Gender & Breeding Initiative

CGIAR

Reality check – can we breed for all “traits?”

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Example: List of preferred traits for cooking bananas in Eastern Africa *(from: Marimo et al. 2019)*

PHYSICAL DESCRIP-TORS	Agronomic	Suckering ability[w]
		Time to maturity -early, quick
		Lifespan of the corm/mats, cultivar longevity
		Fruit during the dry season
		Yield (bunch mass or weight)
		Yield stability
		Plant height
		Hardiness
		Resistance to pests – weevils[b], nematodes
		Resistance to diseases, fusarium wilt*, BLS[b]
		Tolerance to lodging
		Tolerance to drought
		Tolerance to wind
		Tolerance to hailstorm
		Adaptation to poor soil fertility[w]
		Intercropping ability
		Labour requirements
	Size and shape attributes	Bunch size[b]
		Bunch size after maiden crop
		Bunch compactness
		Finger (fruit) size
		Finger uniformity
		Finger shape
		Number of fingers per bunch
		Number of fingers per hand
		Hand size
		Number of hands per bunch
		Pulp: peel ratio
ORGANO-LEPTIC AND SENSORY ATTRIBUTES	Appearance (before processing)	Freshness
		Peel colour (ripe/unripe)
		Peel appearance
		Pulp colour (ripe/unripe)
	Appearance	Pulp firmness
		Colour when cooked
	Texture attributes	Texture of cooked pulp
		Uniformity
	Flavour attributes	Flavour
		Aroma/smell
		Taste (after cooking)
		Juice flavour
PROCESSING AND PRODUCT RELATED TRAITS	Processing attributes	Shelf life/perishability
		Ease of peeling
		Characteristics after peeling
		Cooking quality
		Traits after cooking
		Cookability
		Palatability
		Cooking time
		Suitability for matooke
		Suitability for production of beverage products (multipurpose)
		Quality of processed product
SOCIO-ECONOMIC DESCRIPTORS	Commercial and market life attributes	Market demand, prices
		Rate of sheen loss
		Bruising
		Hand or finger drop
		Ripening traits
		Non-presence of female flower buds
	Cultural attributes	Cultural uses[b]
		Uses of other plant parts
OTHER	Other attributes	Number of consumption uses
		Health benefit
		Accessibility of planting material
		Availability of planting material
		Type of biotechnology used to produce planting material

Traits and Breeding:

Traits can be used in Breeding Programs if:

1. Options for measuring, observing it are repeatable
2. Understanding of its inheritance, genetics is available
3. Understanding of its relations, interactions with other traits, physiologically and genetically is helpful

4. Socio-economic importance of the trait?

Some Examples of Traits

Trait	Examples for differences	Type of observable differences	Type of inheritance
Grain color	Yellow, green, white, red	Discreet classes	Single, or few genes
Plant height	1 – 5 m	continuous	Few genes with major effects, strong environmental effect
Resistance to a disease	Different types, size of lesions on the leaves	Discreet classes, or continuous	Single genes or multiple genes
Adaptation to drought	Can become dormant, Can recover, can produce under severe water stress, …..	Continuous, can be difficult to measure in a repeatable way	complex
Yield	kg/ha	continuous	Complex, with strong environment effect, and interactions.

Breeding is a numbers game: 1

If 12 "*traits*" (loci) segregate independently:

- the chance of having the genotype with all favorable alleles is less than winning 'the jackpot'
- And what about the chance of actually finding it?

