Recent Advancements and Outlooks in Seed Technology

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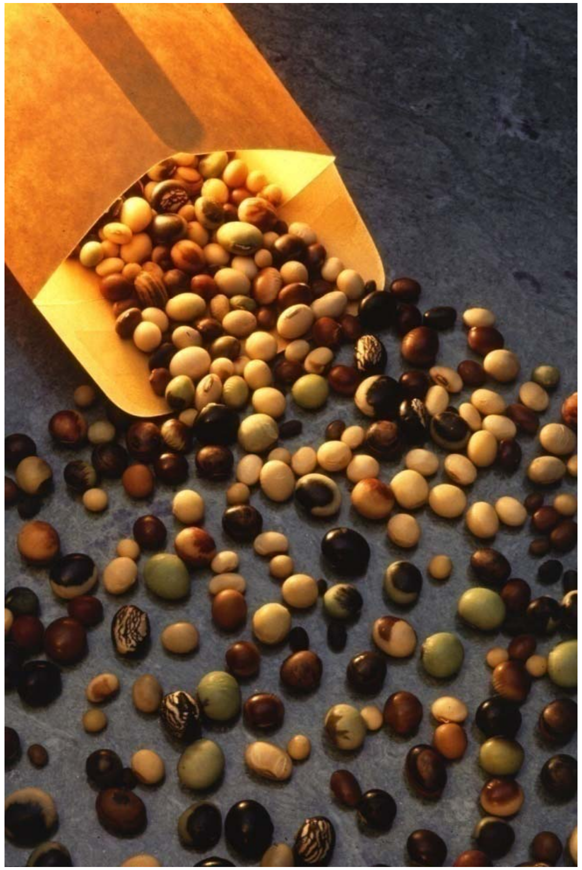
Seed Quality – A Constant Challenge!!

- Objectives
  - How to Produce the Perfect Seed
  - Understand Equilibrium Seed Moisture Content Process
  - Tests for Seed Quality
  - Approaches to Educating Seed Users about Seed Quality

Objective: High Seed Quality

"High seed quality is seed that is genetically uniform, highly viable and free from seed-borne pathogens"



How to Produce the "Perfect" Seed

The "perfect" seed is produced on the plant. Thereafter, we are simply solving problems created during production.

How to Produce the "Perfect" Seed

- Seed production regimes where seed quality is compromised
  - Field/Greenhouse
  - Harvest
  - Drying
  - Conditioning
  - Storage

How to Produce the "Perfect" Seed

- Field/Greenhouse – Most critical
  - Principles
    - High quality plants produce high quality seeds
    - Know thy plant
    - Minimize yield, maximize quality
    - Multiple harvests
    - Understand flower and pollination
    - Understand the "DIW"

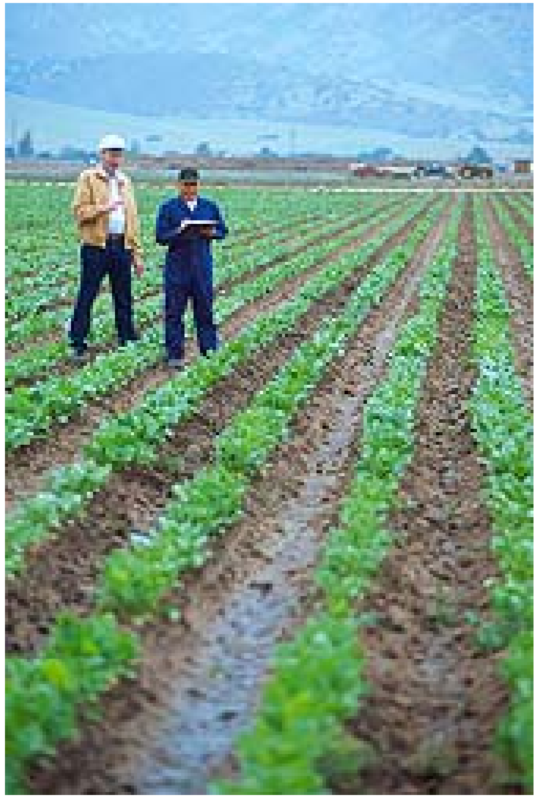
How to Produce the "Perfect" Seed

- Field/Greenhouse
  - High quality plants produce high quality seeds
    - Find the ideal location for plant growth
      - The ideal location for greenhouse production is the tropical highlands
      - Weather conditions mild and even throughout the year

Costa Rica greenhouses

How to Produce the “Perfect” Seed

- Field/Greenhouse
  - High quality plants produce high quality seeds
    - Find the ideal location for plant growth
      - The ideal location for field production is an irrigated desert
        - » Can control moisture and fertilization
        - » Minimize disease
        - » Must have a dry period for harvest



Sugar beet seed production, Salinas Valley, CA

How to Produce the "Perfect" Seed

- Field/Greenhouse
  - High quality plants produce high quality seeds
    - Find the ideal location for plant growth
    - Irrigation
    - Fertilizer
      - Little information on seed yield and quality
      - Do soil and foliar analyses
      - Nitrogen important early, not late
      - Potassium essential for enzymatic activity
      - Phosphorous has little effect on quality

How to Produce the "Perfect" Seed

- Field/Greenhouse
  - High quality plants produce high quality seeds
    - Find the ideal location for plant growth
    - Irrigation
    - Fertilizer
    - Monitor plant for pests
      - Use approved fungicides/insecticides/IPM
      - Do not apply at flowering
        - » Damage stigma
        - » Interferes with pollen tube development
        - » Kills pollinating insects, lowers seed yield

How to Produce the “Perfect” Seed

- Field/Greenhouse
  - High quality plants produce high quality seeds
    - Find the ideal location for plant growth
    - Irrigation
    - Fertilizer
    - Monitor plant for pests
    - Eliminate weeds
      - Lowers seed yield
      - Complicates cleaning
      - Adds noxious weed seeds

How to Produce the “Perfect” Seed

- Field/Greenhouse
  - Know thy plant
    - Identify discrete plant developmental stages

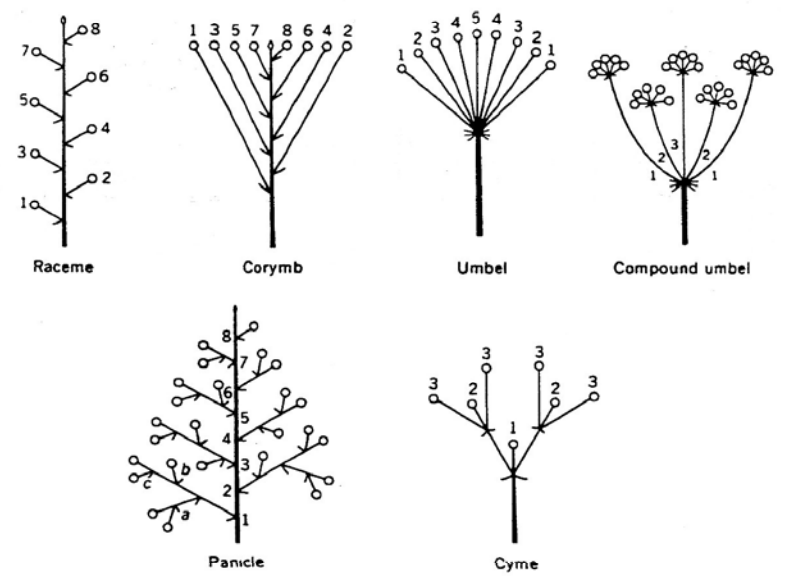
How to Produce the "Perfect" Seed

- Field/Greenhouse
  - Know thy plant
    - Identify discrete plant developmental stages
    - Identify markers for stress

