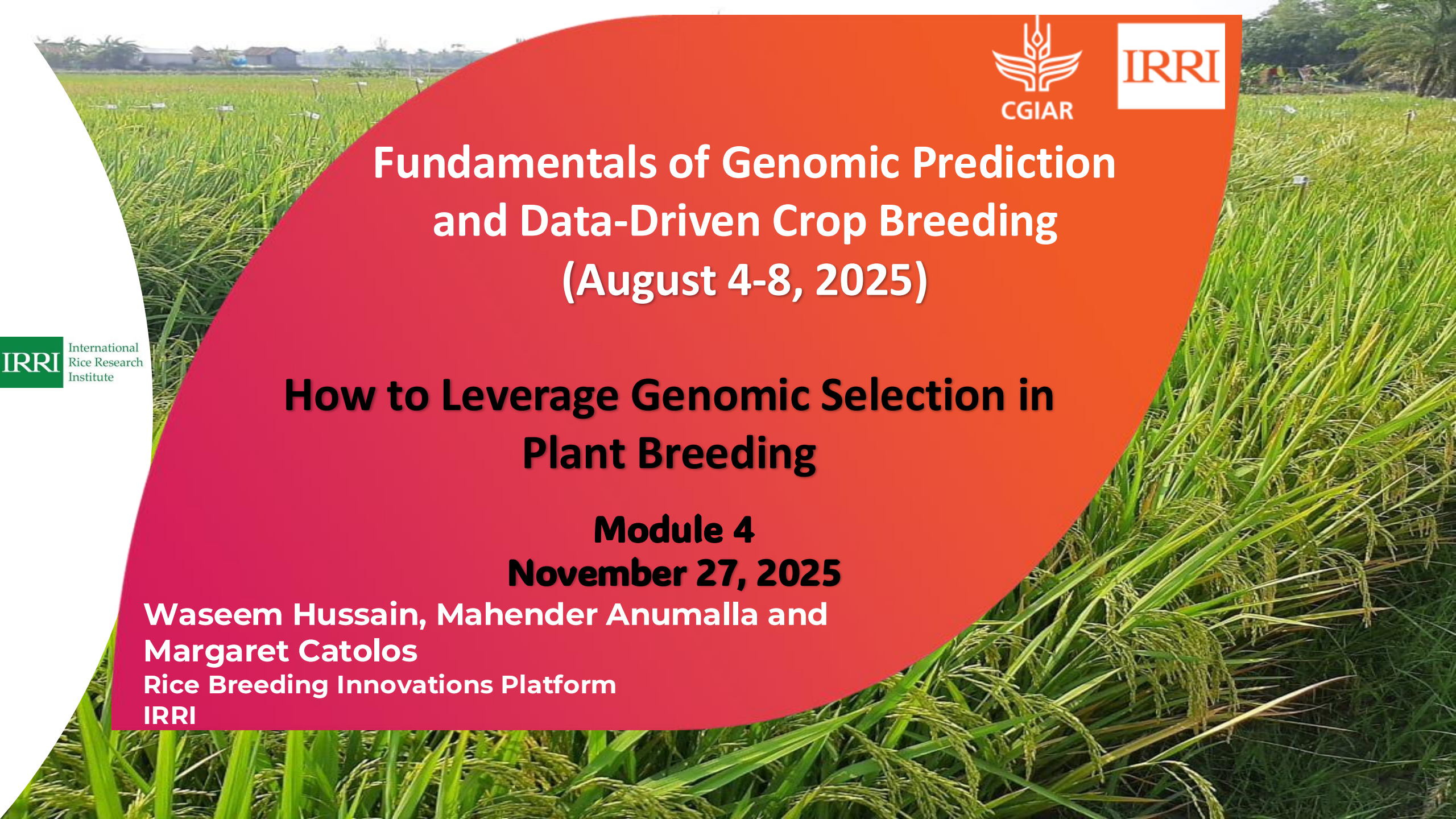


Fundamentals of Genomic Prediction and Data-Driven Crop Breeding (August 4-8, 2025)

