SEED DRYING

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ACQUISITION OF DESICCATION TOLERANCE IN SEEDS

Definitions

DESICCATION TOLERANCE: It is generally interpreted as an adaptive strategy to enable seed survival during storage, to ensure better dissemination of the species and to provide tolerance to severe environmental conditions.

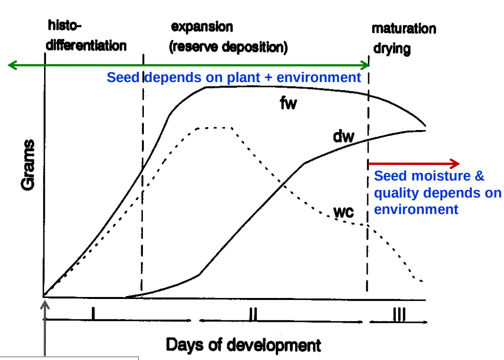
ORTHODOX SEEDS: Those seeds that could be dried to low moisture content (5%), tolerate freezing, and thus be stored for long period of time.

(Steffen, 1960)

Potential mechanisms involved in desiccation tolerance

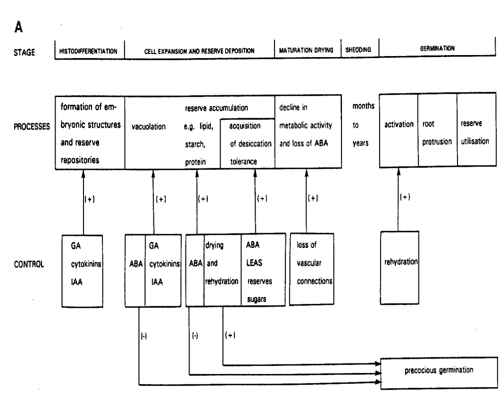
- ABA
- WATER
- SUGARS
- LIPIDS (PLASMA MEMBRANE)
- GENE EXPRESSION
- RADICAL SCAVENGERS

Phases of Seed Development and Maturation



SEED DEVELOPMENT OF ORTHODOX vs RECALCITRANT

(Review article, Farrant et. al., 1993)

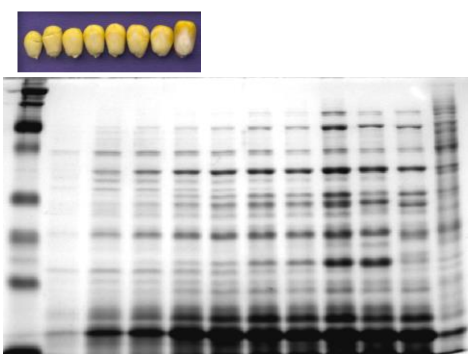


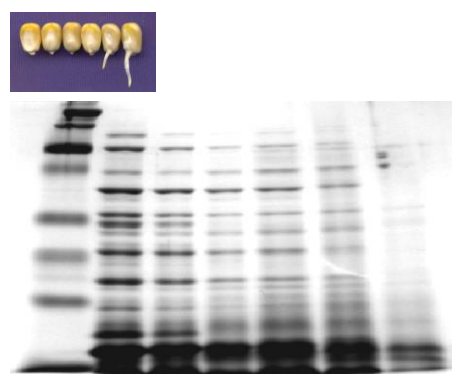
ABA

- Control of precocious germination during seed development in both orthodox and recalcitrant seeds
- ABA declines during drying and in the desiccated state prevents germination.
- Synthesis of storage proteins: Late Embryogenesis Abundant (LEA) PROTEINS.

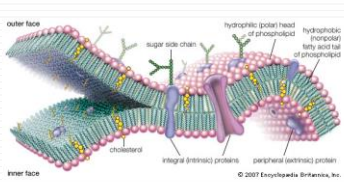
Gene Expression

- Accumulation of mRNAs and proteins during maturation and the onset of desiccation tolerance have been investigated in several species.
- Late Embryogenesis Abundant (LEA) proteins
  - Dehydrin Proteins are perhaps the most studied group





Membrane's stability



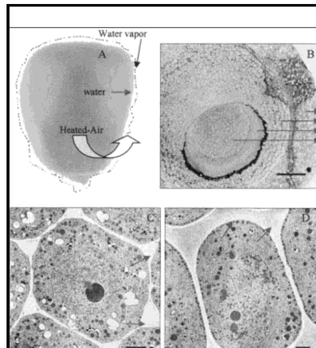
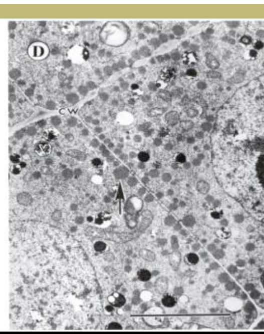


