Accelerated Breeding 2025 Goals: Goal #4 Deep Dive

Accelerated Breeding Team

16th July 2025

Meeting Design

Purpose

- An **Information Sharing** meeting on goal #4 of Accelerated Breeding (AB) high level goals for 2025

Outcomes

- Breeding teams across programs understand AB goal #4, what is expected of them, levels of engagement and where to seek support

Agenda

- Opening remarks: Marianne; 5mins
- Presentation: Dorcus; 40mins
- Discussion: All; 45mins

Breeding Strategy

Breeding Program

↕

Breeding Pipelines

↕

Market Segments each with a unique TPP

↕

Breeding effort focused on a Market Segment

↕

Breeding Schemes

Goal #4: More streamlined and prioritized TD&D

Trait Discovery & Deployment (TD&D) re-focused: Currently, TD&D efforts are applied to a proliferation of traits, many of which have very limited investment levels and insufficient linkages with, and insufficient benefits to breeding pipelines

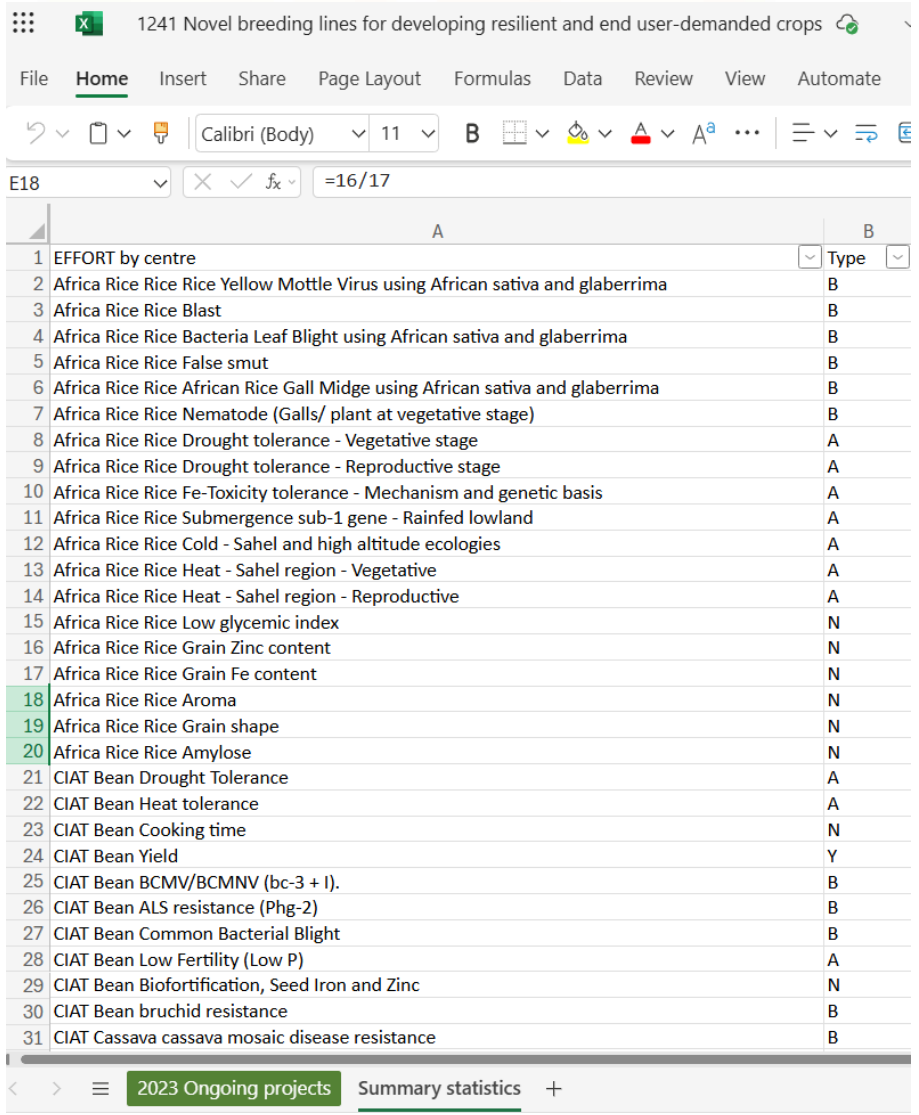
Breeding Programs may lack a strategy to take up and use outputs from TD&D pipelines for essential traits

Support

- ACCELERATE guidelines –Excellence in breeding toolbox Excellenceinbreeding
- ACCELERATE/DISCOVER cross-cutting team
- Breeding Resources

Trait research in CGIAR centers

- Over 160 traits are being researched
- Resources and efforts are scattered among too many traits
- Insufficient impact on breeding



1241 Novel breeding lines for developing resilient and end user-demanded crops

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	A	B
1	EFFORT by centre	Type
2	Africa Rice Rice Rice Yellow Mottle Virus using African sativa and glaberrima	B
3	Africa Rice Rice Blast	B
4	Africa Rice Rice Bacteria Leaf Blight using African sativa and glaberrima	B
5	Africa Rice Rice False smut	B
6	Africa Rice Rice African Rice Gall Midge using African sativa and glaberrima	B
7	Africa Rice Rice Nematode (Galls/ plant at vegetative stage)	B
8	Africa Rice Rice Drought tolerance - Vegetative stage	A
9	Africa Rice Rice Drought tolerance - Reproductive stage	A
10	Africa Rice Rice Fe-Toxicity tolerance - Mechanism and genetic basis	A
11	Africa Rice Rice Submergence sub-1 gene - Rainfed lowland	A
12	Africa Rice Rice Cold - Sahel and high altitude ecologies	A
13	Africa Rice Rice Heat - Sahel region - Vegetative	A
14	Africa Rice Rice Heat - Sahel region - Reproductive	A
15	Africa Rice Rice Low glycemic index	N
16	Africa Rice Rice Grain Zinc content	N
17	Africa Rice Rice Grain Fe content	N
18	Africa Rice Rice Aroma	N
19	Africa Rice Rice Grain shape	N
20	Africa Rice Rice Amylose	N
21	CIAT Bean Drought Tolerance	A
22	CIAT Bean Heat tolerance	A
23	CIAT Bean Cooking time	N
24	CIAT Bean Yield	Y
25	CIAT Bean BCMV/BCMNV (bc-3 + I).	B
26	CIAT Bean ALS resistance (Phg-2)	B
27	CIAT Bean Common Bacterial Blight	B
28	CIAT Bean Low Fertility (Low P)	A
29	CIAT Bean Biofortification, Seed Iron and Zinc	N
30	CIAT Bean bruchid resistance	B
31	CIAT Cassava cassava mosaic disease resistance	B