Potassium deficiency in cabbage

How to Produce the "Perfect" Seed

- Field/Greenhouse
  - Know thy plant
    - Identify discrete plant developmental stages
    - Identify markers for stress
    - Understand inflorescence



How to Produce the "Perfect" Seed

- Field/Greenhouse
  - Minimize yield, maximize quality
    - Seed is a sink for assimilates
    - Reduce inflorescence number (particularly late), maximize seed nutrient uptake
    - Seeds do not mature at the same time
    - Make multiple harvests

How to Produce the “Perfect” Seed

- Field/Greenhouse
  - Understand flower and pollination
    - Defines seed yield, determines genetic purity

How to Produce the "Perfect" Seed

- Field/Greenhouse
  - Understand flower and pollination
    - Defines seed yield, determines genetic purity
    - Critical for hybrid production
      - Labor intensive, requires training
      - Flowers small
      - Damage to stigma results in poor seed set
      - Pollination timing important for optimal seed yield

How to Produce the "Perfect" Seed

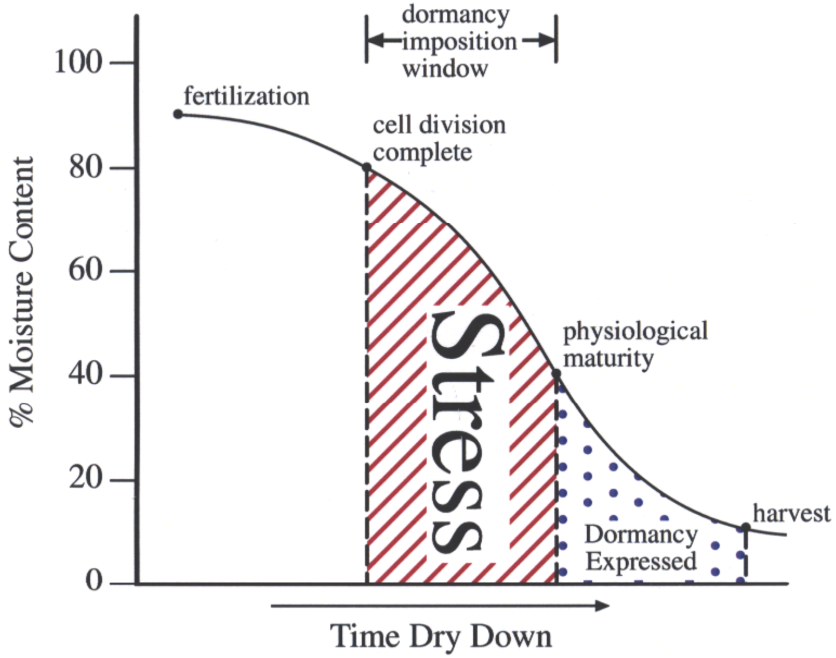
- Field/Greenhouse
  - Understand flower and pollination
    - Defines seed yield, determines genetic purity
    - Critical for hybrid production
    - Field production – know isolation distances (winds/bees)

How to Produce the "Perfect" Seed

- Field/Greenhouse
  - Understand the "DIW" (Dormancy Induction Window)
    - Need to eliminate dormancy and its variability

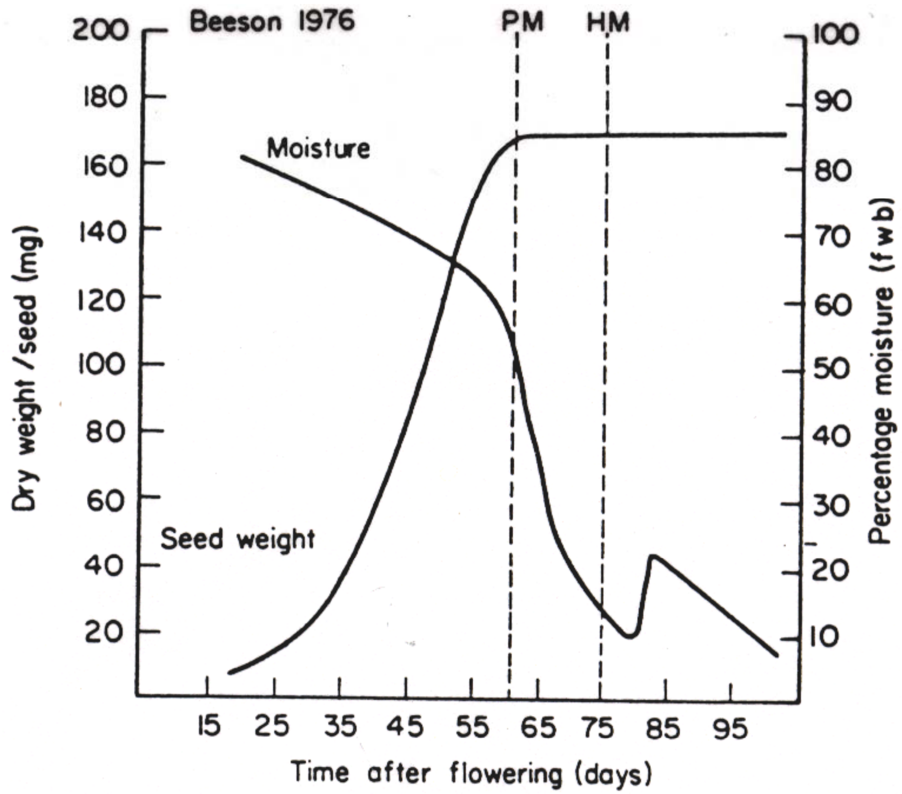
How to Produce the "Perfect" Seed

- Field/Greenhouse
  - Understand the "DIW"
    - Need to eliminate dormancy and its variability
    - Know dormancy induction window "DIW"
      - Dormancy imposed at 70 to 50% moisture content
      - Stress results in high dormancy
      - Understand inflorescence



How to Produce the "Perfect" Seed

- Harvesting
  - Determine PM, identify morphological markers

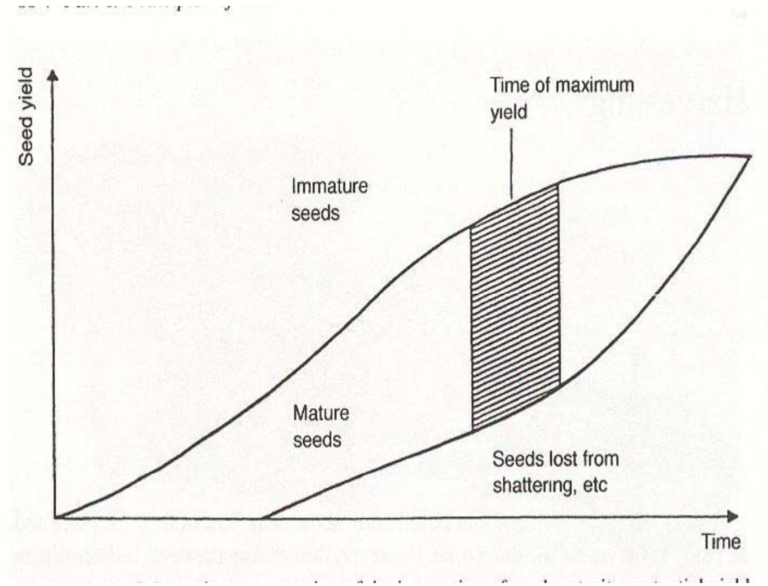


How to Produce the "Perfect" Seed

- Harvesting
  - Hand harvest preferred
    - Minimize mechanical damage
    - Collection of undesired plant appendages
    - Selection of fruits at correct stage of maturity

