Pecan Tree Breeding: Challenges and Opportunities of Breeding a Newly Domesticated Crop

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Pecan – *Carya illinoensis*

Juglandaceae family – includes pecans, hickories, walnuts.
History of Pecan Production

• Collected from wild and a few seedling orchards prior to 1880's.
• First grafted trees sold in 1880's.
• Boom in orchard planting in Georgia in early 1900's due to land speculation.
• Some of these orchards are still in production.
Floral Biology

- Monoecious (male and female flowers).
- Dichogamous (flowers mature at different times).
- Wind Pollinated
- Inbreeding Depression
Characteristics of Pecan

- Heterozygous
- Clonally propagated
- Seedling rootstock
Severe inbreeding depression prevents development of inbred lines
Pecan genetics

• Pecans cultivars are much like people, each is genetically unique.

• When you cross two cultivars you get a lot of variation in the seedlings. Like children, they will resemble their parents, but they will also show much variation.

• Most seedlings will be worse than the worst parent, so you need to look at a large number of seedlings to find a truly good one.

"Quantity makes Quality"
Pawnee x Elliot seedlings

Pawnee = 52 nuts / pound
Elliot = 77 nuts / pound
Breeding Strategy

Recurrent Mass Selection

1. Select superior seedlings from chance populations.


3. Selection superior offspring for use as parents in the next cycle or as cultivars.
Goals of the pecan breeding program

- Increase pest resistance
- Stabilize production
- Increase quality
- Change harvest date
- Increase productivity
Nuts and bolts of pecan breeding
Pollen Collection
Pollination Technique
Seedling Evaluation Phase I

• Initial Screen
  – 10 year selection cycle
  – Evaluate for:
    • nut size and quality
    • tree vigor
    • earliness
    • disease resistance
    • insect resistance
Seedling Orchard Year 1
Seedling Orchard – Year 3
Seedling Orchard – Year 6
Seedling Evaluation Phase I

- Initial Screen
  - Evaluate for:
    - nut size and quality
    - tree vigor
    - early harvest
    - disease resistance
    - insect resistance
Seedling Evaluation Phase II

- Propagate best selections for replicated trials

- Compare to elite cultivars
  - tree productivity
  - alternate bearing intensity

- Use best new selections as cultivars or parents in breeding program.
Where are we now?

- Program started in 1999.
- New crosses made each year.
- 106 controlled crosses.
- 10,000 seedlings screened.
- First nuts produced from the 1999 crosses in 2006.
DNA Markers for Pecan Breeding

DNA markers are signposts along the chromosomes.

Gene A

Marker 1
Marker 2
Marker 3
Marker 4
Marker 5
Marker 6

Gene B

If a marker is close to a gene of interest, the marker can be used to select for the gene.
Large progenies of pecan are expensive and time-consuming to evaluate.

Each seedling requires 150 square feet (290 trees/ acre) for 10 years to be evaluated.
Marker-assisted Selection of Nut Traits

- Select trees at the seedling stage - may save years of time and expense
  - Nut Size, Harvest Date, Flowering Type
Space limit = 4,000 trees

- 0 markers – Select from 4,000 seedlings.
- 1 marker that eliminates ½ trees. Select from 8,000 seedlings.
- 2 markers that each eliminate ½ trees. Select from 16,000 seedlings.
Genetic maps were created for the ‘Pawnee’ and ‘Elliot’ pecan using RAPD and AFLP DNA markers.

**Pawnee:**
- Large nut size
- Early maturity
- Protandrous
- Scab susceptible

**Elliot:**
- Small nut size
- Protogynous
- Highly scab resistant
Markers Linked to Genes

Elliot linkage group No. 16

ACA/CAT 250
Dichogamy
Stigma color
B29-340
B160-800
B160-770

15.4
1.9
9.4
7.8
Future Work

- Establish linkages to other important genes
  - Scab resistance
  - Nut Size
  - Harvest Date

- Develop maps for other cultivars