2023 Ongoing projects | Summary statistics

Goal #4: More streamlined and prioritized TD&D - Objectives

1. All pipelines clearly define, and document TD&D strategies aligned with market demand, scientific feasibility, and gender-intentional TPPs in the Breeding Portal

2. All pipelines use best practice approaches for highest priority TD&D targets
   - Stage-gate process
   - Reliable HTP phenotyping assays

3. Outcome-oriented and informative KPIs for TD&D are used to ensure anticipated return on investment and likelihood of success from TD&D activities

Trait Team functions

Fully aligned and engaged with the Elite Breeding pipeline team:

- Develop high throughput, low-cost phenotyping assays for priority essential traits
- Identify QTL/Haplotypes
- Validation of QTL/Haplotypes across environments and backgrounds
- Trait introgression and augmentation into elite breeding population
- Develop low- and mid-density genotyping panels
  - Must represent the alleles in the target breeding population
- Coordinate routine genotyping activities
- Mainstream QA/QC, MAS, GS into Elite Breeding Pipelines
- Track the traits through product advancement to ensure that they are part of the final products



The primary ‘Ask’ – Focus!

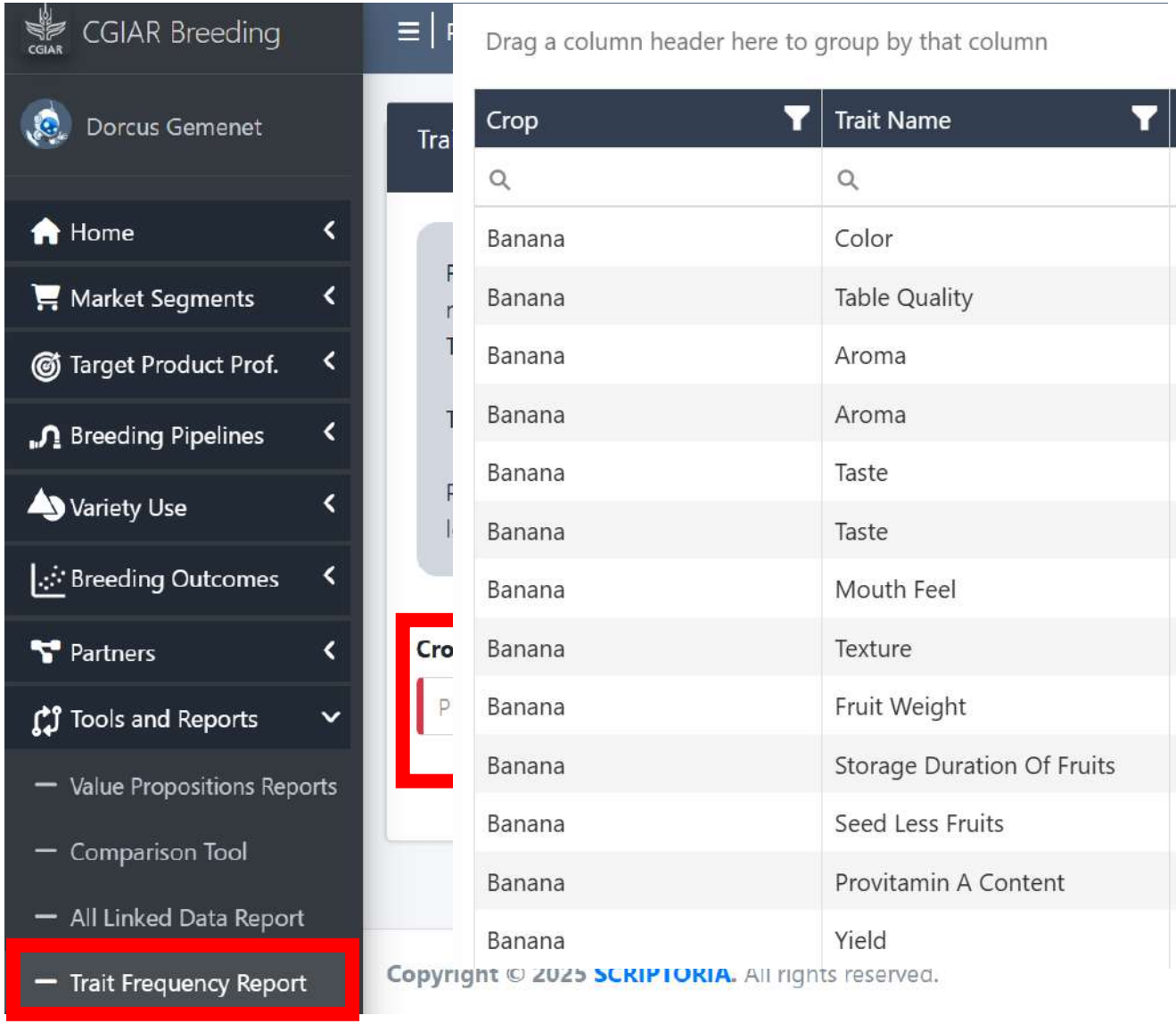
Current: phenotypic and molecular research takes place for too many traits with insufficient impact on breeding

How to change? - Team discussion

1. What traits? - Essential TPP traits!
2. For which essential TPP traits do we lack high-throughput, low-cost phenotyping? => Priorities and responsibilities
3. Do we need better genotypic information? => Priorities and responsibilities
4. Do we need better trait donors? => Priorities and responsibilities for TD&D

Result: Trait Team and Product Development Team roles are defined and aligned for impactful breeding.

