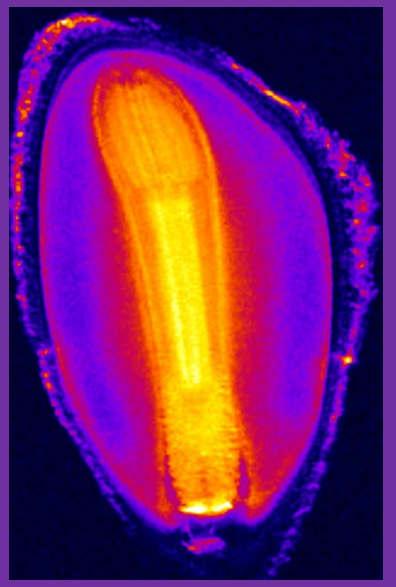
Forgotten Gems and What's on the Horizon for Seed Science and Technology



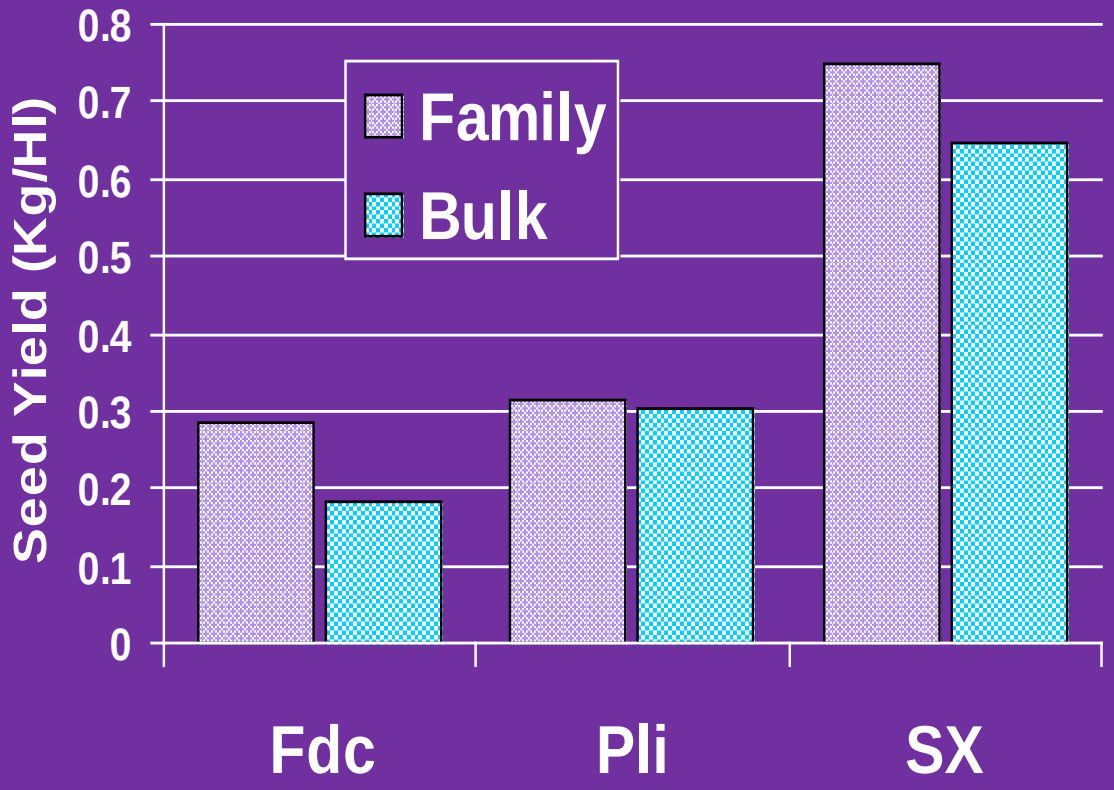
Dave Kolotelo

Connections Through Seed

October 2018

Family Processing (late 1990's)

Comparisons between individual families (10) and bulk processing of the same



Fdc and Sx – average gain of 100 grams / Hl cones

Cost-Effectiveness of Family Processing

Based on reports by Dr. Don Lester (1998)

