



Reversing the Trend: Bottom-up Approach to Increasing Plant Breeding Efficiency in Africa

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Reversing the Trend - Why ?

More and more genomic technologies – and so much more that can be done

More and more genomic knowledge – and so much more that can be discovered

THIS IS ABSOLUTELY GREAT

But let's think a bit at what would really help a national breeding program in Africa

Because they might not need all the latest yet be missing some critical parts here and there



How to Increase Plant Breeding Efficiency ?

1. Understand what plant breeding is
2. Understand what its objectives are
3. Understand how it operates: strengths, gaps, context (constraints)

BOTTOM

4. Identify improvement opportunities
5. Identify/develop the appropriate information and technologies

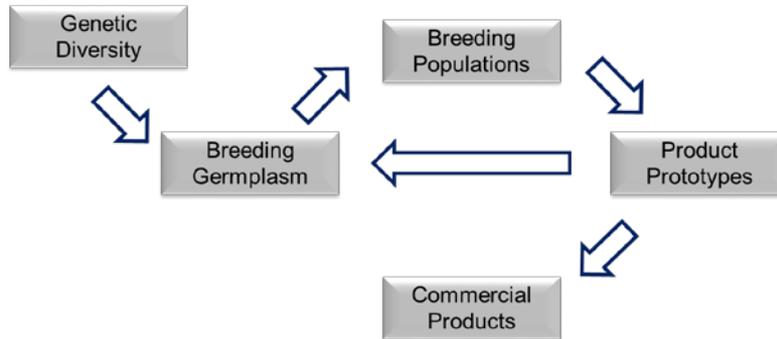
TOP

6. Launch improvement project(s)
7. Run improvement project(s) until completion

RUN



What is Plant Breeding ?



It's about making decisions

How to Increase its Efficiency ?

Finding ways to make better decisions more often

Measuring Success in Plant Breeding

The diagram shows the genetic gain equation $\Delta G = \frac{ir\sigma_A}{y} = \frac{ih^2\sigma_P}{y}$ with the following labels and arrows:

- Rate of Genetic Gain**: points to ΔG
- Selection Intensity**: points to i
- Selection Accuracy**: points to r
- Genetic Variance**: points to σ_A
- Heritability**: points to h^2
- Phenotypic Variance**: points to σ_P
- Years per Cycle**: points to y

The genetic gain equation

How to Increase Success Rate ?

Acting on genetic gain's levers

Breeding Objectives

Yield

- Yield potential – *maintain or increase*
- Preservation of yield potential (response to biotic and abiotic stresses) - *increase*

Product quality

- End-user quality attributes (with respect to preferences) – *maintain or increase*

Production efficiency

- Grower (from planting to harvest) - *maintain or increase*
- Downstream processors (on farm or not) - *maintain or increase*



