Accelerated Breeding 2025 Goals: Goal #5-6 Deep dive

Accelerated Breeding Team

2nd June 2025

Meeting Design

Purpose

- An **Information sharing** meeting on goals #5-6 of Accelerated Breeding (AB) high level goals for 2025

Outcomes

- Breeding teams across programs understand AB goals #5-6, what is expected of them, levels of engagement and where to seek support

Agenda

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

Breeding Strategy

Breeding Program

↕

Breeding Pipelines

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Market Segments each with a unique TPP

↕

Breeding effort focused on a Market Segment

↕

Breeding Schemes

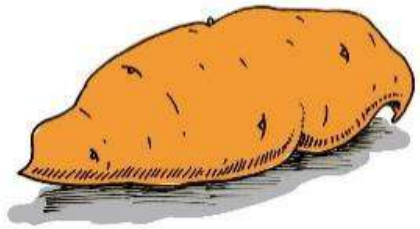
Goal #5: Implementing minimum standards

All breeding teams have in place the minimum standards needed for a successful breeding program

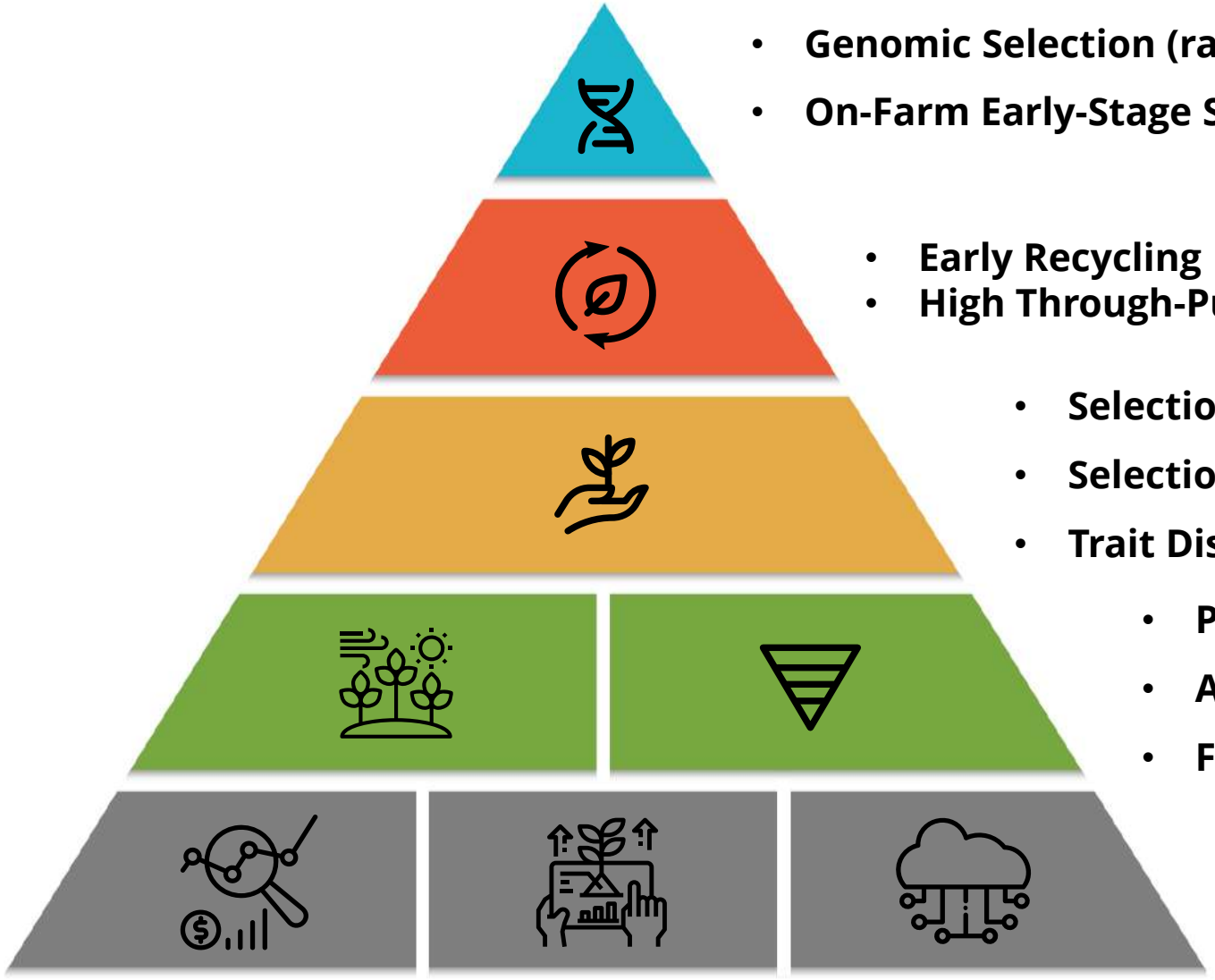
- Breeding programs cannot be successful without having these foundations first
  - Implementing more advanced methods without having the minimum standards in place leads to no progress