IRRI International Rice Research Institute

How to Leverage Genomic Selection in Plant Breeding

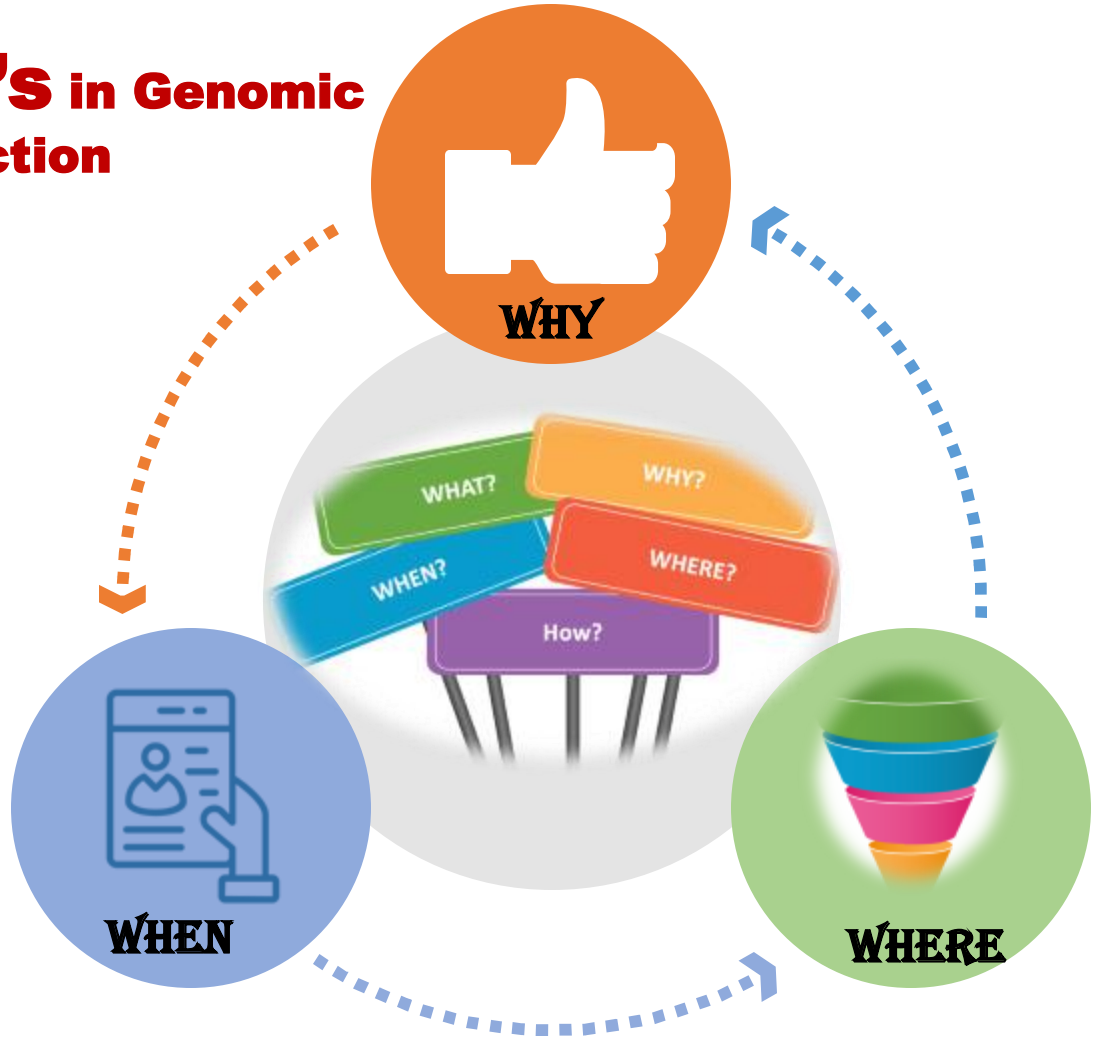
Module 4
November 27, 2025

Waseem Hussain, Mahender Anumalla and Margaret Catolos
Rice Breeding Innovations Platform
IRRI

Genomic Selection in Crop Breeding

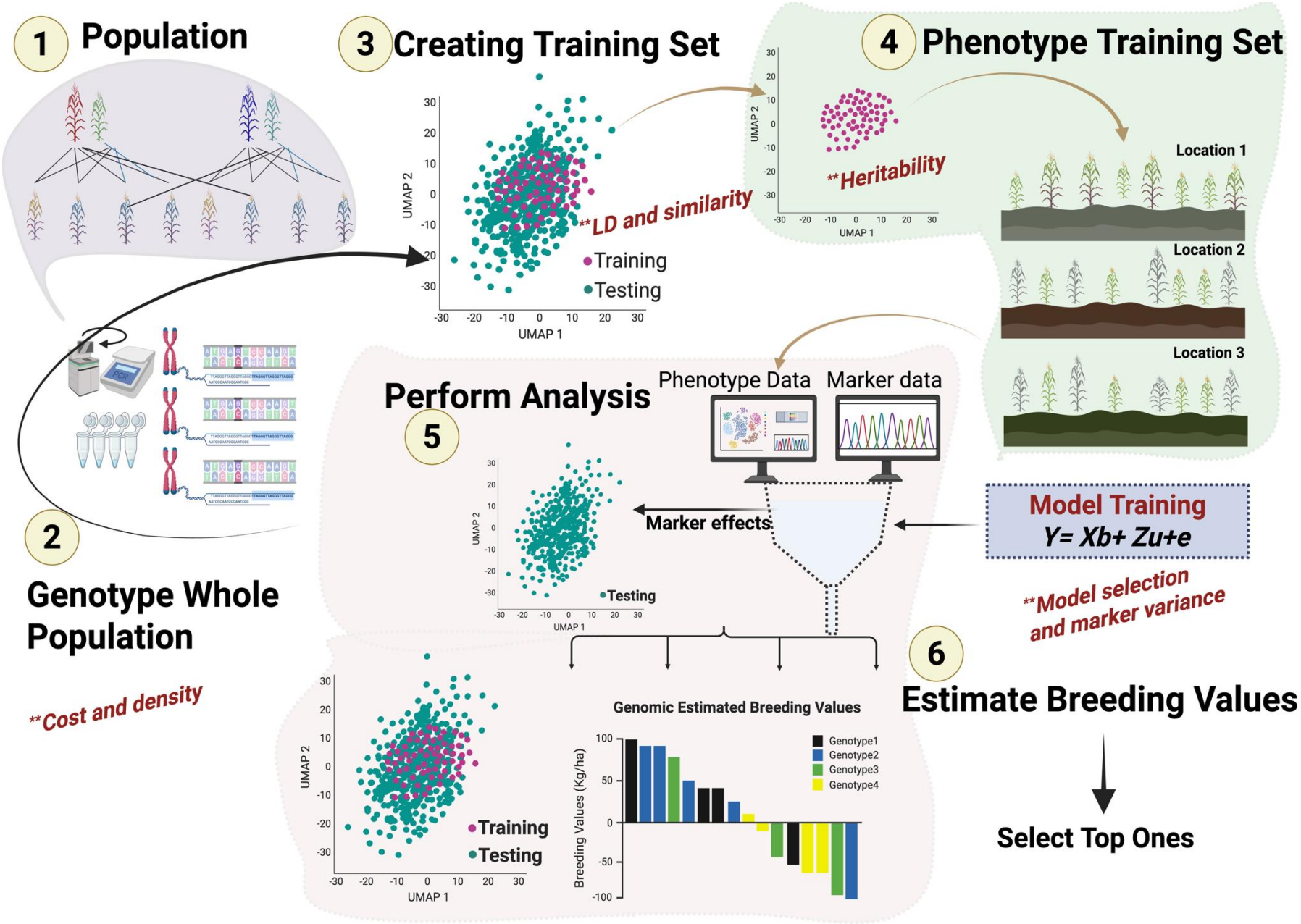
(What benefits and advantages it have over traditional phenotypic BLUP selection)

