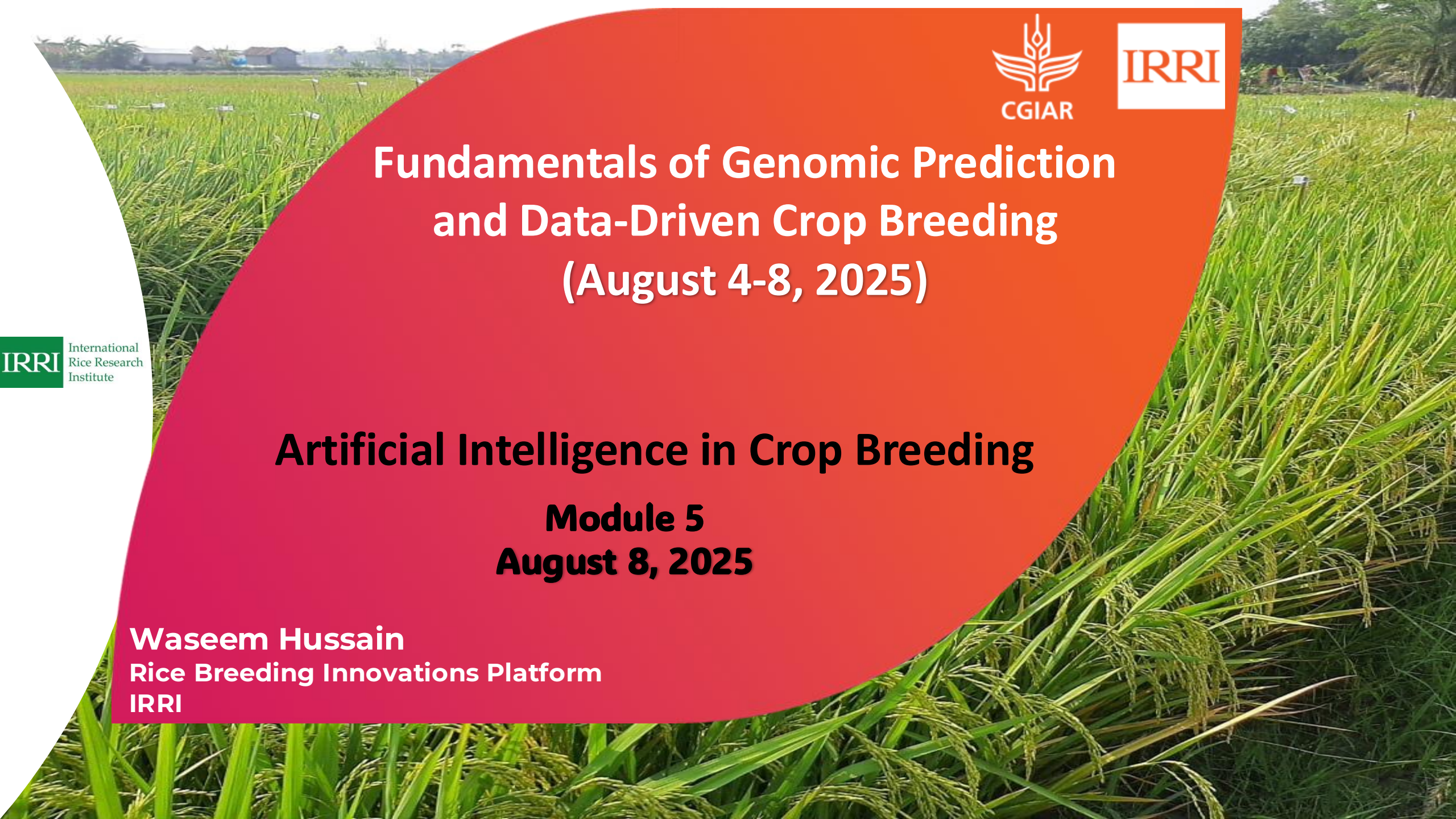


Fundamentals of Genomic Prediction and Data-Driven Crop Breeding (August 4-8, 2025)