Support

- ACCELERATE guidelines –Excellence in breeding tool box Excellenceinbreeding
- ACCELERATE cross-cutting team
- Breeding Resources
- TRANSFORM



Goal #5: Breeding Pipelines and Schemes: Priorities



- Genomic Selection (rapid recycling)
- On-Farm Early-Stage Sparse Testing

- Early Recycling
- High Through-Put Phenotyping

- Selection Criteria
- Selection Method
- Trait Discovery and Deployment
  - Program Size & Germplasm Management
  - Assays for Essential Traits
  - Field Trials (MET)
    - Market Segments & Target Product Profiles
    - Breeding Scheme Design
    - Data Management

Goal #5: Breeding Pipelines and Schemes: Practices

- 100% pipelines implement best practices and meet minimum standards
  - Documented breeding schemes
  - Right germplasm base
  - Data management systems
  - Improved statistical designs and data standards
  - Analytical pipelines (Bioflow)
  - Use QA/QC
  - Proper check strategy
  - Efficient OFVT
  - Key performance indicators
  - …

Goal #5: Documenting breeding schemes

Ask: All programs document and formalize crossing, evaluation and selection (CES) decisions

How?:

- EiB - Breeding Scheme Manager
- **ACCELERATE guidelines and cross-cutting team**

Why?

A well-rationalized breeding scheme, captured in a standardized approach, makes it easier to:

- Discuss pipelines with colleagues, research leaders and funders;
- Work with specialists on optimization research e.g. simulations;
- Estimate genotyping needs for QA/QC, MAS, GS for planning puporses;
- Cost breeding activities across stages of testing;
- Make a stronger investment cases
- Extract information for standard reports;
- Monitor progress and changes made over time.

Goal #5: Right germplasm base

Ask: All programs use the most appropriate germplasm that meets the needs of the markets and consumer preferences

- Benchmarked against most dominant varieties
  - Poor germplasm base – limited progress, less effective, and more vulnerable programs to future challenges, low adoption of new varieties

Support:

- **ACCELERATE guidelines + cross-cutting team**

How?

- All essential traits in the TPP must be represented in the breeding population
- All essential traits should be measurable within the pipeline
  - The earlier in pipeline the better
    - Allows for earlier recycling
- If all essential trait alleles not represented in the right frequency
  - Need to be sourced and strategy for deployment
    - TD&D
    - Other pipelines
    - Genebanks

Goal #5: Data management systems

Ask: All programs use any of the supported databases; EBS, BreedBase, BMS

- Foundational to all breeding programs
  - Support data integrity, enhance efficiency, enable complex analysis, and facilitate collaboration
- Use databases efficiently – all breeding operations not just as repository

How?:

- **ACCELERATE guidelines and cross-cutting team; Breeding Resources**

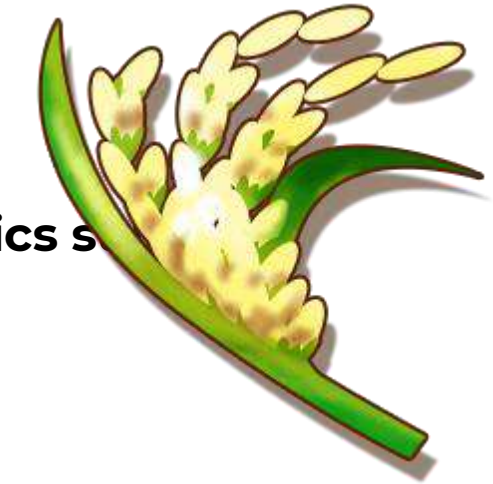
Why?

