Principles & Practices of Clonal Selection

Terminology

• Cloning
  - Process of Vegetatively Propagating a Clone
• Clone
  - Vegetative Offspring of a Single Genotype
• Propagule
  - Plant Part Used for Propagation
• Clonal Selection
  - Process of Selecting an Individual Plant or Plant Part to Create a Clone

Cloning in Nature

• Clones Exist in Nature Where Vegetative Expansion Occurs
• Not a Favored Strategy in Nature
  - No Opportunity for Genetic Variation & Evolutionary Advancement

Advantages of Clones

• Quicker Genetic Improvements
• Uniform Populations
• Control Developmental Phases
• Grafting Multiple Genotype on 1 Plant

Disadvantages of Clones

• Monoculture
• Slow & Costly Reproduction
• Potential for Genetic Variation
• Potential for Systemic Pathogens

Origin of Clones as Cultivars

• 3 Basic Ways to Develop New Clone
  - Seedling Selection
  - Mutation
  - Biotechnology Including Recombinant DNA
Seedling Selection

• Some Well-Known Fruit Cultivars Selected Long Ago
  - Thompson Seedless Grapes 2000 Years Ago
  - Bartlett Pear Since 1770

Mutations

• Genetic Change Involving Some Part of DNA Molecule
• Most Mutations Are Harmful
• Occasionally Horticultural Value

Bud-Sports

• Mutation That Results in Different Phenotype on Branch of Plant

Induced Mutations

• Mutagenic Agents Increase Rate of Mutation in Search for New Cultivars
  - Gamma & X-Rays
  - Specific Chemicals

Biotechnology

• Cell & Tissue Culture
• ‘Micropropagation’
• Recombinant DNA
  - Gene From One Organism Is Inserted Into Genome of Another Individual
  - Change Genotype & Phenotype of Clonally Propagated Cultivar

Phenotypic Variations Within Clones

• Four Sources of Phenotypic Variation Within Clones
  1. Environment × Genotype
     - Differences Among Growing Sites
2. Ontogeny (Phase Changes)
- Phenotype Changes With Increasing Age
- ‘Epigenetic Changes’
  - Expression of Genes
  - Not Alterations in Structure of Genes

3. Permanent Genetic Variation
- Mutations
  - Normal
  - Spontaneous
- Somaclonal Decline
  - Variation in Phenotype After Repeated Propagation Cycles

4. Infection by Systemic Pathogens
- Other Examples
  - Seedless Oranges
  - Thornless Blackberries
  - Fuzzless Peaches
  - Alteration in Bract Color in Poinsettia
- Chimeras Develop in Apical Meristem
- One Layer of Meristematic Cells Knows How to Make Chlorophyll
- Another Layer Does Not

Chimeras
- Chimera Is Plant With 2 Genotypes, Each Expressed Independently
- Variegated Foliage
  - Most of White & Yellow Colors Are Result of Mutations That Cause Leaf Cells to Lose Ability to Produce Chlorophyll

Meristem Layers
- 3 Layers of Cells Origin of All Tissue
- Tunica-Corpus Meristem
  - L1 Is Outer Tunica Layer
  - L2 Is Middle Layer
  - L3 Is Inner Layer
- L1 Cells
  - Leaf Margins
  - Epidermis
- L2
  - Cortex
  - Part of Vascular Bundles
  - Reproductive System
- L3
  - Pith
  - Parts of Vascular System
  - Roots, Rhizomes, etc.
Periclinal Chimera

- Periclinal
- Stable ‘Hand-in-Glove’ Arrangement
- One Whole Layer Mutated
  - Not Other Two Layers
  - Ring of Mutated Tissue
- Mutated Cell Is Near the Apical Dome
  - Resulting Meristem Contains One Layer Which Is Genetically Different From Remainder of Meristem

Mericlinal Chimera

- Only Part of Layer Is Mutant
  - Genetically Different Cells in Same Layer
- Mutated Cell Does Not Entirely Cover Apical Dome
- Maybe Only Portion of Leaf Affected
- Generally Restricted to One Cell Layer
- Outer Tissue Does Not Completely Cover Inner Tissue
  - Hand-in-Glove Except Much of the Glove Is Missing