3W's in Genomic Selection

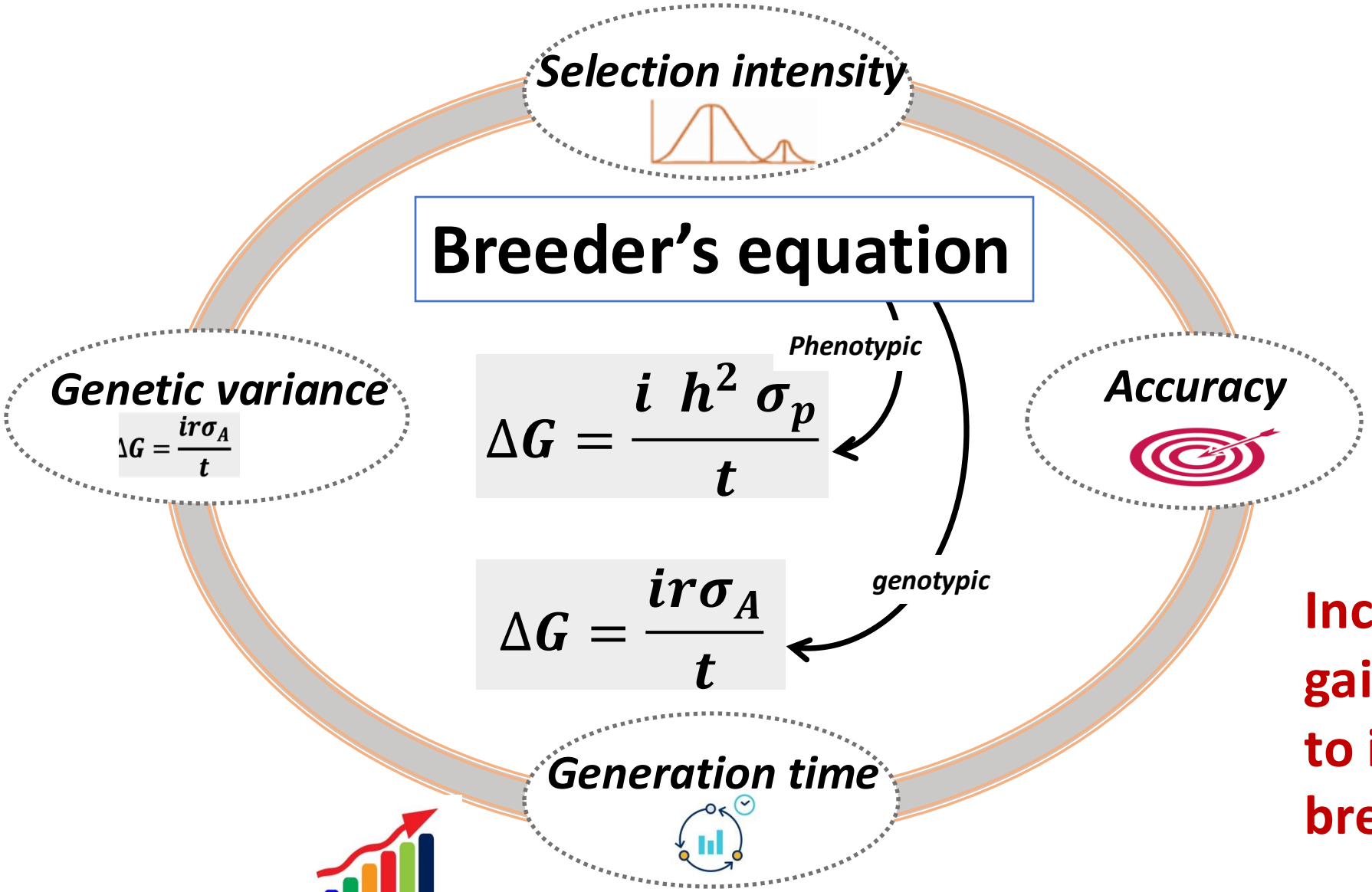


- **Why to use GS**
  - Select from more phenotypes
  - Reduce time of breeding cycle
  - Increase accuracy of selections
  - G x E and complex architecture of traits
- **When to use GS**
  - Requirements (Genotyping, reference populations etc.,
  - Resources
  - Capacity to use GS
- **Where to use GS**
  - What Stage to Apply in breeding Pipeline
  - How to implement it

How Genomic Prediction Works



The guiding principle is Breeders Equation



Increasing genetic gain is main reason to implement GS in breeding programs

$\Delta G = \frac{i\ h^2\ \sigma_p}{t}$

Why Genomic Selection

1

Phenotypes and Phenotyping

- Too many phenotypes
- Traits difficult to phenotype

2

Time and Reliable Selections

- Increased selection accuracy
- Reduction in time
- Quick re-cycling and recombination

