Pecan Breeding at the University of Georgia

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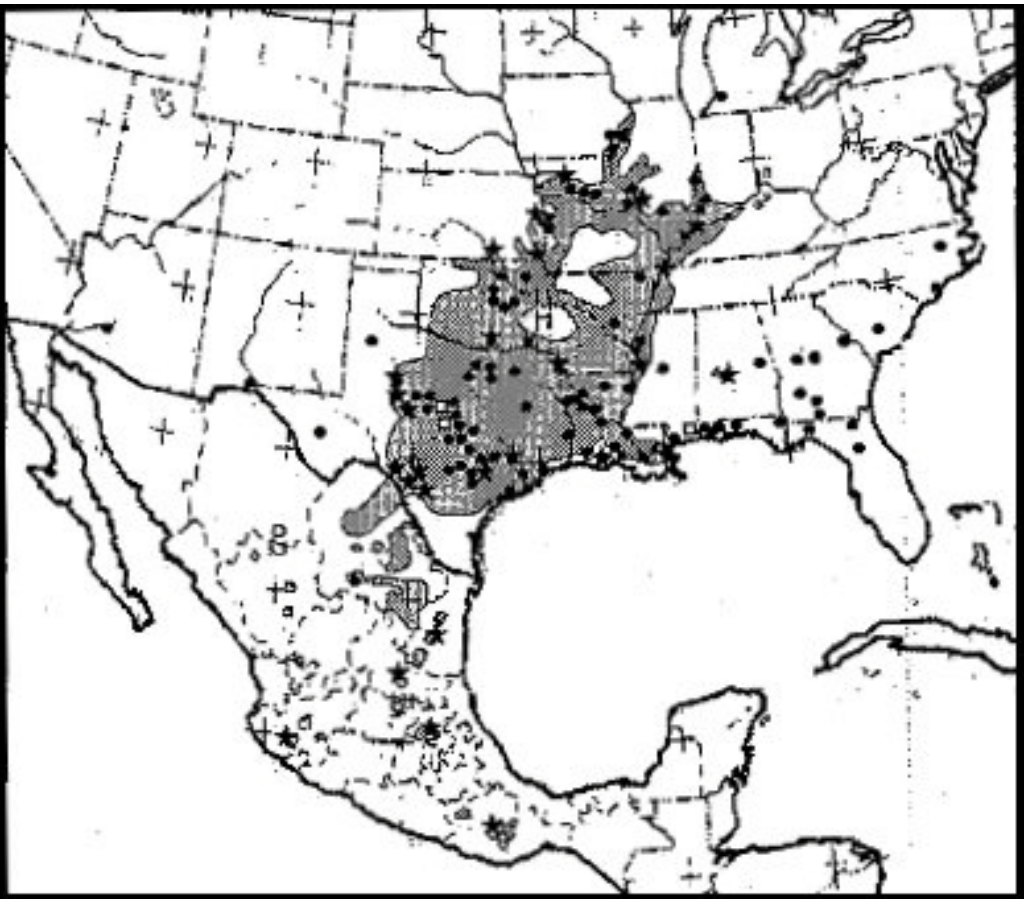
Pecan – *Carya illinoensis*

Juglandaceae family – includes pecans, hickories, walnuts.

Native Pecan Distribution



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.

- Pecan scab #1 production constraint in this region.

Desirable + Stuart = 60% Trees in Georgia

Desirable

Stuart

- Nuts from a sprayed orchard in 2005.

Floral Biology

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

Characteristics of Pecan

- Clonally propagated
- Seedling rootstock
- Heterozygous

Severe inbreeding depression prevents development of inbred lines

Pecan genetics

- Pecans cultivars are very heterozygous due to their sexual biology.
- When you cross two cultivars you get a lot of variation in the seedlings. An F_1 in pecan is similar to an F_2 in an inbreeding crop.
- 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.

Breeding Strategy

Recurrent Mass Selection

1. Select superior seedlings from chance populations.
2. Hybridize among best selections.
3. Selection superior offspring for use as parents in the next cycle or as cultivars.

Cross 2 parents which in combination have the desired traits and select seedlings which have desired traits.