How to Produce the "Perfect" Seed

- Harvesting
  - Single harvest undesirable
    - Immature seeds low in vigor
    - Old seeds deteriorated
    - Seeds at different "DIWs"



How to Produce the "Perfect" Seed

- Harvesting
  - Determine PM, identify morphological marker
  - Hand harvest preferred
  - Single harvest undesirable
  - Harvest middle of inflorescence for highest quality
    - Contains the majority of seeds
    - Early set seeds old, late set seeds immature

How to Produce the "Perfect" Seed

- Drying
  - Slow (3 days), natural drying preferred
    - Windrowing acceptable in absence of rains/dews
    - Keep seeds in pods/fruits

How to Produce the "Perfect" Seed

- Drying
  - Slow (3 days), natural drying preferred
  - Batch driers best for artificial drying
    - Slow dry (35C) until 20%, then fast dry (40C)

How to Produce the "Perfect" Seed

- Drying
  - Slow (3 days), natural drying preferred
  - Batch driers best for artificial drying
  - Minimize moisture fluctuations
    - Enhances membrane stabilization

How to Produce the "Perfect" Seed

- Drying
  - Slow (3 days), natural drying preferred
  - Batch driers best for artificial drying
  - Minimize moisture fluctuations
  - Seeds should enter storage at 8% MC

How to Produce the "Perfect" Seed

- Conditioning
  - Goal: Produce a clean crop
  - Objectives
    - Grade seeds into density/size classes
    - Remove undesired appendages
    - Scarification may be required for hard seeds
    - Seed treatments/coatings increasing

How to Produce the "Perfect" Seed

- Storage
  - Follow the "Rules of Thumb"
    - Each 5^{o}C reduction in temperature, 2x life of seed
    - Each 1% reduction in SMC, 2x life of seed
  - Equation: %RH + ^{o}F $\leq$ 100 satisfactory storage
  - Keep seed MC below 8%, use $CaCl_2$ (RH ~ 45%)
  - Seed chemistry important: High oil seeds store poorly

How to Produce the "Perfect" Seed

- Conclusions
  - Emphasize production of high quality plants
  - Reduce competition among seeds for nutrients (eliminate other seeds)
  - Harvest the most uniform portion of the inflorescence
  - Identify morphological markers of plant/seed development
  - Determine the "DIW" to reduce dormancy

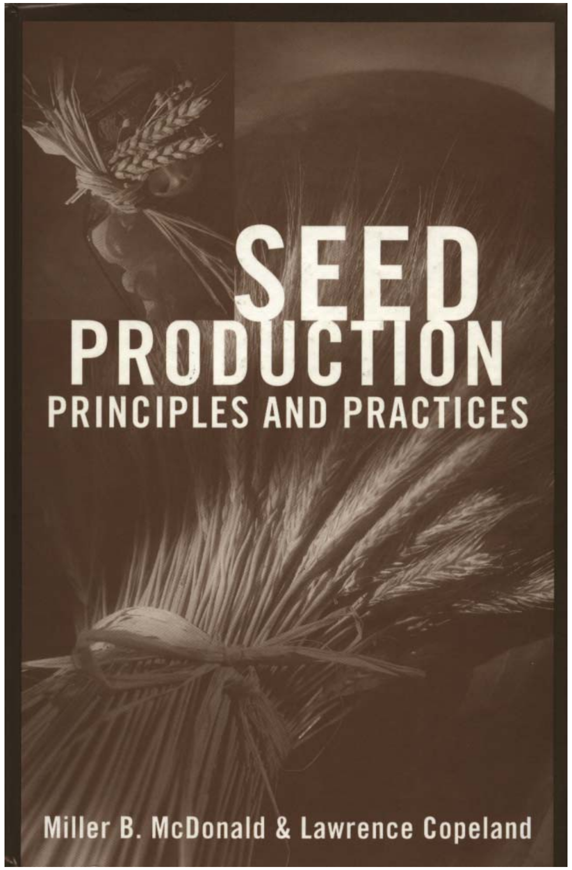
How to Produce the "Perfect" Seed

- Conclusions (continued)
  - Establish PM and harvest fruit at this stage followed by slow drying
  - Condition seed as little as possible to minimize mechanical damage
  - Grade seed according to density/size
  - Place seeds in storage at 8% and follow the "Rules of Thumb"

How to Produce the "Perfect" Seed

- More information:

McDonald, M. B. and L. O. Copeland. 1997. *Seed Production: Principles and Practices*. Kluwer Press. 749pp.

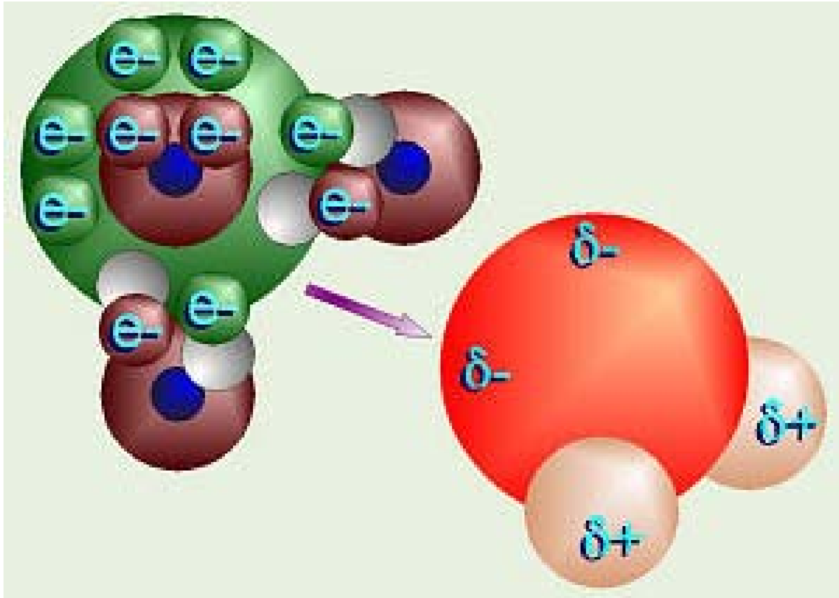


Seed Moisture Content

- Why Is It Important?
  - Seed storage (optimum moisture content)
  - Determines physiological maturity at harvest
  - Seed enhancements (before/after priming/pelleting)
  - Seed drying (improves storability)
  - Seed cleaning (avoids mechanical damage)
  - Harvesting (minimizes shattering/seed damage)
  - Vigor tests (standardizes AA, SSAA, conductivity)
  - Germination (avoids imbibitional injury)
  - etc.