IRRI International Rice Research Institute

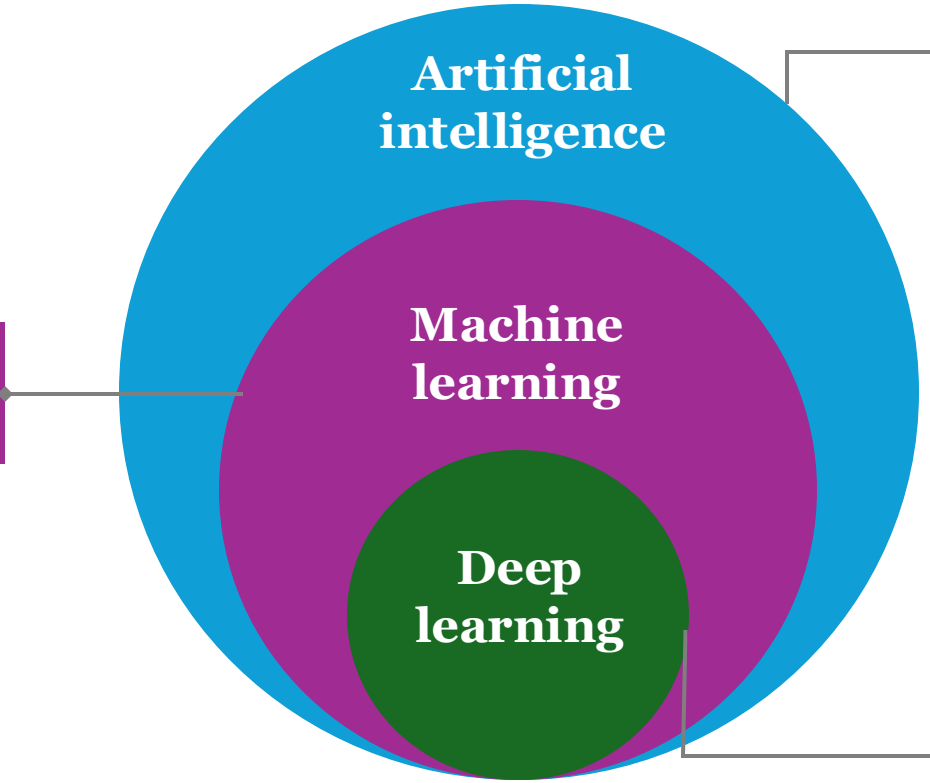
Artificial Intelligence in Crop Breeding

Module 5
August 8, 2025

Waseem Hussain
Rice Breeding Innovations Platform
IRRI

Artificial intelligence

Help in Decision-Making Process



Carry out the tasks as human intelligence

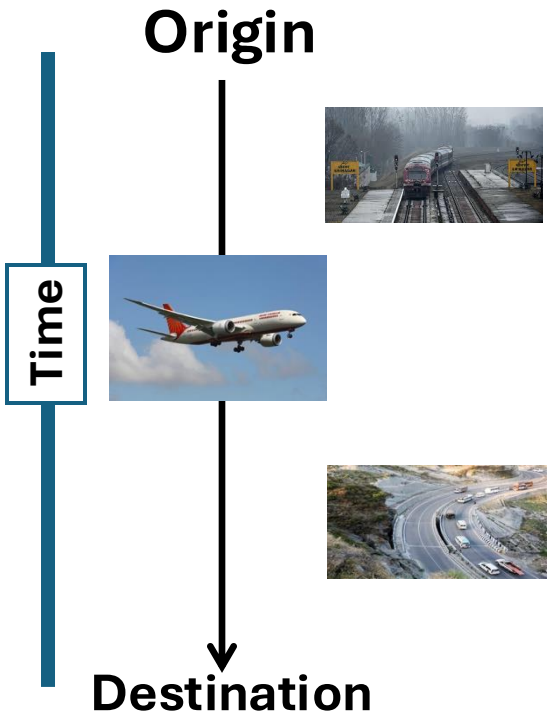
Creates algorithms to learn from data and make decisions