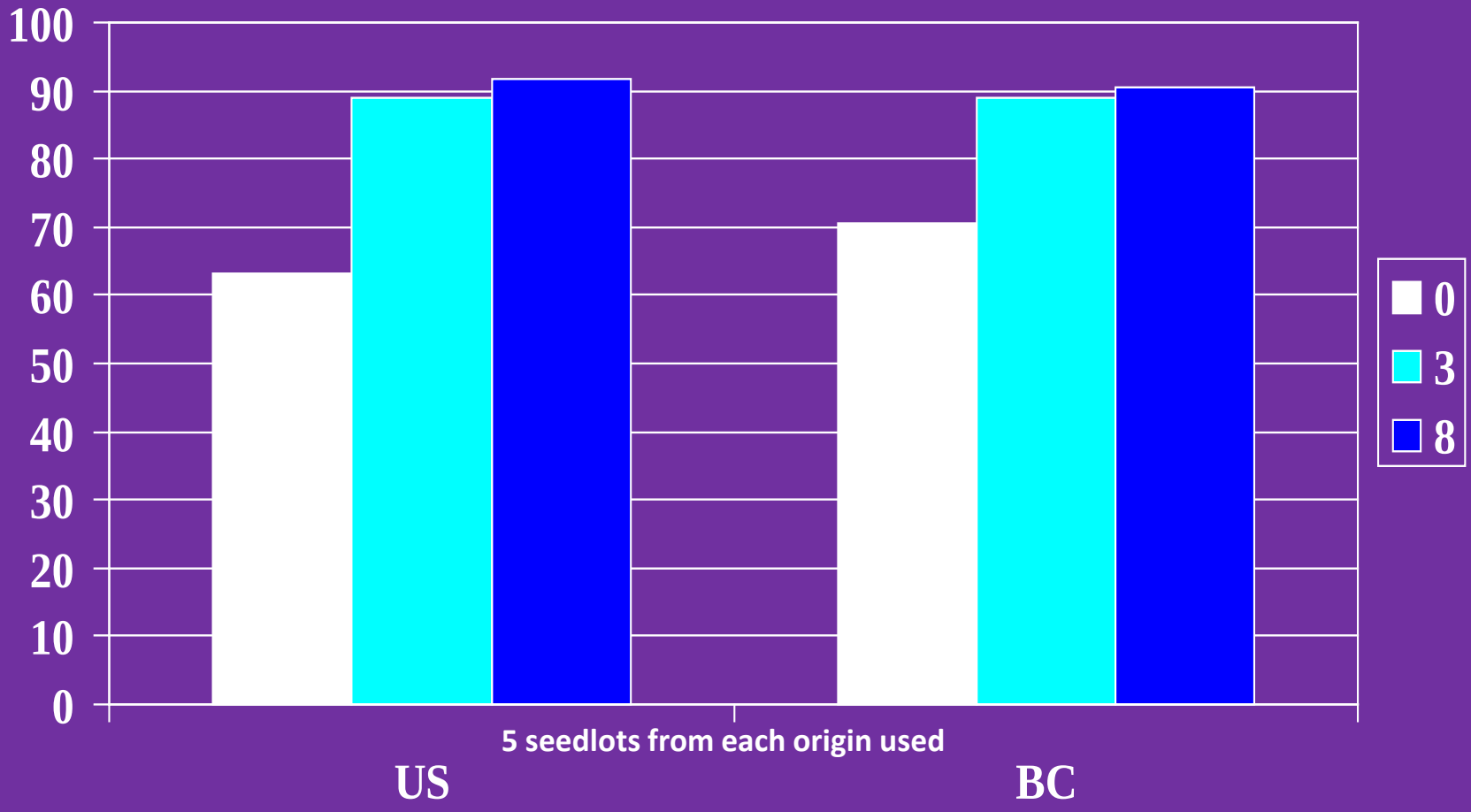
Family lots were in the 10 to 200 litre category

- Large differences between species in cost effectiveness (incremental cost per m^3)
  - Differences in growth rate and rotation age
  - Fdc > Pli > Sx
- Sensitivity analysis looked at ±25% in
  - Site Index
  - Processing costs
  - # Seedlings produced
  - Genetic Gain (%)
- Site Index was by far the most important factor on cost effectiveness
- Family processing has also been used to identify and cull clones with germination problems

Stratification Benefits

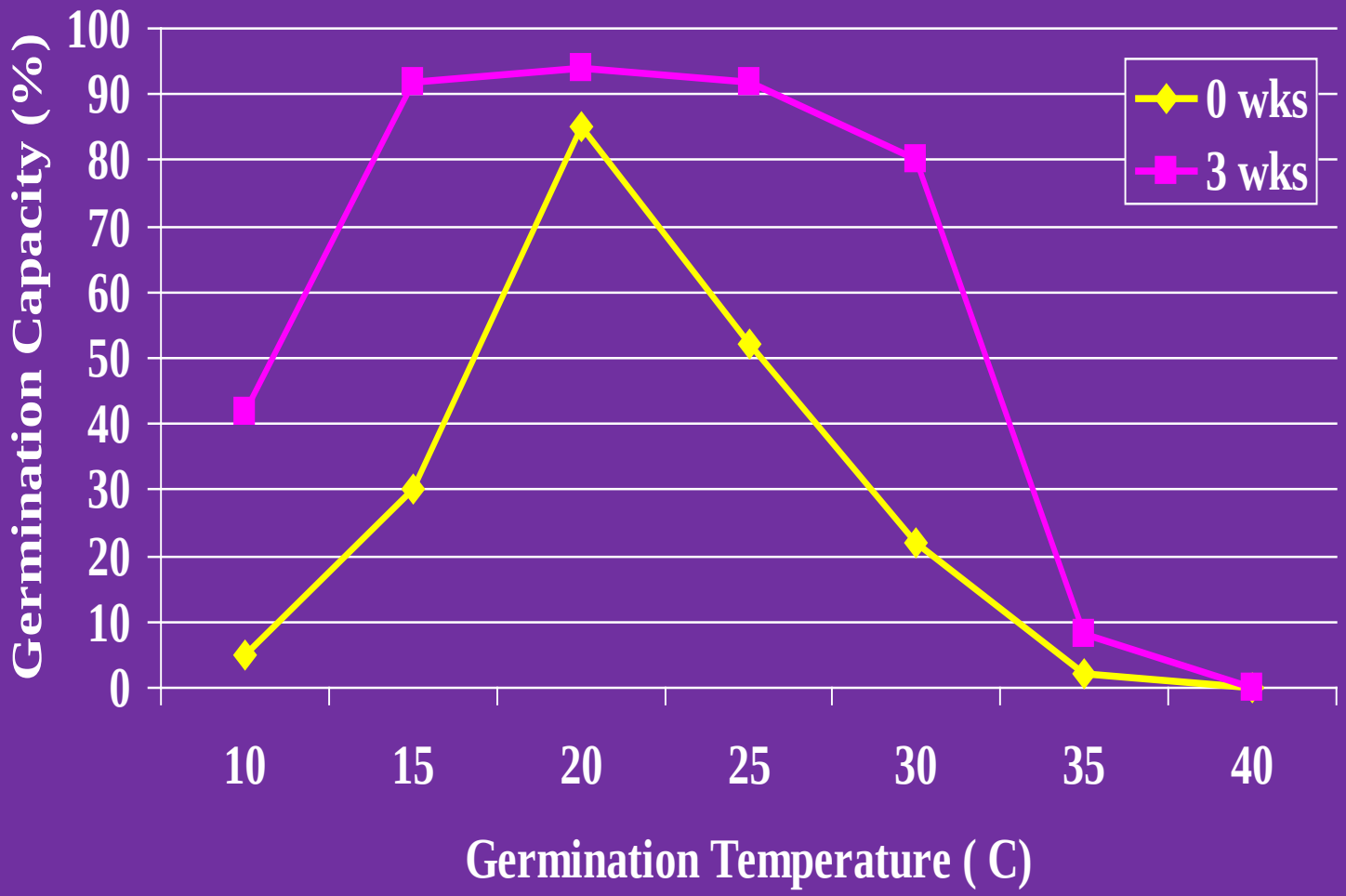
- Overcome embryo dormancy to allow germination to proceed
- Increased speed and uniformity of germination
- Increased vigour (*i.e.* increased ability to germinate over sub-optimal conditions)
- Decreased window of opportunity for pests
- Activation of natural cellular repair mechanisms