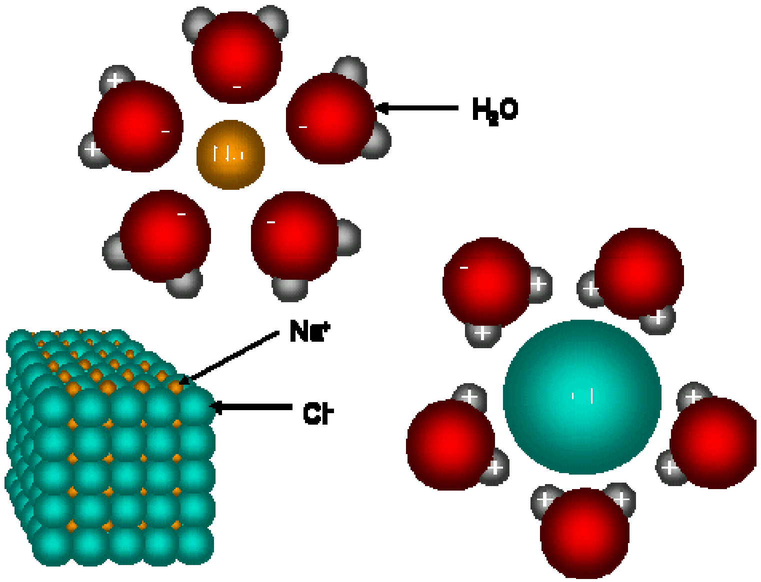
Unique Properties of Water

- Permanent dipole
  - Oxygen shares electrons with hydrogen, but pulls harder on the electrons
  - Center of gravity of the positive charge does not coincide with the center of gravity of the negative charge
  - Results in negative charge around oxygen, positive charge around hydrogen



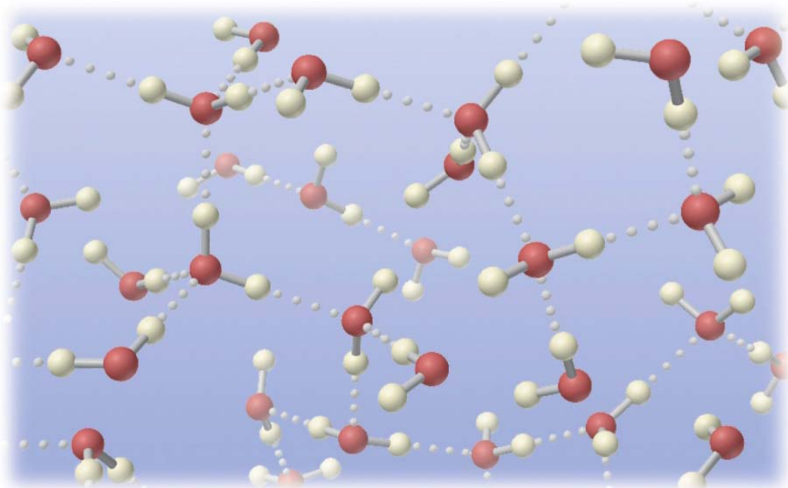
Types of Chemical Forces

- Ionic bonds
  - The charged ends of the water molecules are attracted to charges in other molecules (particularly salts) and cause them to break apart. Water molecules quickly surround the "ions" and create a hydration shell



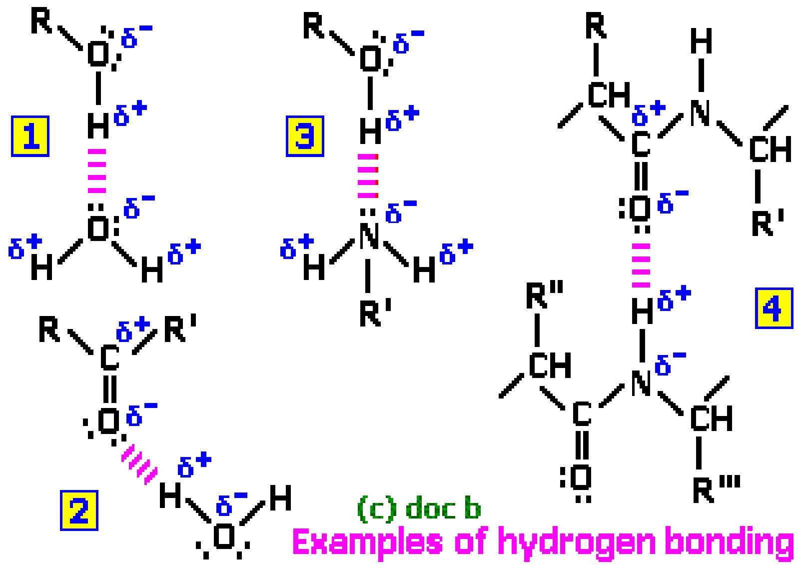
Types of Chemical Forces

- Hydrogen bonding
  - When the partially-positive hydrogen atom on one water molecule is electrostatically attracted to the partially-negative oxygen on a neighboring molecule
  - This is a weak bond: 5 to 15 kcal and can be easily broken (5 to 10% strength of covalent bond)



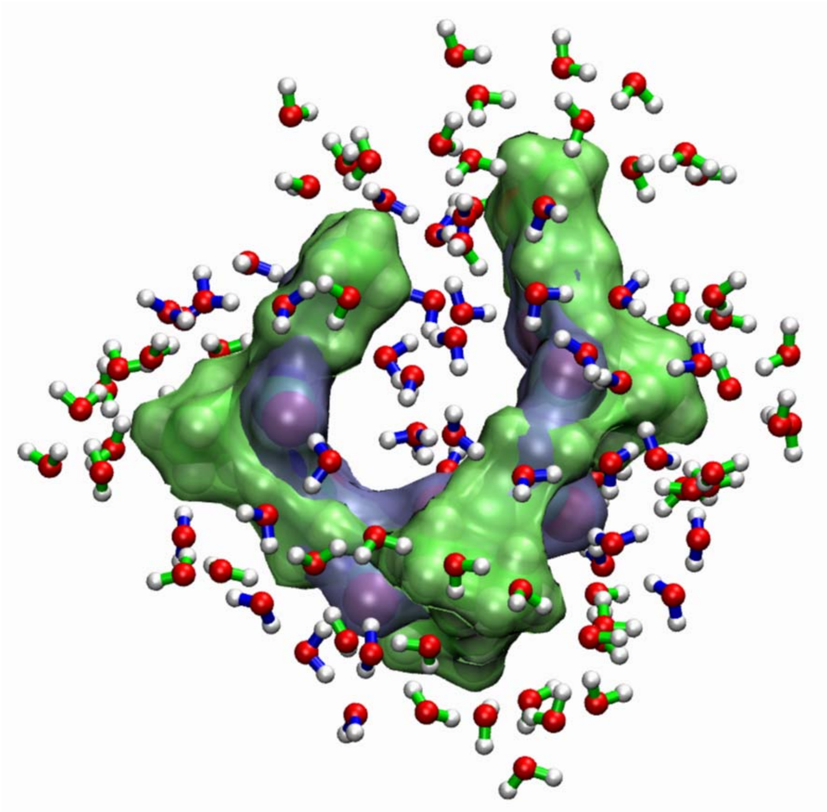
What Does Water Adhere to in Seeds?

- Proteins
  - Polymer of amino acids
  - Amino acids are positively and negatively charged
  - Ideal for hydrogen bonding
  - Water molecules attracted to positive and negative charges



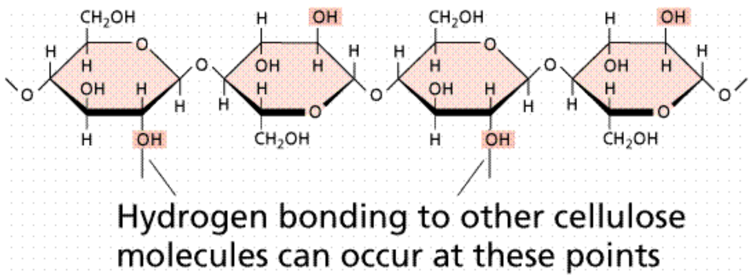
What Does Water Adhere to In Seeds?