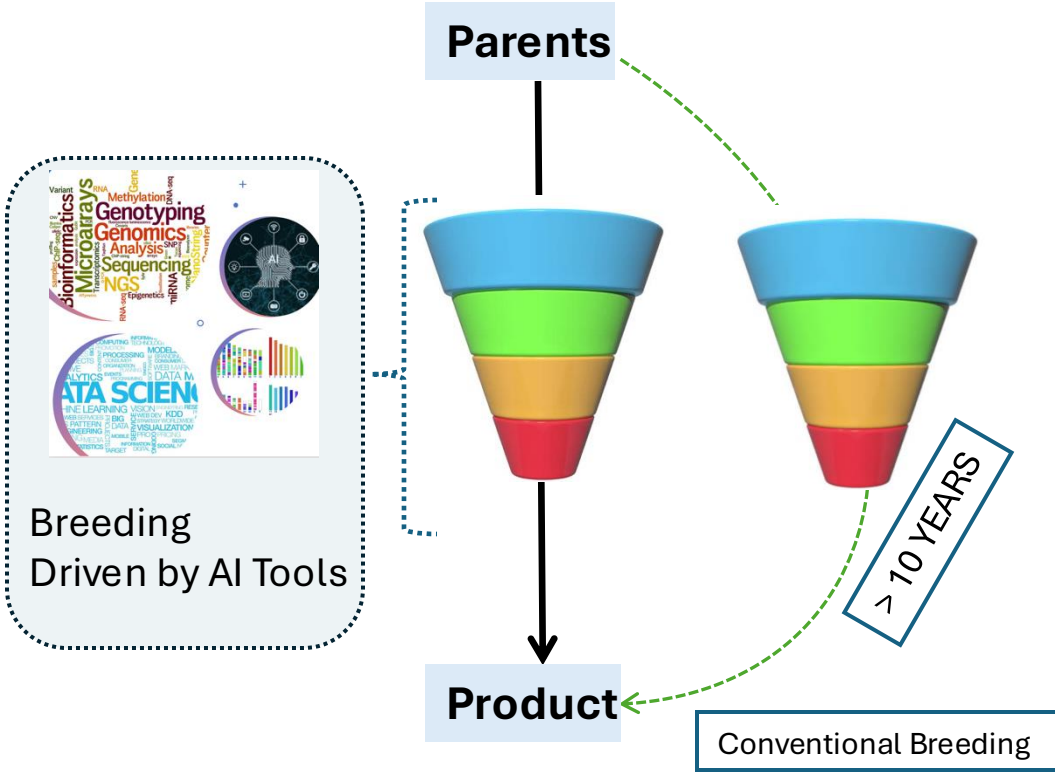
Neural networks to reach conclusions

- **More Accuracy**
- **More Speed**
- **Automation**
- **Monotonus**

High-throughput Phenotyping in Plants

Why Artificial Intelligence in Crop Breeding





Making Breeding Precise, Targeted, Efficient, Effective, and Quick!