3

Manage Resources

Effective use of resources to breed and control the selection intensity

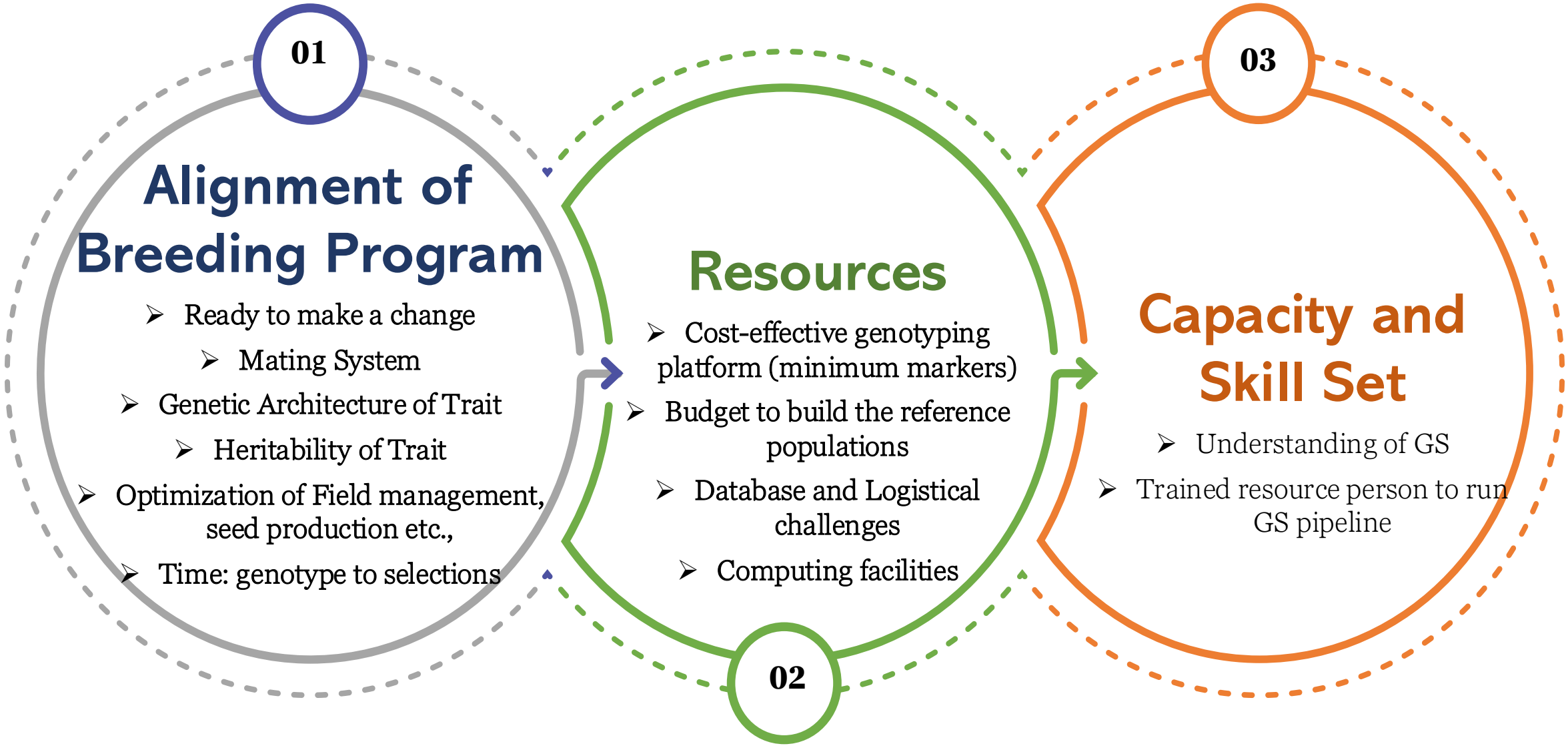
4

Dissecting G x E

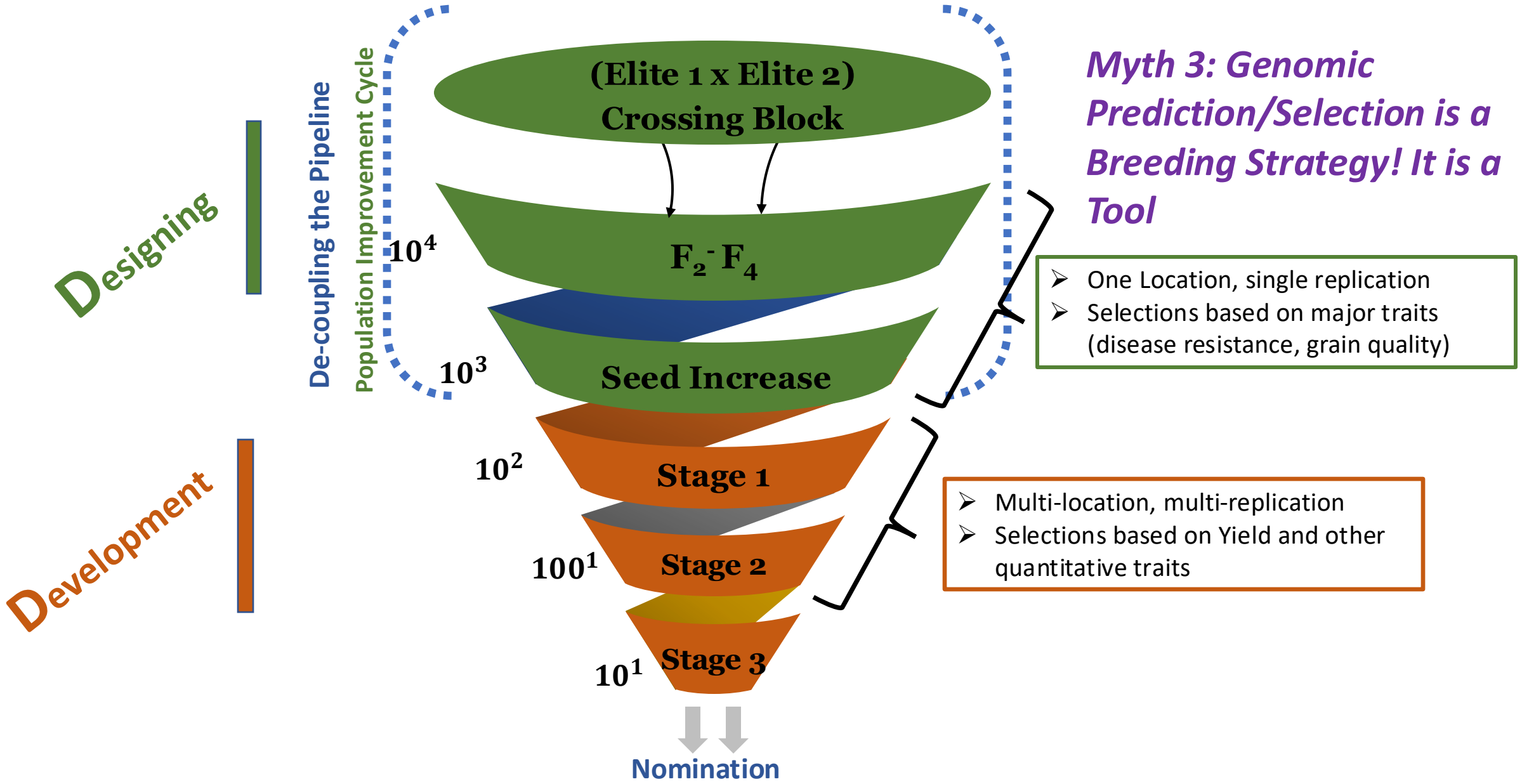
G x E hinders genetic gain

Characterization of Environments (TPE)

When to Use Genomic Selection



Where I can apply GS Tool



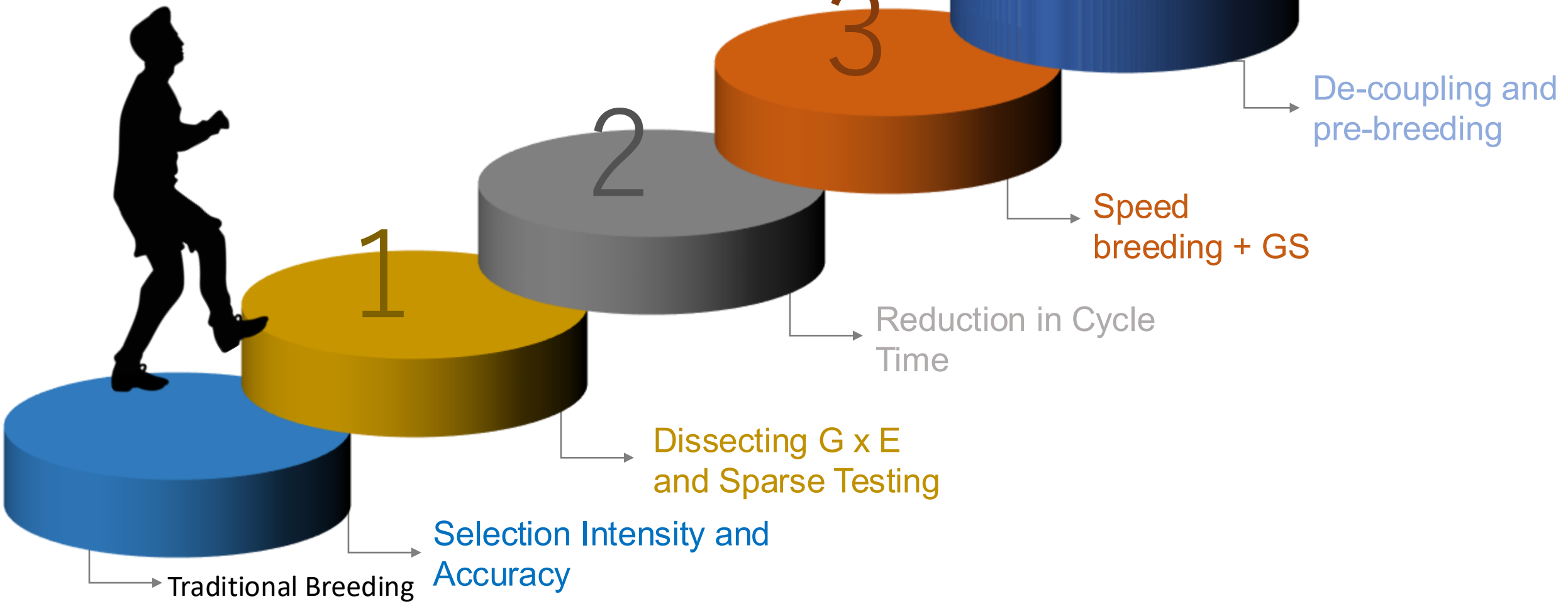
Myth 3: Genomic Prediction/Selection is a Breeding Strategy! It is a Tool

