A novel breeding approach to develop faster cooking biofortified common beans (*Phaseolus vulgaris* L.) for East Africa

Clare Mukankusi Mugisha

August 2023

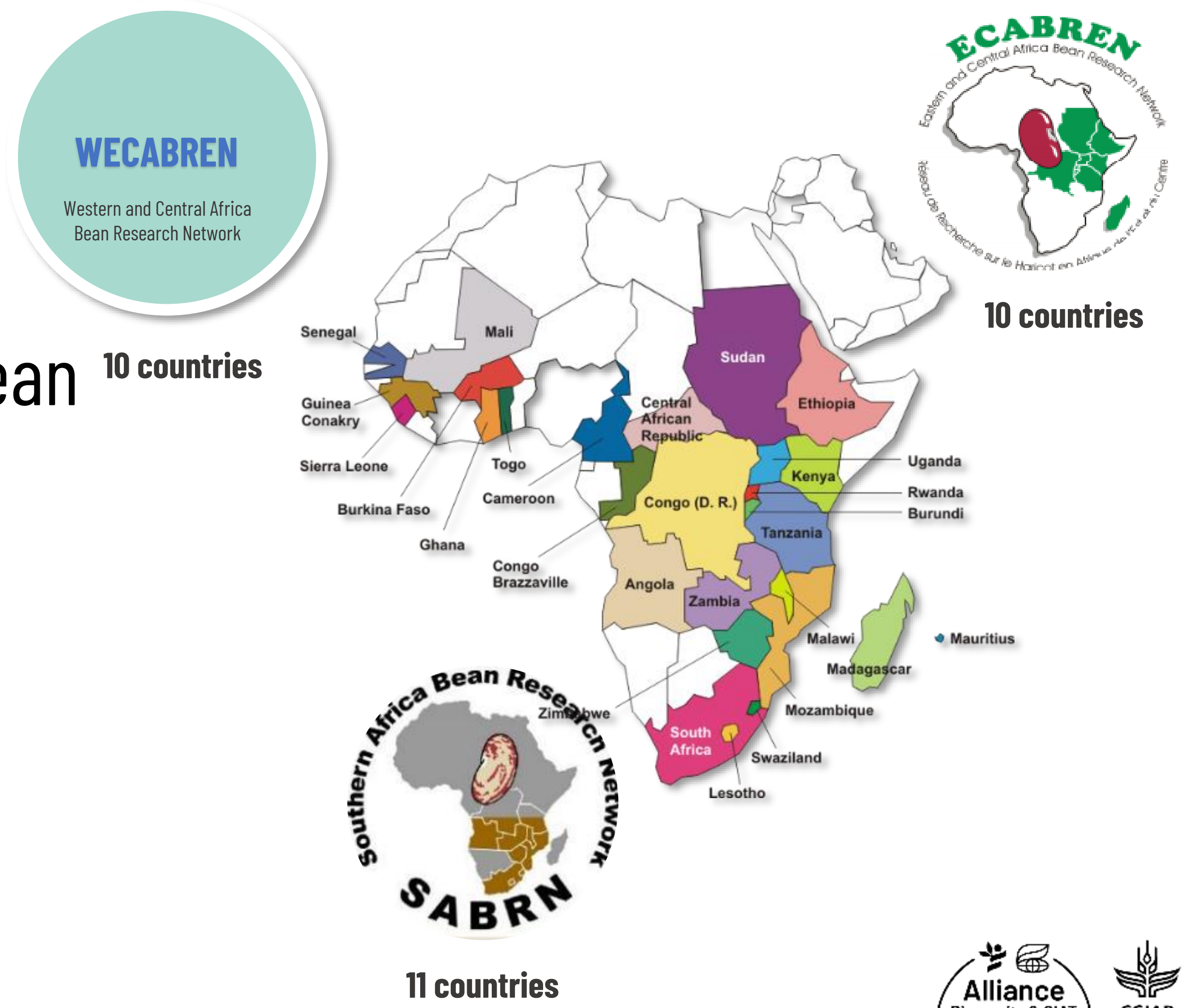
Outline

- Introduction
- Project justification
- Breeding approach
- Founder 1
- Founder 2
- Current status

Alliance-Bean Program: What we do

Delivering better bean varieties for income, nutrition, and resilience

With our partners, we develop improved bean varieties that show resilience under harsh growing conditions resulting from climate change



Common bean (*Phaseolus vulgaris* L.)

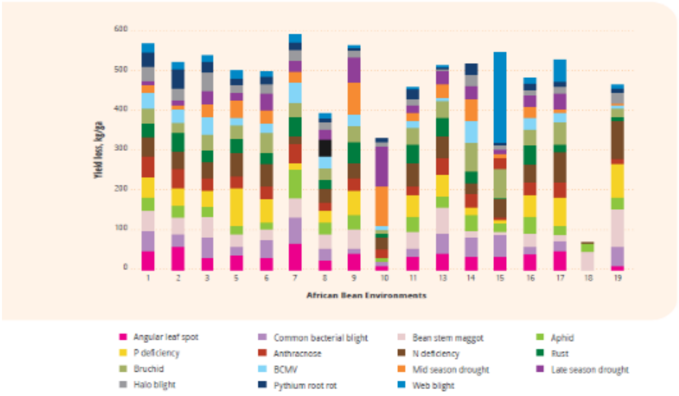
- **Important staple: >**400M consumers
  - **East Africa highest production and per capita consumption**
- **Income crop** : Rapid evolution from traditional subsistence to a market-oriented crop
  - >USD 500M in sales
- **Nutrition and health:** Source of protein, micronutrients iron (Fe) and Zinc (Zn), vitamins, dietary fibre, and low GI
- **Soil fertility**: Legumes ability to fix nitrogen in the soil

Constraints to bean business in East Africa

- Diverse market classes
- Diverse constraints
- Diverse research priorities
- Limited resources
- Unequal capacity

- **ABIOTIC**
  - Drought (>60% area)
  - Heat (beans not viable in 50% area by 2050)
  - Low soil fertility (N deficiency; 60% Africa, P deficiency; 50%, AL toxicity 40%)
  - Excessive rainfall
  - Cold
- **BIOTIC:**
  - Pests (field and post harvest)
  - Diseases (fungal, bacterial and viral)
- **Other factors:**
  - Population pressure – migration to drier areas, less fertile
  - Bean utilisation and marketability

FIGURE 12. Estimated mean yield loss (kg/ha), by AFBE, due to 15 constraints identified as very important to bean production in Africa, assuming an average total loss to all constraints of 1000 kg/ha.



What led to the development of this project?

Long cooking time in beans impacts women and children

- Lost opportunities (school, work)
- Deforestation risk to environment
- Collecting firewood = great personal risk
- Smoke inhalation = health risk
- Lost nutrition

Iron and zinc deficiency impacts women and children

WHO concerns:

- Anaemia
- Wasting, stunting and underweight
- Reduced cognitive ability
- Reduced immune function

Common bean a major staple in East and Central Africa is an accessible avenue of increasing Fe and Zn consumption

Customer analysis along the bean value chains: Example of Uganda (Katungi *et al*, in press)

Customer	Desired traits	Market size (#people)	Growth Potential	Sex	Geographical location
1.Middle/High income & consumers	**Shorter cooking time** Sweet taste, softness	3,053,250	moderate	⚥	peri-urban, urban
2. Low-income household consumers	**Shorter cooking time**, Soup thickness, Larger grain sizes, good taste, Softness , **Swelling grains**	13,242,300	High	⚥	rural
3.Low end Restaurants and fast foods	**Shorter cooking time**, Larger grain size, Soup thickness, Sweet taste, softness, **Swelling grains**	11,062,500	High	♀	Urban/Peri-urban
4.Lower Income schools	**Shorter cooking time**, Larger grain size, Soup thickness, **Swelling grains**, Soup color, **Resistant to storage pest attack**, Softness	7,500,000	High	♂	-Urban/peri-urban
5.Prisons	**Shorter cooking time, Resistant to storage pest attack**, Softness	55,200	Low	♂	Urban/rural