1. What traits? - Essential TPP traits!



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Search...

Crop	Trait Name	Requirement	Frequency (# of TPPs)	Area of usage (Ha)
Banana	Color	Essential: Maintain	26	26,636,140
Banana	Table Quality	Essential: Maintain	10	7,847,497
Banana	Aroma	Essential: Maintain	20	20,489,935
Banana	Aroma	Nice to Have	1	1,690,526
Banana	Taste	Essential: Maintain	18	20,946,274
Banana	Taste	Essential: Improve	1	5,046
Banana	Mouth Feel	Essential: Maintain	17	19,120,017
Banana	Texture	Essential: Maintain	18	19,125,063
Banana	Fruit Weight	Essential: Maintain	4	6,371,262
Banana	Storage Duration Of Fruits	Essential: Maintain	3	4,876,157
Banana	Seed Less Fruits	Essential: Maintain	2	431,164
Banana	Provitamin A Content	Nice to Have	10	7,847,497
Banana	Yield	Nice to Have	7	8,025,567

2. For which essential TPP traits do we lack high-throughput, low-cost phenotyping?

High-throughput, low-cost phenotyping is a prerequisite for ALL breeding and trait research.

- Goal defined by Breeding Leads in the Dubai meeting 2024: **“To establish high-throughput, low-cost phenotyping for all essential traits.”**

>>What are priorities and responsibilities for your trait team?

3. Do we need better genotypic information?

First question: Inheritance of prioritized essential TPP traits

- Simple traits? => Marker/Haplotype identification
  - low-density panels for marker-assisted selection (MAS)

- Polygenic? => Breeding Value estimates using genomic selection
  - Mid-density panels for genomic relationship matrices

***Genotyping panels must be representative of Elite Breeding Populations

>>>What are priorities and responsibilities for your Trait Team to provide and improve genomic information?

4. Do we need better trait donors? – TD&D

- A full-fledged Trait Discovery and Deployment (TD&D) effort requires significant resources
  - Currently, most TD&D efforts do not go beyond QTL definition and have negligible impact on breeding - ☹

- To make decisions between potential TPP traits, use your team's expertise to assess
  - How feasible?
  - How impactful?

- Aggregate resources around most feasible and impactful TD&D projects.

Definitions: Staying on the same page

Trait Discovery

- Identification and understanding of causal variants of priority traits from previously uncharacterized genetic variation
  - Product: Trait donor

Trait Deployment

- **Semi-elite/elite donor development**: Moving new genetic variance of priority traits into adapted and elite background(s)
  - Product: Semi-elite trait donor meeting core pipeline requirements

- **Elite Breeding Pipeline integration**: Introduction of a well characterized priority trait from an elite or semi-elite donor into a broad range of elite backgrounds in the Elite Breeding Population
  - Product: Elite germplasm with native or non-native trait conversion

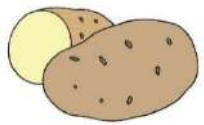
Defining TD&D targets: Criteria

1. Must be an essential TPP trait
   - Not the whole trait wish list
2. Must have insufficiently represented in the Elite Breeding Population
   - Avoid underestimating available variance, especially for quantitative (polygenic) traits
     - Monitor, not maximize, genetic variance – (Refer: Goals #5-6)
       - More is not always better with genetic variance
3. How efficiently and effectively can we select for a trait?
   - Heritability, phenotyping cost, stage at selection

TD&D and trait architecture

Simple and polygenic trait introgression has very different implications and require different strategies and tools for TD&D

Aspect	Simple traits	Polygenic traits
Discovery	Easier—candidate genes can be identified directly	Difficult—requires integration of multiple genes, often unknown
Validation and Deployment	Straightforward	Challenging due to small effects of individual genes
Marker Density	Fewer markers	Genome-wide dense markers (e.g., SNP arrays, GBS)



Trait Discovery and Deployment Focus?

Efficient identification and deployment of major genes

- Stacking major genes for improved performance e.g. disease resistance

Polygenic (quantitative) traits do not run out of variance fast once represented in Elite Breeding Population

- Less amenable to TD&D efforts
  - Needs to be prioritized for TD&D only when absolutely necessary
- More complex TD&D strategies

The TD&D stage and gate process

Stage 1: Trait Scoping

- Essential for TPP and missing in Elite Breeding Population
- Easier to select using markers

Stage 2: Trait evaluation

- Reliable, relevant phenotyping assays
- Identify trait donors

Stage 3: Causal variant identification

- QTL/Haplotype identification
- QTL/Haplotype validation (Background and Environments)

Stage 4: Elite donor development

- Introgress trait into elite background
- Develop reliable methods to track QTL/Haplotypes

Stage 5: Product testing

- Validation of elite donors by phenotyping
- Fine-mapping

Stage 6: Product deployment

- Elit donor introduction to the Elite Breeding Pipeline
- Genotyping platform deployment

Adapted from Rice Trait Deployment Pipeline: https://doi.org/10.1007/s11104-025-07399-2

Trait Team composition

Trait Teams are multidisciplinary:

- Molecular biologists, discovery breeders, quantitative geneticists, physiologists, pathologists/virologists