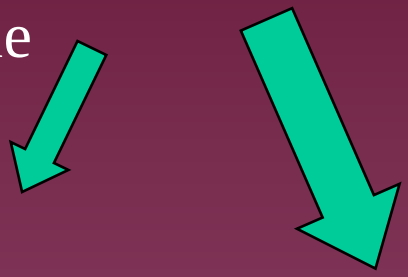
Cultivar #1

1. Large nuts
2. Early harvest
3. Disease susceptible

X

Cultivar #2

1. Small nuts
2. Late harvest
3. Disease Resistant



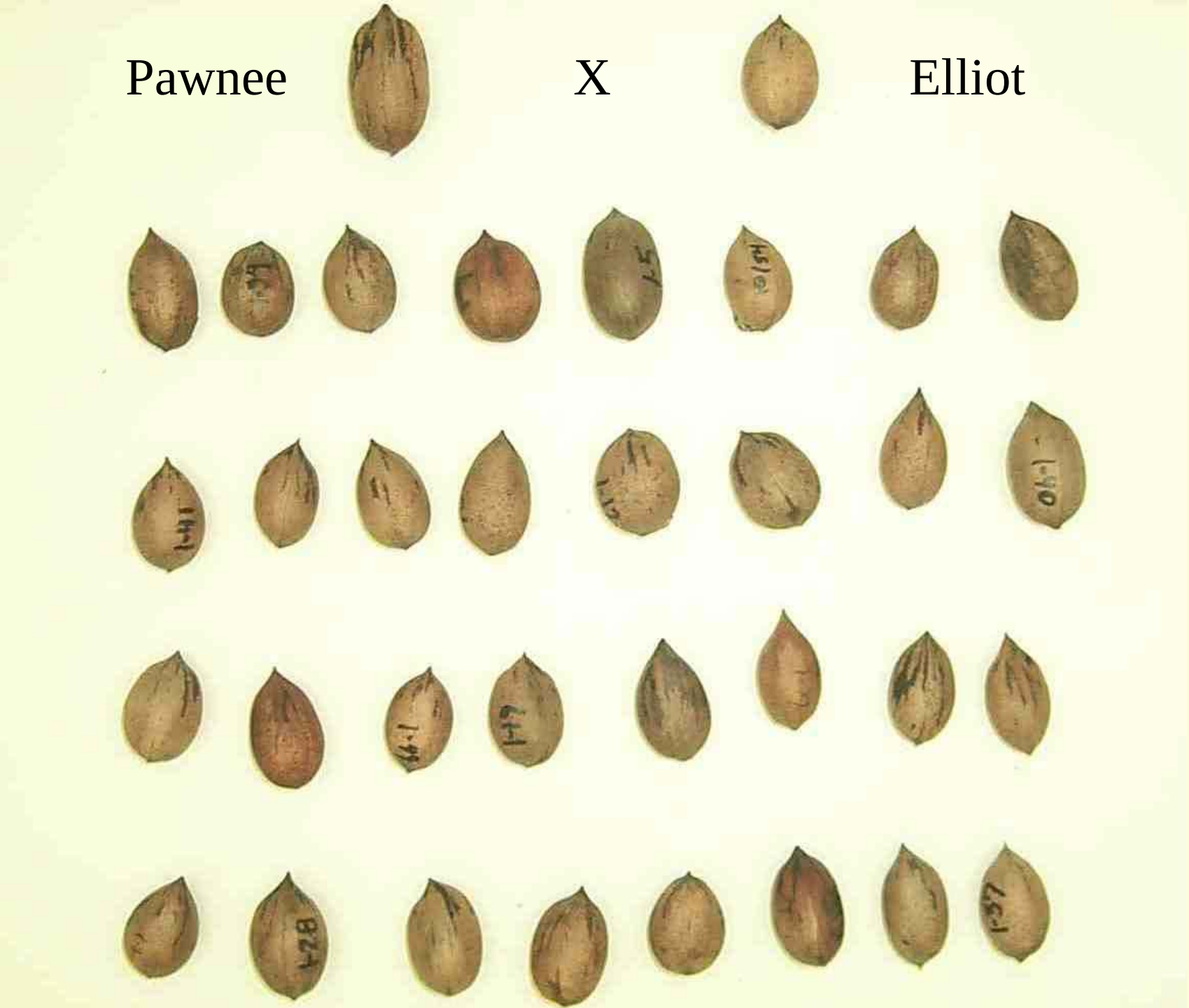
New cultivar

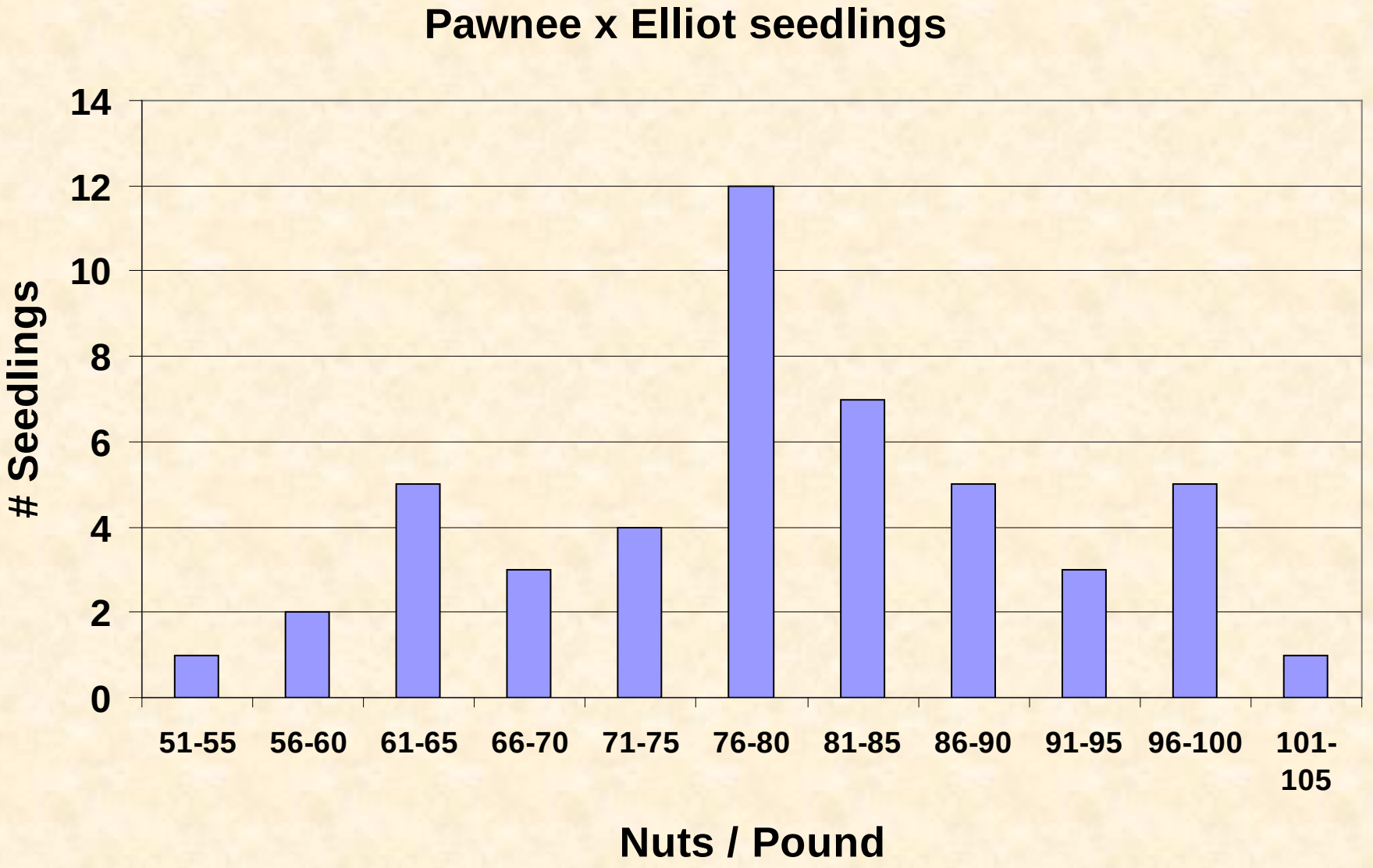
1. Large nuts
2. Early harvest
3. Disease resistant

Most seedlings

1. Small nuts
2. Late harvest
3. Disease Susceptible

"Quantity makes Quality" – The breeder must find clever ways of selecting from as many seedlings as possible.