Our solution: Breed rapid cooking beans, biofortified with Fe and Zn

(with high yield and environmental resilience)

ACIAR project CROP-2018-132: Rapid cooking beans

ISABU
Institut des Sciences Agronomiques du Burundi
EIAR
Rwanda RAB Agriculture Board
TARI
Transforming Agriculture
Australian Centre for International Agricultural Research
KALRO
Kenya Agricultural & Livestock Research Organization
NaCRRI
National Crops Resources Research Institute
THE UNIVERSITY OF WESTERN AUSTRALIA
SEEK WISDOM
PABRA
Pan-Africa Bean Research Alliance
Better Beans for Africa
Alliance Bioversity & CIAT
CGIAR

	Target Product Profile					
Market Segment Description	**Medium and large seeded bush beans for East Africa**					
	Beans, ESA, EAF, Medium and large seed, Red/red mottled & sugar, Low & Mid altitude, Bush, Rainfed, Early					
Crop	Beans					
One CGIAR Region	East Africa Southern Africa					
One CGIAR Sub Region	East Africa					
Countries	Burundi: 201,300; Ethiopia: 144,780; Kenya: 1,004,087; Rwanda: 192,281; Tanzania: 996,000; Uganda: 600,000; DRC: 385,611;					
Hectares in ONE CGIAR sub region	3,524,059					
Material Type	Variety					
Biological Region/Eco System	Low and mid altitude areas					
Growing season	Burundi: (March-July); Ethiopia: (June-October); Kenya: (March-May); Rwanda: (September -December and March-May); Tanzania: (March-May) Uganda: (March-May and September-December); DRC: (February-May and September-December)					
	Trait	Scale	Min Score	Trait requirement	Improve trait	Threshol trait
Color	Red/Red mottled/sugar /yellow/kablanketi/white/brown	Varied, however red mottled commands 30% of current market share followed by sugars, reds and lastly the yellows	Varied, the types all require the same traits and farmers do switch among them based on the strength of a trait in any one of them e.g., taste, cooking time, yield etc.	Essential		Y
Processing traits	Color retention (Color retention after canning/ precooking process)	Color before and after canning/ precooking process the same	>=local check (e.g CAL96)	Nice to have		
Consumption traits	Fast cooking (reduction in cooking time) for dry grain	cooking time in min	30% < commecial checks in ECA in specific market group	Essential	Y	
Nutritional Enhancement Traits	Iron (Fe) grain content	mg per Kg	20-30%> commercial checks in specific grain classes	Essential	Y	
	Zinc (Zn) grain content	mg per Kg	10%> commercial checks in specific grain classes	Essential	Y	
Yield	Gain yield (t/ha)	tons/ha	10%> commercial check (850-1500kg/ha); in specific grain class	Essential		Y
Agronomic traits	Early maturity	Days afer planting (dap)	= < 75 dap (RWR2245)	Essentail		Y
Disease traits	Angular leaf spot resistance	1 to 9	<4 on the Disease severity scoring scale (presence of Phg2 gene); Bench marks: RWR22245, RWR2154, NAROBEAN3/MOORE8802, KATB1, JESCA, SAB713, Nyota)	Essentail		Y
Insect traits	Bruchid resistance	Presence of arcelin gene	Presence of arcelin gene	Nice to have		
Key Competitive Products	NABE 14; Selian 13; KAT B1; CODLMB003; Nyota					

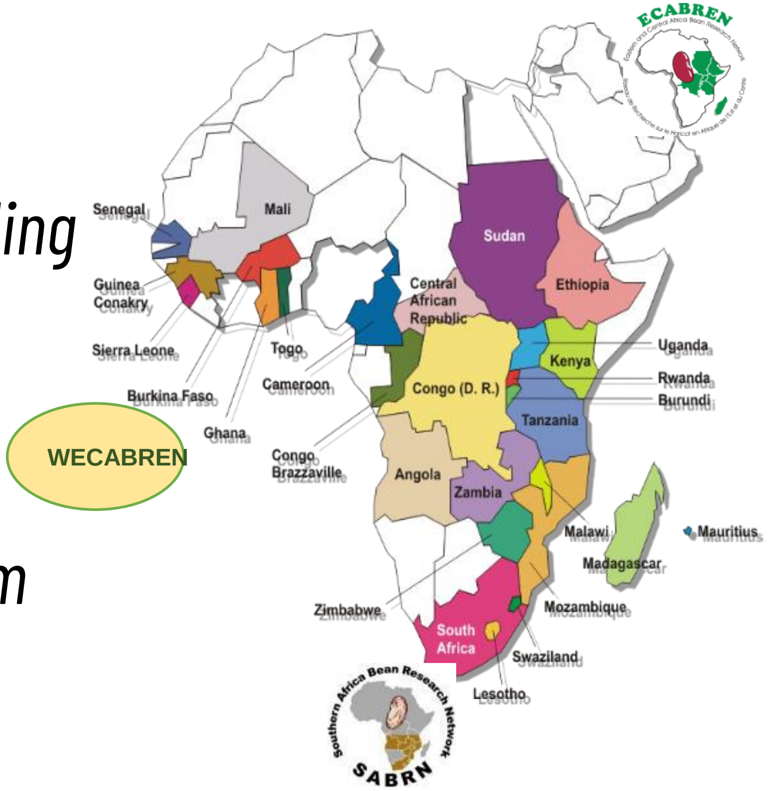
Objective

- Goal to reduce cooking time by 30% and increase Fe grain content by 15% and Zn 10% after 5 cycles of annual recurrent selection

Based on diverse "founder" population (African bean panel)

Use pedigree and genomic information to generate accurate breeding values in a selection index, together with optimal contribution selection (OCS) to accelerate breeding in annual cycles

"Road-test" and release new varieties rapidly through PABRA system



Australian Centre for International Agricultural Research

PABRA
Pan-Africa Bean Research Alliance
Better Beans for Africa

The Team


Prof Wallace A. Cowling
UWA

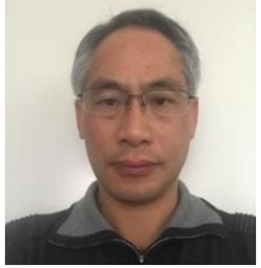

Dr Clare Mukankusi
AB-CIAT, Uganda


Dr Renu Saradedevi
UWA


Winnyfred Amongi
AB-CIAT, Uganda


Jean-Claude Rubyogo
PABRA, Kenya


Dr Brian Kinghorn
UNE, NSW


Dr Li Li
UNE, NSW


Prof Kadambot Siddique
UWA


Dr Eric Huttner
ACIAR, Canberra


Eric Nduwarugira
ISABU, Burundi


Blaise Ndabashinze
ISABU, Burundi


Dr Tigist Shiferwa
EIAR, Ethiopia


Dr Reuben Otsyula
KALRO, Kenya


Shamir Misango,
KARLO, Kenya


Annuarite Uwera
RAB, Rwanda


Julius Mbiu
TARI, Tanzania


Dr Stanley Nkalubo
NaCRRI, Uganda

THE UNIVERSITY OF WESTERN AUSTRALIA

une University of New England

ISABU

EIAR

KALRO

NaCRRI

RAB

TARI

Alliance Bioversity & CIAT

CGIAR

Genetics of Cooking Time

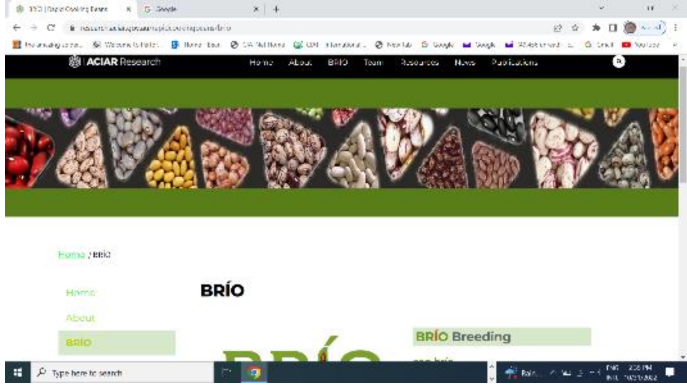
- Large genetic diversity in cooking time
  - 20-120 mins in a Mattson cooker
  - 1.5-3.5 hrs traditional cooking methods
- Relatively low G x E variance
- High heritability ($h^2 = 0.74$, Jacinto-Hernandez et al. 2003)
- Genomic regions on three chromosomes (Cichy et al. 2015)
- Relatively few QTL (Berry et al, 2020; Diaz et al, 2021)

Iron and Zinc Grain Content

- Iron and zinc content are quantitatively inherited and positively correlated (Blair *et al., 2009)*
- Influenced by the environment, but varies depending on the source genotype (Cichy *et al.*, 2009)
- Shorter cooking time correlated with improved Fe bioavailability (Wiesinger et al. 2018).