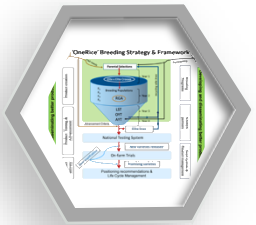
Breeding Framework: End to End Process

Product Concept and Market Segmentation

Demand

Designing the Product

- Discovery
- Pre-Breeding
- Crossing



- Advancement
- Speed Breeding
- Predictive Breeding

Designing

Developing Product

- Field Evaluation
- G x E Interactions
- Genomic Selections

Development

Disseminating Product

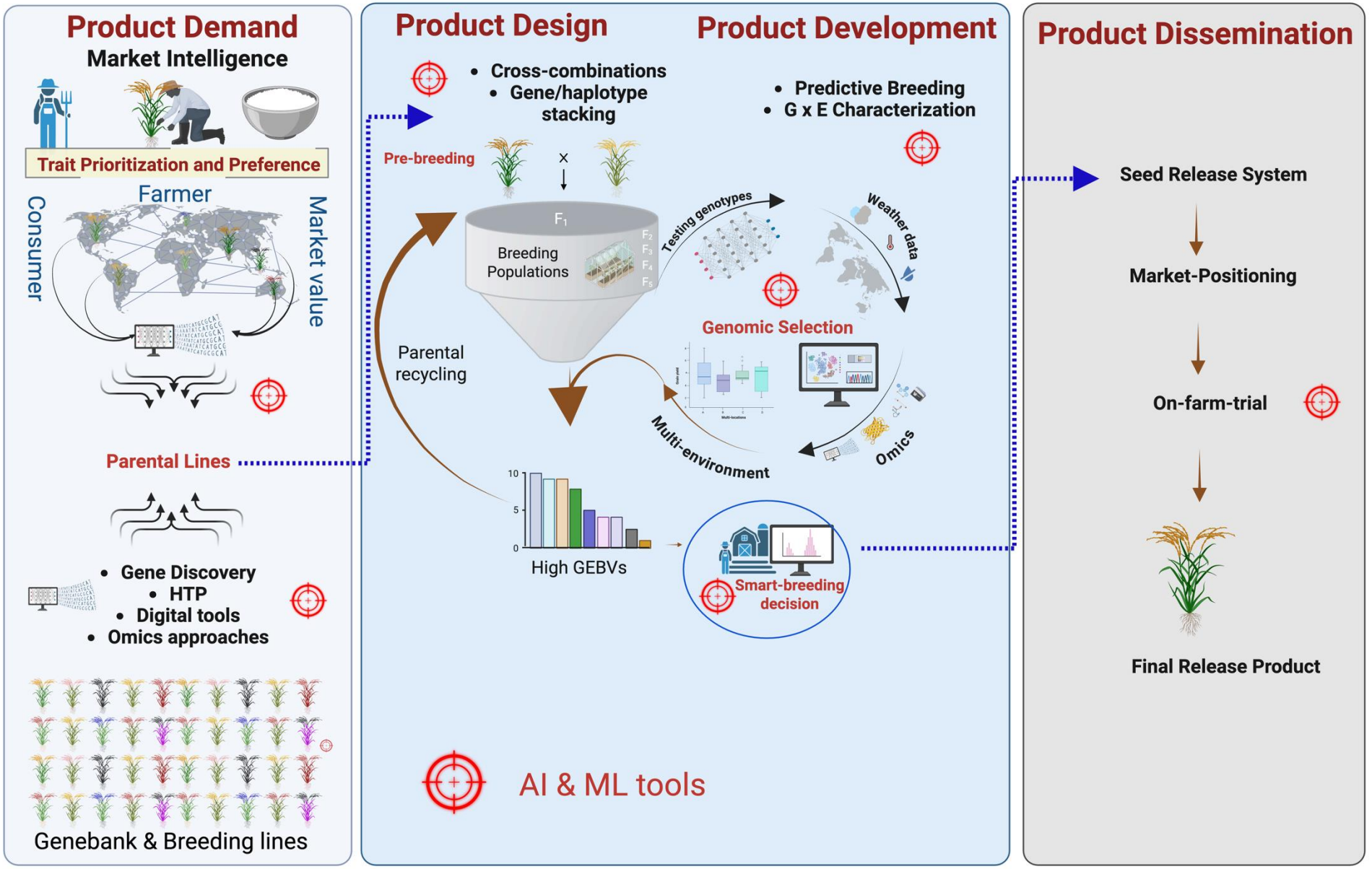
- Advance Trials
- On Farm-trials
- Validation trials