Responsibility

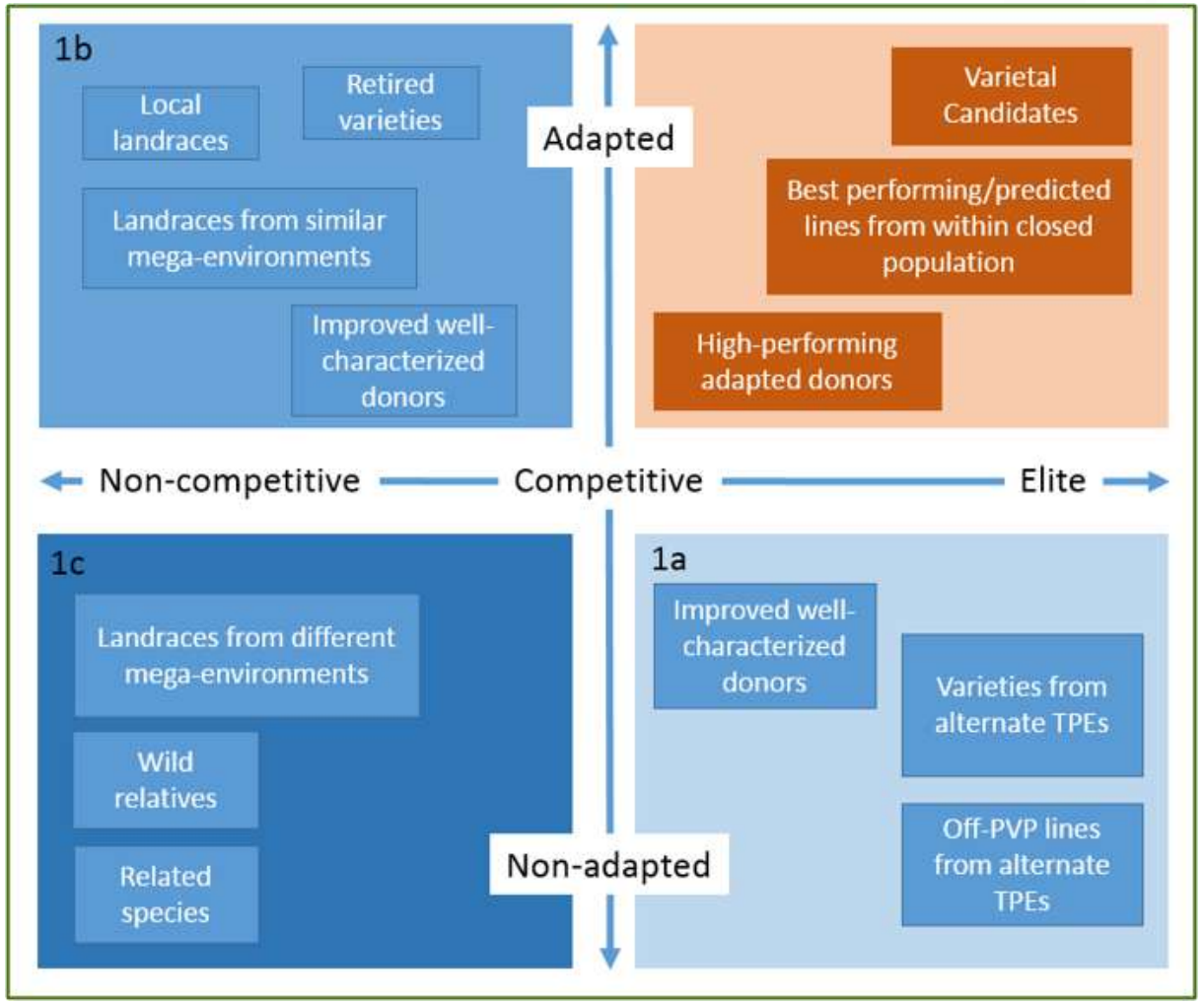
Physiology TD&D team (includes pathology/virology)

- Stage 2 and Stage 5
  - Phenotyping assays, donor identification and validation phenotyping