	AB	**aB**	**Ab**	**ab**
AB	AABB	AaBB	AABb	AaBb
aB	AaBB	aaBB	AaBb	aabB
Ab	AABb	AaBb	AAbb	Aabb
ab	AaBb	aaBb	Aabb	aabb

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Breeding is a numbers game: 2

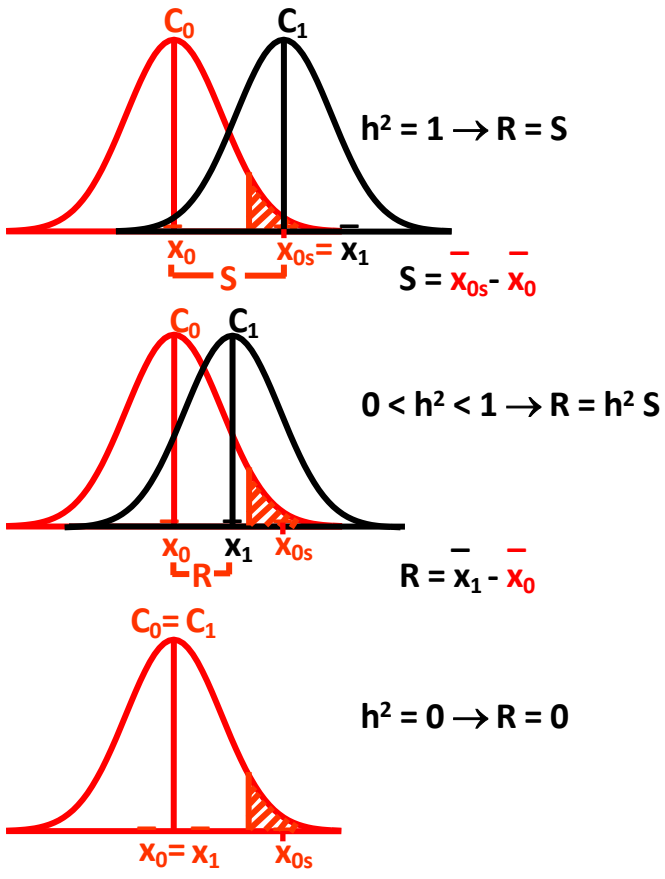
Estimating expected genetic gain, for each trait separately:

$$R = i_{(\alpha)}\sigma_p h^2$$

$i_{(\alpha)}$: Selection Intensity

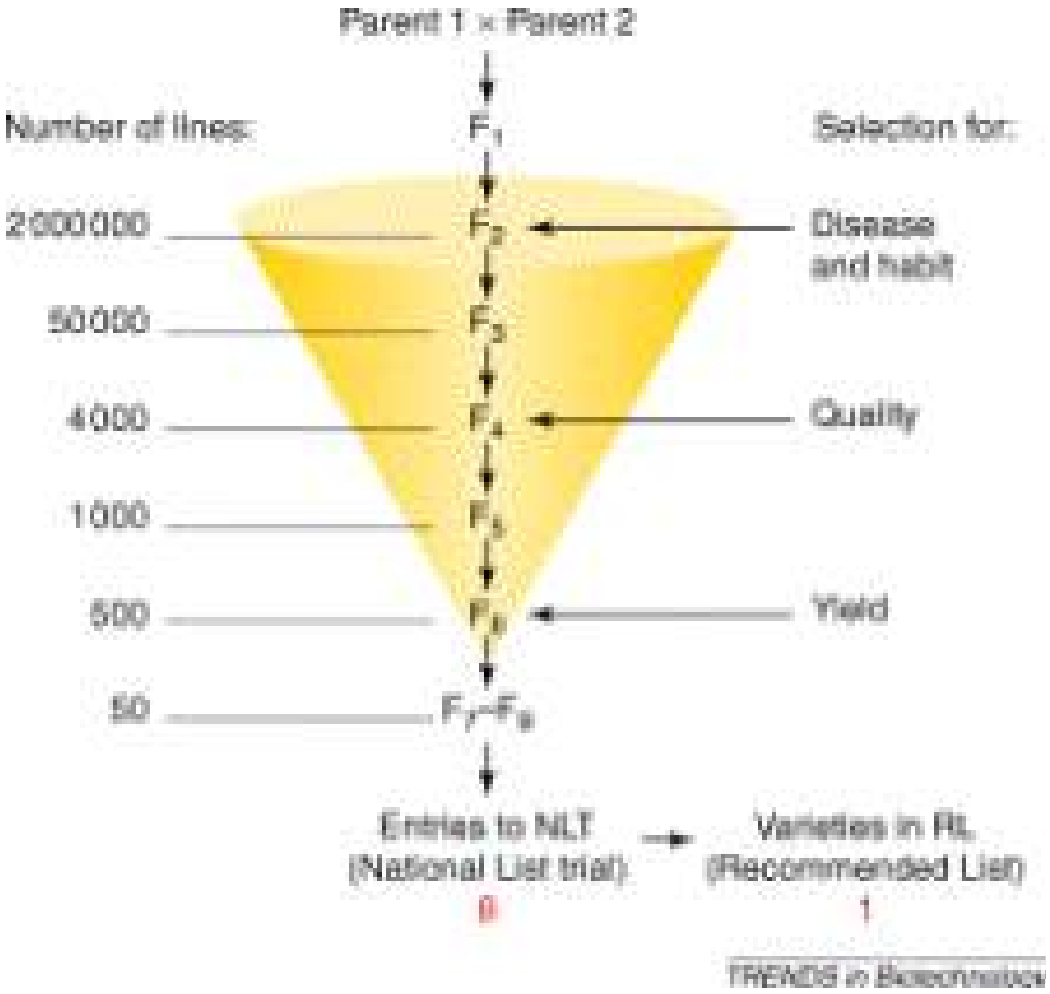
σ_p: Phenotypic Diversity (Standard deviation)