New Elite Breeding Lines

Dissemination

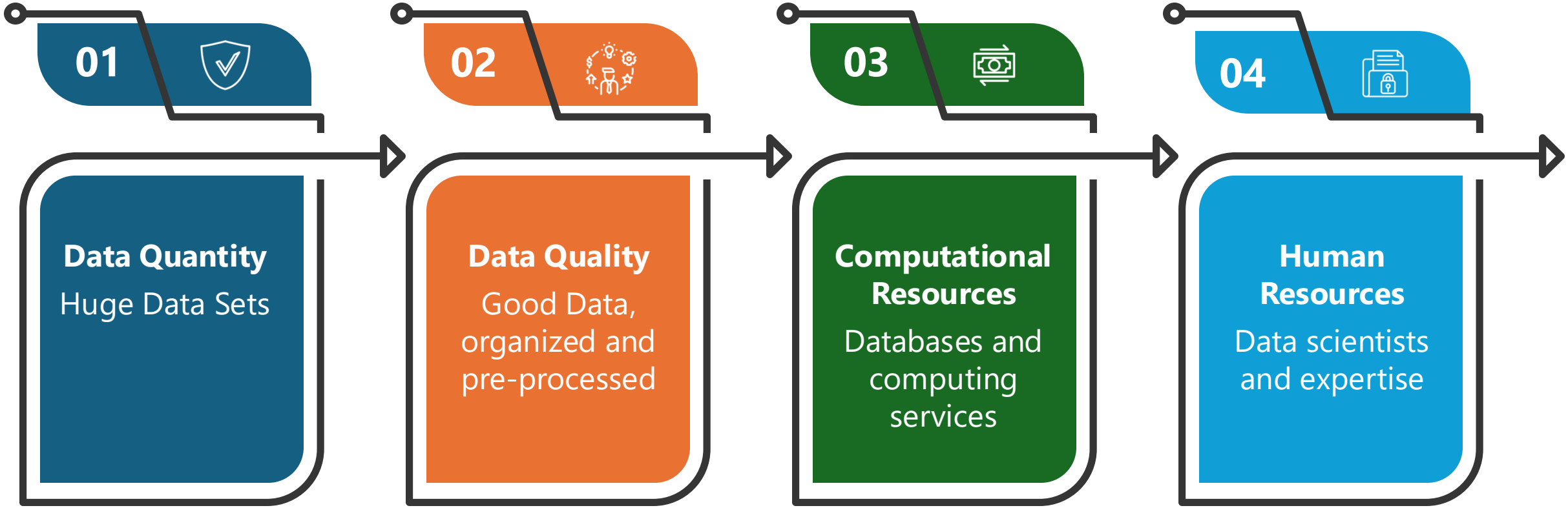
4D's in Plant Breeding

AI Breeding Framework: End to End Process



Challenges in AI and Data-Driven Breeding

Deep Understanding of Problem and Solution



- Do we have the large data and resources to implement AI effectively?
- Transition to AI models must consider available data and resources?
- Know the Problem and Solution: Can Simple tool help Solving Problem

AI-Driven Crossing Strategy: Save Resources and Time

Precision Breeding

Systematic pre-breeding and strictly elite x elite crosses

1 Parental pool

2 Crossing block design

Process of Crossing

1. High Breeding Value
2. Relationship Matrix (Co-variance)
3. Major QTLs
4. **Usefulness Criterion and Optimal Contribution (AI-driven Approach)**

30–40; pop size 240 — Crossing Block (Elite x Elite)

~7000 lines — F_2 - F_4 RGA + MAS

Seed amplification (F_5)

1200lines — Stage 1

~50 lines — Stage 2

5 Product advancement

Variety Release System

6 Parental recycling

Base population — Cycle 1, Cycle 2, Cycle 3 — Selected lines

Genomics

Quantitative Genetics

Phenotyping

Trial Design and Analysis

Space for innovations

Precision Crossing: Driven by AI

Cross Combinations (Traditional)

