Optimization of the Rice Breeding Program at the Louisiana State University AgCenter

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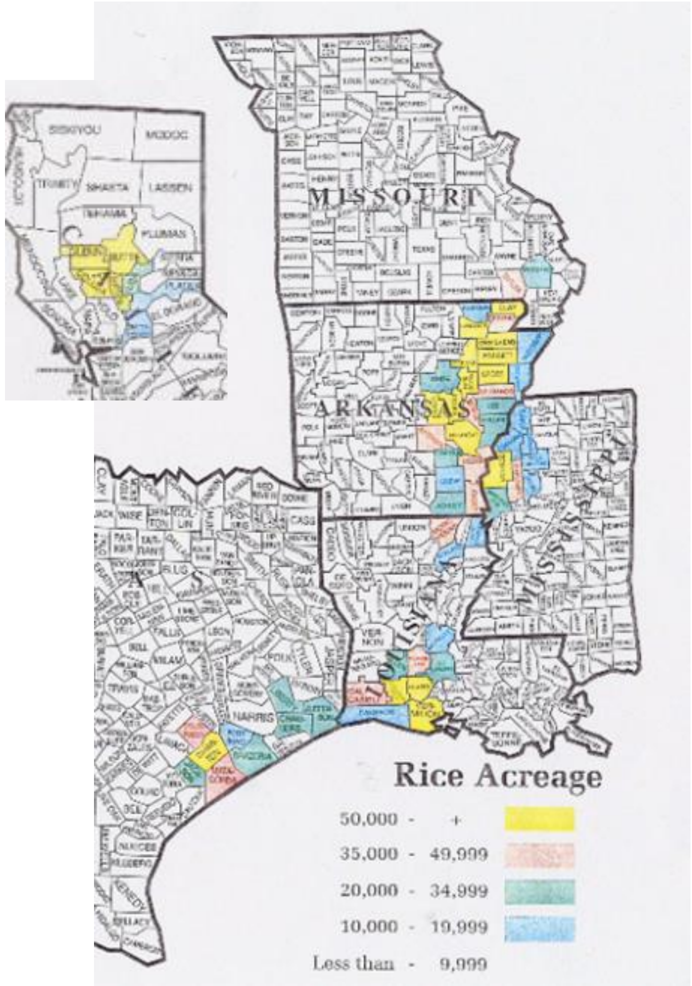
Outline

- Introduction and Background
  - Rice in the US
  - LSU Rice Breeding History
- General Breeding Considerations
- LSU Rice Breeding
  - Traits and Priorities
  - Stages and Activities
  - Markers and Genomic Selection
- Optimization across stages
- Summary

Rice in the United States



- $34 Billion Economic Contribution
- 10 Million Tons Produced
- ~1.1 Million ha
- Accounts for 80% of rice consumed within US
- 50% Exported to over 120 Countries
- 5th Largest Rice Exporter

https://www.usarice.com/thinkrice/discover-us-rice/where-rice-grows

Rice in Louisiana

- ~190,000 ha in 2023
- ~200,000 ha in 2024 estimated
- Primarily Long and Medium Grain
- Crawfish is the primary rotation in Southwest Louisiana (~100,000 ha)
- Ratoon (2nd) Crop along Gulf Coast production areas

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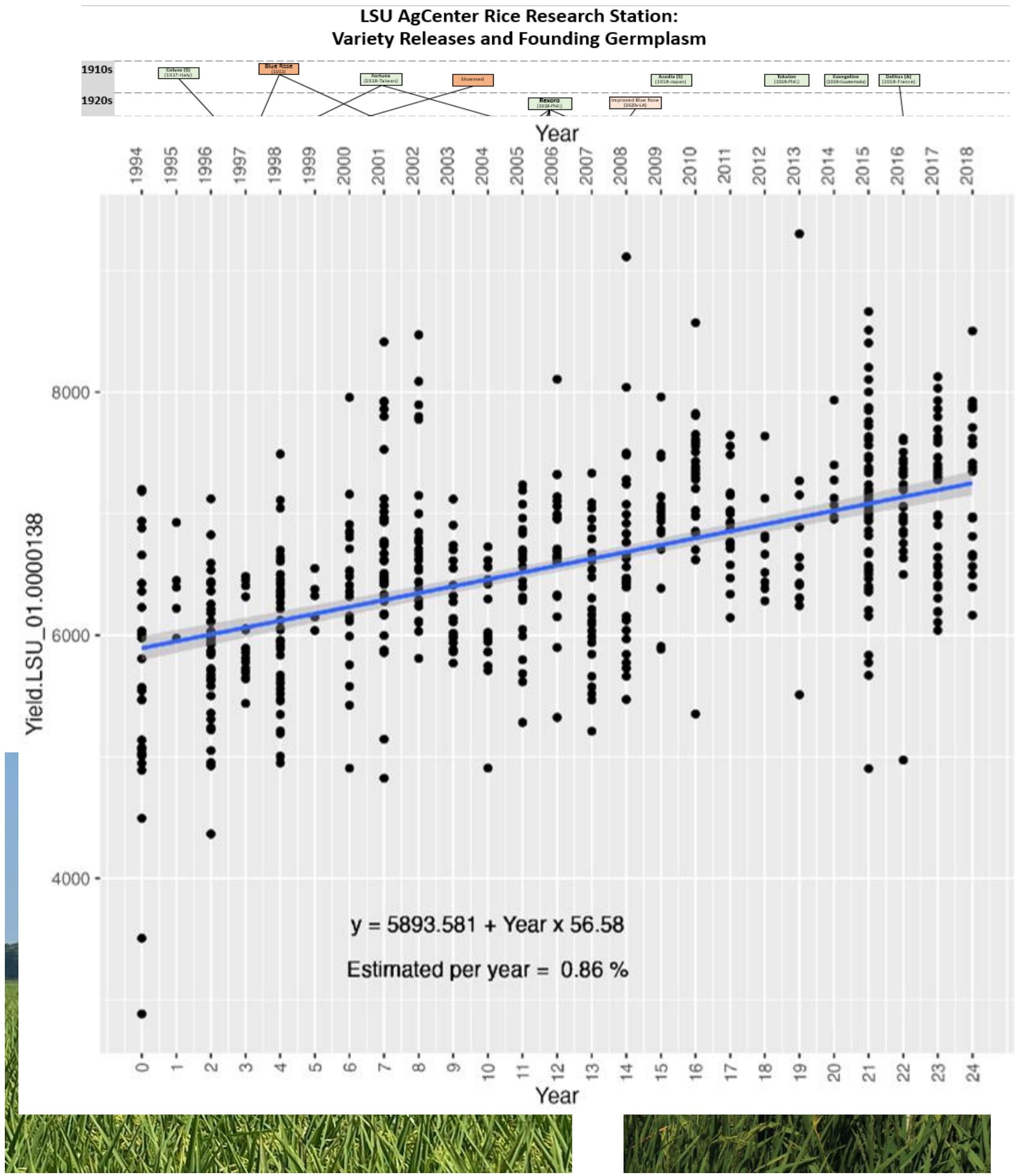
History of LSU Rice Breeding

