The Art of Plant Breeding

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“Imagination is more important than knowledge”  Albert Einstein
“Plant breeding is a unique science in at least 2 ways. First, it uses knowledge and techniques from many basic science areas and second, its contribution to agricultural progress is measured not only by information, but also by material products such as crop varieties, hybrids, cloned, etc.”

K. J. Frey 1965

“Plant breeding, broadly defined, is the art and science of improving the genetic pattern of plants in relation to their economic use.”

D. C. Smith 1965
**Plant breeding is a team sport**

**Players**

<table>
<thead>
<tr>
<th>Breeders</th>
<th>Economists</th>
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<tbody>
<tr>
<td>Geneticists</td>
<td>Soil Scientists</td>
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<tr>
<td>Molecular Geneticists</td>
<td>Food Scientists</td>
</tr>
<tr>
<td>Pathologists</td>
<td>Weed Scientists</td>
</tr>
<tr>
<td>Entomologists</td>
<td>Physiologists</td>
</tr>
<tr>
<td>Systems Agronomists</td>
<td>Statisticians</td>
</tr>
<tr>
<td>Extension Specialists</td>
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</tbody>
</table>

**Input from:**

- Producers
- Consumers
- Industry

*“Intelligent selection is imperative to success”*

H. M. Beachell, 2001
Selection requires making a Choice

- Parental Germplasm
- Breeding Methods
- Genotypes for testing
- Testing Procedures
- Cultivars ultimately released as varieties

Selection Criteria Change

- Economic conditions change
- Crop management practices change
- Environmental conditions change
Primary Goal of Selection

Identify Desirable Genotypes

Selection Method Depends on:

- Objectives of the program
- Inheritance patterns of traits to be improved
- Germplasm available
- Goals of the program
RICE BREEDING OBJECTIVES

- **Quality**
  - Maintain or improve cooking quality
  - Increase grain length
  - Minimize chalkiness
  - Increase product diversity
    - Specialty rice
    - Nutriceuticals

- **Yield**
  - Higher yields, both rough rice and milling
  - Plant type
  - Yield and milling stability over environments

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RICE BREEDING OBJECTIVES

- **Stress resistance**
  - Biotic
    - Combined disease resistance
    - New sources of blast resistance
    - Sources of rice stink bug resistance
  - Abiotic
    - Cold tolerance

- **Maturity**

- **Water Conservation**
Germplasm Available

- Genetic variability of the current populations
- Variability available from plant introductions
- Variability from other cooperative programs

“Choice of germplasm is a critical decision in a breeding program that requires considerable thought; it will determine maximum potential improvement that can be attained via breeding; the breeding system will determine how much of that maximum potential can be realized.”

A.R. Hallauer & J. B. Miranda, Fo 1981
Goals of the program

Breeding population - Maximum variability
A pure line is a heterogeneous population of homozygous individuals

Genetics population - limit variability
A pure line needs to be created from 1 male and 1 female.

Breeding Procedures

- Pedigree
- Backcrossing & Forward crossing
- Recurrent selection
- Induced mutation
- Single seed descent
- Bulk selection
- Mass selection
Breeding Program Objectives

Short- intermediate- and long-term goals

Short Term Goal

Cultivar Development
Intermediate Goals

Developing Potential
Materials for the future

Long Term Goals

Creating populations and
Genetic Conservation
Genetic Gains are also made in conjunction with improvements in management.

Average Rice Yields for Arkansas

*Record state Yield of 6910 lbs/a (154 bu/a) in 2004
4th consecutive year for new record
Genetic Variability

Simple Screens for Traits of Interest
The act of visually selecting desirable plants remains a part of plant breeding today.

Success in plant breeding hinges on ability to integrate information from all disciplines.
Parental Selection Based on Genetics

Ideotype

A model plant type in terms of morphological and physiological characters.

W. R. Fehr 1987, Rasmusson and Gengenbach 1983
Art of Plant Breeding

- College Courses
- Scientific Literature
- Communications
- Experiments
- Observations
- Experience

“Sight is a faculty; seeing is an art”

George Perkins Marsh
“Tenacity – a personal trait of the individual scientist who is sometimes guided only by his own convictions and conceptions in the “art” of breeding. After gathering insights and experiences from as many sources as possible the designer or architect may have to forego the support of his team and fashion his work with his own vision and intuition.”

H. M. Beachell 2001

“Once a dog always a dog. If you don’t like a line at some point in the process, don’t question your decision at a later date, throw it out.”

W. R. Fehr
“The wider the range of conditions investigated in the experiments, the greater is the confidence we have in the extrapolation of the conclusions.”

D. R. Cox 1958

**Time Required to make a Variety**

Newbonnet – cross 1968; released 1983; certified seed 1985 = 17 years
Katy - cross 1979; released 1989; certified seed 1991 = 12 years
LaGrue - cross 1985; released 1993; certified seed 1995 = 10 years
Wells - cross 1989; released 1999; certified seed 2001 = 12 years
Marker assisted selection is not a time reducing tool but an accuracy and efficiency tool.

What are your goals for the future?
“We need to anticipate future needs and strive for goals not easily pictured by others – far-sightedness and tolerance of uncertainty are useful attributes – long term commitment and patience are required.”

H. M. Beachell 2001

“We have not found the best way to do anything”

G.W. Burton 1979
Plant Breeding is a numbers game

“If yield is important, and it usually is, few tools are as efficient as the trained eye for selecting the better plants among thousands of individuals”

G.W. Burton 1979
### My ideal plant type

**Is subjective & includes:**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedling vigor</td>
<td>Dark green</td>
</tr>
<tr>
<td>Stiff strawed</td>
<td>Stay green</td>
</tr>
<tr>
<td>Erect plant</td>
<td>Intermediate width leaves</td>
</tr>
<tr>
<td>Erect leaves</td>
<td>None to slight awning</td>
</tr>
<tr>
<td>Large panicle</td>
<td>95-100 cm height</td>
</tr>
<tr>
<td>Compact – intermediate</td>
<td>100-125 days to maturity</td>
</tr>
<tr>
<td>Size and shape of grain</td>
<td></td>
</tr>
<tr>
<td>Secondary branching</td>
<td></td>
</tr>
<tr>
<td>Some tillers</td>
<td></td>
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### Phenotype

![Phenotype images]
“Biotech won’t soon replace “conventional” breeding”

David Mackill in Rice Today 2003

Quote from Planning of Experiments Dr. D.R. Cox 1958

“Spratt-Acher barley was almost everywhere a great success; yet in one district the farmers refused to grow it, alleging that their own race of barley was superior. After some time the Department of Agriculture, to demonstrate Spratt-Acher’s superiority, produced a single line culture of the native barley and tested it against the Spratt-Acher in the district in question. — The farmers were perfectly right: the native barley gave the higher
yield. –The barley in question grew more and was able to smother the weeds, which flourished in the area; Spratt-Acher – was the victim of the weeds. Thus, the original experiments, carried out on well-farmed land, were definitely misleading when their conclusions were applied elsewhere.”

“When one starts tugging at a single thing in nature he finds it attached to the rest of the world”

John Muir