Breeding Context/Constraints

Biological constraints

- GxE (yield, quality)
- seed setting

Nursery resources

- Capacity
- Quality

Phenotyping resources

- Capacity
- Quality

Genotyping resources

- Capacity
- Quality
- Turnaround

Data management resources

is what it is

+/- difficult to fix

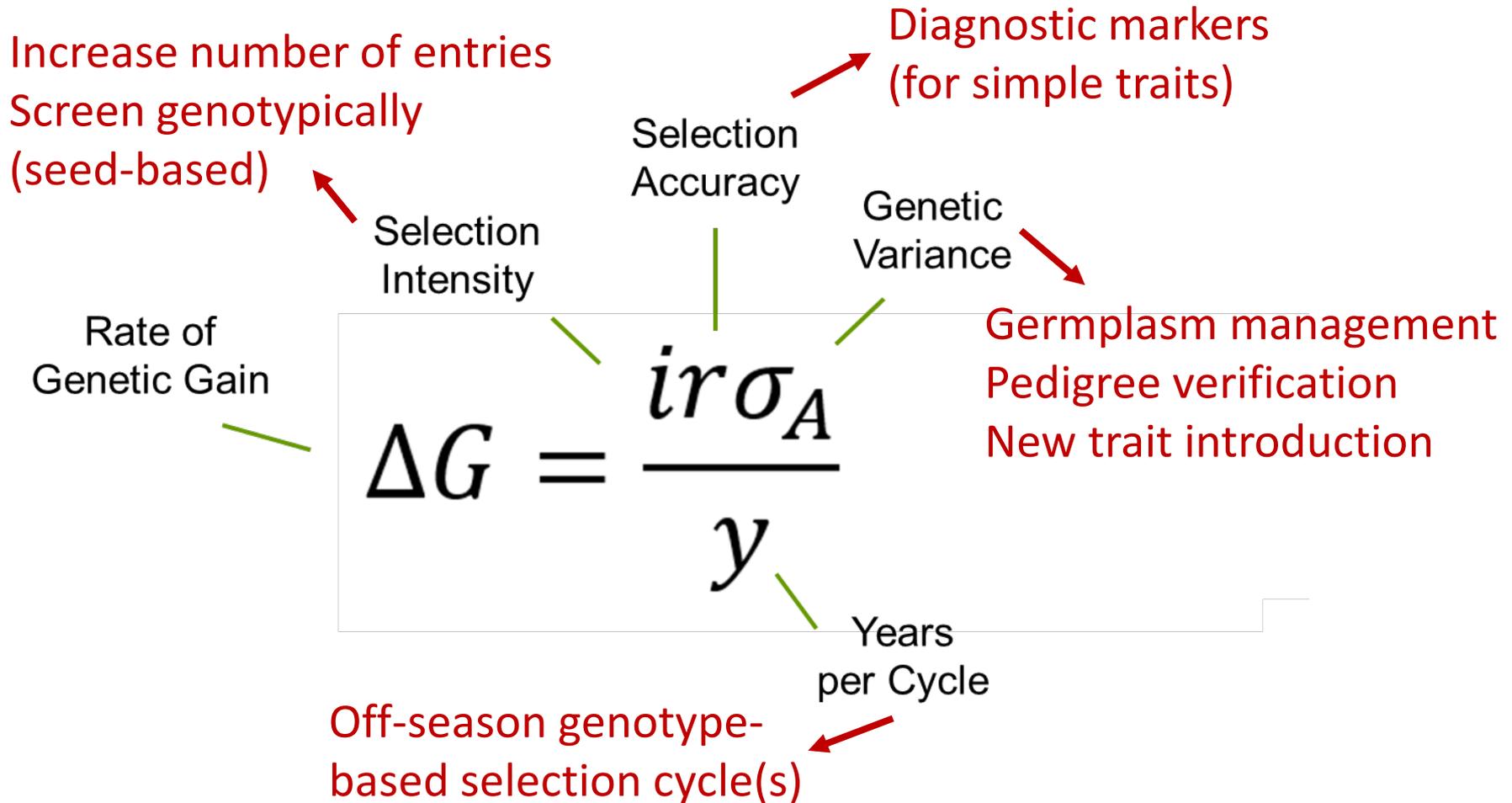
very difficult to fix

easy to fix

easy to fix



Improvement Opportunities



Quality Control / Pedigree Verification

Ensure that entries submitted to selection are what they are supposed to be

- ▶ Check lines, F1's, BC1's, F2's (?)
- ▶ Maximize impact of decisions
- ▶ Requires few genome-wide markers (10's) polymorphic in breeding material



Germplasm Management

Extract the maximum value out of the available germplasm

- ▶ Genotype elite materials (lines)
- ▶ Actively manage use of germplasm: wide vs narrow crosses, exploitation of diversity
- ▶ Requires few genome-wide markers (100's) polymorphic in breeding material
- ▶ Requires regular (yearly) genotyping of new materials
- ▶ Requires genotypic diversity analysis and visualization tools



Pre-Screening for Simple Traits

Increase selection intensity without increasing nursery or phenotyping workload

- ▶ Ensures that all complex trait phenotyping resources are used with maximal efficiency (no entry will be dropped because of a simple trait)
- ▶ Requires availability of very highly diagnostic (very tight linkage between marker and causal polymorphism) markers (single or haplotypes) for valuable simple traits (yield preservation)
- ▶ Would greatly benefit from availability of non-destructive seed-based protocols



Off-Season Selection

Decrease cycle duration

- ▶ Conduct additional cycles of selection based on genotypes in seasons when phenotypic data cannot be collected
- ▶ Genotype-based selection with diagnostic markers for valuable simple traits
- ▶ Would greatly benefit from availability of non-destructive seed-based protocols



New Trait Introduction

Introduce and broadly deploy favorable alleles from any source for valuable simple traits

- ▶ Benefit from favorable diversity without being negatively impacted by associated negative effects
- ▶ Marker-assisted backcrossing aimed at generating “clean” donors for subsequent deployment of trait in breeding material (foreground, recombination and background selection)
- ▶ Requires few genome-wide markers (100's)



Data Management

Facilitate all breeding processes, especially genotype-based ones, and accumulate phenotypic data in an orderly, retrievable manner

- ▶ Maintain pedigree relationships to facilitate pedigree verification and tracking of favorable alleles at simple trait loci
- ▶ Accumulate highly valuable phenotypic data for subsequent development of predictive models for increasingly complex traits



Conclusion

Simple knowledge and technologies that, if available, would impact breeding decisions in national African programs immediately, and result in increased genetic gain in the very short term:

- ▶ Highly diagnostic markers for valuable simple traits (5 traits x 10 crops = 50 diagnostic markers)
- ▶ Hundreds of genome-wide markers polymorphic in breeding material
- ▶ Seed-based genotyping protocols
- ▶ Cheap and high quality genotyping (for 1-5 markers per sample or 100 to a few 100 markers per sample)



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