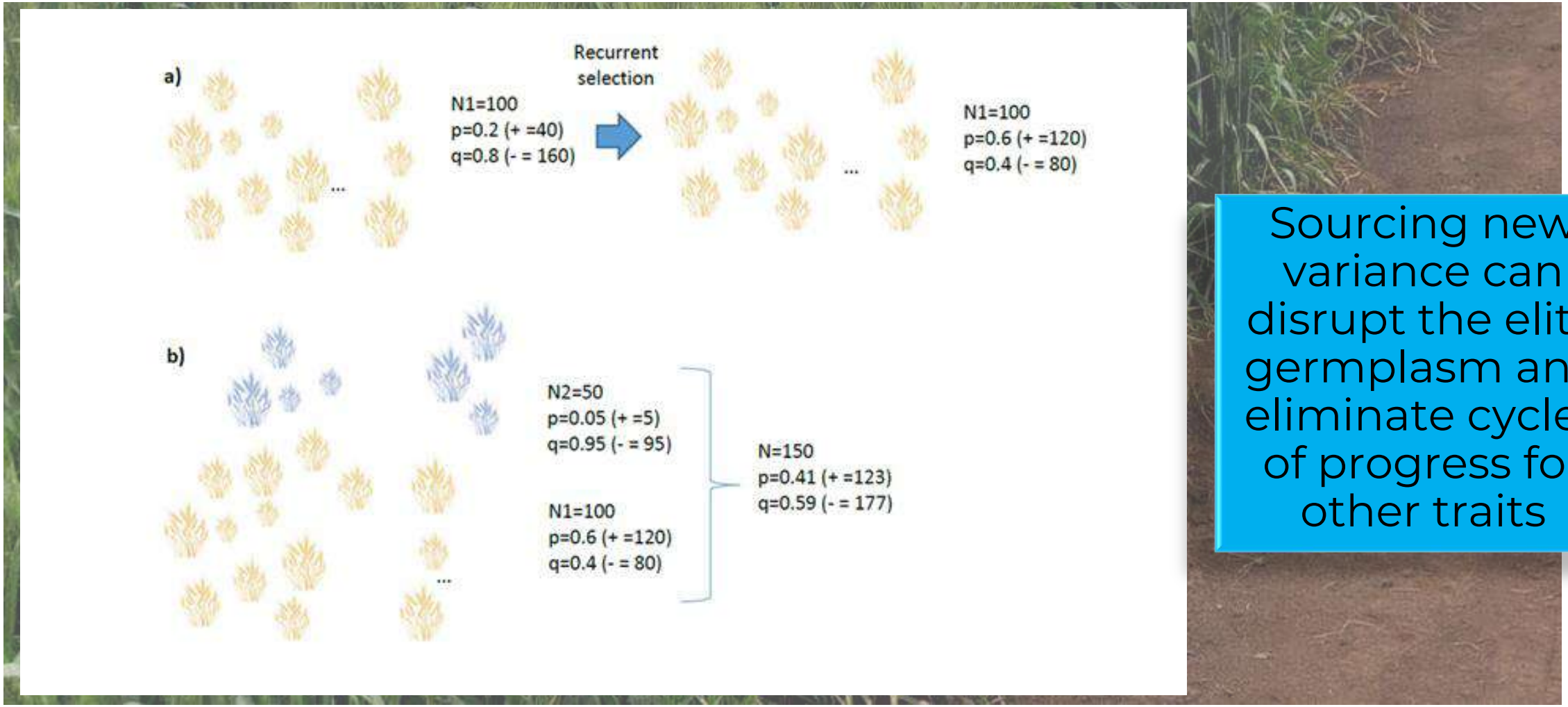
Genetic TD&D team

- Stage 3, 4 and 6
  - QTL/Haplotype identification, introgression, tracking, augmentation and genotyping platforms

Trait Discovery: Sourcing new variance



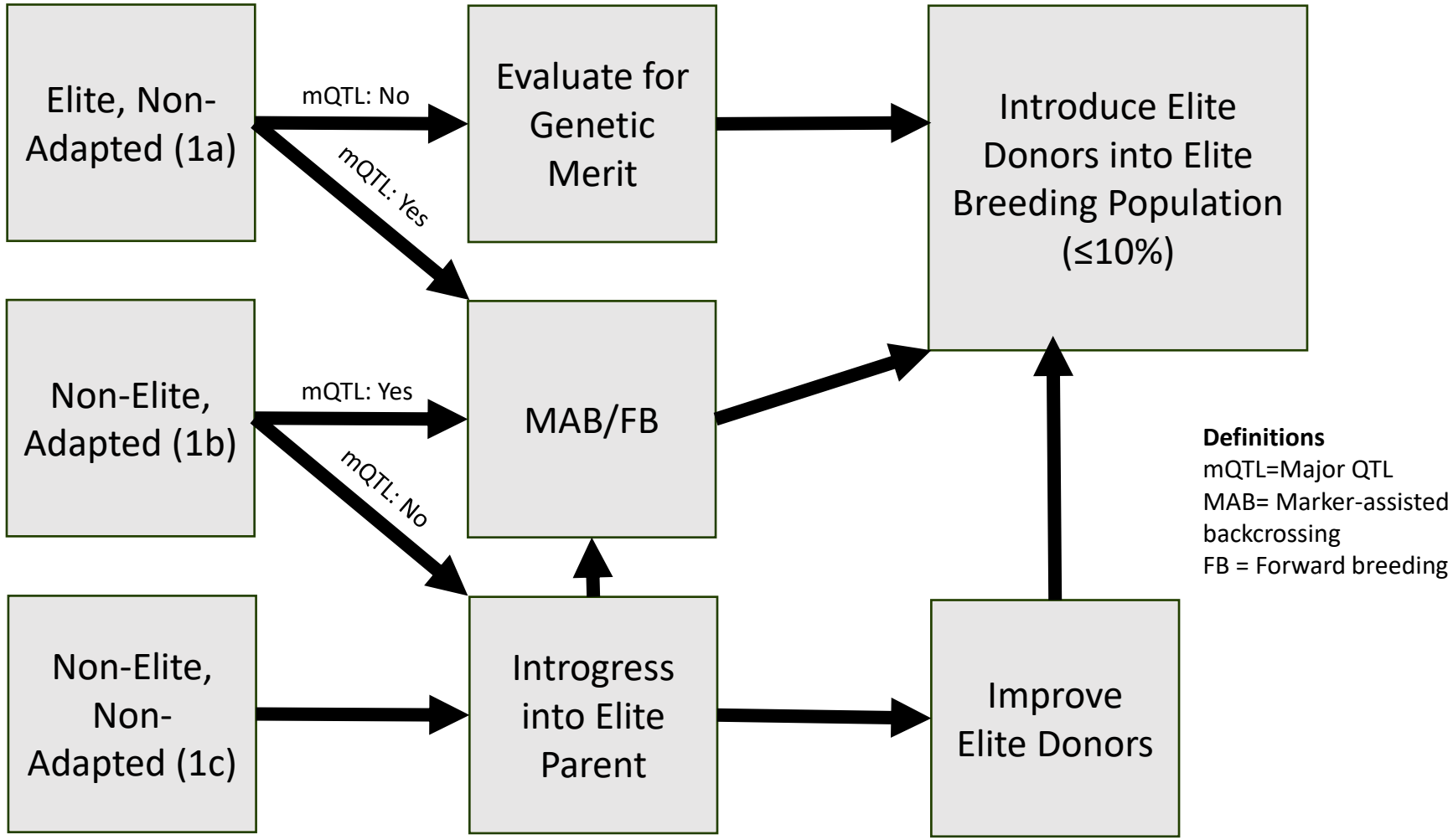
Trait Discovery: Why, What, How?