- Protein
  - Depending on strength of polarity can have differing levels of water
    - carboxyl – 4 to 5 H_2O
    - Amino group – 3 H_2O
    - Hydroxyl group – 3 H_2O
    - Carbonyl group – 2 H_2O
  - Strong affinity for water

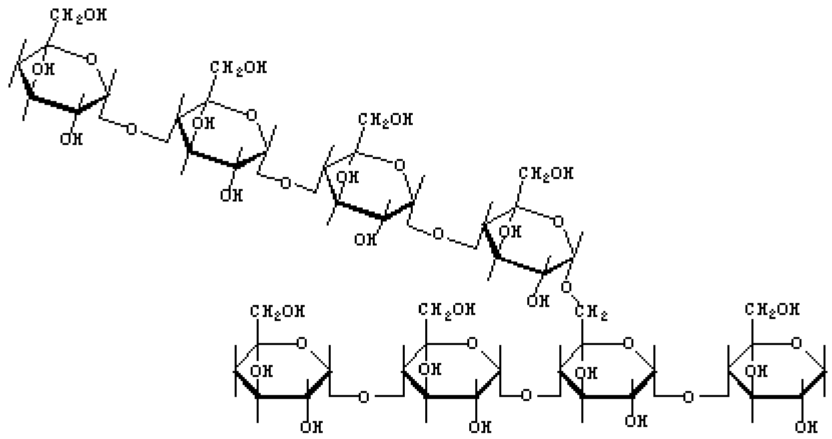


What Does Water Adhere to In Seeds?

- Starch
  - Polymer of long or branched chains of glucose
  - Amylose and Amylopectin - principal storage forms
  - Characterized by
    - Hydroxyl groups on ring
    - Bridge oxygen
    - Ring oxygen
    - All are points of polarity



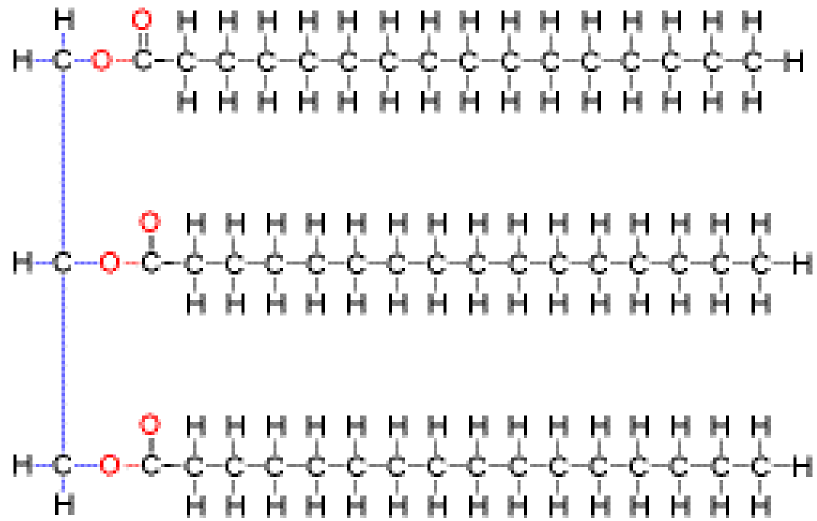
Amylose



Amylopectin

What Does Water Adhere to In Seeds?

- Fats
  - Polymer of glycerol and 3 fatty acids
  - Nonpolar
  - Do not dissolve in water
  - No hydrogen bonding
- No attraction for water



Glycerol 3 Fatty acids

Equilibrium Moisture Content

- Isotherms: A curve describing the equilibrium relationship at a specified temperature of the amount of water sorbed by the seed at a specified vapor pressure or relative humidity.

Water Sorption Isotherm

- Phase I – adsorption of water
  - Deposition of water on polar sites
    - Clusters of water molecules
    - Form a monolayer of tightly bound water
  - Displacement toward moisture content axis indicates strong intermolecular forces

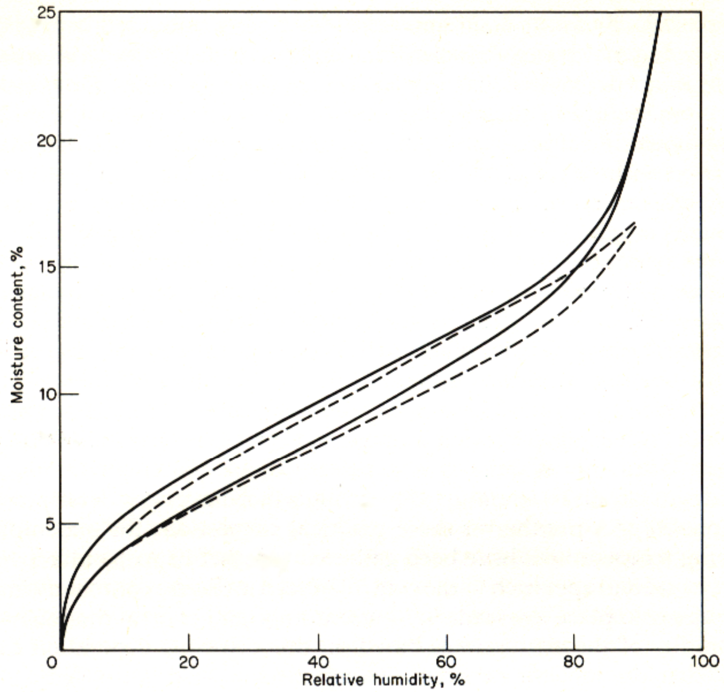
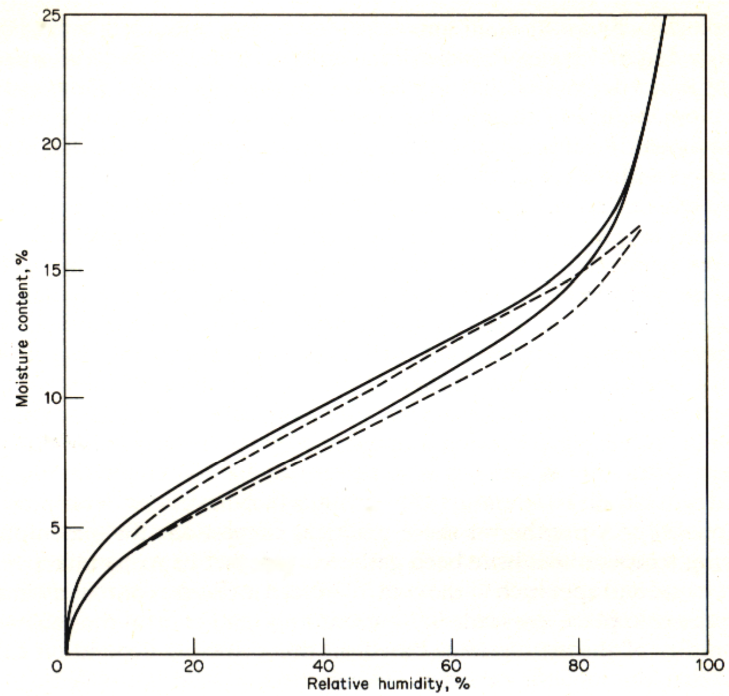


FIGURE 2.5 The hygroscopic equilibrium relationships of wheat at 35°C (——) and paddy (rice in the husk) at 25°C (-----). In both cases the upper curve represents the desorption relationship and the lower curve the absorption relationship. Data for wheat from Hubbard, Earle and Senti (1957) and for paddy from Breese (1955).