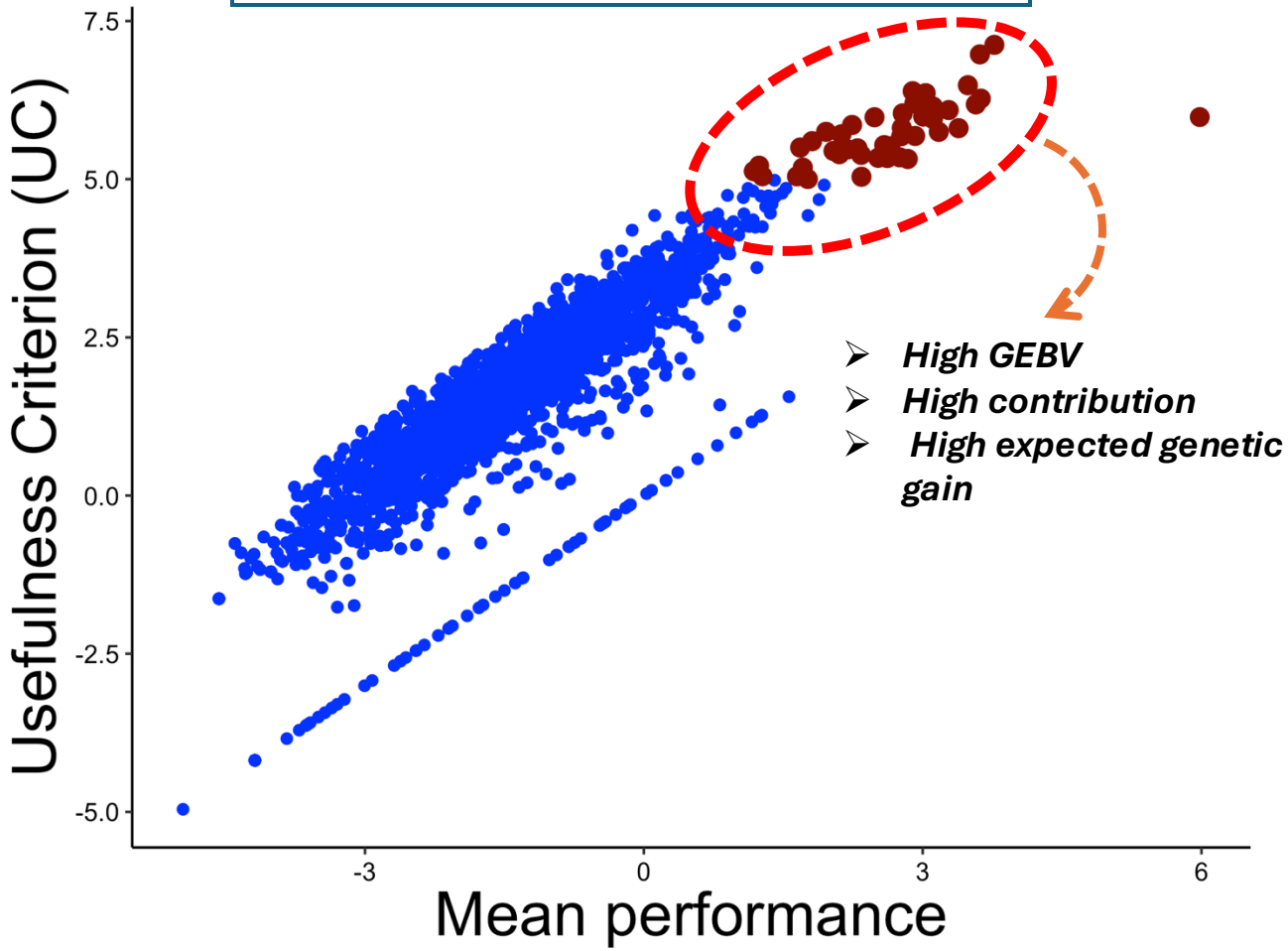
Breeding Pipeline

- **50-60** Parents
- 30 crosses/pipeline
- **n(n-1) or n(n-1)/2,**
- For example, 61 Parents =3,599 crosses
- Excluding 3,569 cross combinations!

Designing Crossing Block is Random!!!!