Pawnee
X
Elliot

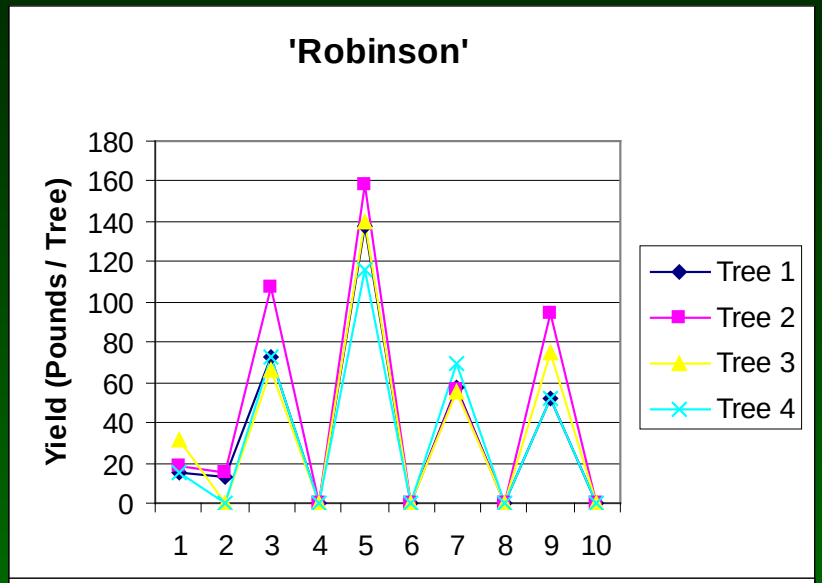


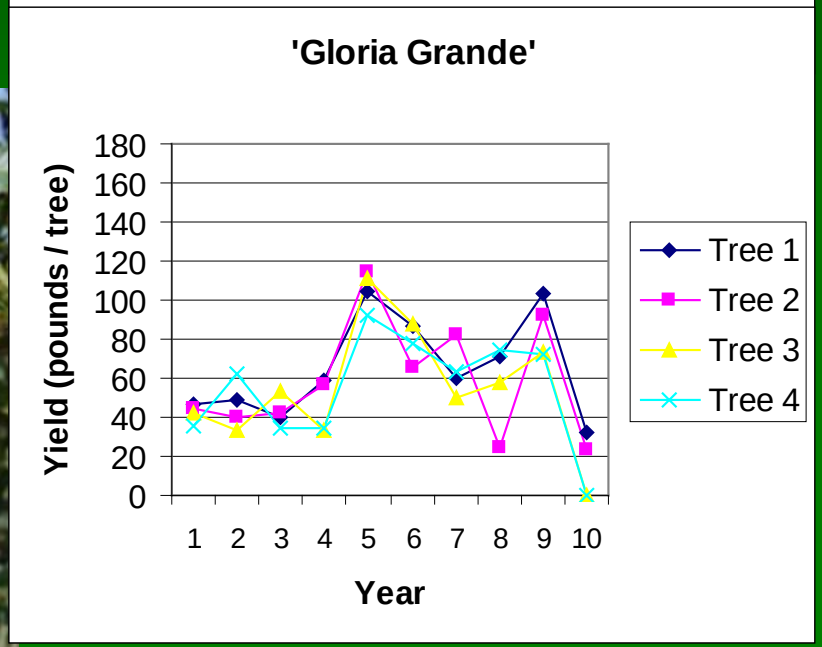
Pawnee = 52 nuts / pound

Elliot = 77 nuts / pound

Goals of the pecan breeding program

- Increase pest resistance
- Stabilize production
- Increase quality
- Earlier harvest date
- Increased productivity





Nuts and bolts of pecan breeding

Pollen Collection

Pollination Technique


6/7/1999


1/23/1999

Seedling Evaluation Phase I

- Initial Screen
  - 10 year selection cycle
  - Evaluate for:
    - **nut size and quality**
    - **tree vigor**
    - **earliness**
    - **disease resistance**
    - **insect resistance**

Seedling Nursery - Year 1

Seedling Nursery - Year 2


3/7/2002

Seedling Orchard Year 3

Seedling Orchard – Year 3

Seedling Orchard – Year 6

Seedling Orchard – Year 9

Seedling Evaluation Phase II

Takes 5-15 years to complete.