Sourcing new variance can disrupt the elite germplasm and eliminate cycles of progress for other traits

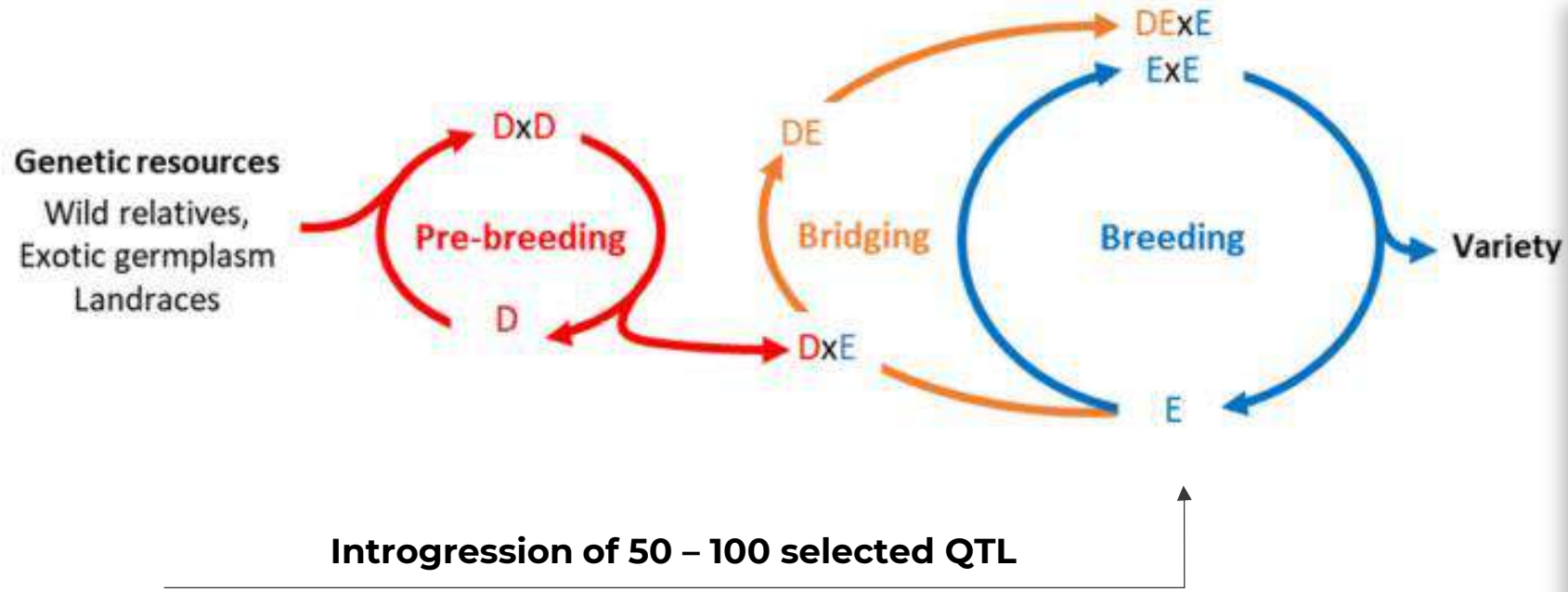
https://excellenceinbreeding.org/

Trait Deployment: Decision Support



What if polygenic?

Polygenic traits: TD&D strategy 1

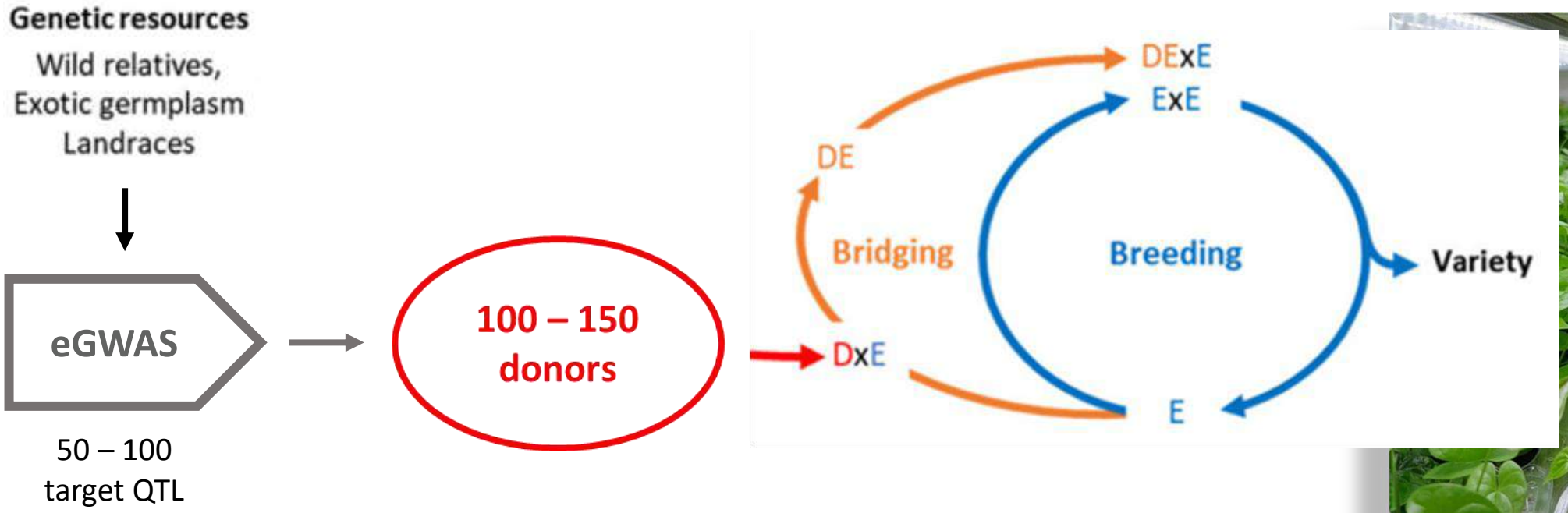


Allier et al. 2020: https://doi.org/10.1186/s12864-020-6756-0

Limitations: Strategy 1

- Extensive source of allelic diversity (beneficial and unfavourable)
- Not adapted to TPE
- Low agronomic performance