- Started in 1908
- Focus has evolved with the industry
- 65 Released Varieties
- Developed the Clearfield trait and the first Clearfield herbicide tolerant varieties (2001-present)
- Developed the first 3 Provisia herbicide-tolerant varieties (2018-present)
- 100% non-GMO
- Accounts for ~65% of Louisiana rice area



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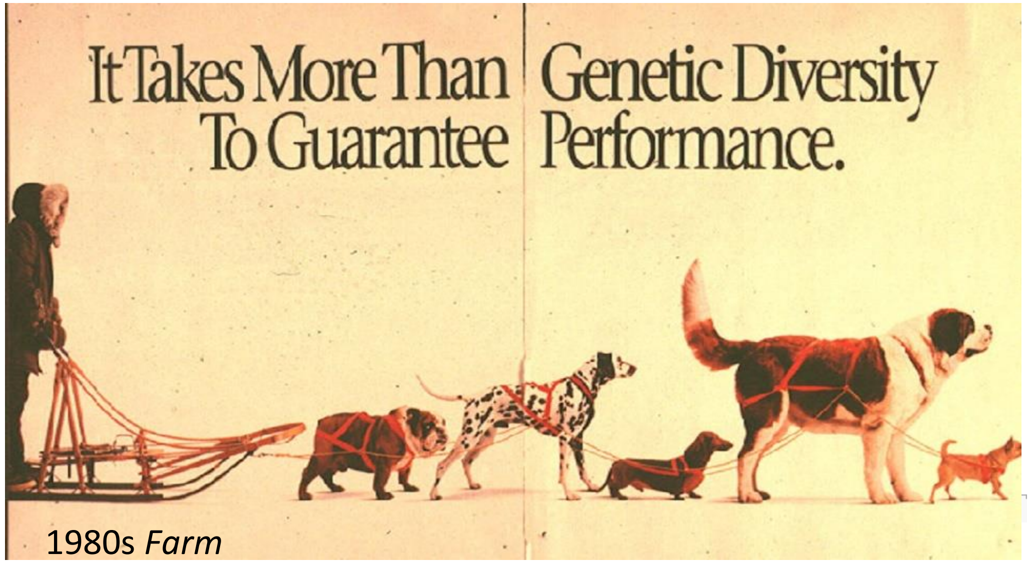
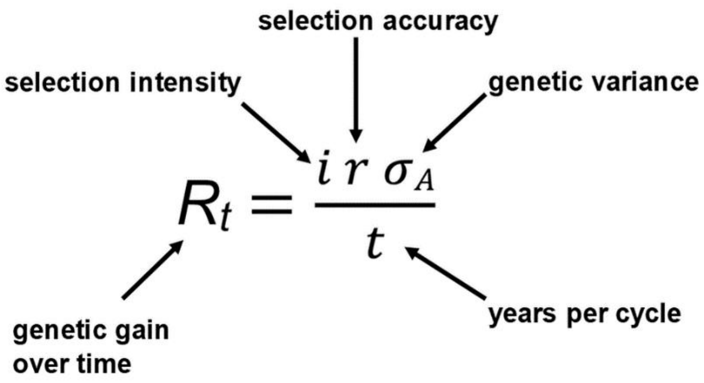
Breeding Strategies and Considerations

- Breeder's Equation
- Balancing Tradeoffs
  - Time vs. Accuracy
  - Short term vs. Long term
    - Products and germplasm
  - Selection Intensity and Genetic Diversity
  - Genetic Gain AND performance

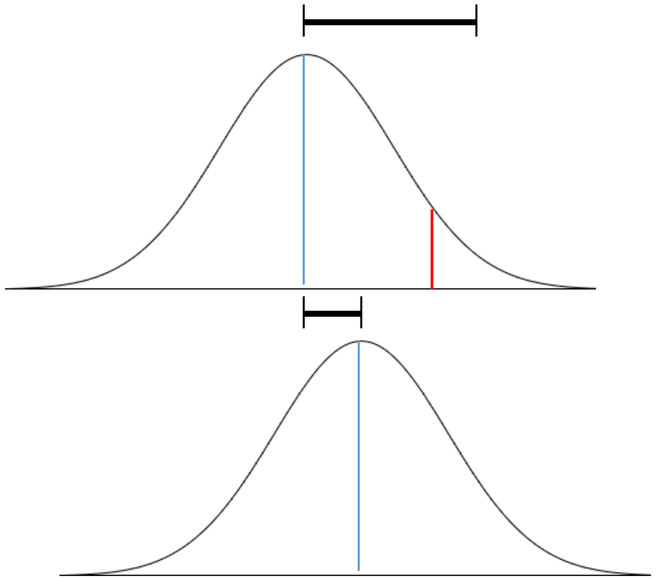


1980s *Farm Journal*

The breeder's favorite equation



Nonoy Bandillo (NDSU)