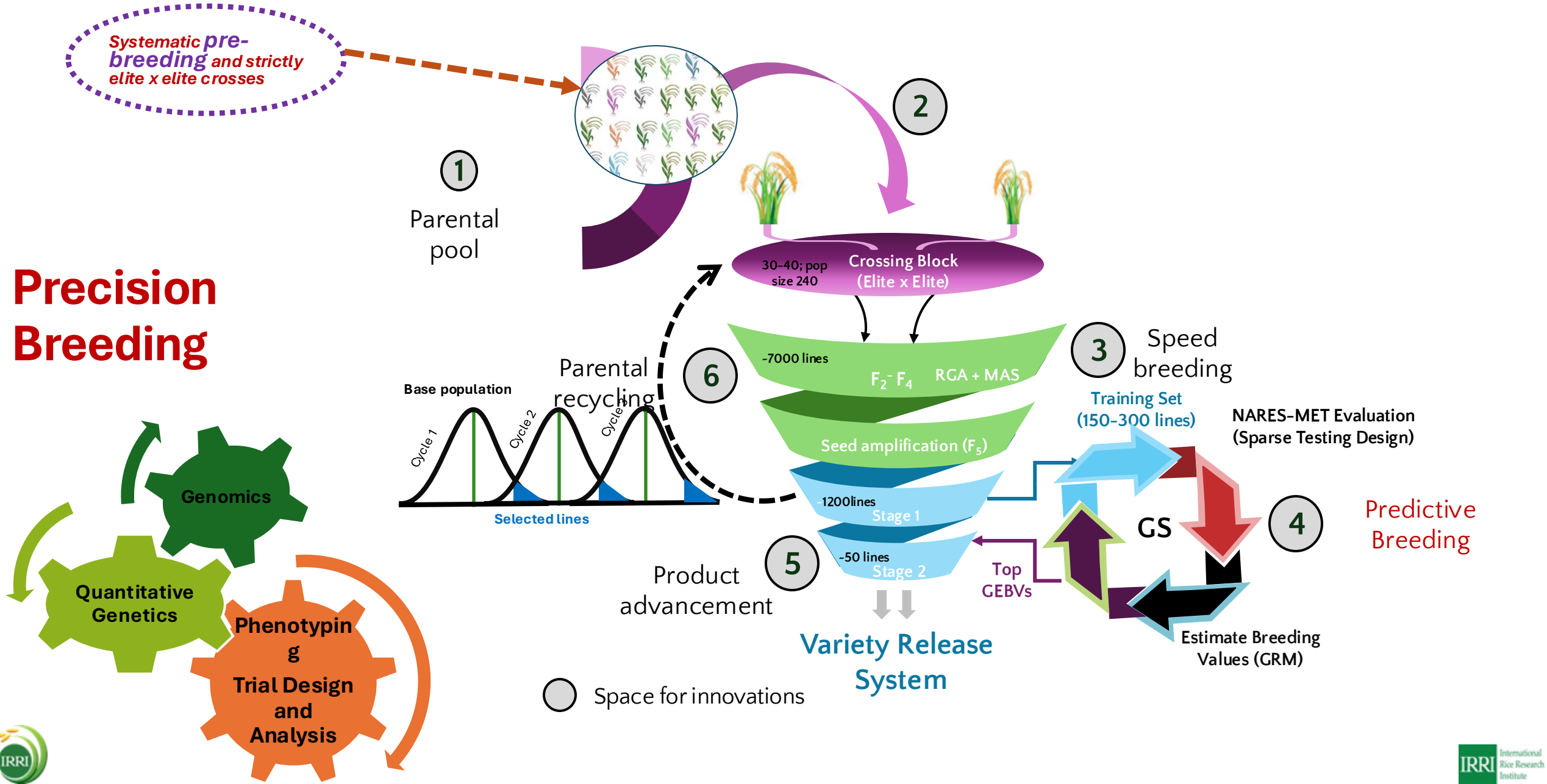
Designation	IR16T1538	IR16F1251	IR 126952-28-55-9-9-4-2-7	IR 126957-B-48-5-1-3	IRRI 185	IR13V163	IR16T1662
IR16T1538							
IR16F1251							
IR 126952-28-55-9-9-4-2-7	X				X		
IR 126957-B-48-5-1-3							
IRRI 185			X				
IR13V163							
IR16T1662							
IR 91648-B-117-B-1-1							
IR19L1046							X
IR15L1737			X				
IR18T1025							
IR 117755-B-80-1-AJY 1-2							
GSR IR 1-5-D20-D3-Y2			X	X			
IR16M2035							
IR16F1037							
IR 117764-B-24-1-2							
IR15F1912					X		X
IR16F1147							
IR15F1709							
IR15F1729						X	
IR16T1159					X		
IR13L499							
IR14V1034							

Cross Combinations (AI-driven)