A- class Fdc - 0, 3, 8 wks Stratification



- Extended stratification has limited benefits under optimal conditions
- Extended stratoification may be extremely useful when you cannot provide optimal conditions

Stratification increases Vigour



Stratified seed is able to germinate to its potential over a wider ‘temperature’ range

BIG Bang - Thermal Priming

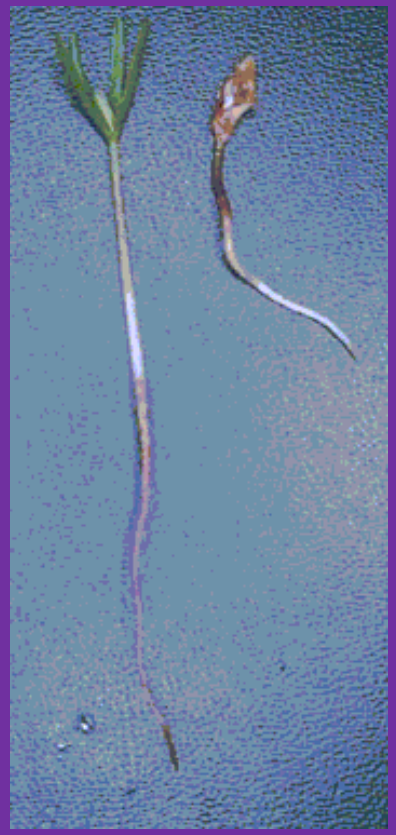
- **Best investment you can make at the nursery !!**
- Thermal priming – accumulate heat units into stratified seed prior to sowing
- BIG cost savings by accumulating some initial heat sums for germination in confined space vs. entire greenhouse

  - Seed should be fully hydrated and stratified
  - Slower build-up @10-15 C less risky for pre-germination than @ 25-30
  - Build-up and develop a local program slowly (not buy a piece of equipment,
  - Most to gain in colder climates
  - **Monitoring** - Ensure seed is not drying out, germinating, or growing mould
    - Weighing and Visual monitoring

Seed Thermal Requirements

(this is relative to 4X radicle criteria)

Standard 30:20 regime (All except Abies, H_)			
	30	**20**	
Threshold Temp.	8 hours	16 hours	**Degree Hours**
5 ° C	25 =200	15 = 240	**440**



- From the germination temperature regime we can determine thermal requirements for germination (4X radicle)
- Using **5 ° C** as the threshold we know in testing that each day 440 **degree-hours** are accumulated
- When does germination begin? At least with 4X criteria?

Degree-Hours to Germination (=4X radicle)

Sp	1st Germ Day @ 4X
Pli, Py	5.3
Fdi	5.6
Lw	5.7
Pw	6.3
Sx	6.7
Bl*	**7.3**

- So, how much heat is required for Fdi germination to reach 4X radicle? 440*5.6 = 2464 degree-hours
- We don't have radicle emergence data – 2 to 5 days is realistic **= 880 to 2200**
- If I'm priming @15 ° C how long should I prime? 10*24= 240 degree-hours/day
- 880/240 = 3.7
- 2200/240 = 9.2
- **What's your risk tolerance??**
  - **Radicle emergence – damage**
  - **Drying the seed out**

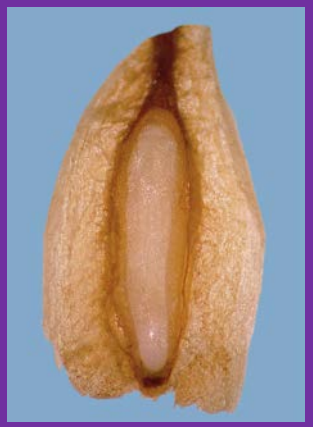
*Bl tested with 25:15 regime = 320 degree-hours vs. 440 degree-hours