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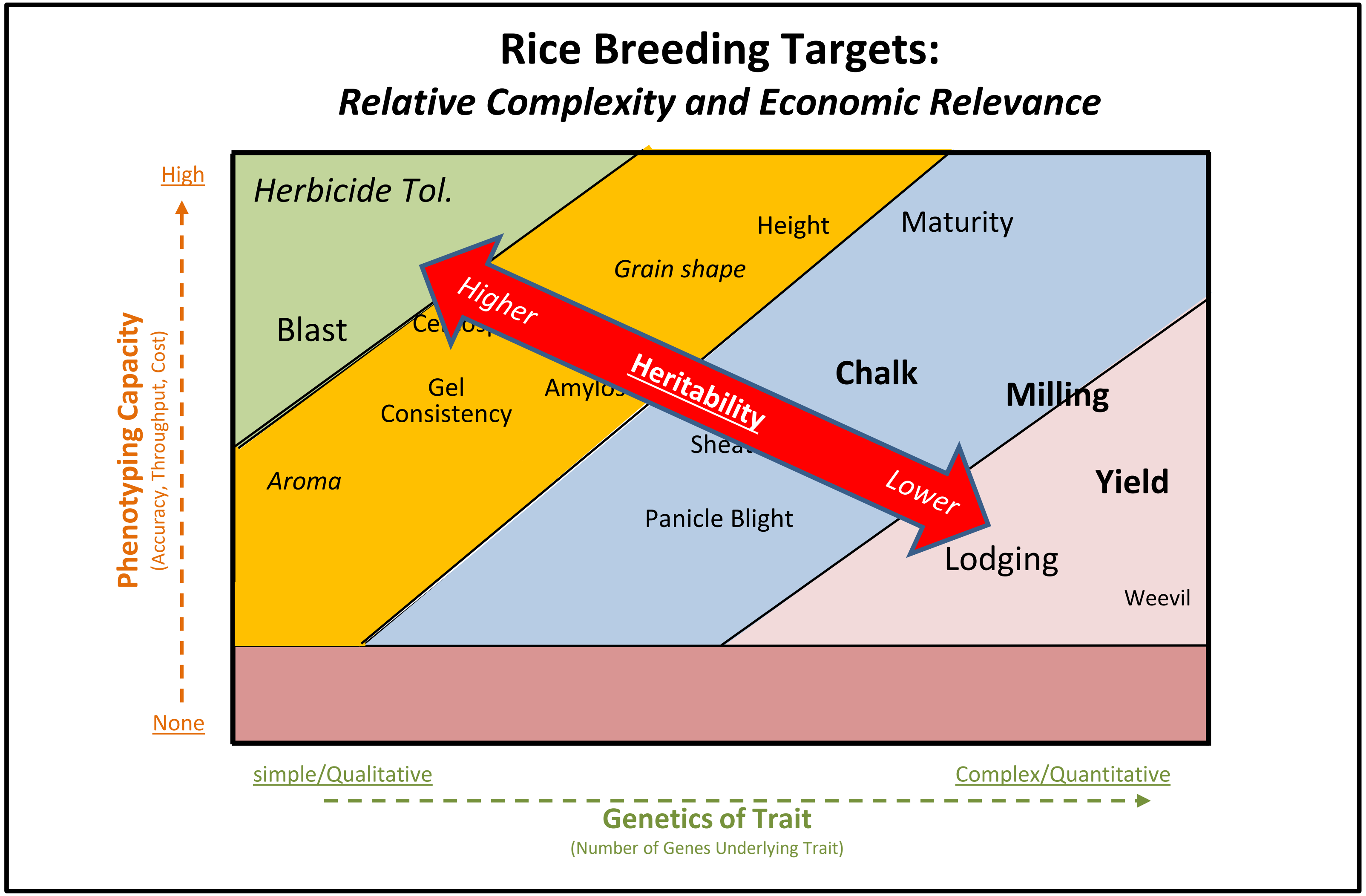
LSU Rice Breeding: Traits and Priorities

- Profitability and Sustainability
- Primary Traits:
  - Yield and Quality
- Secondary Traits:
  - Herbicide tolerance
  - Disease resistance
  - Lodging resistance
  - Early Maturity
  - Vigor
- Characterization Traits

LSU Rice Breeding: Traits and Priorities



LSU Rice Breeding: Breeding stages

Pop. Development	Breeding Crosses	Yr. 1	• 300 new pops/yr. • Elite x Elite
	Single Plant Selection	Yr. 1	• F2 • 200 pops • PR or GH Adv.
Line Development	Progeny Row stage 1	Yr. 2	• F2:F3 • 20,000 rows • Visual selection
	Progeny Row stage 2	Yr. 3	• F3:F4 • 9,000 rows • Visual selection
Preliminary Yield Testing	Preliminary Yield Test	Yr. 4	• 1500 F3:5 Entries • 2 env. / 1 rep • Yield, Agro, G.Q.
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	Pre-comm. Test	Yr. 7/8	• 5 Entries • 25-30 env. / 3 reps • Yield, Agro, GQ, Path
Purification and Increase	Foundation Increase	Yr. 8	• Breeder seed with last year of testing

Higher heritability traits

Lower heritability traits

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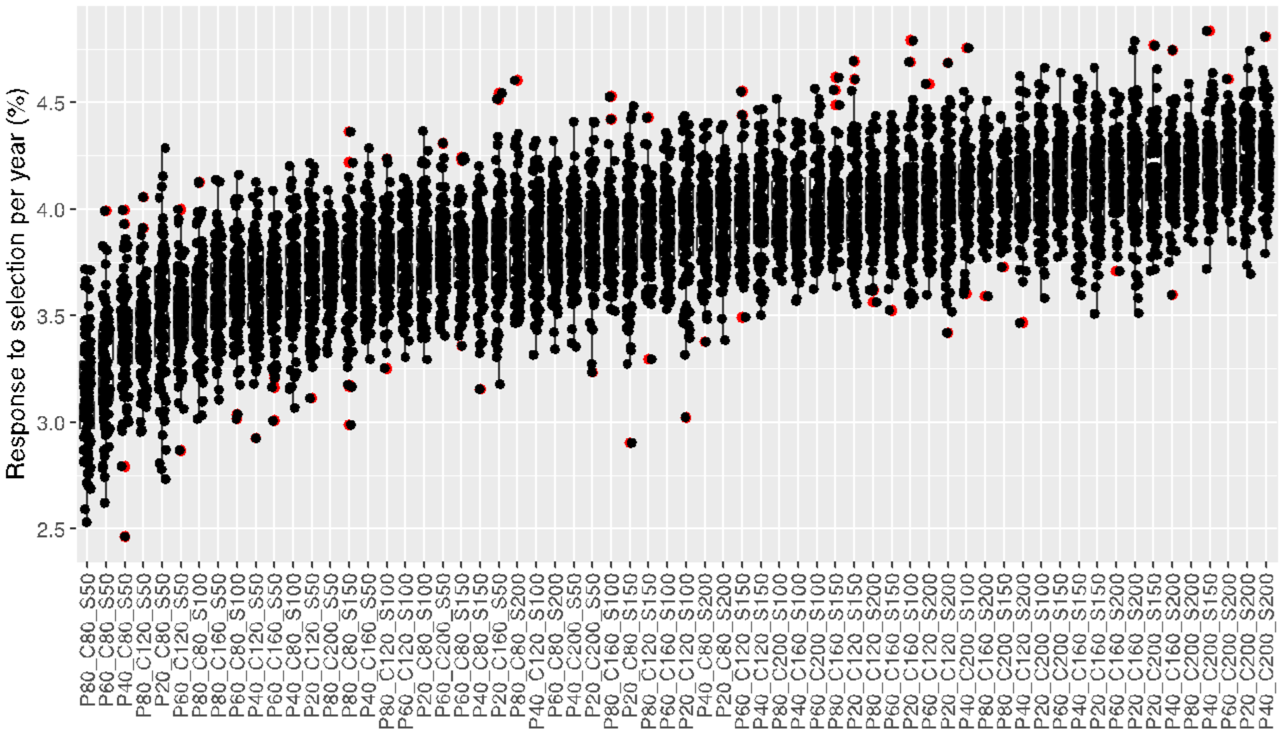
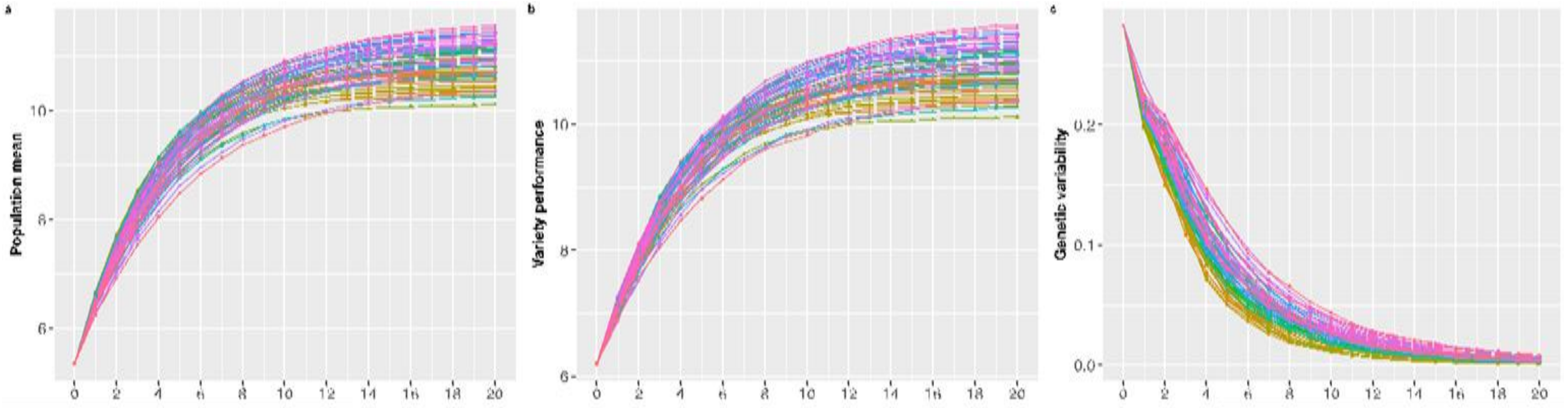
LSU Rice Breeding: Pop. Development