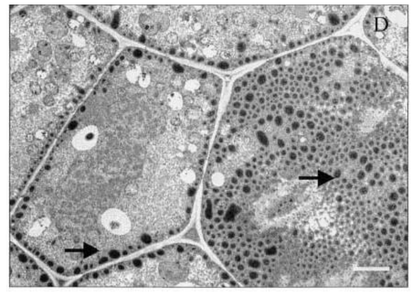
Fig. 7. Hypothetical model of water loss of an individual shelled maize seed, A) evaporation of water from seed surface; B) water migration from internal tissue as maturation drying progresses (Bar =80 μm); C) and D) water movement to intercellular space early during drying and more advanced drying stage (notice the alignment of lipid bodies along the plasma membrane). Arrows denote water movement; Bar = 2 μm.

(Cordova and Burris, 2001)

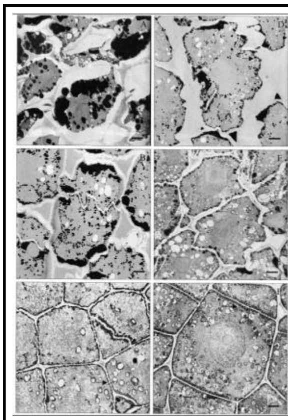
Perdomo and Burris, 1998



Cordova and Burris, 2001



(D) Contrasting visualization of one-dimension view of lipid bodies in TEM, sectioning in left cell occurred far from cell surface and sectioning in right cell occurred just below cell surface. Bar 2 µm. Arrows point out lipid bodies.



Alignment of lipid bodies along the plasma membrane in inner quiescent center cells of the embryo radicle after the seed was dried under different conditions in 1998, (A, B and C) seed harvested at 550, 400, and 320 g H_2O kg^{-1} fw, respectively, and dried in the fluidized bed without pre-conditioning (PC); (D and E) seed harvested at 550 and 500 g H_2O kg^{-1} fw, respectively both with 48 h PC; (F) seed harvested at 500 g H_2O kg^{-1} fw dried entirely at PC (35°C) conditions. Bar = 2 µm and arrows point at lipid bodies.

(Cordova and Burris, 2001)

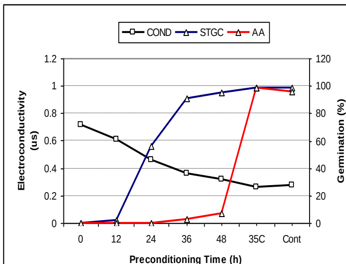


Figure 3. Electroconductivity of seed leakage and germination of seed corn harvested at ~50% MC submitted to preconditioning drying times before fast drying. Ames 1998.

(Cordova and Burris, 2001)

Seed driers must be designed to allow pre-conditioning of very wet corn to avoid seed deterioration

Seed Drying

(Steffen, 1960)

Seed drying is defined as the removal of excess water from the seed in nature by the sun and wind, or artificially using air flow and temperature.

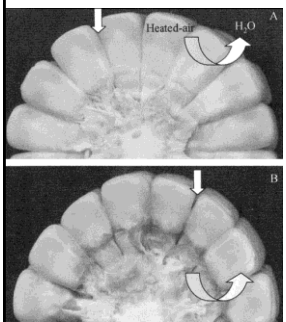


Fig. 6. Hypothetical representation of maize seed drying on the ear, A) in an early stage of seed development, seed compaction will restrict air movement to the seed surface (endospermic area); B) with maturation or moisture loss space between seed is opened and air is able to reach lower levels. Arrows indicate space between seeds and curved arrows indicate dry air circulation.

(Cordova and Burris, 2001)

Seed Drying

AIR FLOW: provided by fans that will create a positive pressure and move the air through the mass of seed.

TEMPERATURE: the maximum temp. at which seed viability is not affected. Modern day driers do not exceed the temperature of 105°F. Lower temperature if seeds are wet (high moisture content)

Relative Humidity

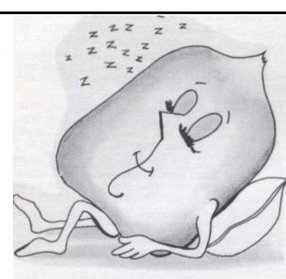
- Defined as the ratio between the vapor pressure in the air to the saturated vapor pressure at a certain temperature.
- Vapor pressure is the partial pressure exerted by the water vapor molecules in moist air.