Pelleting

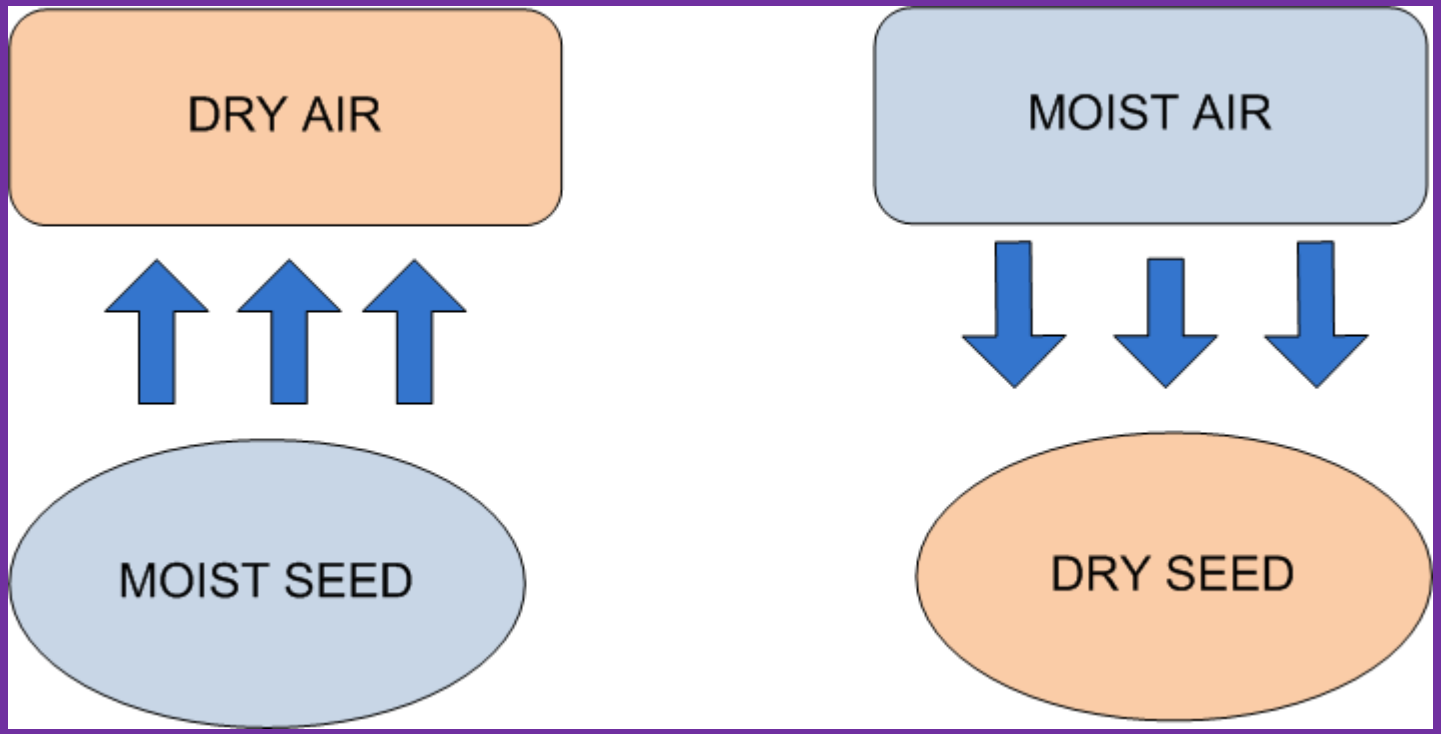
- To aid sowing efficiency Cw and Dr are
- pellet coated
- Results in a 10X increase in mass

- Pelleting –increase weight, size shape →sphere
- Encrusting – smooth out seed, make it easier to handle
- Film Coating – application of a fixitive for applying antifungals, insecticides, biostimulants, colouring

All techniques allow the introduction of additional ‘elements’ to tree seed Are there benefits to justify these investments?



THE BASIC MOISTURE CONCEPT



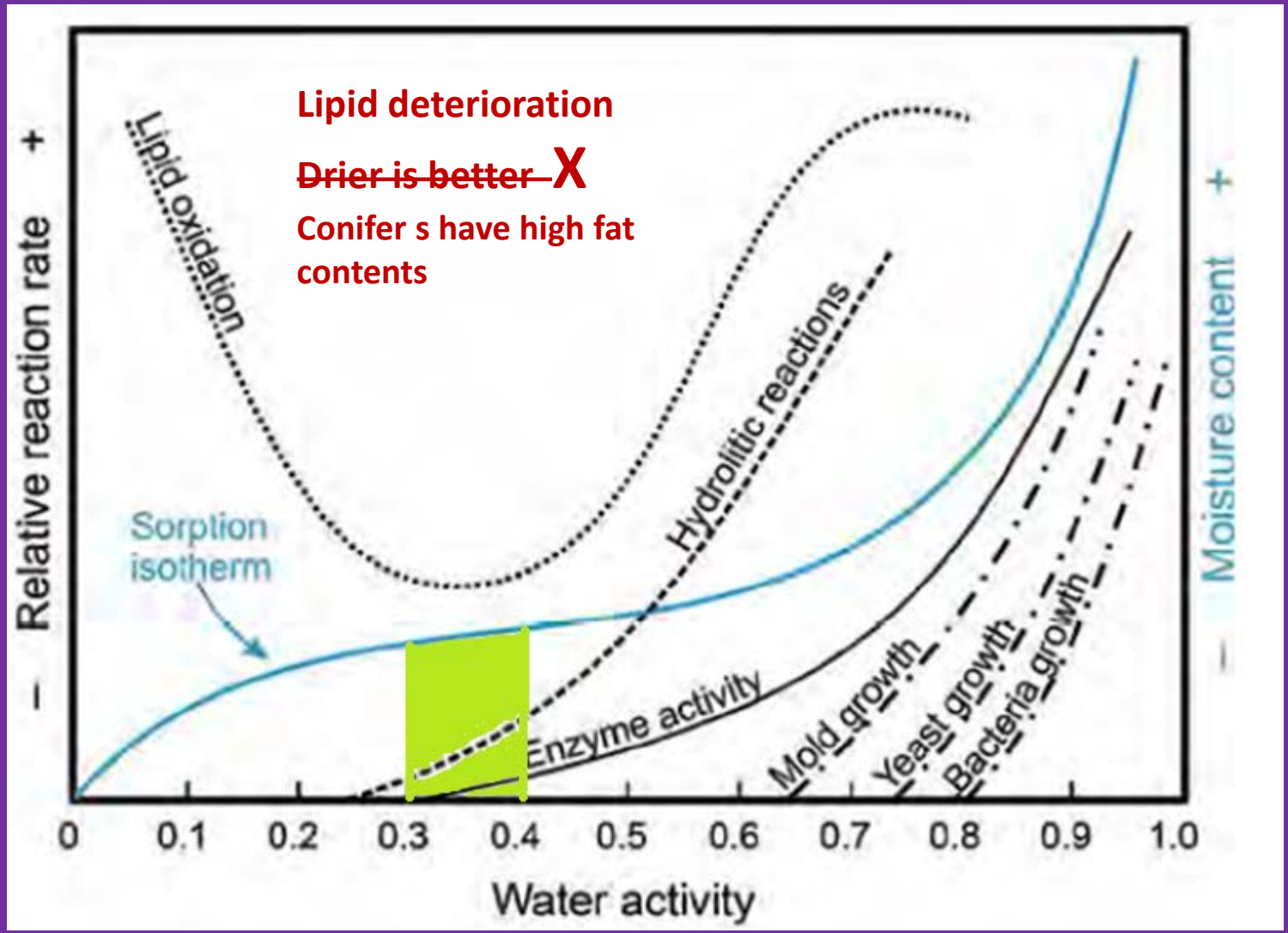
- Seeds are hygroscopic
- Seeds will lose or gain moisture to the environment until an equilibrium condition is reached
- Equilibrium will also be influenced ↓ by fat content
- Fat will not attract water, starchy seeds will attract+ hold water