- Parent selection
  - Traits
  - Breeding value
  - Diversity
- Considerations
  - Number of parents
  - # of Pops
  - Pop. Size
  - Budget and Logistics
- Targets
  - 40 parents
  - 150 pops x 100 lines





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Breeding Objectives: Line Development

Breeding Crosses	Yr. 1	• 300 new pops/yr. • Elite x Elite
Single Plant Selection	Yr. 1	• F2 • 200 pops • PR or GH Adv.
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Foundation Increase	Yr. 8	• Breeder seed with last year of testing

- Year 1-2, F2-F3 and generations
- Considerations
  - Seed
  - Segregation
  - Traits/Heritability
  - Environments
- Objectives
  - Homogeneity and inbreeding
  - Highly heritable traits
  - Time: most significant opportunity to speed up breeding cycle

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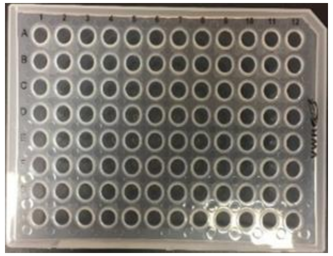
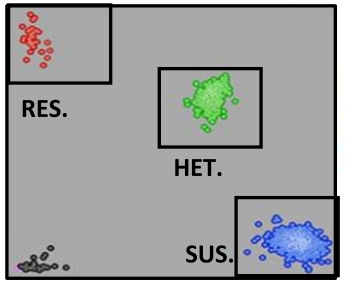
Winter Nursery- observational traits

Marker Assisted Selection for Qualitative Traits





		Locus 1	Locus 2
Group 1	~6%	Fix (.25)	Fix (.75)
Group 2	~19%	Fix (.25)	Enrich (.75)
Group 3	~56%	Enrich (.75)	Enrich (.75)

Breeding Objectives: Preliminary Testing Stages

Breeding Crosses	Yr. 1	• 300 new pops/yr. • Elite x Elite
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Foundation Increase	Yr. 8	• Breeder seed with last year of testing

- First stage evaluation
- Good source for GS Training Set (TS)
- Limited number of environments tested
  - Large number of entries
  - Seed limitations
- Objective is to select best materials to advance to next stage
  - Maintain diversity within advancements

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Preliminary Testing stages

Breeding Crosses	Yr. 1	• 300 new pops/yr. • Elite x Elite
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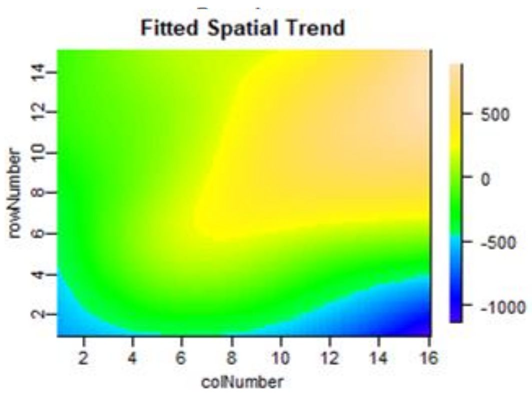

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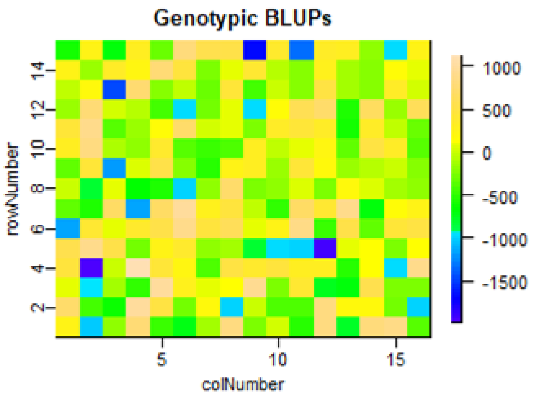

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LSU Rice Breeding: Preliminary Testing stages