Sectorial Chimera

- Solid Section Through All Layers of Apical Meristem Is Mutant
- Altered Genotype Extends Through All Cell Layers
- Arranged Like Pie Piece-Shaped Wedge (Sector)
- Gymnosperms & Ferns
- Unstable
  - Can Give Rise to Shoots & Leaves Which Are Not Chimeras
  - Any Bud on Mutated Wedge Will Be Different From Buds ARISING From Non-Mutant Portion
Propagation of Chimeras

- Mericlinal, Sectorial Chimeras Not Same When Propagated
- Periclinal Chimeras Usually Reproduced True to Type
- Exceptions
  - Propagules of Periclinal Chimeras Arise From Adventitious Buds

- eg: Thornless Blackberry
  - Adventitious Roots on Blackberry Stem Cutting or Tip Layer Originate in Subepidermal Tissues of Stem (L2 & L3)
  - Adventitious Shoots Do Not Contain Layer With Thornless Genotype (L1) if Root Cuttings Are Taken From These Plants

Growth Phases & Propagation

Paradox in Terminology

- The Part of Seedling Plant Nearest to Base Is ‘Oldest’ in Terms of Chronology But Actually ‘Youngest’ in Terms of Maturity
- Outer Part of Stems & Branches Are ‘Oldest’ in Maturity But ‘Youngest’ in Chronology

Ontogenetic Aging

- Propagule From Juvenile Results in Juvenile Offspring
- Cuttings From Top or Periphery of Tree Tend to Produce Biologically Mature Progeny

Hastening Maturity

- Keep Plant Growing Continuously to Promote Shift From Juvenility to Maturity
  - Crabapple Seedlings
    - Grown Continuously in Greenhouse Flower in 13 Months From Germination
    - Flower in 4 Years When Grown Outdoors
• Establish Hedge Rows of Stock Plants
  - Severely Prune Plants Annually
  - Continuous Supply of New Shoots
  - Original Material
    • Seedlings
    • Rooted Cuttings
    • Grafted Plants on Rootstocks

• Mound Layering Beds
  - Cut Shoots Nearly to Ground
  - Allow New Shoots to Begin Growing
  - Mound Material Nearly to Tips of New Shoots
  - Creates Dark, Moist Environment at Base of New Shoots Where Rooting Can Occur

Rejuvenating

• Plants Approaching Senescence
  - Reproduction
  - Pruning
  - N Fertilization

Take Advantage of Growth Characteristics

• Topophysis
  - Effect of Location of Propagule on Phenotype of Progeny
  - Orthotropic
    • Upright Growth When Progeny Is Taken From Upright-Growing Branch
  - Plagiotropic
    • Lateral Growth When Progeny Is Taken From Laterally-Growing Branch

Plants With Topophysiologic Growth

• Coffa
• Many Conifer Species
  - Araucaria heterophylla
  - Sequoia
• Lonicera japonica, Japanese Honeysuckle
• Several Lamiaceae Species
  - Vegetative Shoots Are Plagiotropic
  - Generative Shoots Are Orthotropic

Selection & Management of Propagation Sources
Characteristics of Sources Must Be Maintained

- True-to-Name
  - Plants Must Be Correctly Labeled by Scientific &/or Cultivar Name
- True-to-Type
  - The Plant Should Have the Phenotype Expected for That Specific Cultivar

Detecting Pathogens in Propagation Sources

- Visual Inspection
- Culture Indexing
- Virus Indexing
- Serology
  - ID Unique Proteins Associated With Pathogens
- Biochemical Methods
  - Gel Electrophoresis to ID Viral Nucleic Acids

Eliminating Pathogens

- Propagate Uninfected Parts of Plant
- Heat Treatments
  - Hot Water, Hot Air, Aerated Steam
- Thermotherapy
  - Moderate Temps, Longer Duration
- Growing Seedlings

Sources of Propagation Material

- Commercial Plantings
- Nursery Crops
- Stock Blocks
- Clean Stock Programs
- Botanical Gardens
- Plant Collections
- Clonal Repositories

Quarantines & Movement of Vegetatively Propagated Material

- Quarantines Control Movement of Plant Materials From Country to Country
- Decreases Risk of Spreading Dangerous Pests

False ‘Off-Type’ Appearance
- Plant May Be True-to-Type But May Express Different Phenotype
  - Different Environments
  - Unusual Treatments
  - Infected

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