Example from IRRI's Breeding Program

Genomic Prediction: Increase Selection Accuracy



Collaboration Opportunities in AI Space

Human Capital: Shared Learning

Data Collection, Sharing and Standardization

Joint Projects and Model developments

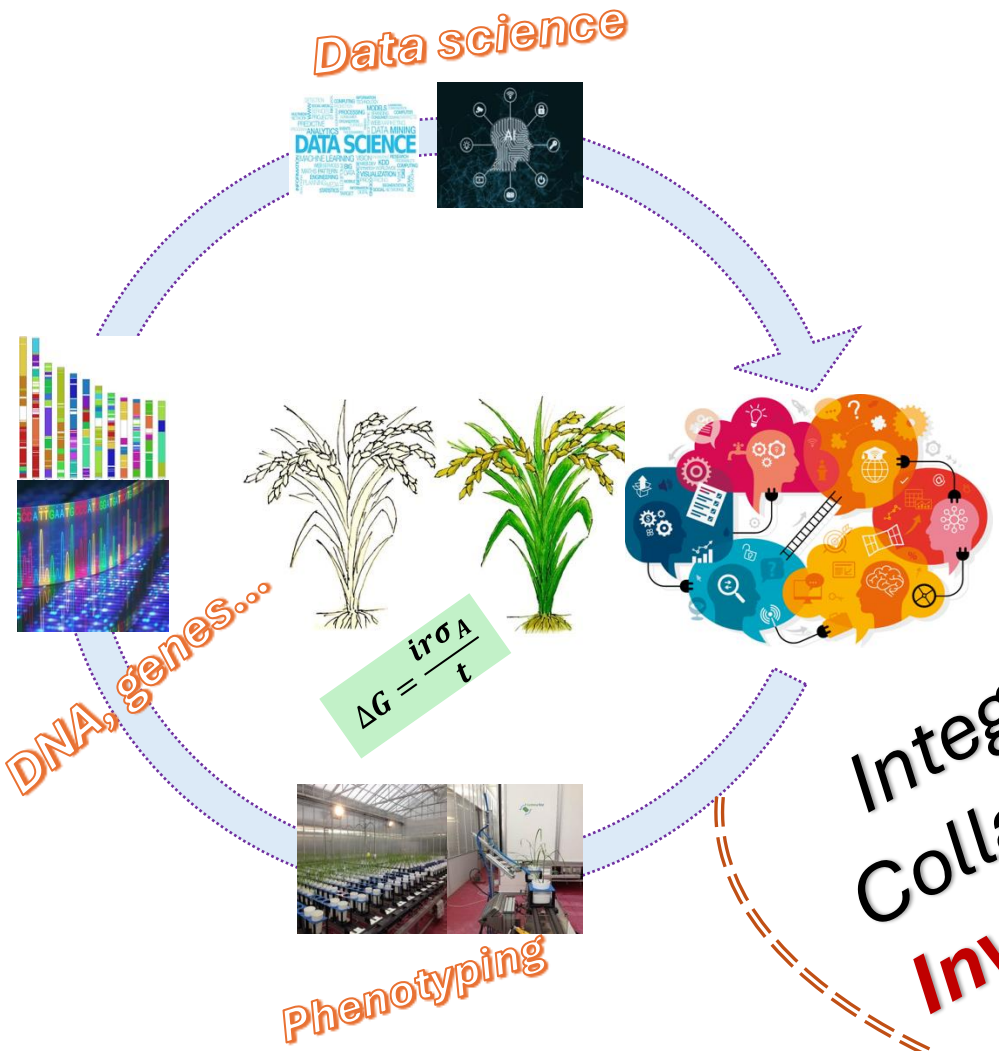
Breeding Optimizations

Germplasm Sharing

Joint Computational Facilities

Joint research can develop AI algorithms for predicting plant traits, optimizing breeding, and enhancing crop resilience.

Take Home Message



Integration
Collaboration
Investments

- *Future breeding is collaboration*
- *Need Army of Skilled people to drive the program?*
- *Breeding is more Science than Art.*
- *Making "Breeding Equation" better!*
- *Need to be smarter! Know when, how and where to through technologies!*

Innovations do not come from brain, innovations come through sharing of ideas