Breeding Crosses	Yr. 1	• 300 new pops/yr. • Elite x Elite
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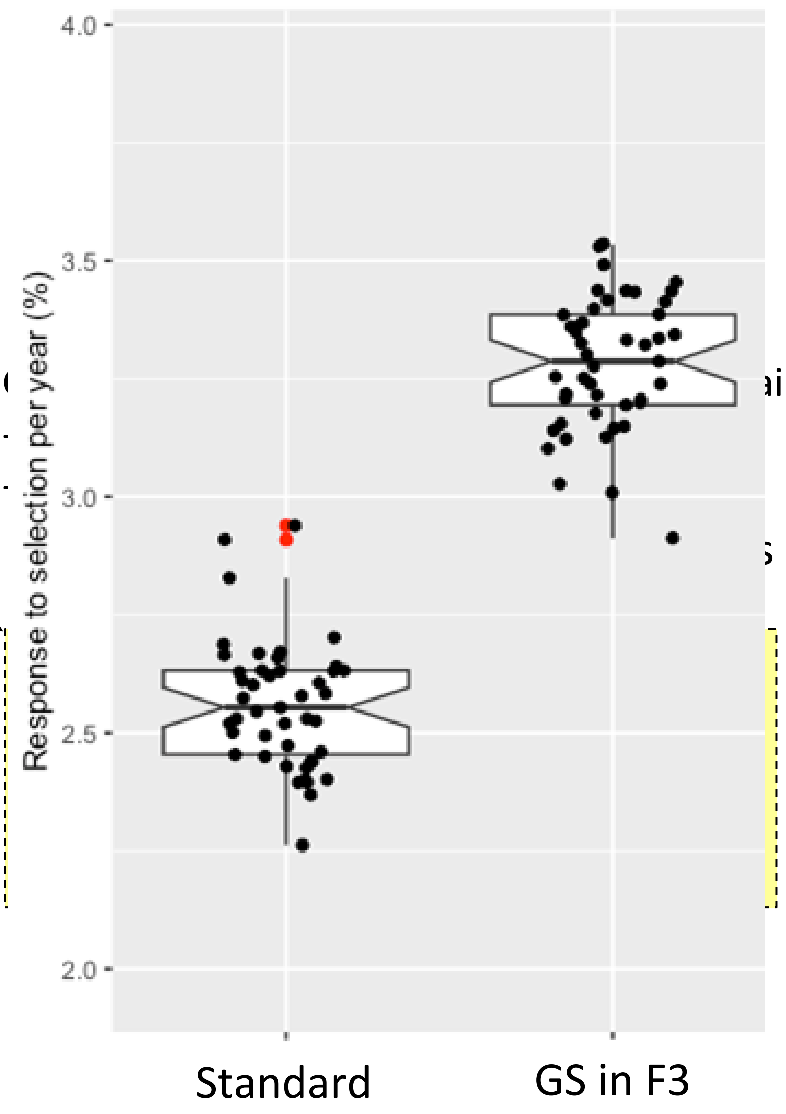

ain Chalk

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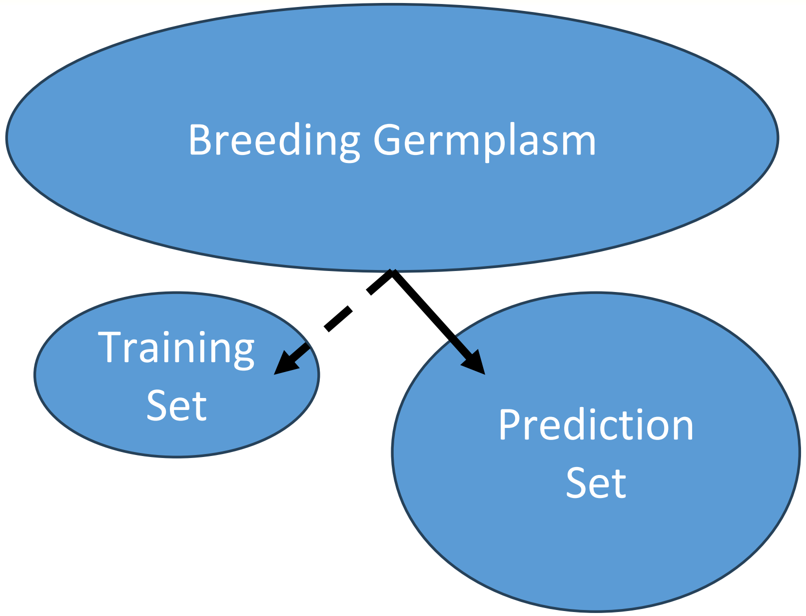
Genomic Selection

- Utilizes genome-wide marker data to estimate performance
- Does not require special/additional data, utilizes routine breeding data
- Most beneficial for quantitative traits and traits with lower heritability
- What are the benefits?
  - Accuracy (stage dependent)
  - Cost and logistics
  - Increased population sizes and selection intensity
  - Reduced cycle time
  - Maintain genetic diversity



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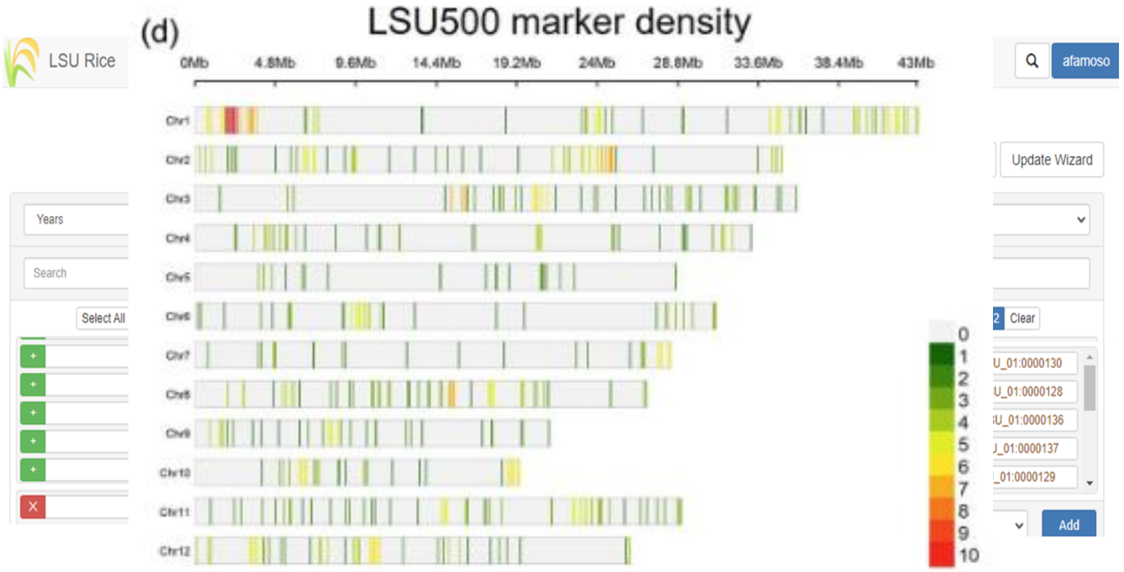
Genomic Selection Implementation

- GS Infrastructure
  - Breeding and Marker Database
  - Adequate marker set
- Considerations
  - Sampling and tracking
  - Logistics and time
  - Cost vs. Accuracy
  - Analysis methods
- Factors influencing accuracy
  - Trial quality/heritability
  - Genetic relatedness between training and prediction sets
  - Similarity of environments between training and prediction sets
  - Marker data quality