Image adapted from Bob Karrfalt

Water Activity (Aw)

- This technology was developed and used in the food industry in the 1950's to extend shelf life and stability of foods
- Describes the strength of water's connections or energy status with other molecules
- Aw is equivalent to "equilibrium relative humidity" (ERH) measured in a closed container
- Water will flow from substances of high Aw to low Aw
- Aw ranges from 0 to 1 (pure water)
- **Raisin Bran** is a good simple example – if raisins have a much higher Aw water will move to the bran making the bran soggy and raisins hard. Food formulators use Aw to predict water movement and target the Aw of ingredients. To avoid this
- Also think of historic use of 'water binders' like salt or sugar which **reduces available or free water**

The Aw (energy status of water) controls the biological and chemical deterioration of substances NOT moisture content



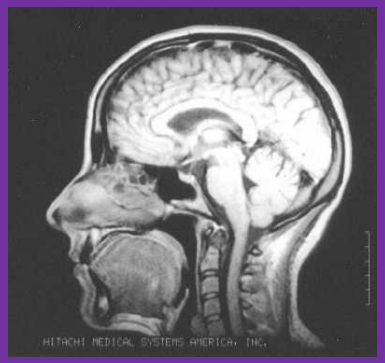
Advantages

- **<u>Non-destructive</u>** (*that was the big incentive using Aw to test our unique, single-tree genetic conservation samples*)
- Relatively rapid results (5 to 10 minutes usually) and can be adjusted to the precision required
- Independent of seed size, maturity, purity, or percentage of empty or dead seeds
- Reference humidity standards (salt solutions) available for calibration

Magnetic resonance imaging (MRI)

NMR tomography

256x256 pixels



25 cm

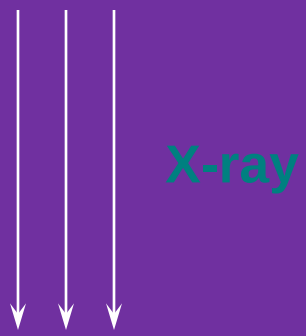
Resolution 1x1 mm^2

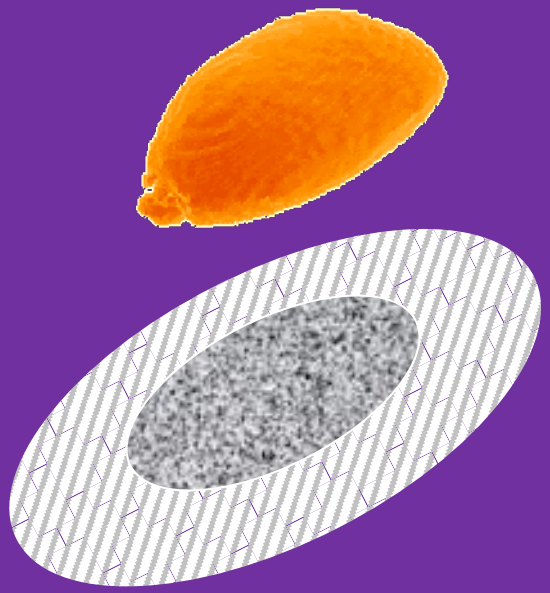
NMR microscopy (microimaging)