Static pressure of the drying air

- Force required for the air to flow through the mass of seed
- The deeper the mass of seeds, the greater the pressure (force) required
- The greater the air pressure, the bigger the capacity (horsepower) of the fan

Equilibrium Moisture Content

- Equilibrium MC: is the seed moisture in equilibrium with the RH of the surrounding environment
- EMC varies with seed composition: starchy and high protein seed will equilibrate at higher MC than oily seed exposed to the same RH

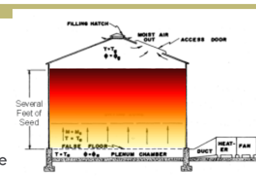


(Steffen, 1960)

Seed Dryers

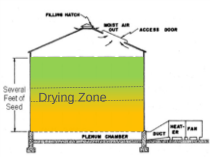
- Used to provide rapid drying at a controlled rate to maintain seed quality
- Manual, pallet box, or bulk dryers
- Forced air heated drying
- Temperature control is critical

- Seed placed in dryer bin
- Airflow provided by a fan or blower
- Air passes through seed, picking up moisture prior to exhaust
- Creates moisture and temperature fronts

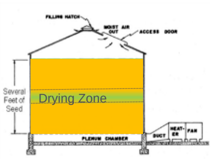


Fixed bed batch drying process

- Seed below drying zone in equilibrium with drying air
- Seed above drying zone is at (or above) initial moisture
- Drying zone position and size affects moisture variation

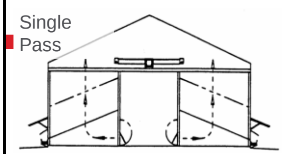


Drying zone size is related to air velocity
- Higher air velocity causes drying zone to spread
- Velocity affects moisture uniformity and energy required to dry seed

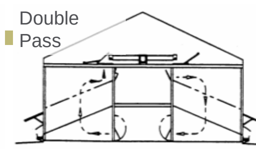


Drying zone location affected by reversal
- Highest moisture near air exhaust
- Air reversal gradually switches moisture gradient direction
- Frequent reversal can cause moisture gradient problems within bin depth

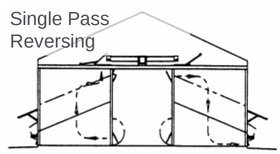
Single Pass



Double Pass



Single Pass Reversing

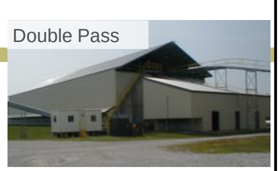


Based on Airflow Pattern
- Airflow Direction Changes

Key Differences:
- Management Complexity
- Airflow Volume Required
- Energy Efficiency

Single Pass

Double Pass



Single Pass Reversing

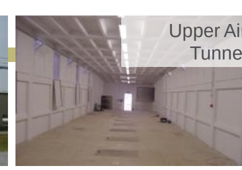
Single Pass
- Lowest cost per bushel
- Small lots – shallow depth limits

Single Pass Reversing
- Modular independent bins
- Relatively simple management

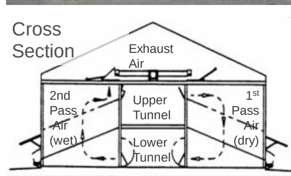
Double Pass
- Energy Efficiency
- More difficult to manage

Dryer & Burner House

Upper Air Tunnel



Cross Section



- Warm air enters upper tunnel
- 1st pass air - down through bins containing relatively dry seed
- 2nd pass air – up through bins containing relatively wet seed
- Air controlled by tunnel doors
- Needs multiple bins for cycle

References Drying

Antonio Perdomo and **Joseph S. Burris**. 1998. Histochemical, Physiological, and Ultrastructural Changes in the Maize Embryo during Artificial Drying. Crop Sci. 38:1236–1244.

Leobigildo Cordova-Tellez and **Joseph S. Burris**. 2002. Alignment of Lipid Bodies along the Plasma Membrane during the Acquisition of Desiccation Tolerance in Maize Seed. Crop Sci. 42:1982–1988.

Leobigildo Cordova-Tellez and **Joseph S. Burris**. 2002. Embryo Drying Rates during the Acquisition of Desiccation Tolerance in Maize Seed. Crop Sci. 42:1989–1995