Water Sorption Isotherm

- Phase II –region of deflection
  - Deposition of second layer of water on first layer
    - Water being attracted to water due to hydrogen bonding



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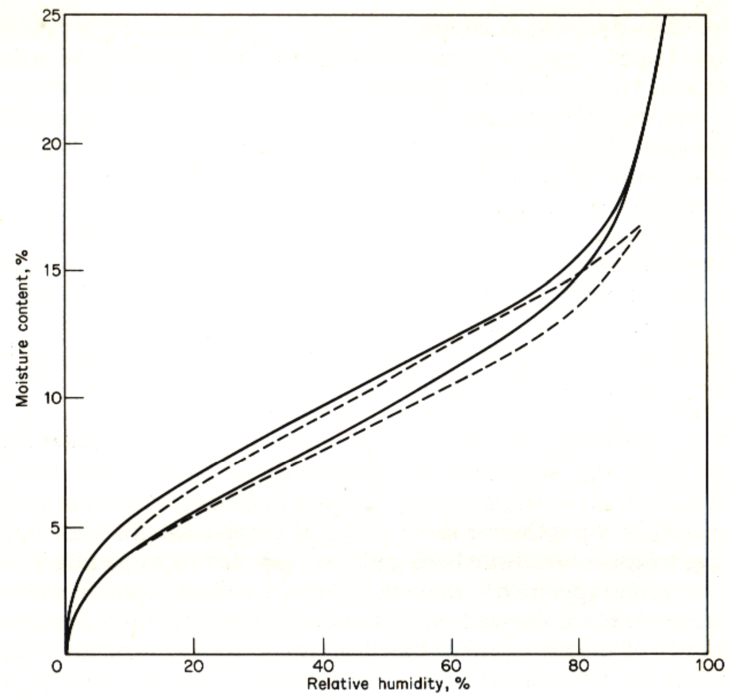
Water Sorption Isotherm

- Phase III – rapid increase in seed moisture content
  - Addition of water to more water layers by capillary forces
  - Layer possesses properties of free water



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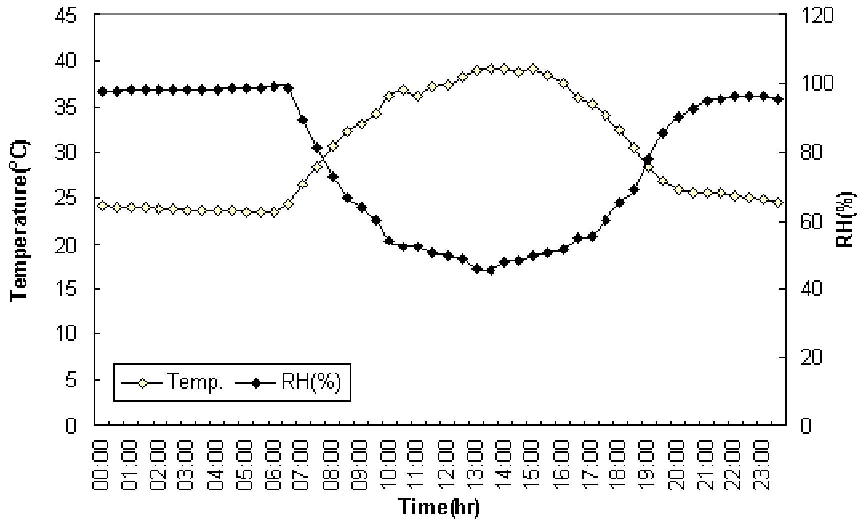
Water Sorption Isotherm

- General Observations
  - Third region begins at 80% relative humidity and is deposition of successive layers of water
    - Relatively large amounts of water become available to seed and microorganisms
      - Seeds start to germinate
      - Microorganisms grow
      - Seeds deteriorate rapidly

Implications of EMC

- When do seeds deteriorate in open storage?
  - During daily fluctuations in RH, RH is greatest at night
  - Outer seeds deteriorate before inner seeds
  - Conclusion: Deterioration occurs generally in outer seeds during the night, results in variability in seed quality in the seed lot



Implications of EMC

- Remember: Seed moisture content is expressed on a whole seed basis
- Chemistry of seed parts varies
- Influences MC of seed parts
- Moisture in seed is not uniform

Implications of EMC

Percent moisture content of seed parts from large and small seeds at germination for six crops (McDonald, unpublished).

Crop	Axis	Cotyl./Endo	Whole Seed
	-------------------% Moisture-------------------------		
Sunflower	64.5	35.5	45.6
Peanut	54.7	34.2	34.9
Pea	63.1	54.1	53.4
Cotton	56.1	47.8	50.5
Corn	57.4	27.1	34.7
Wheat	63.6	35.6	45.8

Conclusions

- Understanding seed moisture content is important to maintain seed quality
- Seeds are hygroscopic and their moisture content comes to equilibrium with the relative humidity of the air surrounding them
- The unique properties of water lead to covalent, ionic and hydrogen bonding in seeds – each with a differing level of attraction
- Water adheres to protein > starch and very little to lipids
- The increase/decrease in water uptake pattern by seeds at differing relative humidities (equilibrium moisture content) is sigmoidal suggesting three types of water binding
- Above 80% RH, free water exists in seeds and causes rapid deterioration
- Water content in a seed differs among seed parts even though seed moisture content is commonly expressed on a whole seed basis
- Understanding relative humidity is key to understanding seed moisture content

Conclusions

Want to read more?

McDonald, M. B. 2007. Seed moisture and the equilibrium seed moisture content curve. J. Seed Technol. 29:7-18.

Seed Vigor

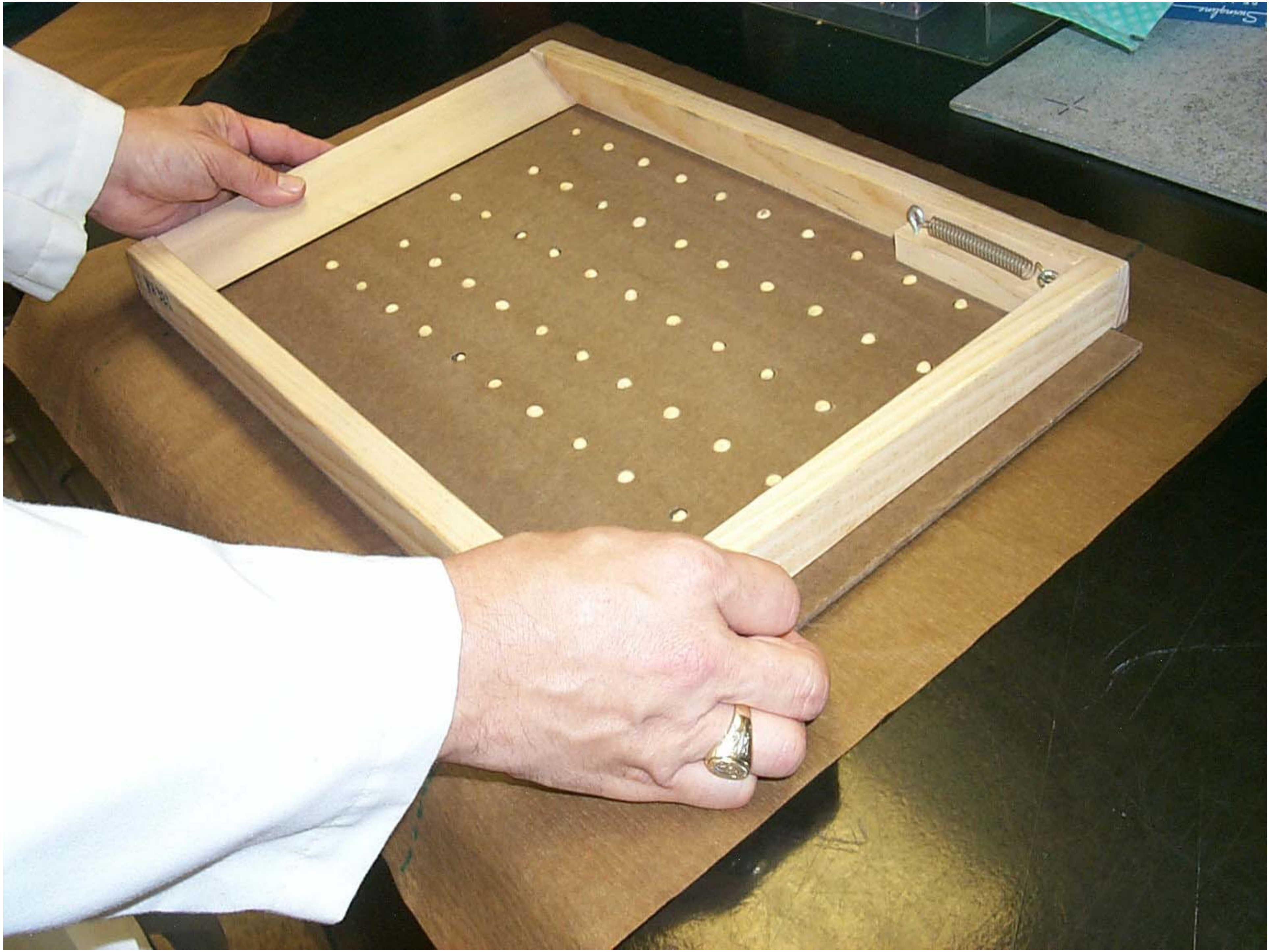
Definition:

"Seed vigor comprises those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions."