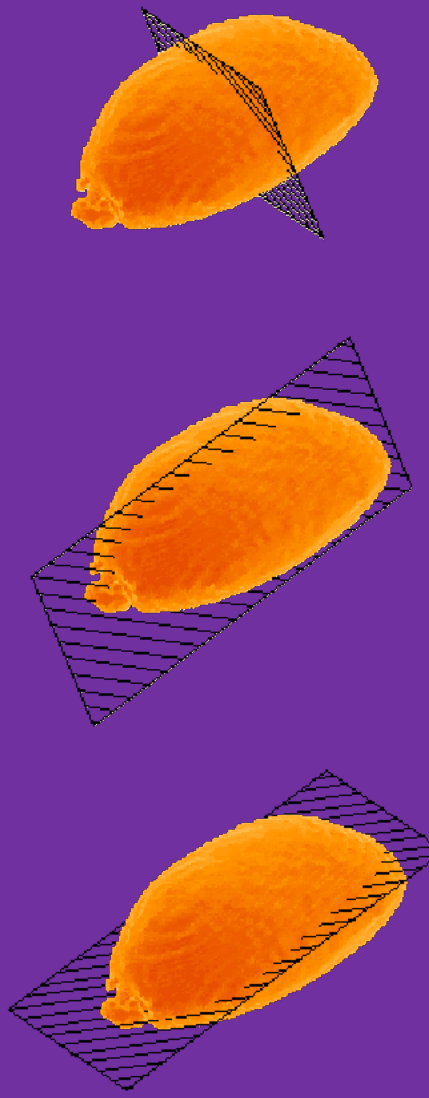
5 mm

Resolution 20x20 μm^2

X-ray vs. MRI

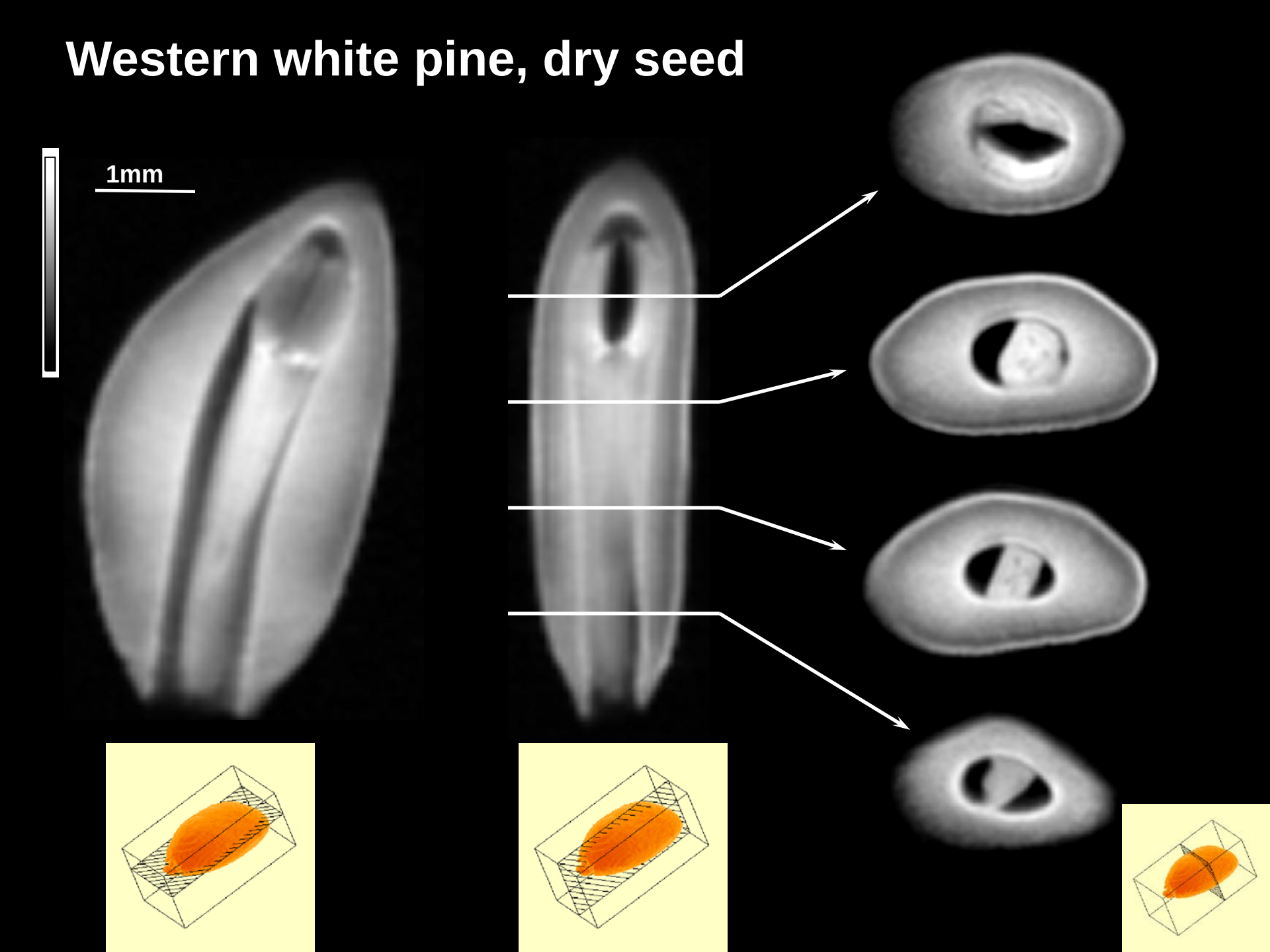




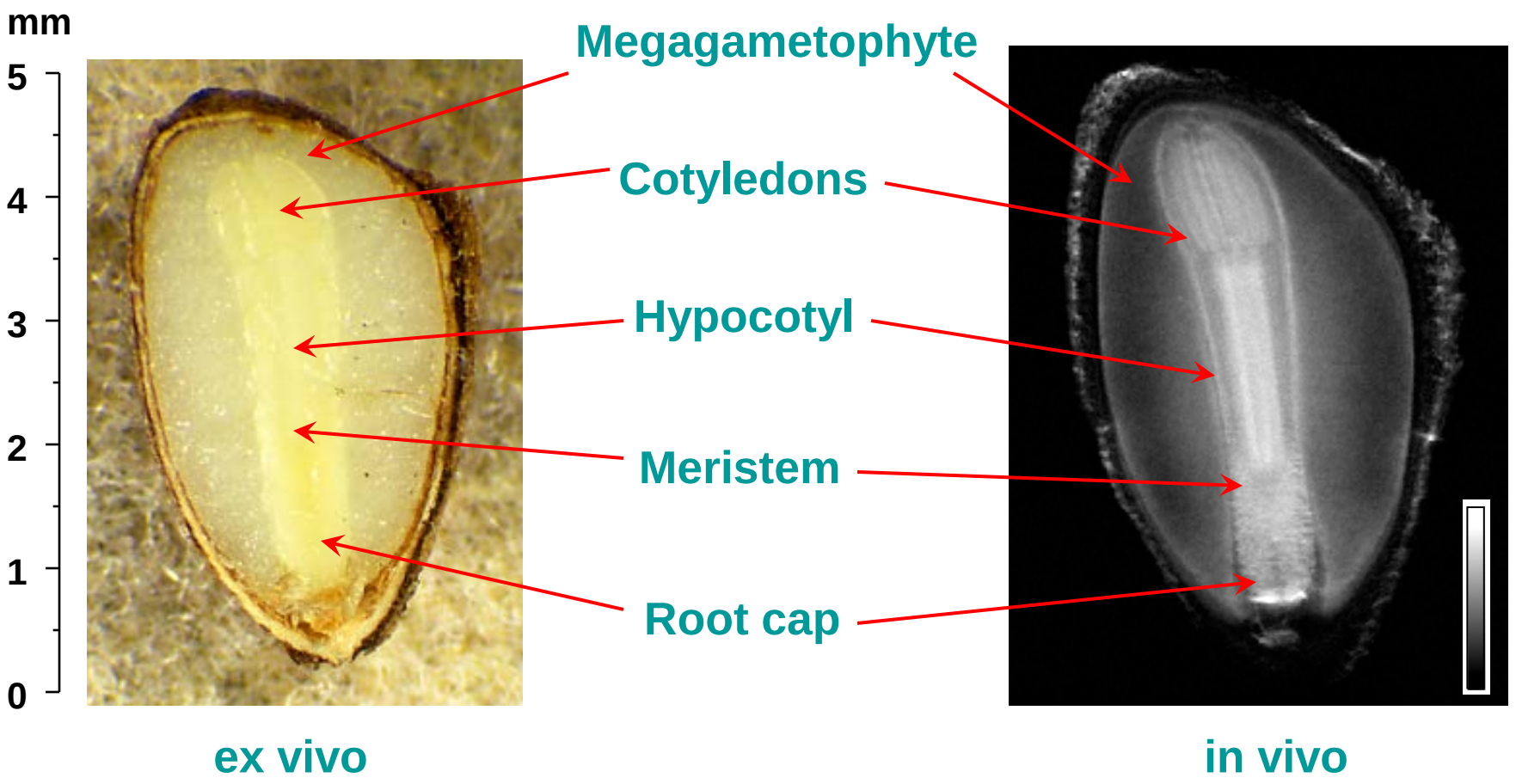