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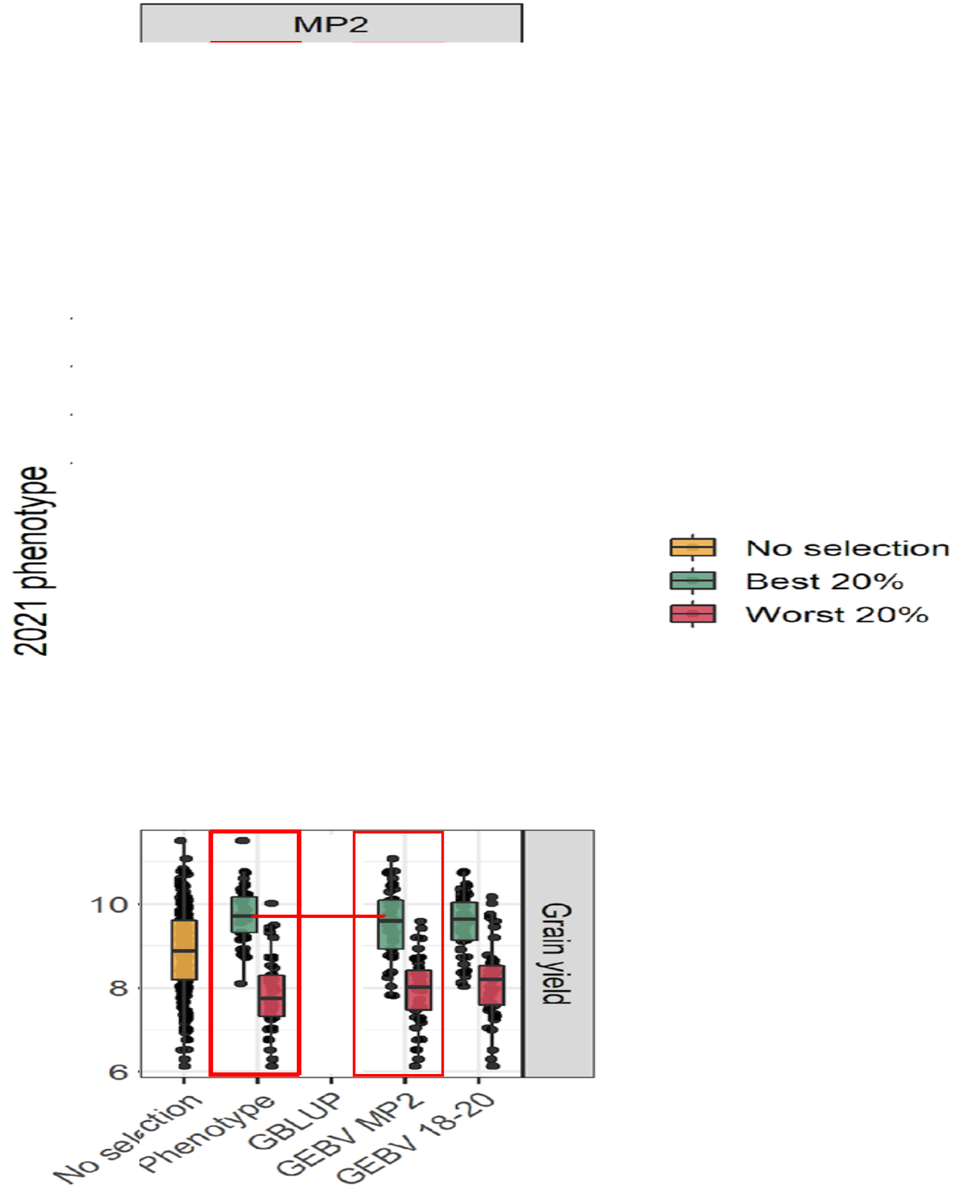
Genomic Selection Accuracy

- Factors influencing accuracy
  - Trait/Trial heritability
- Across three trials, DTH had consistently higher heritability than Yield
- As expected, the prediction accuracy for DTH is higher than Yield
- However, when we compare the performance of lines advanced based on phenotype vs. predictions, we observe improved predictions for Yield over DTH
  - Equal performance for yield in 2021 among lines advanced by predictions and lines advanced by 2020 phenotype
  - Slightly worse performance for DTH 2021 among lines advanced by predictions and lines advanced by 2020 phenotype
- This is not unexpected, as with the high heritability for DTH, the phenotype is more accurate and harder to beat.



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LSU Rice Breeding: Advanced Testing stages

Breeding Crosses	Yr. 1	• 300 new pops/yr. • Elite x Elite
Single Plant Selection	Yr. 1	• F2 • 200 pops • PR or GH Adv.
Progeny Row stage 1	Yr. 2	• F2:F3 • 20,000 rows • Visual selection
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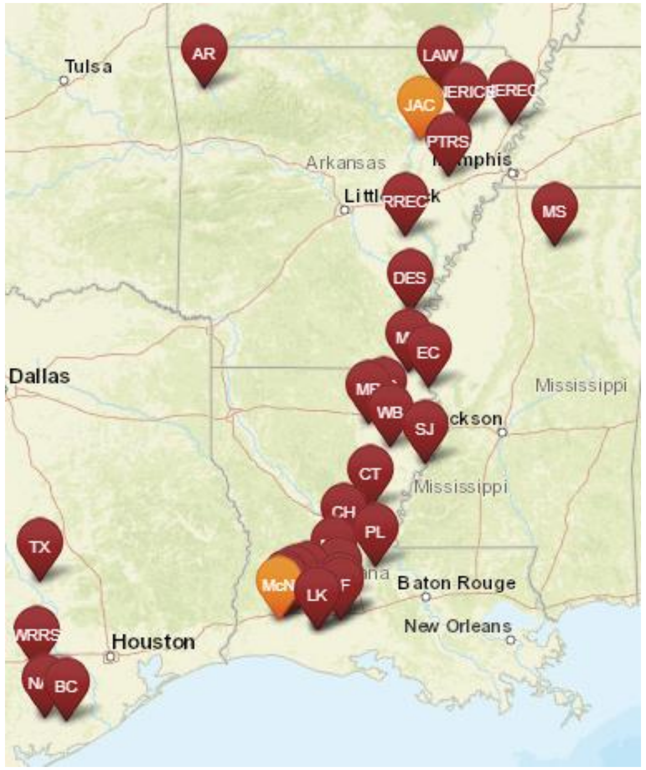
Foundation Increase	Yr. 8	• Breeder seed with last year of testing



- Collaborative Testing
- Selection based on phenotype
  - BLUEs
- Comparison to commercial checks
- Test as much as possible to give the line opportunities to show its flaws