Polygenic traits: TD&D strategy 2



Allele mining project

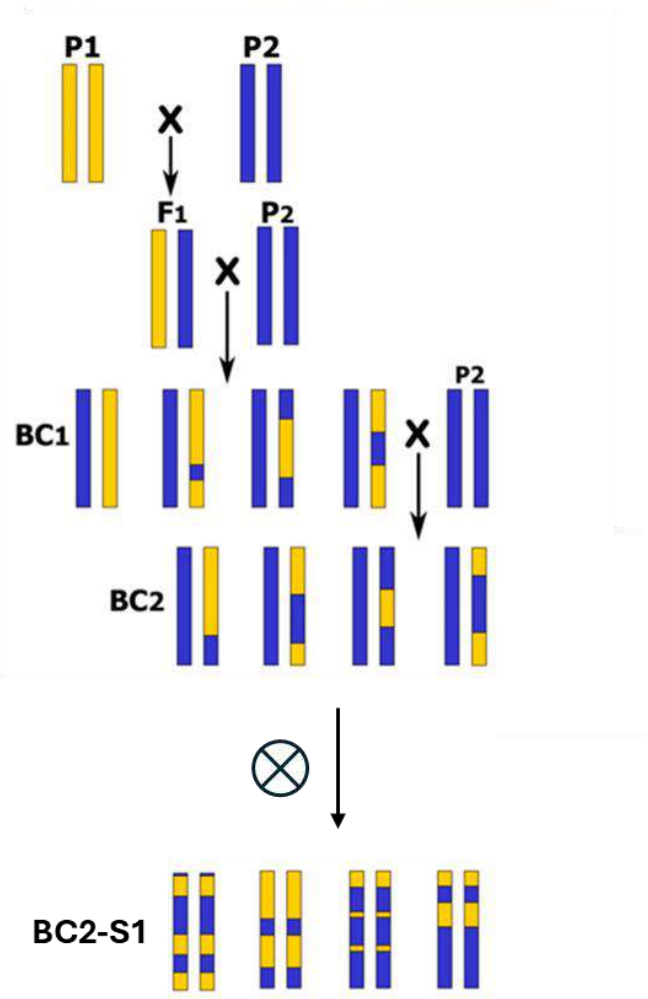
Limitations: Strategy 2

Bridging requires backcrossing to recover the elite parent's genome

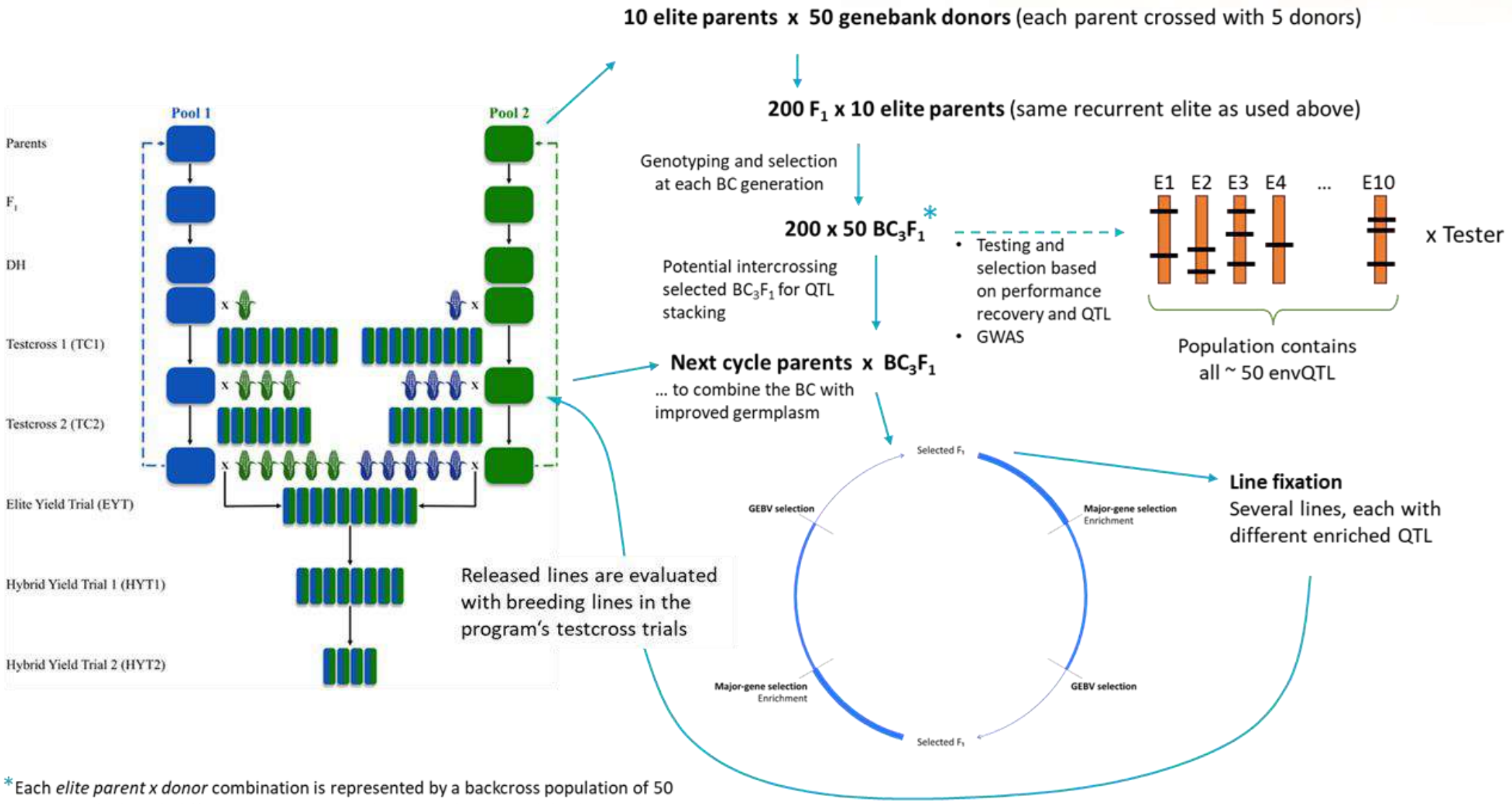
- Removal of undesired donor regions
- Minimisation of flanking donor regions around target QTL (linkage drag)

Problems

- We cannot directly control this process
- No backcross will contain all target QTL
- Many backcrosses will contain target QTL and undesired donor regions
- Some backcrosses may contain no target QTL



Polygenic traits: TD&D strategy 3 - Proposed



*Each *elite parent x donor* combination is represented by a backcross population of 50 BC_3F_1 individuals with different QTL introgressed into the elite parent's background.