BRÍO Breeding: from canola to beans

https://research.aciar.gov.au/rapidcookingbeans/brio



BRÍO Breeding

- **con brío: with vigour, vitality, energy, strength**

B Breeding values (BVs) accurately predicted from analysis of phenotypic and genomic and/or pedigree relationship data accumulated over cycles

R Rapid cycles of recurrent selection (2-3 years)

Í Index selection on BVs weighted for economic value

O Optimized mating designs for sustainable and superior genetic gain

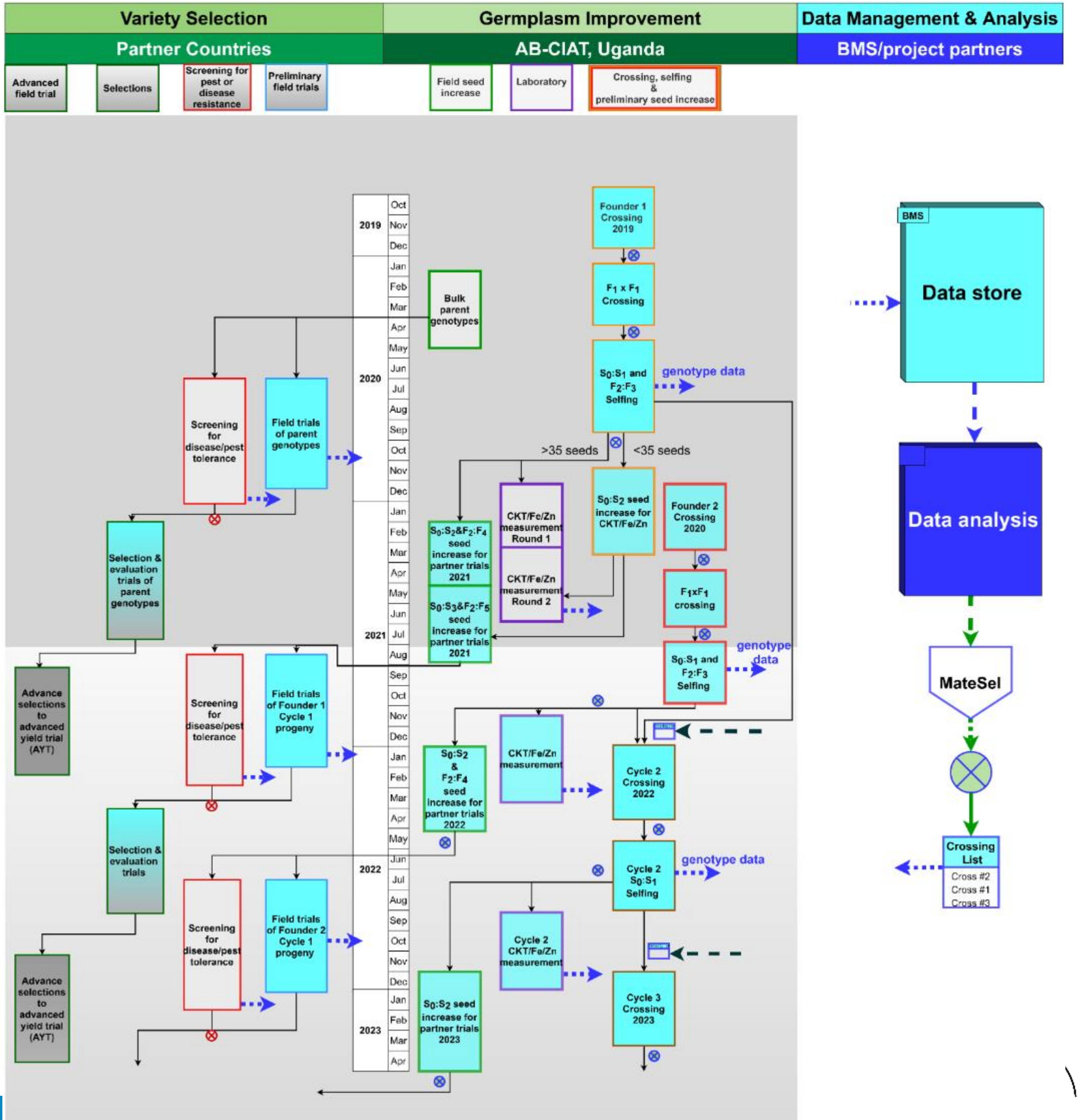
Saradadevi *et al* 2021
Cowling *et al* 2023

Breeding Scheme:

12 month cycles for crossing, seed increase, and selection for CKT, Fe, Zn in the lab, followed by field trials by partners

LEGEND

- Linked to BMS
- Seed flow
- Data flow to BMS
- Data exported from BMS for data analysis
- Results of data analysis
- MateSel output
- Decision making process at project coordinating team
- Decision pathway
- Decision making process at project partners
- Crossing list



CGIAR

Summary: Population development and advancement

Population	Number candidates/trials	Training population	Number of markers	Cycle 1	Cycle 2	Market groups
Founder 1 Cycle 1	4 trials, 258	161 entries	Two SNP panels	67 parents (160 crosses)	206 crosses; 900+ progeny to be field tested	Six
Founder 2 Cycle 1	33 trials, 876/358 genotypes	141 entries	Two SNP panels	120 crosses		Four and emphasis on bc3
Cycle 2 begins			Mid density (SNP platform)	n/a	88 crosses	Four

Founder 1 population

Parental selection

- African diversity panel
- Two trials: 258 lines (key grain classes)
  - Grain yield (GY)
  - Cooking Time (CKT): *50 g of dry seed ground into a powder; Seed Fe and Seed Zn concentration determined using EDXRF spectrometry*
  - SeedFe and SeedZn: *25 seeds randomly picked from clean harvested seed from each plot*
- Two SNP panels:
  - Panel 1: 770 SNP array with 94 genotypes was a
  - Panel 2: More than 20,000 SNPs with 298 genotypes based on DArT

Towards an Optimised mating design

GEBV's for GY, CKT, Fe, Zn

Make selection index
(optimised economic weights)_ DESIRE software

https://bkinghor.une.edu.au/desire.htm

Optimal contributions selection (OCS)
"Matesel" optimises mating design

Cross parents following mating design

Prof Brian Kinghorn, University of New England-Armidale

MateSel

https://bkinghor.une.edu.au/matesel.htm

Genomic Breeding Values and Heritability in the African Bean Panel

Dr Li Li, University of New England-Armidale

- Imputation of a genomic relationship matrix for 161 genotypes from two SNP panels
- GEBVs for GY, CKT, SeedFe and SeedZn calculated

Trial/site	Trait	No. candidates with GEBV values	Mean value of candidates in trial	GEBV minimum	GEBV maximum	Genomic heritability (h^2) (* P<0.05; ** P<0.01, NS not significant)
Bush2015	Yield (kg/ha)	161	986	-449	+570	0.40 *
Bush2017	Cooking time (min)	161	77.6	-27.0	+59.0	**0.81 ** **
Bush2015	Fe (ppm)	161	64.9	-8.4	+10.5	0.53 *
Bush2015	Zn (ppm)	161	30.4	-1.6	+1.8	0.28 NS

Correlation of genomic estimated breeding values for GY, CKT, Fe and Zn

	GY	CKT	Fe
GY			
CKT	-0.25 (0.10)		
Fe	0.13 (0.09)	-0.23 (0.10)	
Zn	0.15 (0.09)	-0.22 (0.10)	0.64 (0.05)

Optimized selection index-Optimized economic weights

- Economic weights (EW) on GEBV for GY, CKT, Fe and Zn reflecting current market prices in east Africa (0.85 US$/kg) and average GY in the trials (869 kg ha^{-1})
  - 15% price bonus for 10% shorter cooking time and a 10% price bonus for 10% improvement in Fe and 5% price bonus for 10% Zn content.