Seed Vigor

- Seed vigor test categories
  - Physical tests – measure some physical component of the seed such as size/weight
  - Physiological tests – utilize some parameter of germination or growth such as speed
  - Biochemical tests – monitor chemical reactions involved in cellular maintenance

Seed Vigor Assessment System *for Soybean*

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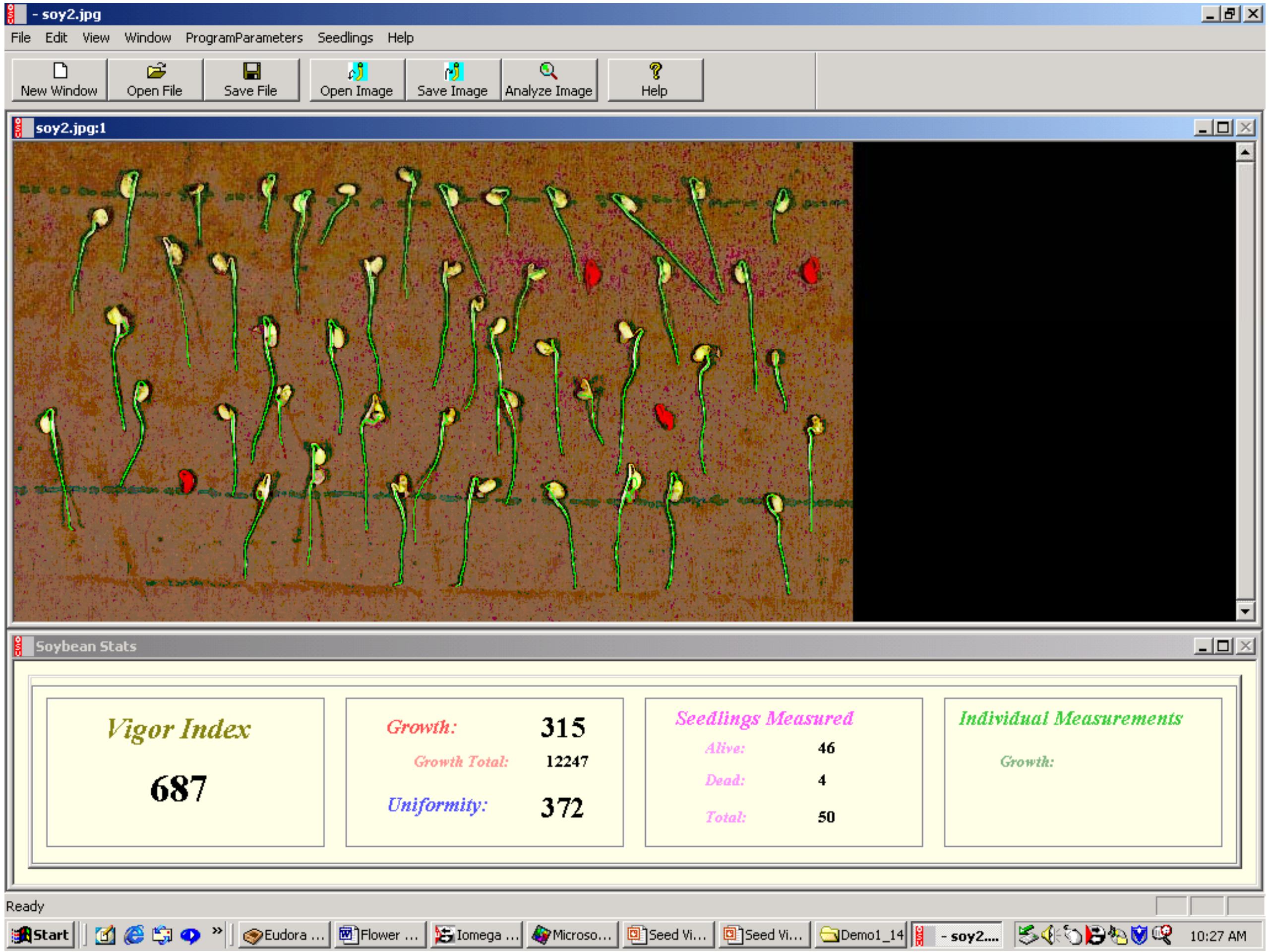
Screen Shot of Printout



OHIO SEED IMPROVEMENT ASSOCIATION

Seed Vigor Scanner Results

Field Inspection

- Itemized List by Variety
- Itemized List by Grower
- Outstanding Affidavits
- Insp. Directory

Lab Reports

- Lab Reports
- Tag Reports
- Germ. Avg./Var.
- Germ. Avg./Test
- Herb Tol. Sum.
- Monthly Germ Sum.
- Member Germ Sum.
- Seed Vigor Image System (SVIS)

Administration

- Get Help
- Logout

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Lab Number Selected: 118851

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Lab Number Selected: 118851

Average Growth: 384 Average Uniformity: 831 Average Vigor Index: 518
Average AA Growth: 190 Average AA Uniformity: 627 Average AA Vigor Index: 320

Images starting with 'A' are from the Accelerated Aging test.

Image Selected: 118851a

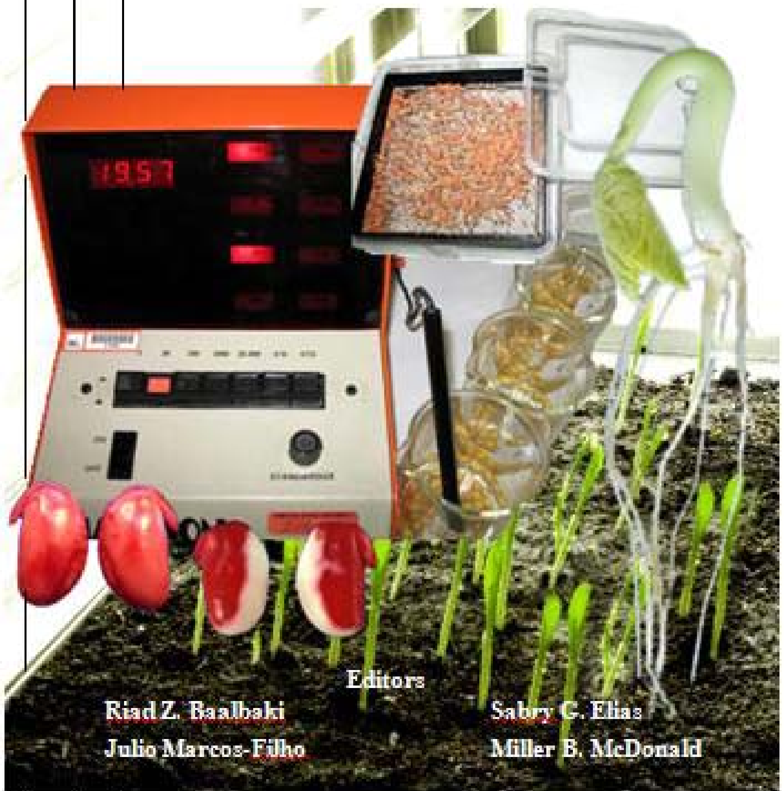
Image Size: 400

Want to read more?