- Propagate best selections for replicated trials
  Grower trials and university trials.
- Compare to elite cultivars
  - tree productivity
  - alternate bearing intensity
- Use best new selections as cultivars or parents in breeding program.

Why do we need to test for so long?

- For many selections quality declines as trees come into full production.
- Hidden problems sometimes only appear in the right environment.
- Replanting an orchard is very expensive!

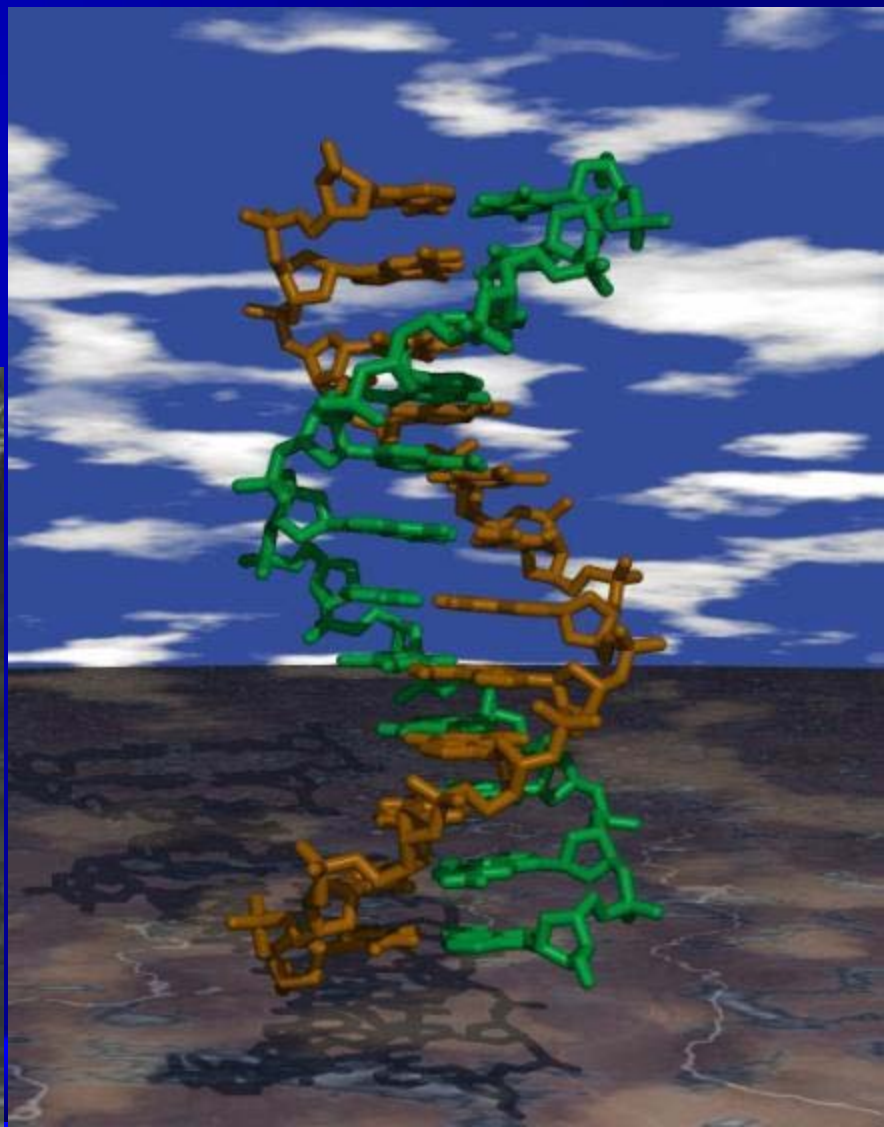
Cultivar	% kernel years 1-10	% kernel years 11-20	Alt. Bearing Index
Kanza	51.3	51.5	0.73
Kiowa	53.1	52.2	0.65
Melrose	54.1	49.8	0.79
Pawnee	55.0	53.2	0.58
41-19-20	52.5	40.0	0.85
53-9-1	51.8	45.5	0.81

Where are we now?

- 142 crosses made, 18,000 seedlings produced.
- Selections evaluated from 1999, 2000, 2001, 2002, 2003 progenies.
- 11 seedlings selected for replicated testing.