projection vs. slice

Western white pine, dry seed



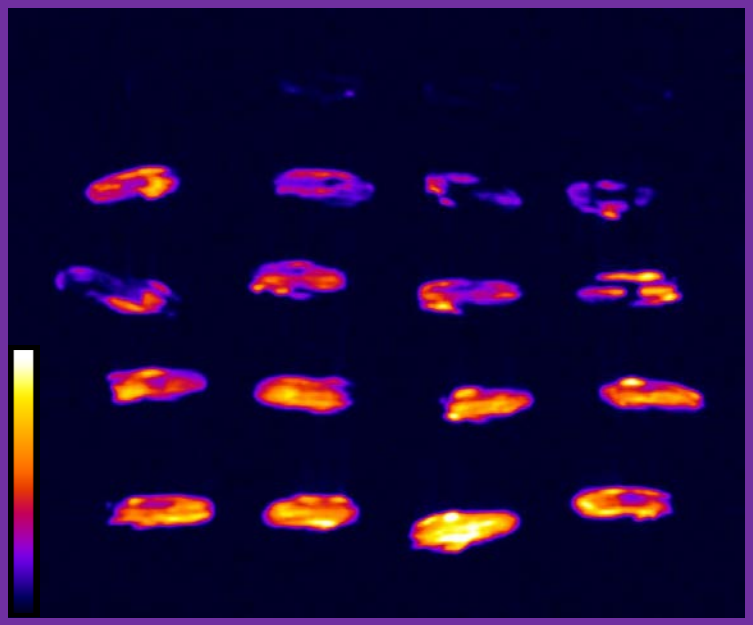
^{1}H NMR imaging
imbibed western white pine seed