McDonald, M. B. 2007. Computer imaging to assess seed germination performance. In: *Seeds: Biology, Development and Ecology* (eds. S. Naïve, S. Adkins and S. Ashmore). Pp. 307 – 314. CAB International, Wallingford, UK.

ASSOCIATION OF OFFICIAL SEED ANALYSTS

SEED VIGOR TESTING HANDBOOK



Editors

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Miller B. McDonald

2009 CONTRIBUTION NO. 32

Consortium for International Seed Technology Training (CISTT)

A New Way to Conduct Seed Technology Training in the Year 2009

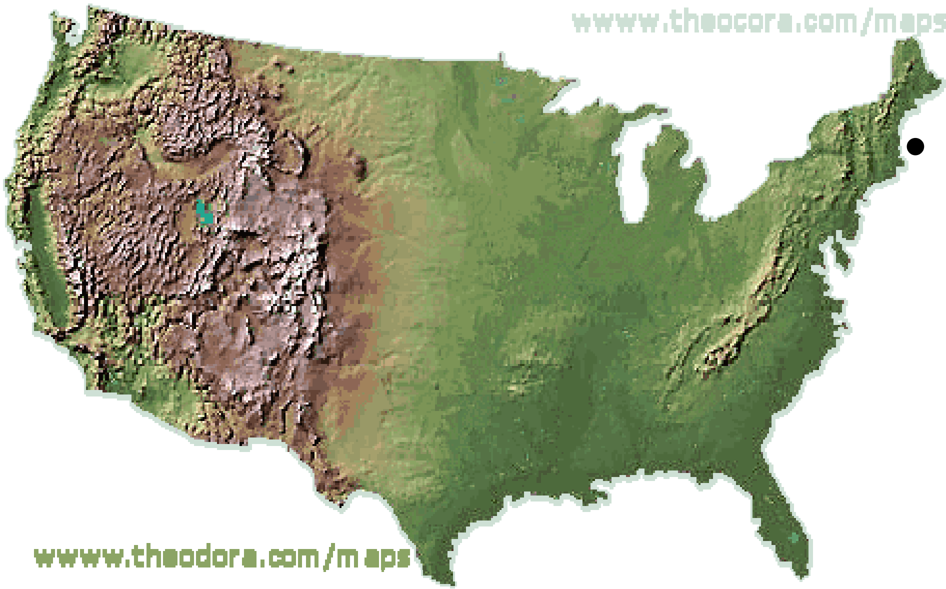
CISTT Partners

- Ohio State University (OSU), US
- Escola Superior de Agricultura “Luiz de Queiroz” (ESALQ), Brazil
- Pontificia Universidad Catolica (PUC) de Chile, Chile
- Lincoln University
- University of California Davis

Three Clientele

- Industry – continuing education of personnel
- Seed technologists – must meet certification examinations
- Graduate/undergraduate students – better global understanding of seed production and global crops

Advantages of CISTT



- Seed technology capability
- Comprehensive/Deep
- Geographic location
  - OSU: North America, corn/soybean belt, high technology
  - UC Davis: Seed Biotechnology Center
  - Lincoln University: Minorities

Advantages of CISTT

- Seed technology capability
- Comprehensive/Deep
- Geographic location
  - OSU, UC Davis, Lincoln:
  - ESALQ: South America, recalcitrant/orthodox seeds, long relationship

Advantages of CISTT

- Seed technology capability
- Comprehensive/Deep
- Geographic location
  - OSU, UC Davis, Lincoln:
  - ESALQ: South America, recalcitrant/orthodox seeds
  - PUC: South America, seed production in a desert, all crops, counter-season production

Advantages of CISTT

- Seed technology capability
- Comprehensive/Deep
- Geographic location
- Facilities
  - OSU: State-of-the-art research and training facilities
  - ESALQ: Model on-site seed processing plant
  - PUC: Diversity of seed production
  - Lincoln University: 1890s minority institution
  - UC Davis: Seed biotechnology center

Advantages of CISTT

- Seed technology capability
- Comprehensive/Deep
- Geographic location
- Facilities
- Established seed industry/association relationships
    - Local seed industries differing in capabilities
    - ISTA, AOSA, SCST, ISF, UPOV, etc.

Utilize Advances in Communication Technologies

- Video end-point conferencing units
  - Installed in Brazil, Chile, OSU, UC Davis and Lincoln University
  - Allows immediate communication for
    - Classes
    - Examinations
    - Conferences
- Develop DVD modules on seed testing/production
- Use distance education (PowerPoint presentations)

Conclusions

- Consortium for International Seed Technology Training
  - New distance education approach of courses
  - Develop DVDs
  - Establish global educational nodes

Conclusions

CISTT Consortium for International Seed Technology Training

Home
Members
People
Activities
Research
Seed banks
Links

Seed ID

The establishment of a five-member Consortium for International Seed Technology Training (CISTT) is a novel approach to global training in seed technology. Recent advances in distance education led by new developments in computer and interactive technologies have clearly decreased the size of the world allowing CISTT to take advantage of the vast expertise of several institutions that differ culturally and environmentally. Five of the world's leading academic institutions (The Ohio State University, University of California Davis, Lincoln University, Escola Superior Agricultura "Luiz de Queiroz" and Pontificia Universidad Catolica de Chile) with recognized qualification in seed technology training muster together a greater variety of faculty expertise, provide greater breadth of academic training, cover a greater diversity of agricultural crops, utilize differences in technological capability of countries around the world and result in an internationalization of a curriculum consistent with the technological advances occurring in a global seed industry.

Mission/Vision

The Consortium for International Training in Seed Technology provides leadership in educating students, industry personnel, and agriculturalists in seed science and technology. We will offer global and comprehensive program, utilizing a variety of educational techniques to advance local seed systems around the world.

Justification

- Video
- Poster

Products

– Establishment of Consortium for International Seed Technology Training (www.seedconsortium.org) courses
  - International Seed Production
  - International Seed Physiology

CISTT DVDS

Snippets can be viewed at:

http://www.seedconsortium.org/activities_education.html

CISTT DVDS

- DVDs can be purchased from the Society of Commercial Seed Technologists at:

  http://www.seedtechnology.net/DVDs.htm

- Cost
  - Seed Production DVDs (maize, sunflower, tropical forage grasses/coffee): $70 each or $150 for all three
  - Seed Testing DVDs (importance of seed testing, seed quality testing, tetrazolium testing, genetic purity testing): $70 each or $200 for all four

Conclusions

- Maintaining seed quality requires
  - Production of the “perfect” seed
  - Understanding seed moisture content and its relationship with relative humidity
  - Developing sensitive, standardized seed quality tests
  - Educating seed industry personnel, seed quality technologists, and students in seed science and technology to better serve a global seed industry

Seed Quality – A Constant Challenge?

- Seed is an essential, indispensible component of agricultural production
- Seeds are biological units responding to their environment
- The diversity of crops requires unique physiological knowledge of seeds and their production for an international industry
- Better educated students/professionals are required to ensure high quality seed production
- **YES**, seed quality is a constant challenge!!