- Data loss and poor data management – poor collaboration and knowledge sharing
- Reduced efficiency and increased labor – delayed analyses and response to challenges
- Errors and inconsistencies – inaccurate records and lack of standardization
- Limited decision support – No historical data to meet regulatory and stakeholder standards
- Limited use of modern tools (machine learning, predictive modeling and automated phenotyping)
- Loss of institutional memory – staff turnover and limited learning from past experiences

Goal #5: Statistical designs and data standards

Ask: All breeding programs use improved experimental designs and improve data quality using good plotmanship

- Cornerstone in all breeding programs
- Cheap option with large potential for improving programs



How?

- **ACCELERATE guidelines and cross-cutting team, Breeding analytics s**
- Databases

Why?

Influence the efficiency, accuracy, and impact of breeding outcomes

- Enhanced accuracy and reliability – minimize errors and increase repeatability
- Increased statistical power - Better detection of genetic differences, optimal resource use
- Facilitates genomic selection and AI integration using high quality phenotypic data
- Resilience to climate and environmental variability – account for GxE

Goal #5: Analytical pipelines - Bioflow

Ask: Programs use Bioflow for robust and standardized analysis and decision support

How?:

- ACCELERATE guidelines and cross-cutting team, Breeding Analytics support
- Center representative steering committee – being put in place
- CGIAR Bioflow

Why?

Hosts robust, state-of the art models in a semi-automated fashion to facilitate routine selection decisions in breeding programs

Main modules

- Genotypic and Phenotypic QA/QC
- Proper handling of experimental design effects (STA)
- Multi-trial analysis (which may include genomic data to predict GEBVs or GTGVs)
- MAS (If QTL/major gene information is available)
- Estimation of multi-trait selection indices for recycling
- Optimal contribution selection (requires accurate pedigree and/or marker data)
- Tracking of realized and predicted genetic gain
- GWAS
- Population Structure analysis
- In development: tracking of genetic variance (LD, genic variance)

Goal #5: Quality assurance and quality control

Ask: All programs carry out QA/QC

- Provides the foundations of credibility and success by ensuring that every variety released meets the genetic, agronomic, and market expectations
    - Even large programs in industry make astoundingly many mistakes thatwe think

How?

- **ACCELERATE guidelines, Genotyping slots from BR, Bioflow**

Why?

- Monitor and verify that breeding lines are true to type
- Regular audits/checks for data accuracy, outlier detection, and error correction
- Reduces noise and increasing confidence in selection decisions
- Prevents propagation of poor-quality or mislabeled materials, avoiding repeated or failed trials
- Ensures that documentation, trial protocols, and variety characteristics meet certification requirements
- Proper recordkeeping and verification enable traceability of breeding steps and genetic materials
- Demonstrates reliability and accountability in breeding outputs to farmers and seed companies

Goal #5: Use of a good check strategy

Ask: All programs use the recommended check strategy

- Ensures meaningful, accurate, and relevant comparisons
- Stronger scientific, practical, and economic value of breeding decisions

How?

- **ACCELERATE guidelines and cross-cutting team**

Why?

Checks serve different purposes in breeding trials

- Benchmark new varieties against known, widely grown, or high-performing varieties
- Standardize across environments – consistent and reliable performance evaluation
- Detecting experimental errors – poor trial management, mislabeling, etc
- Statistical rigor – improves precisions of comparisons
- Ensuring relevance – enhances targeting relevant varieties that can adopted

Goal #5: Efficient on-farm verification trials

Ask: All programs carry out on-farm verification trials to bridge the gap between breeders and end-users

- New varieties are agronomically sound, economically viable and socially acceptable
  - Real-world performance evaluation
  - Farmer engagement and acceptance – accelerated adoption

How?