- EW optimized as implied-EW's using the tactical desired gains approach in the program DESIRE

Assigning Economic Indices to Genotypes

- Economic index of an individual genotype is calculated by adding the value (US$/ha) of its GEBVs for each trait, that is, (a) + (b) + (c) + (d)

- It follows that a genotype with

(a) GEBV GY +0.1 t/ha
(b) + GEBV CKT -1 min
(c) + GEBV Fe +1 ppm
(d) + GEBV Zn +1 ppm

= economic index **US$132.95 /ha**

(relative to population mean $0)

GEBV GY (%)			-10%	0%	+10%
GEBV GY (kg/ha)			-100	0	+100
GEBV GY ($/ha)		(a)	-$85.00	$0.00	+$85.00
GY (kg/ha)			900	1000	1100
				Contribution to index ($/ha)	
GEBV CKT ($/ha)	-1 min	(b)	+$14.71	+$16.35	$17.98
GEBV_CKT ($/ha)	0 min	(b)	$0.00	$0.00	$0.00
GEBV_CKT ($/ha)	+1 min	(b)	-$14.71	-$16.35	-$17.98
GEBV_Fe ($/ha)	+1 ppm	(c)	+$11.77	+$13.08	+$14.38
GEBV_Fe ($/ha)	0 ppm	(c)	$0.00	$0.00	$0.00
GEBV_Fe ($/ha)	-1 ppm	(c)	-$11.77	-$13.08	-$14.38
GEBV_Zn ($/ha)	+1 ppm	(d)	+$12.75	+$14.17	+$15.58
GEBV_Zn ($/ha)	0 ppm	(d)	$0.00	$0.00	$0.00
GEBV_Zn ($/ha)	-1 ppm	(d)	-$12.75	-$14.17	-$15.58

Optimized selection index

- Inputs into DESIRE; EW's, h2 for each trait, SD of BVs, and the genetic and phenotypic correlations between traits.
    - 1º emphasis was to reduce CKT
    - 2º emphasis was to increase Fe and Zn while also improving GY

- Optimized selection index (*GBLUPindex$_i$*) calculated for each individual *i* from *j* traits (Cowling *et al.*, 2017)
    - $GBLUPindex_i = \sum_{j=1}^{nTraits} e_j . GEBV_{i,j}$

Generation of Optimized Mating Design

- An optimised mating design was generated with OCS in 'Matesel' (Kinghorn and Kinghorn 2019)
- 'Matesel' provides a balance between next-generation genetic gains and parental coancestry
  - *"**MateSel** is a tool that enables breeders to optimize breeding outcomes by creating a suggested mating list based on a group of candidate sires and dams"*
- A conservative approach to OCS was used to favour retention of genetic diversity while advancing the population mean index

Included consideration of consumer preferred grain market classes.

- red mottled beans-Uganda, Kenya, Burundi and Rwanda
- yellow beans in Tanzania, Uganda, Rwanda and Burundi
- white beans in Ethiopia and Madagascar;
- Sugar bean (cranberry) in Tanzania, Malawi, Zimbabwe and Uganda

Optimized Mating Design in 6 Market Groups (Founder 1)

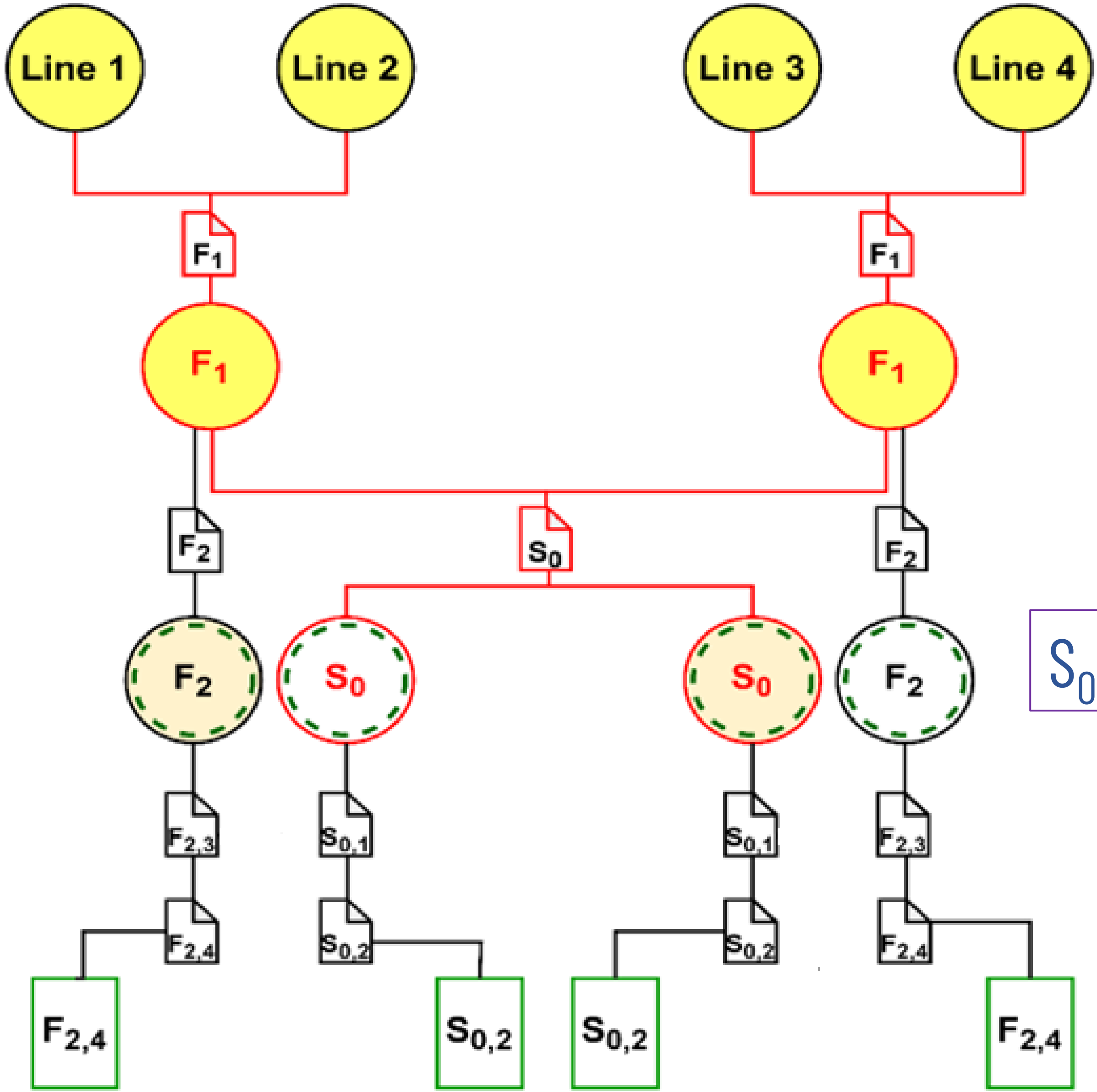
Market Class Group	Seed color	Candidates with phenotypes	Candidates with GEBVs	Candidates selected for mating	Times used in mating
Gp1	Cream/Beige/Yellow	51	28	13	24
Gp2	White	43	18	8	18
Gp3	Red	61	42	14	46
Gp4	Black/Purple/Calima	62	30	13	34
Gp5	Striped/Pinto	42	30	14	28
Gp6	Speckled/Cranberry/Other	19	13	5	10
Total		278	161	67	160