- One Location, single replication
- Selections based on major traits (disease resistance, grain quality)

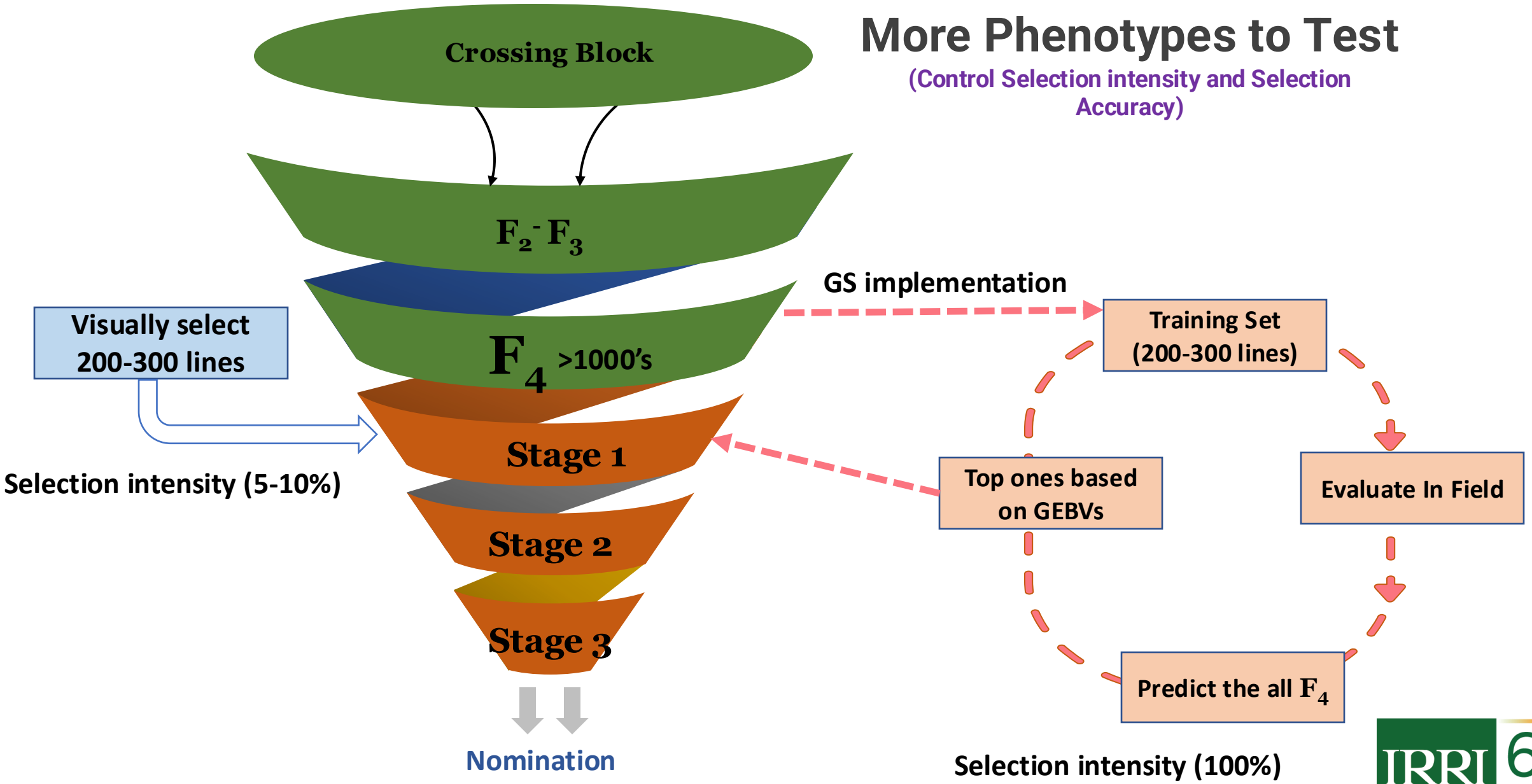
- Multi-location, multi-replication
- Selections based on Yield and other quantitative traits

Step by Step Approach to GS

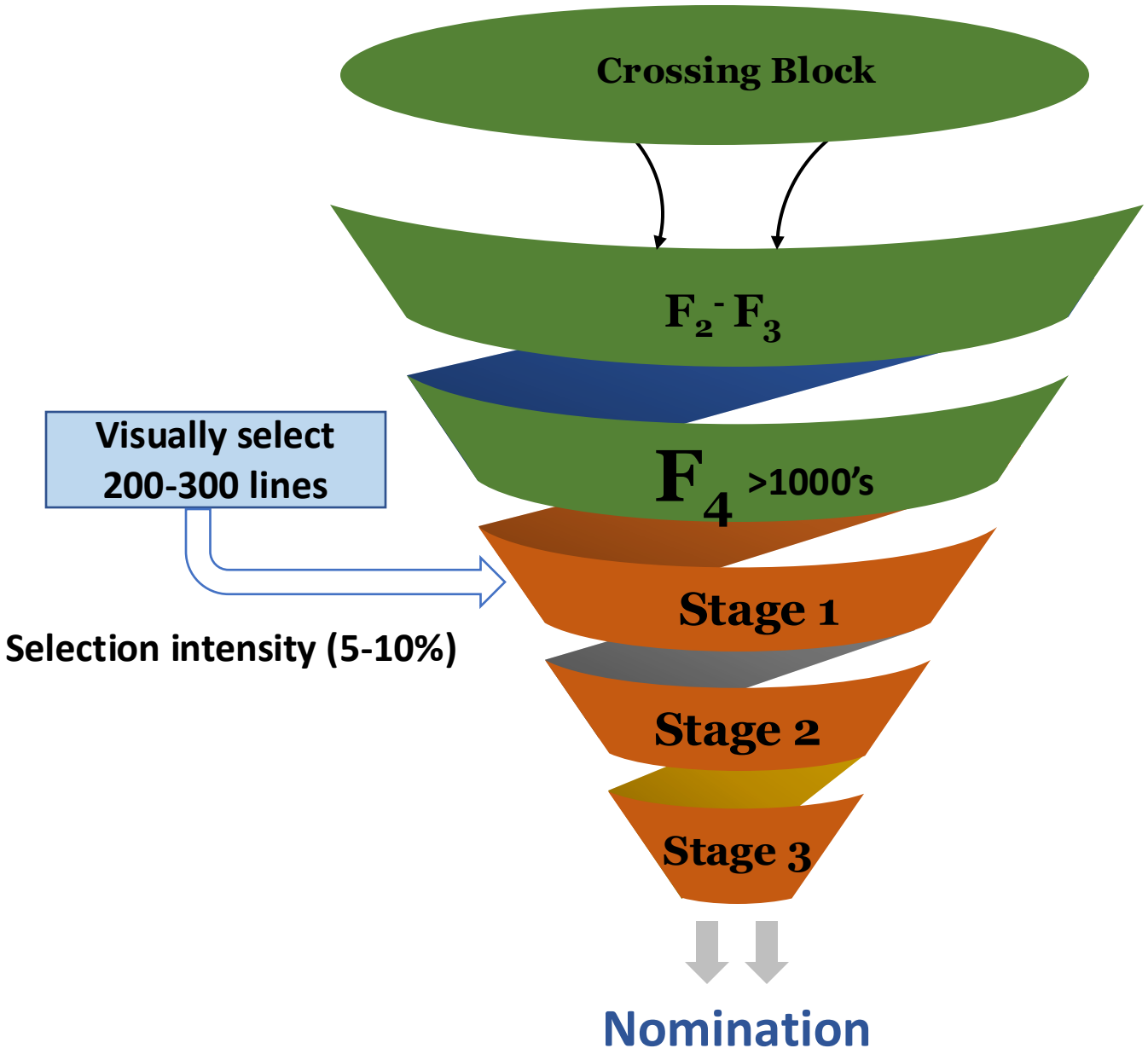
Myth 4: Genomic Selection can be applied anytime, anywhere!