- **ACCELERATE guidelines, AB-Transform, BR**

Why?

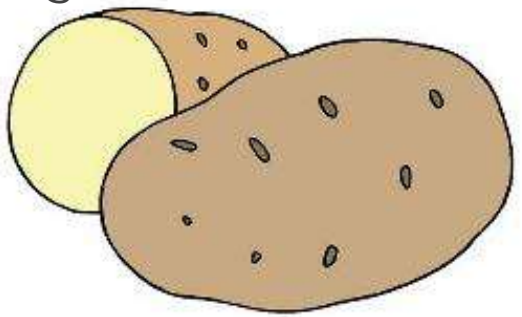
Enhances the relevance and impact of new varieties

- Seed systems make strong cases for uptake not based on on-station data only
- Famers are convinced of new varieties with large enough improvements
- A feedback loop to make breeding objectives more relevant
- Policy and registration support – data leveraged for release

Goal #5: Key performance indicators

Ask?: All programs generate and provide information needed for the harmonized crop report (HCR)

- KPIs defined by ReORG and TRANSFORM can be extracted from PMP, Breeding portal, Bioflow and EBS for HCR
  - Easier and standardized reporting to stakeholders – less workload to programs



How?

- **CGIAR PMP, Accelerated Breeding support**

Why?

KPI provide a structured, measurable way to track progress, assess success, and guide decision-making

- Performance measurement and comparison with peers
- Decisions making - Effective resource allocation and budget justification
- Strategic alignment – organizational alignment, transparency and accountability
- Continuous improvement – feedback loops and innovation monitoring
- Stakeholder communication of breeding progress to non-specialists

Goal #6: Accelerating genetic gains

ASK: With feasible, impactful and in-demand TPPs, minimum standards in place, breeding teams design and implement optimal breeding schemes for priority pipelines

- A menu of options as programs are at different stages with different resourcing and capacity

Why?

To improve the average genetic value of priority essential traits in a population over generations by maximizing recombination and exploiting genetic variance

How?

- Increase selection intensity
- Increase selection accuracy
- Manage genetic variance
- Reduce cycle length

Goal #6: Increasing selection intensity

Ask: Breeding programs select ≤15% for recycling depending on program size

- Dimishing returns on large population sizes

- **ACCELERATE guidelines and cross-cutting team**

Why?

With careful management, - faster, more significant improvements in performance

- Trade-offs with genetic variance

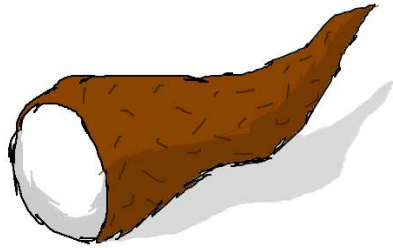
How?

Elite-by-elite crosses

- Ensures offspring have high genetic merit that maximizes selection differential

Use of multi-trait selection based on selection indices

- Use desired gains index for well-defined and prioritized TPPs
  - Desired gains are well quantified
  - Objective is to increase genetic gains of defined essential to improve traits



Goal #6: Increasing selection accuracy

Ask: Breeding programs review, update and continuously improve their testing strategies to ensure more accurate selections

- How do we represent the TPE better?
  - Representative set of on-farm conditions, mimic on-farm conditions on-station, account for year effects etc

- **ACCELERATE guidelines and cross-cutting support, BR**

Why?

Accurate selections ensure that the traits to improve are actually being passed on, making the program faster, more cost-effective, and more reliable

How?

High throughput phenotyping assays for **all essential traits**

Increase the relevance of early testing:

- Ensure all essential TPP traits are assayed during Early testing
- Improve the understanding of relevance of current early testing and, as needed, change locations or management, or add locations and/or managed stress trials.
  - Drop locations with consistently poor data even with good plotmanship
- Ensure the inclusion of representative on-farm conditions earlier in the breeding process.

Use well connected reference populations and new genomics- and AI-driven methods

Goal #6: Manage genetic variance

Ask: Breeding programs continuously **monitor** genetic variance for all essential traits in the breeding population

- Define strategies for managing optimal genetic variance in breeding populations
- **ACCELERATE guidelines and cross-cutting support**

Why?