Predicted Outcome from Founder 1 crossing

- A major improvement in population mean for the Economic index : +286.77 US$/ha
- 6.2% increase in GY
- 7.3% reduction in CKT
- 1.1% Increase in SeedFe
- 0.7% increase in SeedZn
- Achieved increase in population co-ancestry of 0.0753

Trait	Predicted change in trait in progeny	Predicted change in trait in progeny (%)
Economic index (US$)	+ 286.77 US$/ha	
Yield	+ 61 kg/ha	+ 6.2%
Cooking time	- 6.0 min	- 7.3%
Fe	+ 0.7 ppm	+ 1.1%
Zn	+ 0.2 ppm	+ 0.7%

Founder 1 Cycle 1 (2019)



Founder Crossing

F1 x F1 Crossing

S_0 & F_2 Selfing, cooking, Fe/Zn

Bulking

Preliminary field trial

Correlation of genomic estimated breeding values – Founder 1 cycle 1

CKT increases as Fe/Zn increases ☹️

CKT decreases as WAC increases 🙂

Zn goes up as Fe increases 🙂

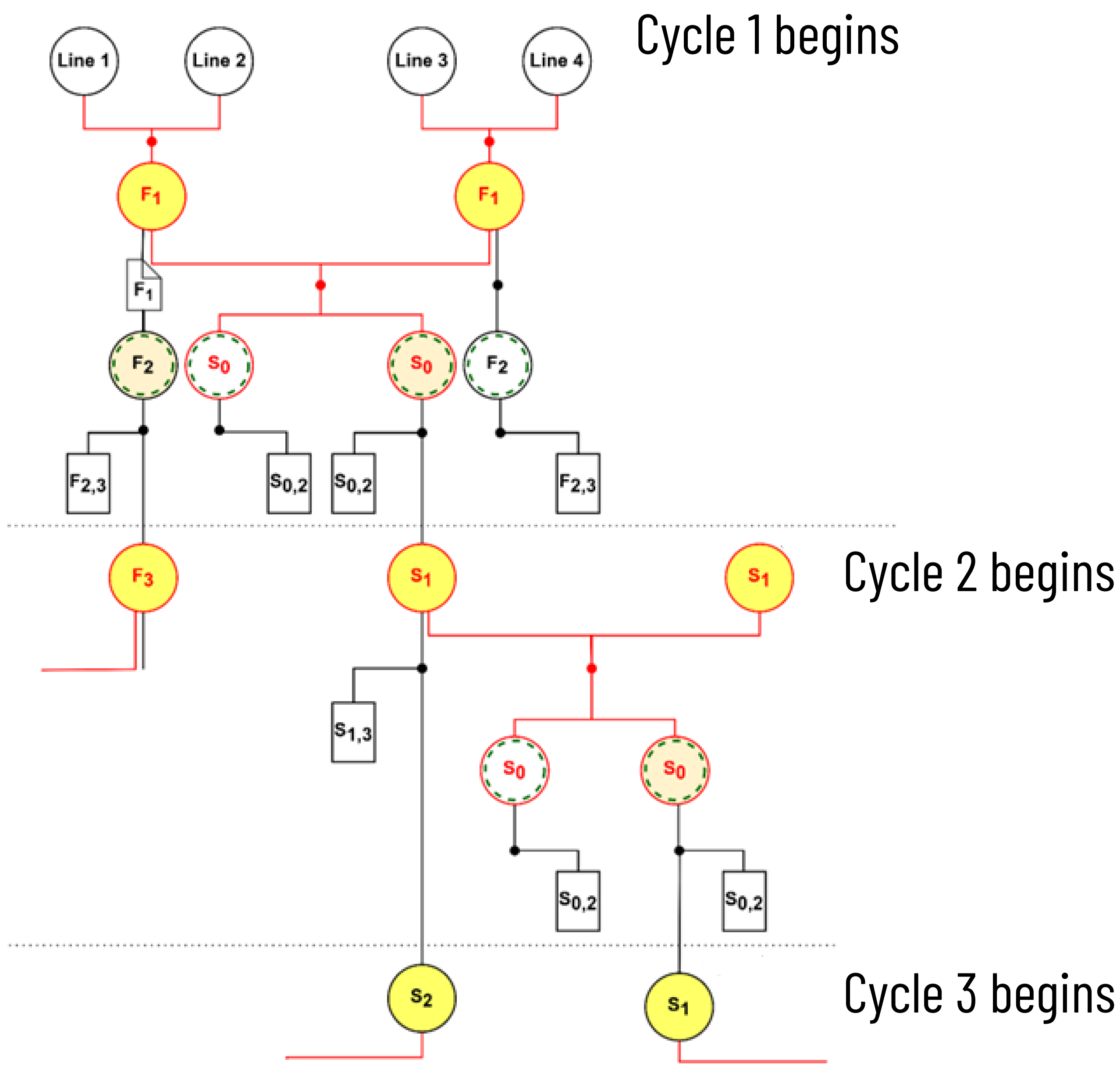
Small seeds have high iron 😔

	CKT20	CKT12	Fe	Zn	DryWt
CKT12	0.98				
Fe	0.42	0.48			
Zn	0.26	0.27	0.58		
DryWt	-0.11	-0.12	-0.27	-0.12	
WAC	-0.79	-0.81	-0.29	-0.26	0.18