Polygenic traits TD&D: Standing questions

- How many donors (already addressed)?
- How many elite parents for bridging?
- Which and how many *donor x elite* cross combinations?
- How many backcross and selfing generations?
- Which confirmation and tracking strategy?
- Which augmentation strategy?
- Which strategy to maintain and increase the frequency of the introgressed alleles in the elite pool?
- How to include this as a routine process in our breeding programs?

Extensive simulation work will be required!

TD&D in heterogenous or polyploid crops

1. Do not over-estimate the need for additional variance especially for polygenic traits
   - Already have a lot of variance at all loci
     - No need for consistent wide crosses

2. Elite Breeding Populations have not been sufficiently closed to move the genetic mean of priority essential traits too far from the adapted landraces
   - Start with the right germplasm base (Refer to Goal #5-6)
     - Elite Breeding populations should have adapted landraces carrying priority essential traits as part of the pedigree

3. For simple traits, traits completely missing in the Elite Breeding Population or could be selected better using markers:
   - Marker-assisted backcrossing is not possible
   - The polygenic TD&D strategy 3 above is best bet
     - Slower, more complex

Summary: The primary ‘Ask’ – Focus!

Current: phenotypic and molecular research takes place for too many traits with insufficient impact on breeding

How to change? - Team discussion

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Result: Trait Team and Product Development Team roles are defined and aligned for impactful breeding.

Trait Team key performance indicators: Suggested

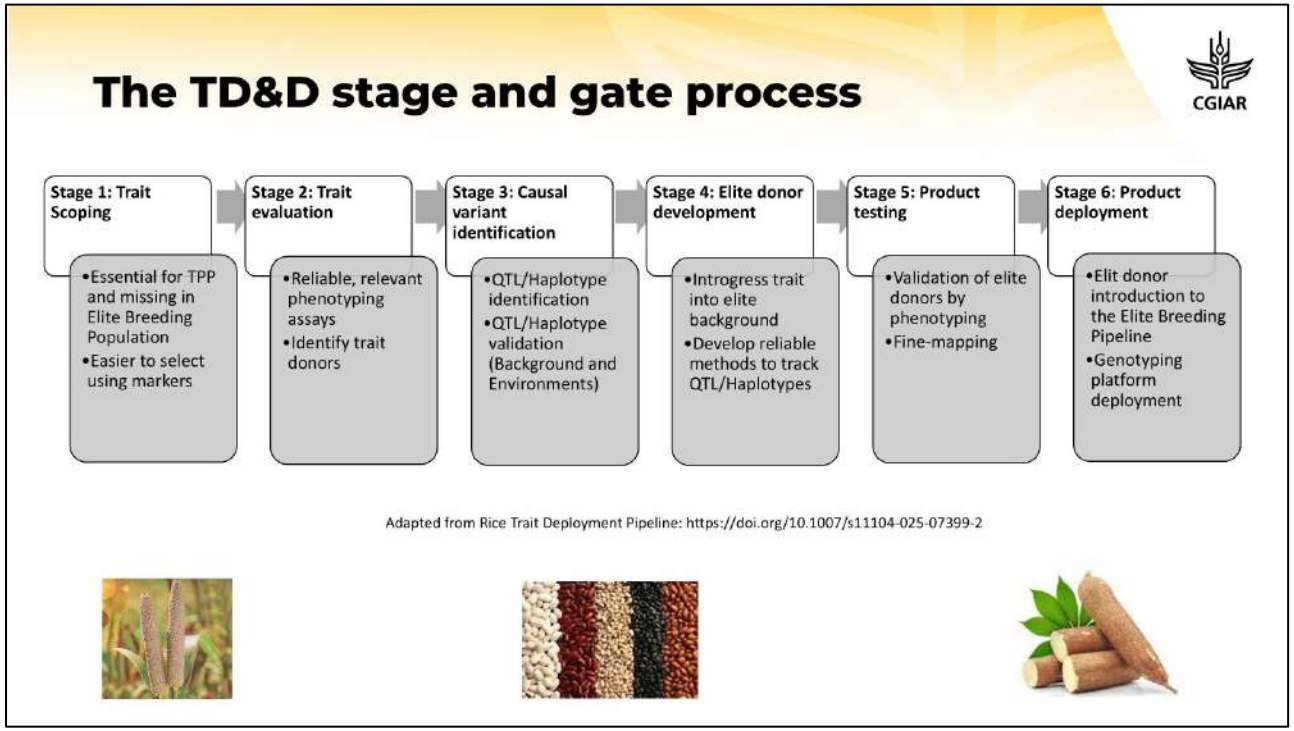
1. Number of pipelines that have prioritized essential traits, documented and mainstreamed TD&D targets
2. Number of essential traits having relevant phenotyping assays at scale
3. Number of essential traits with trait donors identified
4. Number of QTL/Haplotypes validated
5. Number of QTL/Haplotypes introgressed into Elite Donors
6. Number of Elite Donors validated and have reliable tracking methods
7. Number of traits successfully deployed into the Elite Breeding Population
8. % representativeness of the genotyping panels of Elite Breeding Populations
9. …

How will we capture CGIAR's TD&D efforts?

2022-2024: EXCEL files in Sharepoint

2025: TD&D Module in Breeding Portal (in development), aligned with TD&D stages > to support best practice application

Allows to extract KPIs



Thank You!

Questions and Discussion

CGIAR
Science for a food-secure future