GS Implementation: Scenario 1



GS Implementation: Scenario 1



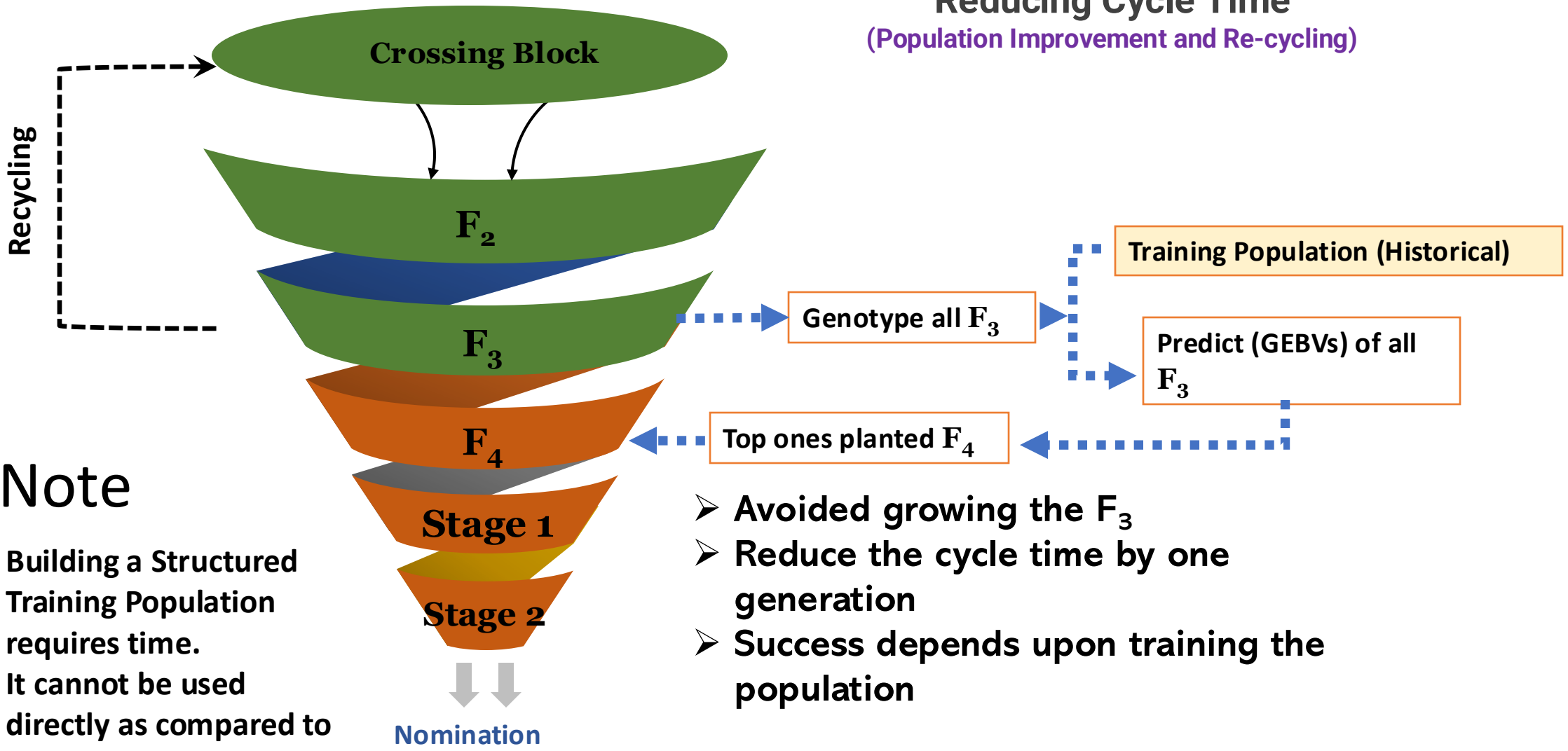
More Phenotypes to Test

(Control Selection intensity and Selection Accuracy)