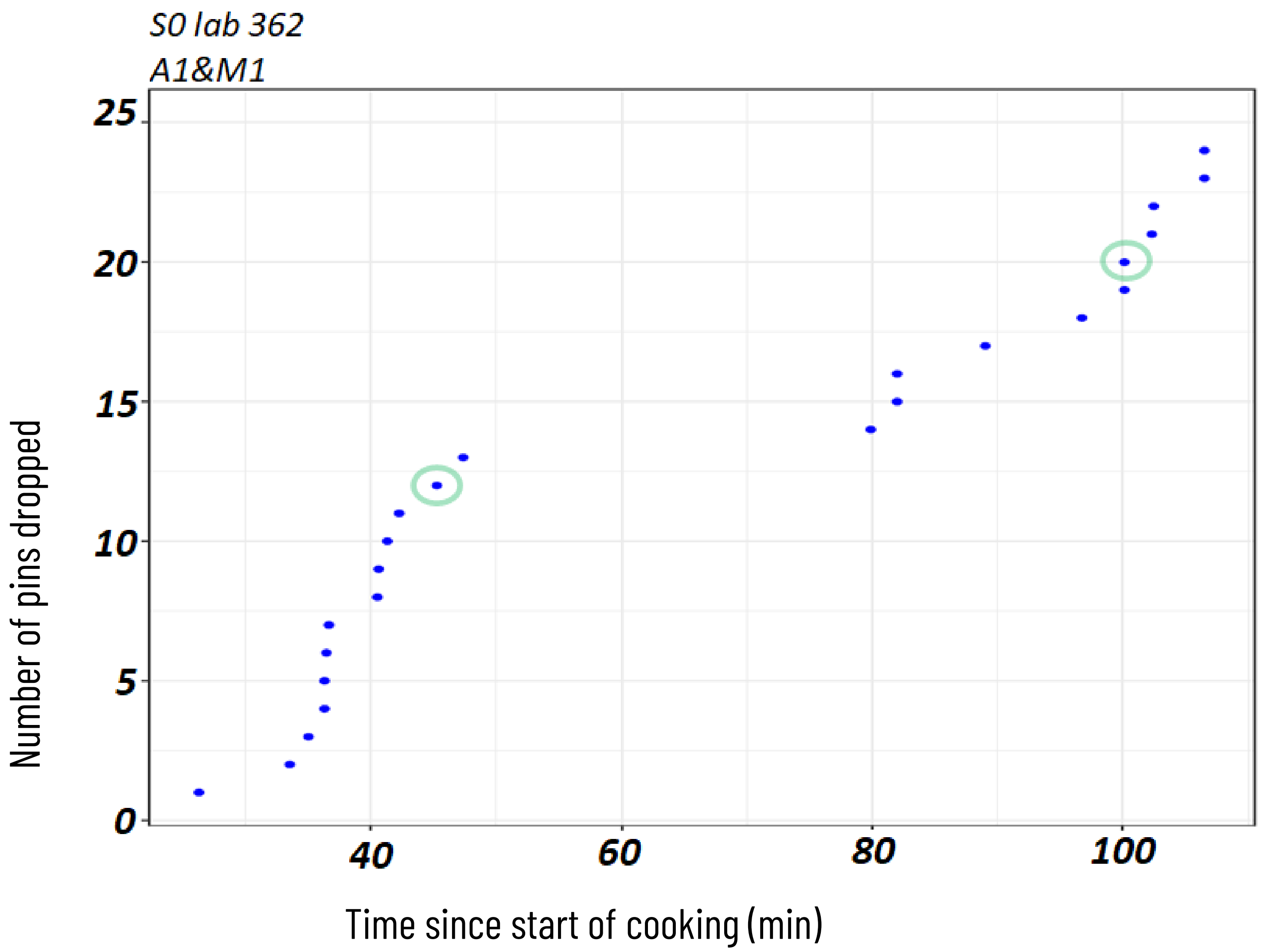
Founder1 Cycle2 crossing

BRÍO in action

BRIO - Rapid cycles of early-generation selection



S_0 progeny segregating for CKT



CKT20 = 100 min

CKT12 = 47 min

Multivariate genomic analysis of laboratory traits measured on Founder1 Cycle1 $S_{0,2}$ and $F_{2,4}$ progeny

CKT20	= time from start of cooking to 20th pin drop (min)
CKT12	= time from start of cooking to 12th pin drop (min)
SeedFe	= Fe content in dry bean powder after cooking (ppm)
SeedZn	= Zn content in dry bean powder after cooking (ppm)
DryWt	= weight of 25 beans (g)
WAC	= % increase in weight of 25 beans after 18 hours soaking

Mid density SNP panel of approx 1800 markers

Combined pedigree and genomic relationship matrices = H-BLUP analysis


Matson cooker

EDXRF

BCMNV resistance important in East Africa

SNP marker (bc-3a) for bc3 resistance gene

Resistant SNP allele: A

Susceptible SNP allele: C

Presence of resistant allele in Founder1 S_0 & F_2 progeny

Homozygous resistant (AA): 26

Heterozygous (AC): 82

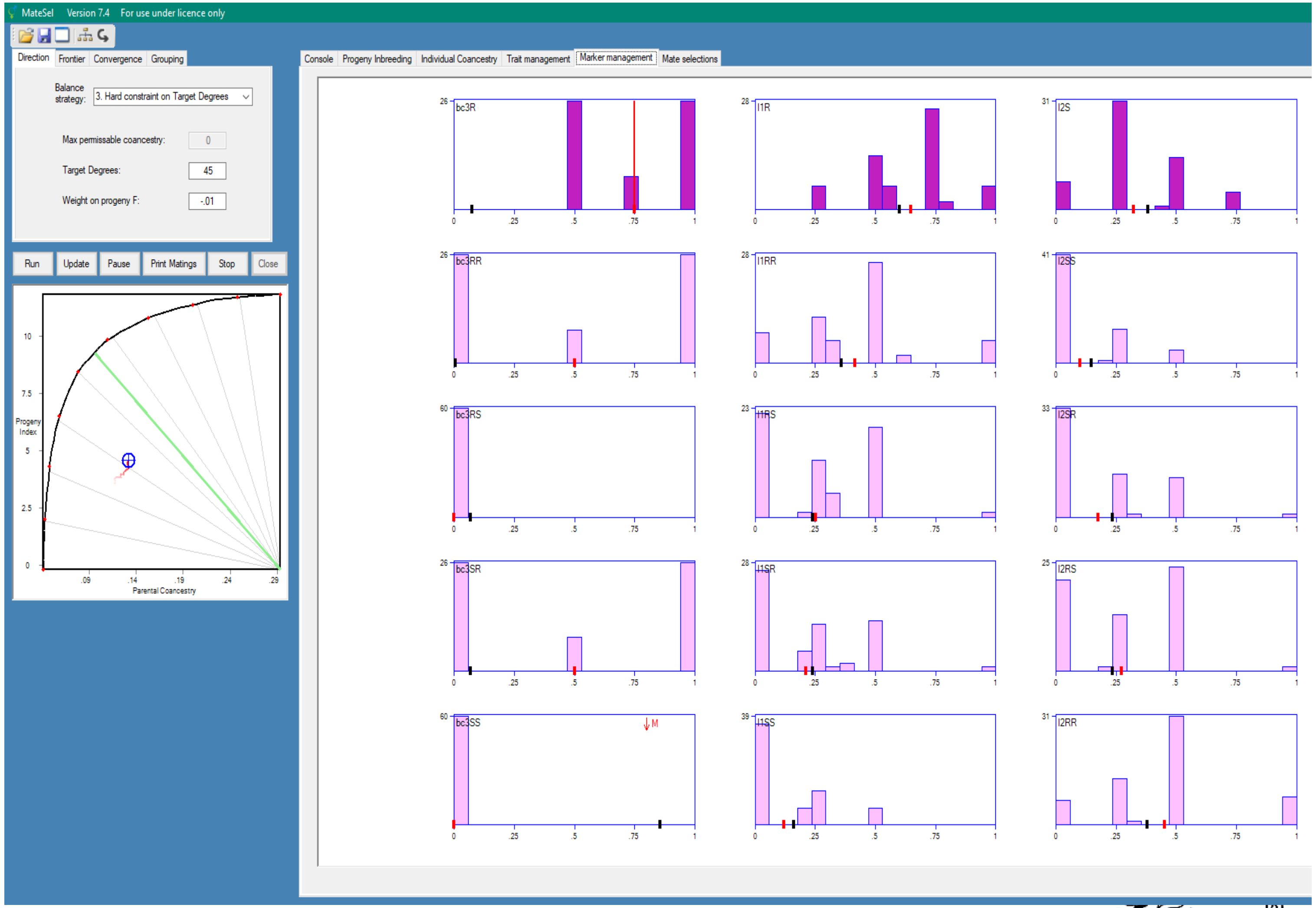
Homozygous susceptible (CC): 800

Devote one crossing group for bc3 resistance allele in MateSel

- Make 60 crosses where all progeny must be at least heterozygous for resistant SNP allele