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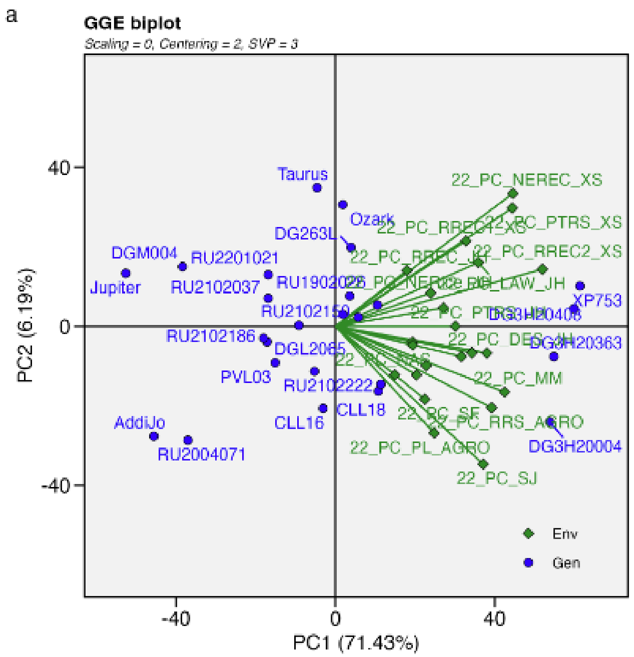
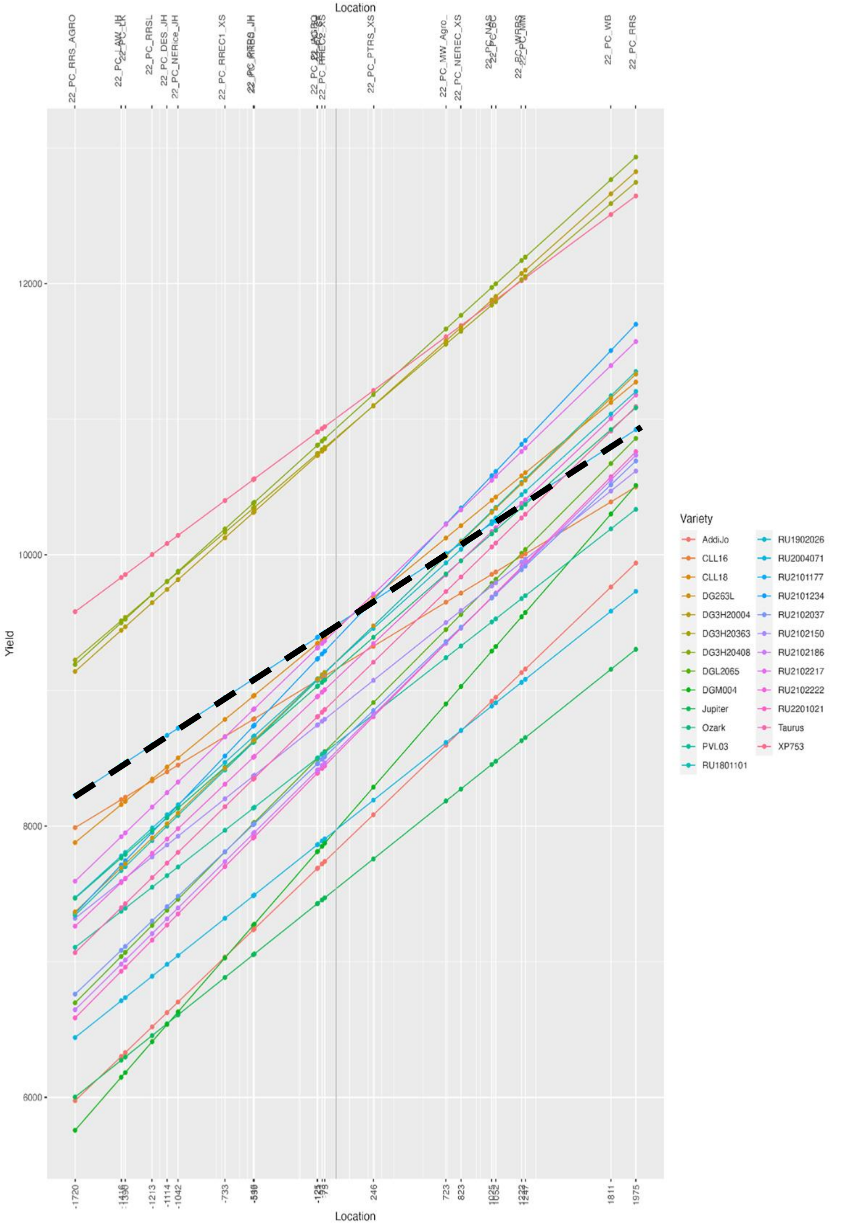
Breeding Objectives: Advanced Testing Stages

- Fewer entries
- Increased investment per line
- Multiple locations, reps, years
  - Increased heritability
  - Better understanding of stability
- Advancement focused toward on commercial potential





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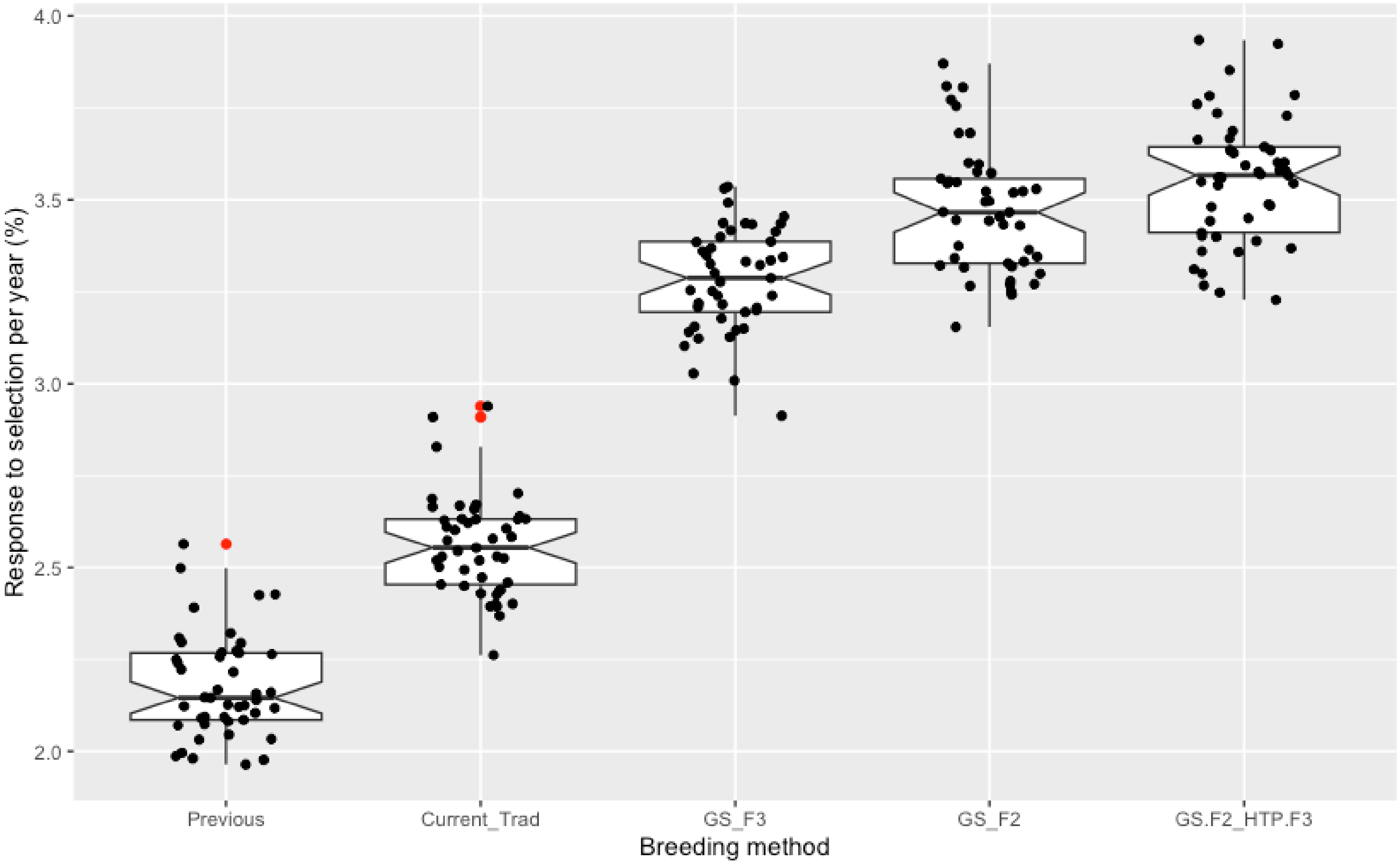
LSU Rice Breeding: Simulations