Myth 5: Genomic Selection is more reliable than Phenotypic BLUPs

Yes True! If the accuracy of Selection is high

GS Implementation: Scenario 2



Note

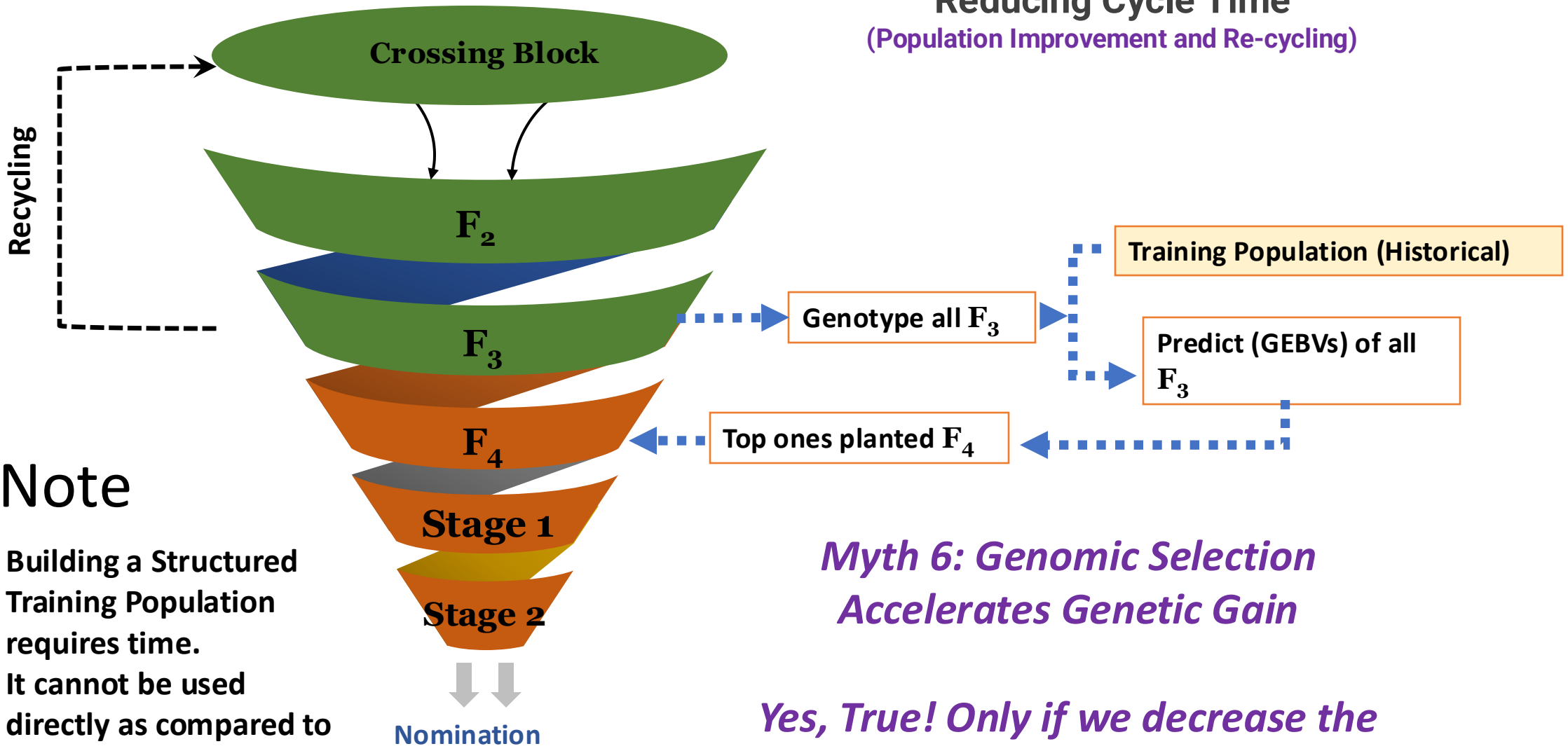
- Building a Structured Training Population requires time.
- It cannot be used directly as compared to scenario 1

- Avoided growing the F_3
- Reduce the cycle time by one generation
- Success depends upon training the population

- High relationship with the testing set
- LD structure should be same
- Need to update the training population

IRRI 65 YEARS

GS Implementation: Scenario 2



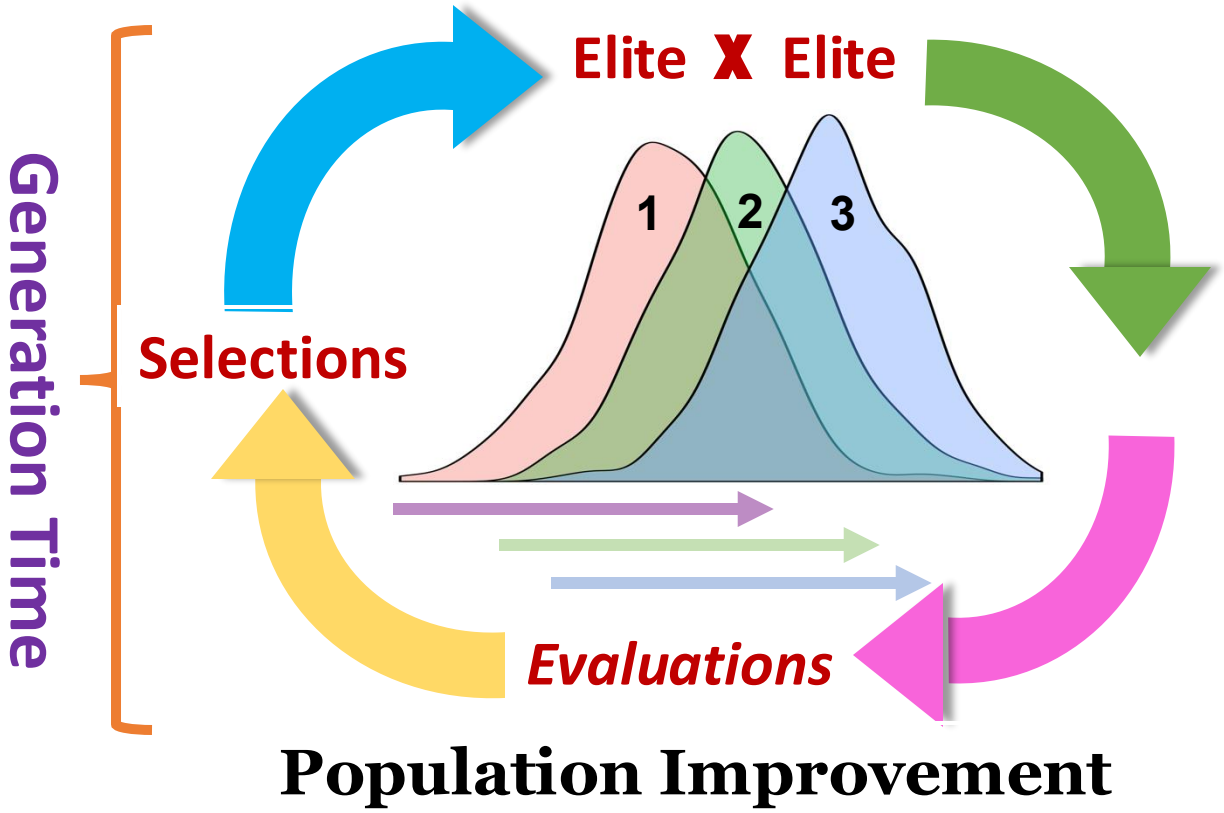
Note

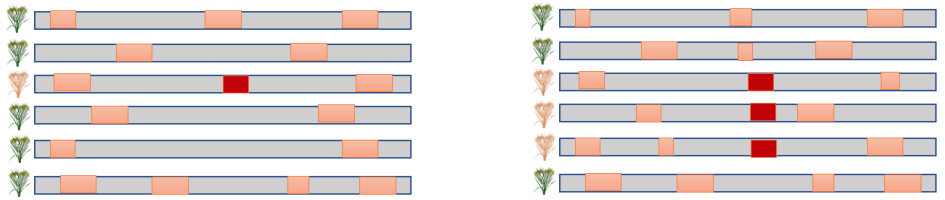
- Building a Structured Training Population requires time.
- It cannot be used directly as compared to scenario 1