DNA Linkage Maps for Pecan

Pecan Breeding in the 21st Century

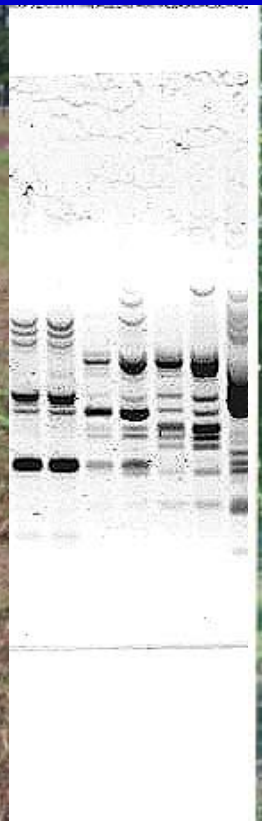


Large progenies of pecan are expensive and time-consuming to evaluate.

Each seedling requires 150 square feet (290 trees / acre) for 10 years to be evaluated for nut characters.

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

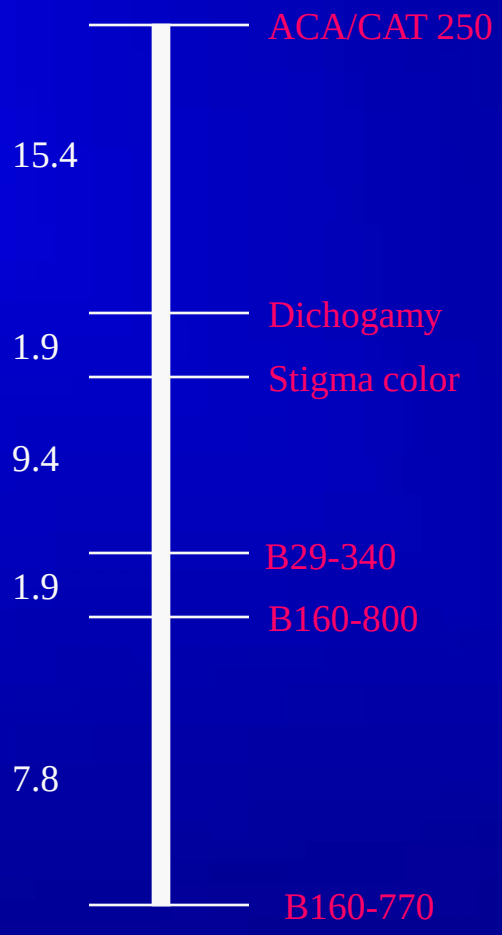
Protogynous

Highly scab resistant

Pawnee and Elliot Maps

	Pawnee	Elliot
No. of markers in map	220	178
No. of major linkage groups	16	15
No. of minor linkage groups	13	11
% of genome covered	83 %	57 %

Markers Linked to Genes



Elliot linkage group No. 16

Difficulties of Molecular Mapping.

- Relatively small crop with a limited number of people and funding available.
- Inbreeding depression prevents development of the most informative populations.
- Expensive to grow and evaluate the large populations needed to effectively analyze quantitative traits.
- A large array of traits is needed in new cultivars, and most have a complex inheritance.

Future Work

- Establish linkages to other important genes
  - Scab resistance
  - Nut Size
  - Harvest Date
- Develop maps for other cultivars

What makes fruit breeding different?

- Most fruit crops are clonally propagated.

Genetic improvement can be immediately fixed in pecan since only vegetative propagation is used.

This partially makes up for the long generation times.

What makes fruit breeding different?

- Large plant size
- Long generation times (7-10 years)
- Long variety testing periods needed (5-15 years)
  - Requires a large amount of land, time, people, and resources.

The breeder is breeding for the future.

Patience is required of the breeder, the growers, and administration.

You only get a few generations in your lifetime, make them count!

What makes fruit breeding different?

- A multitude of factors determines the ultimate success of a cultivar.
  - Yield, harvest date, pest resistance, color, size, taste, plant form, annual bearing, etc.

The breeder MUST be familiar with the crop and how it is grown.

Hold field days.

Visit growers.

Attend grower meetings.

(Don't be a lab rat!)

What makes fruit breeding different?

- Many fruits are relatively new crops.
  - Pecan 2-3 generations from wild trees.

These crops are in their infancy. Much of the available variation has yet to be used, or even described.