- *also*, select for lower CKT and higher Fe and Zn in these crosses

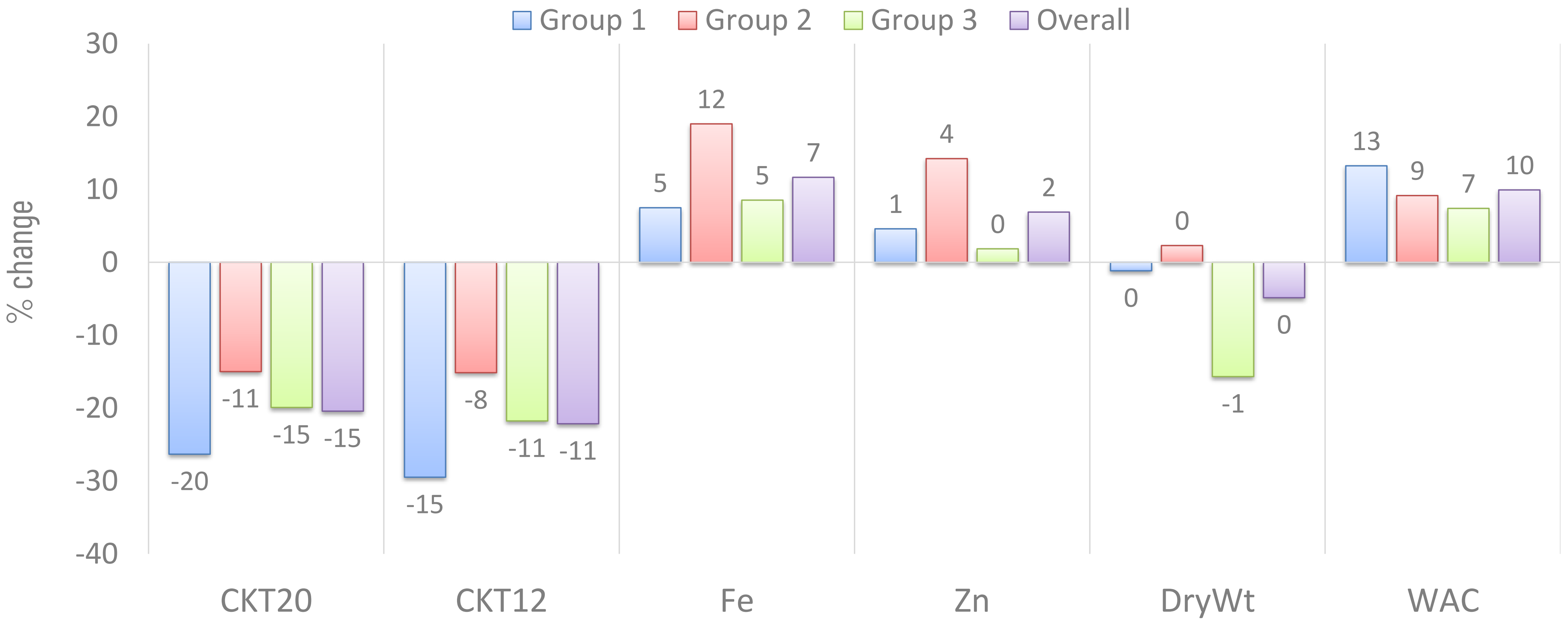
- - allows future genetic gain for CKT, Fe, Zn *and* BCMNV resistance in this group



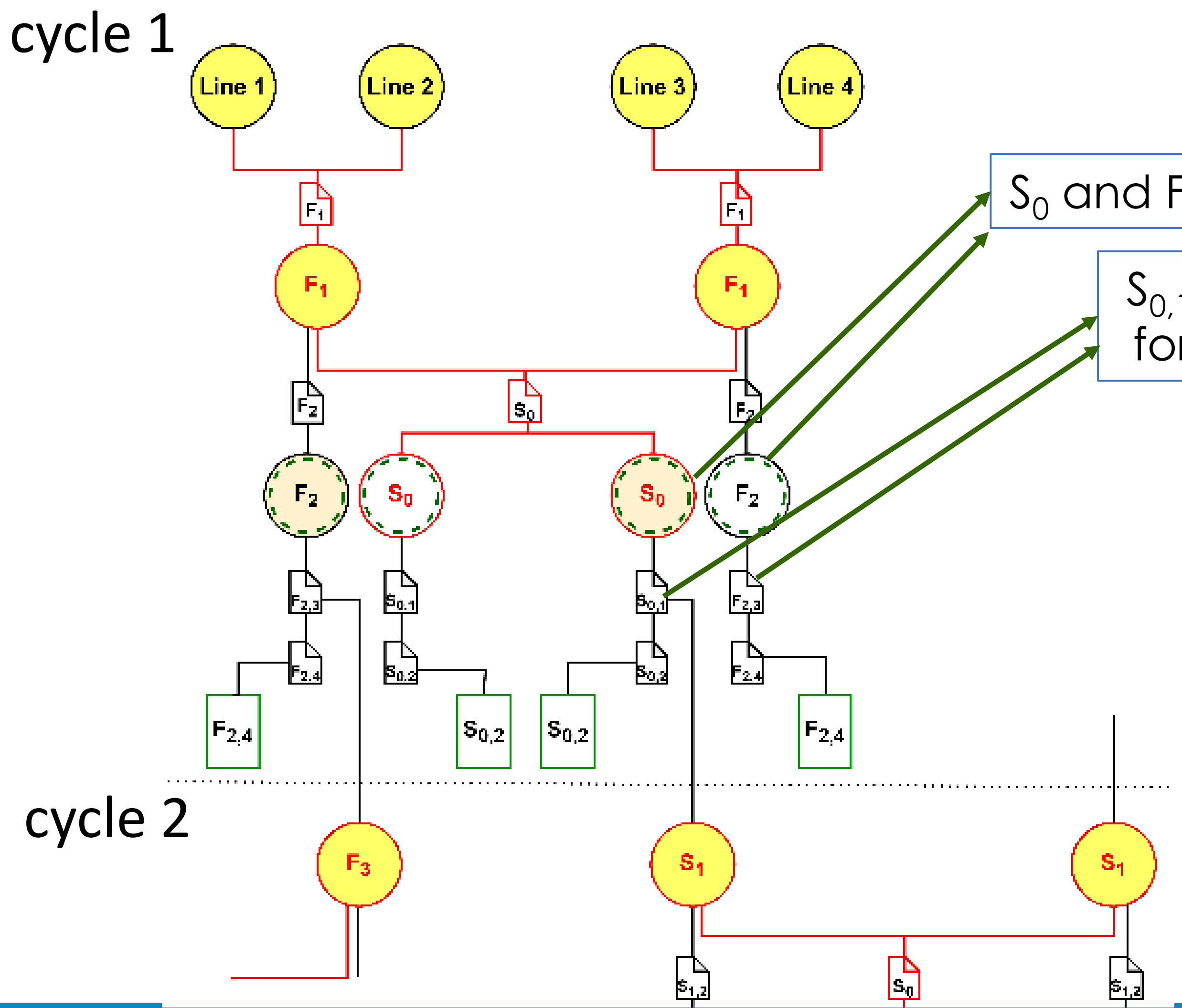
Generate optimised crossing designs for 3 groups

- **Group 1 (94 crosses):** primary goal to reduce CKT, and secondary goal to increase Fe and Zn
- **Group 2 (46 crosses):** primary goal to increase Fe and Zn, and secondary goal to reduce CKT
- **Group 3 (66 crosses):** primary goal to retain BCMNV resistance, and secondary goals to reduce CKT and increase Fe and Zn
- **Total = 206 crosses**

Predicted genetic gain in Founder 1 Cycle 2 progeny in MateSel



Year 3 Crossing Program - Founder 1 Cycle 2 (2021-22)