h^2: Heritability



(Kind courtesy, W. Schipprack)

- Generating Diversity
- Selection of exp. varieties
- Evaluating experimental varieties



How to address multiple traits in a breeding program? **STEP 1**

Clarify Priorities:

Trait	Reference demanded	Priority	Selection Target
Grain color	white	***Must have***	Reach threshold
Plant height	More than 2.0 m, less than 4.0 m	***Must have***	Reach threshold
Resistance to a disease/pest	*Striga* resistance	**Important**	Reach threshold
Adaptation to drought	Photoperiod sensitivity Flowering at a fixed date	**Important**	Reach threshold
Yield	Under poor soil fertility conditions, better then local check	***Must have***	Maximise
Stover quality	Improved digestibility of dry stover	Nice to have	Opportunistic
Grain quality	As efficient as local varieties for home processing	***Must have***	Reach threshold

How to address multiple traits in a breeding program?

STEP 2 Choice of Germplasm

Trait	Reference demanded	Priority	Selection Target	Improved Materials	Local Varieties
Yield	Under poor soil fertility conditions, better then local check	Must have	Maximise	+++	++
Grain color	white	Must have	Reach threshold	+++	++
Plant height	More than 2.0 m, less than 4.0 m	Must have	Reach threshold	-- (mostly shorter than 2m)	++
Grain quality	As efficient as local varieties for home processing	Must have	Reach threshold	---	+++
Resistance to a disease/pest	*Striga* resistance	Important	Reach threshold	--	++
Adaptation to drought	Photoperiod sensitivity Flowering at a fixed date	Important	Reach threshold	?	++
Stover quality	Improved digestibility of dry stover	Nice to have	Opportunistic	+++	-

How to address multiple traits in a breeding program? **STEP 3**

- Understand trade offs between traits
- Study availability of genetics tools
- Identify options for screening for ‘threshold traits’ as early as possible (markers, visuals, assessments)
- Build breeding populations that have all ‘threshold traits’ at expected levels, and good diversity of ‘maximize’ traits

How to address multiple traits in a breeding program? **STEP 4**

Build selection indices, based on knowledge of
economic importance and
trait relationships

$$I = b_1X_1 + b_2X_2 + \ldots b_nX_n = \Sigma b_iX_i$$

b_i's are the index weights and X_i's are the phenotypic values for each trait

Traits and Selection Strategy

1. Choose the germplasm, parents, populations so that they have most of the 'threshold traits' for the new variety
   - Adaptation traits
   - Grain quality traits
   - Processing traits
2. Keep the number of traits for genetic improvement to a minimum, not more than 2-3
3. If many 'threshold traits' need to be considered, it may be advantageous to
   - to includes one backcross generation
   - to use genetic markers in early stages of selection

Thank You

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