination

- Caron et al 1990
- 18 Op white spruce trees
- Collected at time of seed shedding

Impact of prolonged cone storage as important as stratification!!!
Cone Storage

• Cones collected over several dates were subjected to three treatments
  • Immediate extraction
  • Ambient Temperature
  • Controlled Environment
    • (4 weeks)
    • (4 weeks 5°C – 75-100% RH)

• At all collection dates the controlled environment treatment maximized germination
Cone Transport

- Communication, communication, communication

- Palleted shipments please!
  - Aeration
  - Cone tags facing out
  - Seedlot / family separation clarity important

- Keep Shipment cool
  - Shipping distance
  - Moisture content of cones

- Later collected (close to shipping) material is...
  - higher MC / expedited racking / extra ventilation
TSC Perspectives/ Activities

- General sense that many conelots arrive at TSC with moisture contents below the optimum seed extraction = cones too dry
  - Earlier shipping
  - Multiple shipments?

- Conducting trials this fall looking at various kilning regimes to improve efficiency (mini-kiln on site= controlled temperature*humidity chamber)
  - Lab scale ➔ inform large scale needs
  - Increased extraction efficiency / decreased energy + time required

- Call for Cones !
  - We don’t just sample your cones
  - Anyone interested in participating, please contact me
  - Rough estimate would be 100 cones  (Pli probably more)

- Call for fspec information
  - Most orchard crops are open on arrival and we can’t get an accurate estimate
  - Is information available ???
Cone Opening

• Cones react to RH% similar to the way a bimetallic strip responds to temperature
• Difference are due to orientation of cell wall microfibrils
• **Upper Scale** – low angle microfibrils resist elongation
• **Lower Scale** – high microfibril angle allows elongation when damp closing cone

• Cones can be calibrated to be a hygrometer **HYGROMORPHS**

• For serotinous species the resin bond must be first broken before RH plays a role in cone opening
Different method for looking at water status of seeds / cones
- Used extensively in food industry
- Provides a more accurate assessment of deterioration risks
- Relates to moisture availability for biotic and abiotic factors
- Potential use for determining when physiological maturity is complete

- Technology is also used for constructing seed and pollen driers
  - Drying without heat
  - No chance of overdrying
- Not efficient for large-scale driers (kilns) – cabinet style

- Baldet + Colas article in Tree Planters Notes
EXTENSION
Tree Seed Working Group Newsbulletin

Dave.Kolotelo@gov.bc.ca
TREE SEED

"HANDLE" WITH CARE
"STORE"
IN COOL AREA
OPEN UPON RECEIPT

PERISHABLE