Affects both short-term and the long-term gains in a pipeline

- Trade-off between variance and gain – faster recycling
- Breeding teams over-estimate the need for new variance
  - Polygenic traits have a lot of variance – do not need consistent wide crosses

How?

Controlled selection strategies and mating systems

- Optimal cross-selection, GPCP in Bioflow
- Maintaining heterotic groups to exploit dominance variance

Maintaining optimal population sizes to avoid drift and inbreeding depression

- An optimization exercise – not exponentially huge populations

Strategies of introducing new variance

- TD&D or other pipelines
- Aligned with TPPs

Goal #6: Reducing cycle length

Ask: Breeding teams review and consistently explore novel ways to further reduce cycle lengths

- All essential traits need to be measured earlier
  - Use the best quality data available – do not wait
- **ACCELERATE guidelines and cross-cutting support**

Why?

A strategic and powerful way to maximize genetic gain, speed up innovation, and respond proactively to global agricultural challenges

How?

Reach stage of parent selection in shorter time through…

- Faster advancement of generations
  - Speed breeding, rapid generation advance (RGA), doubled haploids, shuttle breeding

Select parents earlier in the breeding pipeline…

- Needs sufficient and accurate information on key traits
  - Improved testing strategies
  - Use of cutting-edge methods e.g. genomic selection

Goal #6: Apply genomic tools

Ask: Breeding programs mainstream molecular breeding tools and genomic selection

- There is clarity of roles among molecular breeders, breeders and biometricians
  - Should not be beyond all CGIAR programs to incorporate genomic data

- **ACCELERATE guidelines and cross-cutting support, BR**

Why?

Significantly improve the efficiency, precision, and speed of developing improved varieties

How?

Applying marker-assisted selection in population improvement pipelines

Developing and applying genomic selection capabilities

- Selection intensity, selection accuracy, genetic variance, cycle length

Ensure that low and mid-density panels are representative of breeding populations

Goal #6: Genomic selection

Genomic selection is a necessary tool for breeding teams to improve breeding efficiency

- Built into the breeding scheme rather than having custom genomic selection populations
    - GS is not a parallel breeding pipeline

Need to have the basics in place first

- Feasible TPPs, ability to measure all essential traits, high-quality data management

Genomic Selection is most efficient at early stages of selection

- Many individuals, low replication, few environments (on-station), low heritability, no or limited data across years, …

The biggest benefit of Genomic Selection is reduction of the cycle length by selecting parents early

- More focus on population improvement

Goal #6: Breakthrough products

Ask: Varieties with **on-farm performance gains** large enough to drive faster adoption

- Clearly recognizable improvements via:
  - Product-focused population improvement
  - Product-focused deployment of high value haplotypes
- **ACCELERATE guidelines and cross-cutting support**

How?

A Breakthrough Product replaces one or more widely grown varieties

- Only target **major market segments**
- Are recognizably differentiated from the replacement target
  - ≥25% productivity and/or value improvement compared to the varieties to be replaced
- Have adequate offtake potential to reliably improve farmer income, with evidence of demand to drive adoption