Myth 6: Genomic Selection Accelerates Genetic Gain

Yes, True! Only if we decrease the cycle time

Why Population Improvement is Central to GS





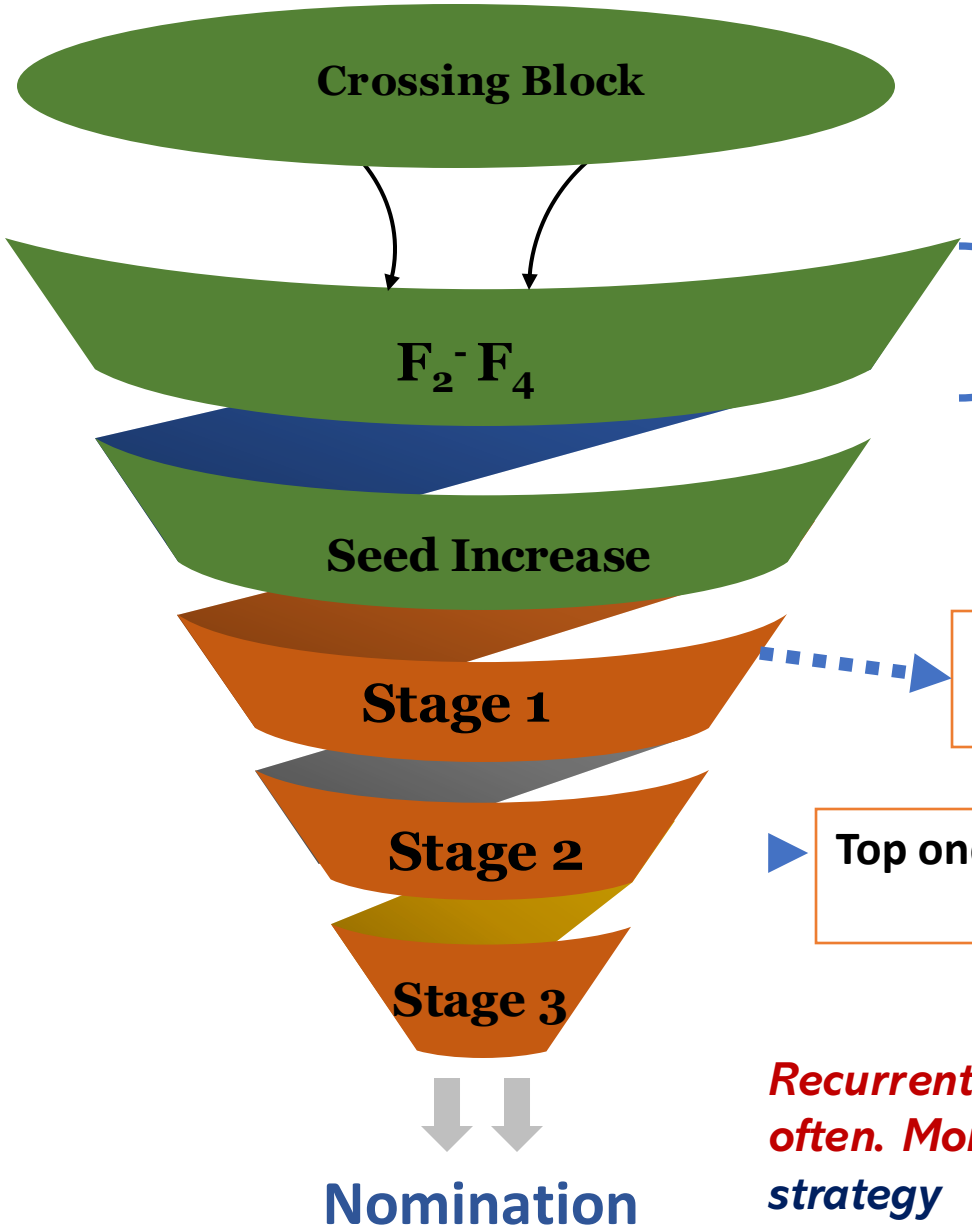
Selection and recombination Increase the frequency of favorable allele

Myth 7: GS alone will do magic and accelerate genetic gains

GS Implementation: Scenario 4

Speed Breeding + GS

Early Recycling



All Generation in SB facility

- No selections
- Maybe Forward breeding (Major traits)

Training Population (Historical)

Genotype all F_3

Predict (GEBVs) of all F_3

Top ones planted F_4

Recurrent genomic selection recombines quickly and often. More genetic gains called as De-coupling strategy

GS in IRRI's Rice Breeding Program

Timeline

Year 1

Year 2

Year 3

TLaMF-I x TLaSF-R

Crossing Block
(Elite x Elite)

Parental recycling

F_2 - F_4 (RGA + MAS)

Seed amplification (F_5)

Stage 1 (~1200)

Stage 2 (30)

Variety Release System

Process of Crossing

1. High Breeding Value
2. Relationship Matrix (Co-variance)
3. Major QTLs
4. Usefulness Criterion (Mean and Variance)

Recurrent Selection

Training Set
(200-300 lines)

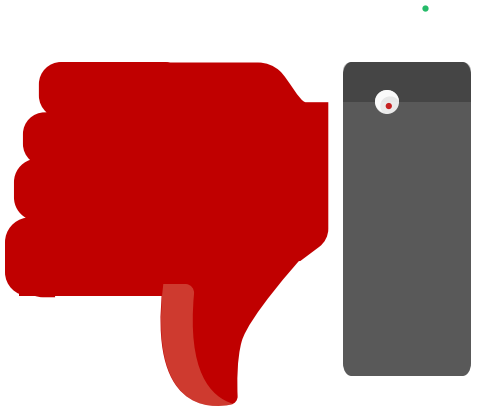
NARES-MET Evaluation
(Across Asia and Africa)

Top GEBVs

Predict all ~1200 lines
(Estimate Breeding Values)

Genomic Selection Implementation

Think Twice Before Go for GS



- Un-related populations (GS exploits relationships)
- Lack of the genotyping facility
- High cost of genotyping may halt implementation of GS
- Lack of understanding, capacity, and skill set to run GS pipeline
- Aim is not to improve major haplotypes but drive population improvement.
- Phenotyping is cheaper! Go for it.

Use the Genetic Gain Equation as a Reference and Model

Thank you!