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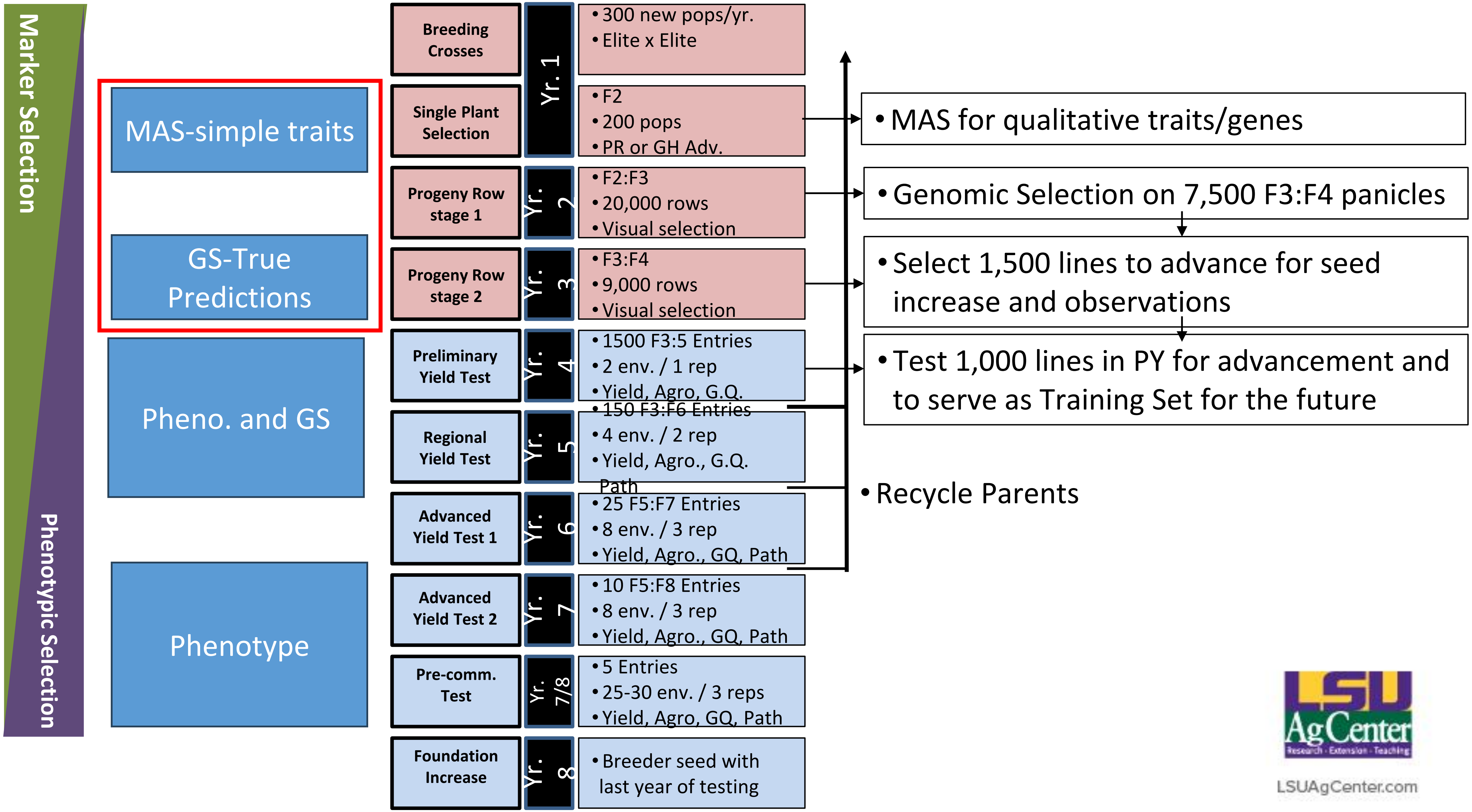
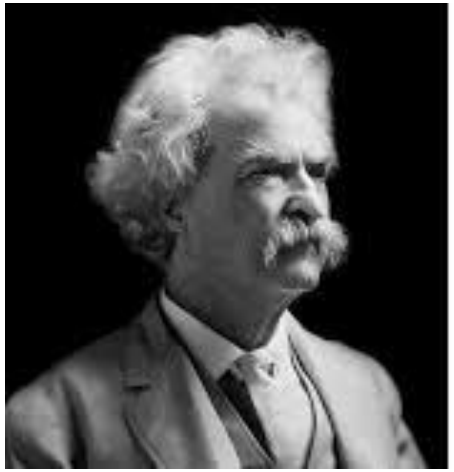
LSU Rice Breeding: Overall Summary



Summary

- Variety development and breeding strategies are a balancing act
- There is “no one size fits all” approach
- A solid foundation is required to build upon
- Start with the lowest hanging fruit that will have the most tangible benefit
- Execution is more important than good ideas
- Programs should constantly evolve, but we must be careful not to disrupt the program by trying to do too much at once
- Prioritize short-term deliverables first
- A team with complementary skill sets and an aligned vision is critical



“Continuous improvement is better than delayed perfection” - Mark Twain

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  - Topher Addison (Corteva-Cotton Breeder)
  - Raul Guerra (Pepsi Co.-Potato Breeder)
  - Chris Hernandez (Asst. Professor, UNH-Vegetables)
  - Jose Moreno Amores (Faculty, USFQ, Ecuador-QG)
  - Paola Mosquera (CIAT-Rice Breeder)
  - Frank Maulana (CA Rice Experiment Station-Breeder)
  - Maria Montiel (Horizon Ag.-Rice Breeder)
  - Jennifer Manangkil (Current)
  - Jomar Punzalan (Current)
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