Example: The archetype for rapid cycle genomic selection

https://hdl.handle.net/10883/23152

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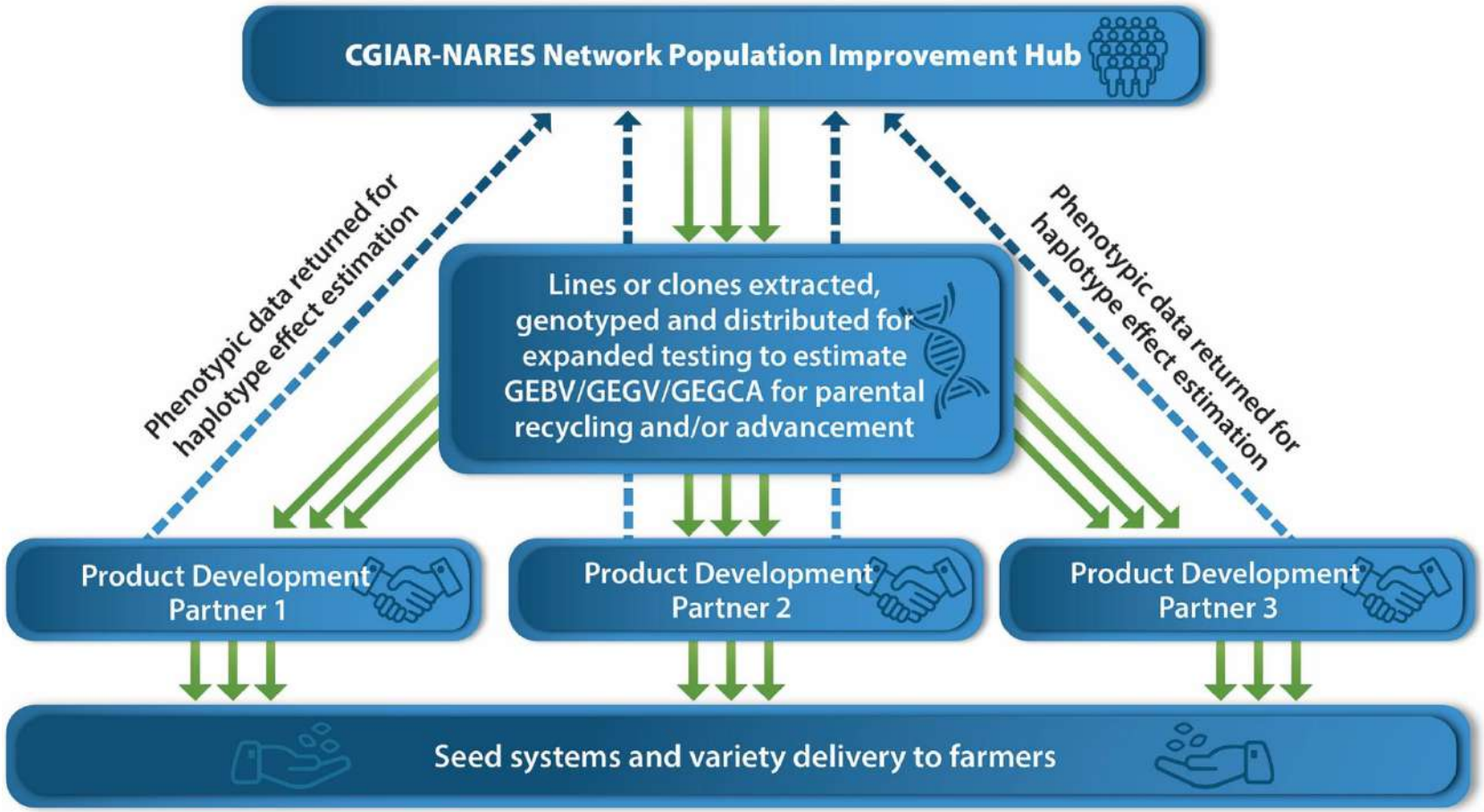
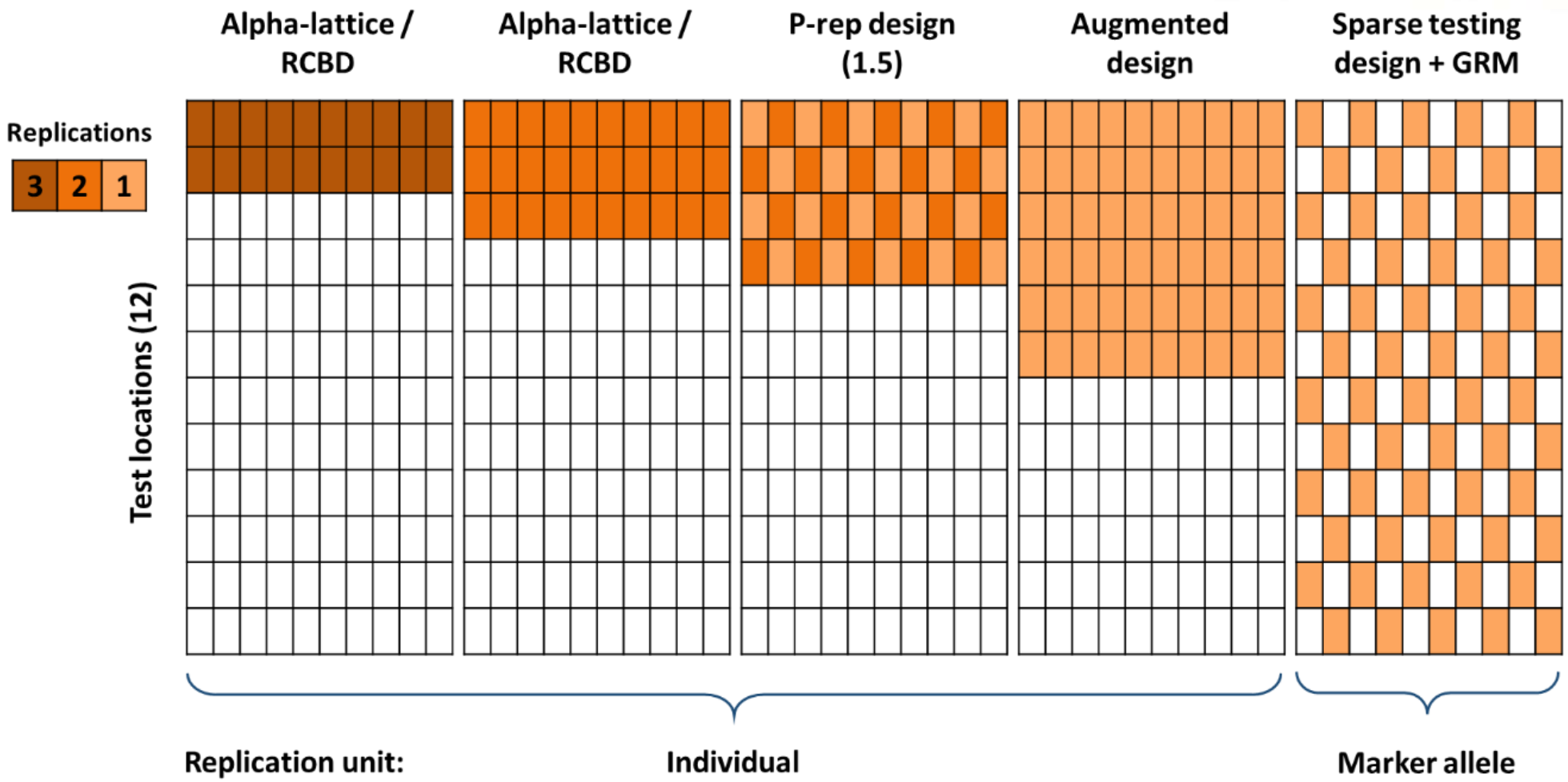
The Objective

- While considering all cross-cutting and unique barriers and enablers;
  - ✓ Improve our population improvement efforts to continuously deploy favorable alleles and haplotypes
  - ✓ Further reduce generation interval (cycle length) – target is 2-3 years using rapid cycle genomic selection
  - ✓ More accurately select for farmer-relevant conditions by having more trial sites in the TPE for trials in the first year of testing, to better represent the target population of environments (TPE)

Pipeline redesign



Sparse testing: Optimal resource allocation



Expectations on breeding teams

Develop implementation roadmaps

- Identify barriers and enablers to overcome
- Allocate resources
- Implementing RCGS

Forecasting

- Genotyping support – data turn-around
- Level of improvement in heritability from improved operations
- Keeping up with crop calendars of partners

Improved efficiency multiplication and transfer of germplasm

- SOPs for planting material multiplication and exchange
- Research into multiplication ratios and new multiplication methods.

Improved data management and analytics

- Use of databases and analytical pipelines

Breeding Strategy: Next steps

- ~~TPP feasibility~~
- ~~Priority setting~~
- Alignment to and evaluation of the feasibility of breeding pipelines
- Breeding scheme design and optimization

Thank You!

Questions and Discussion

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