MRI in vivo: non-invasively & non-destructively

Allows one to follow the same seeds over time

Oil distribution in seeds of western redcedar via ^{1}H magnetic resonance imaging (MRI)



seedlot

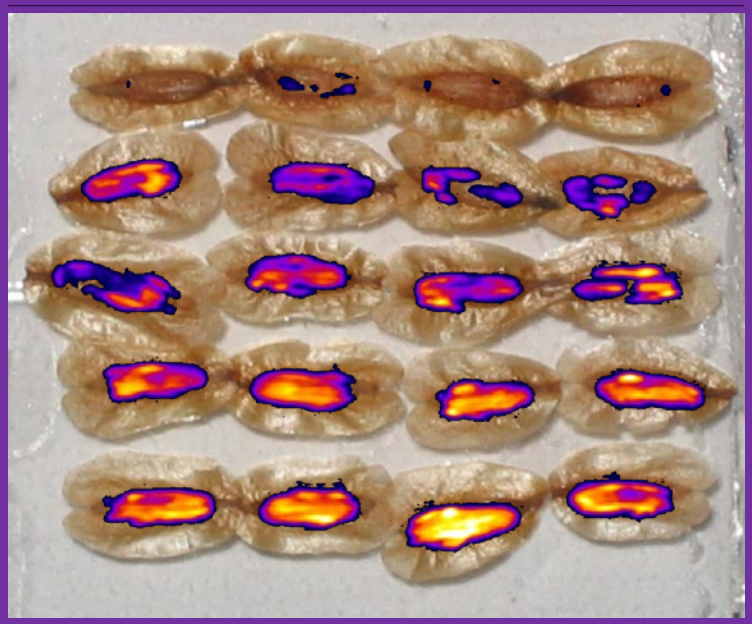
04790 (0%)

20202 (0%)

08484 (0%)

09035 (24%)

27153 (86%)



Lipid oxidation leads to “solidification” of oil due to oxidative polymerization. As a result in deteriorated seedlots the oil ^{1}H NMR signal is broadened and the intensity of the corresponding ^{1}H MRI images is greatly diminished.

Resin Vesicles (*Abies, Thuja, Tsuga, Juniperus*)

Damage to resin vesicles will reduce germination

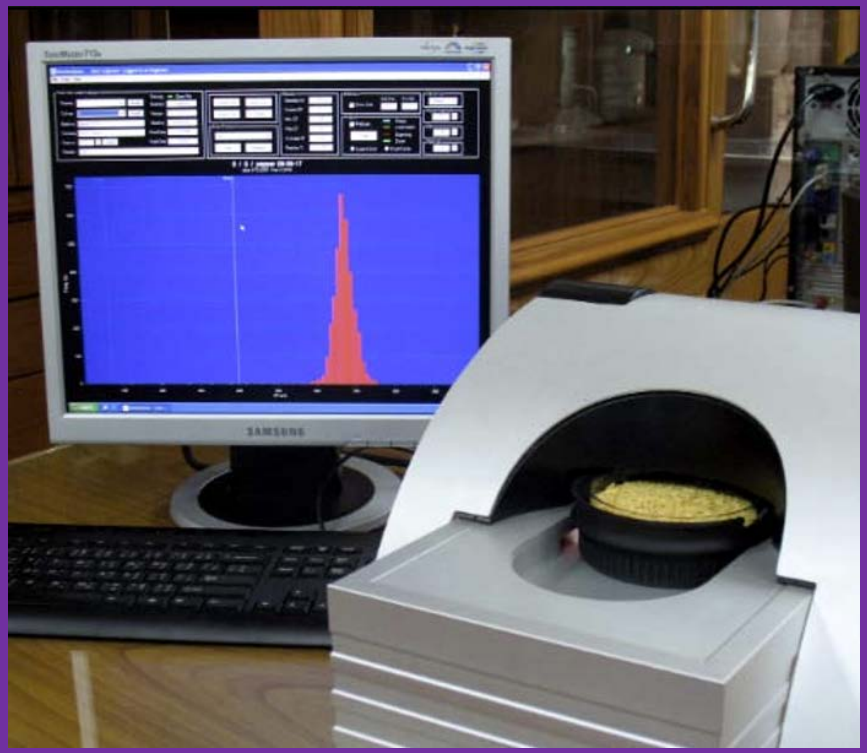
Recent work at UBC and SFU addressing resin vesicles, terpene profiling, damage impacts

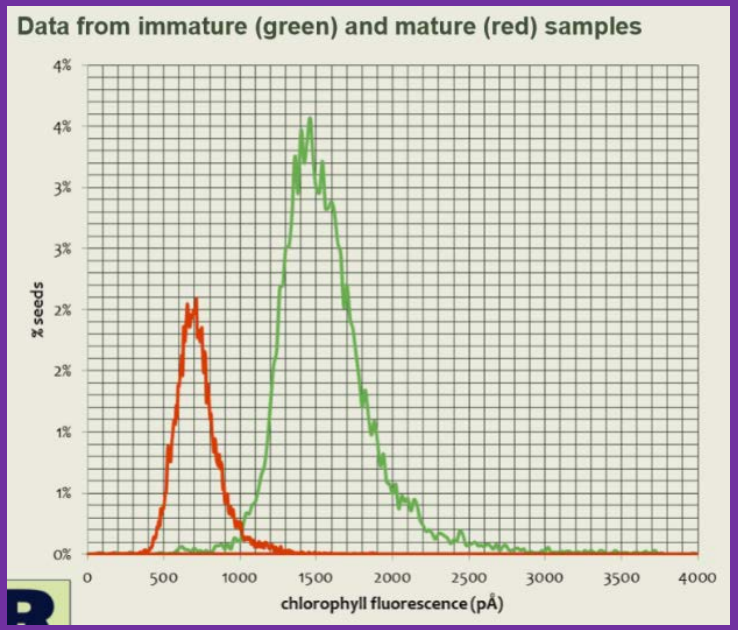
X-Ray estimates for whitebark pine viability

USDA Seed Storage, Fort Collins CO

- We are quite fortunate with storage of conifer tree seed

Chlorophyll Fluorescence





Used for determining crop maturity

Cool Story

- 33% of worlds food production goes to waste!
- Aflotoxins (carcinogenic molds) impact 4.5 Billion people worldwide
- In many areas crops are harvested, but may not be dry enough for storage
- This simple RH% measurement card dry allows farmers to easily determine when seeds/grains are dry enough for storage