S_0 and F_2 plants **genotyped**

$S_{0,1}$ and $F_{2,3}$ seeds: phenotyped for **CKT, Fe, Zn** in the laboratory

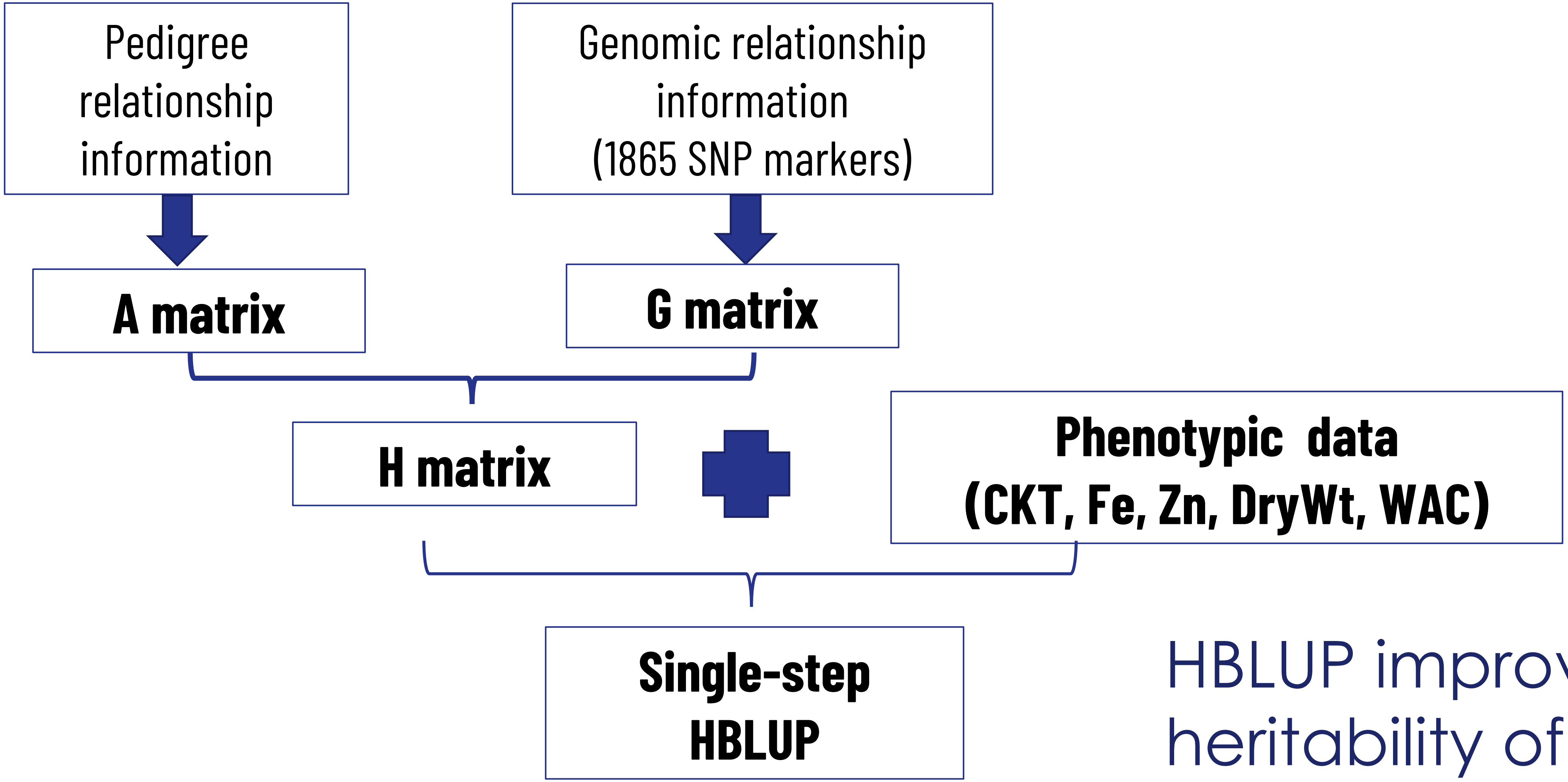
HBLUPS for CKT, Fe, Zn, DryWt, WAC

Optimised selection **Index**

Optimal Contribution selection

Founder 1 Cycle 2

Cycle 1 breeding values – HBLUP analysis



HBLUP improved heritability of CKT

Heritability (h^2)

	A BLUP	G BLUP	H BLUP
CKT20	0.04	NC	0.17
Fe	0.13		0.38
Zn	0.17		0.25

Combining pedigree and genomic relationship data improved heritability of all traits

CKT Heritability (h^2)

	A BLUP	G BLUP	H BLUP
CKT20	0.04	NC	0.17
Fe	0.13		0.38
Zn	0.17		0.25

	H BLUP	HBLUP (CKT12)
CKT20	0.19	0.34
CKT12		0.55
Fe	0.36	0.37
Zn	0.24	0.27
DryWt	0.33	0.33
WAC	0.25	0.25

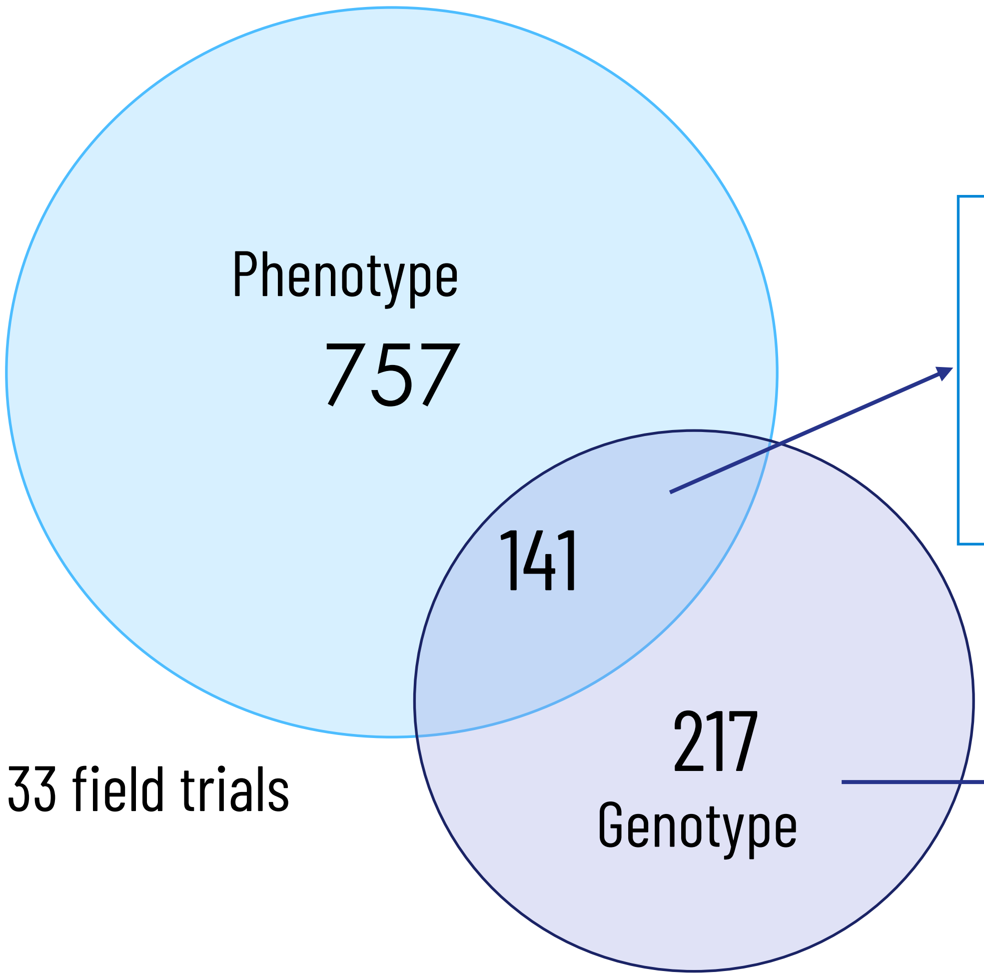
Including CKT12 in the analysis improved heritability of CKT20

Founder 2 population

Why?

Better data
= better predictions
= better parents
= faster genetic gain

Founder 2 crossing (2020)



Training population = phenotypes and genotypes

Test population = genotypes only

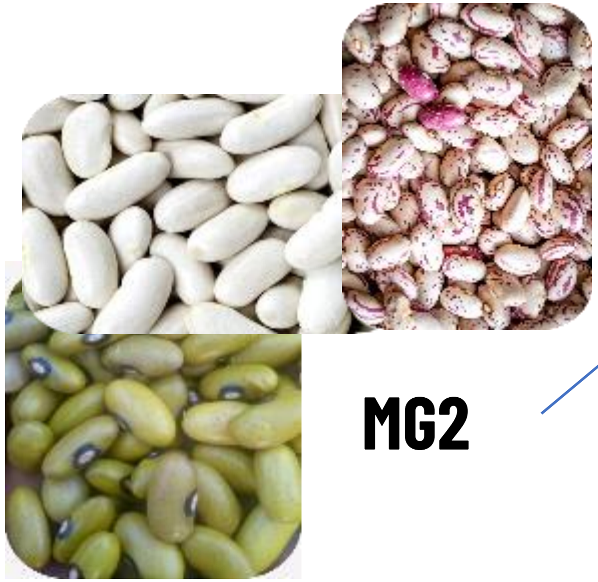
African bean panel (358 genotypes)

OCS-predicted genetic gain in Founder 2 cycle 1 progeny

MG1

MG3

GY : +12.4%
Fe : +6.9%
Zn : +4.5%
CKT : -9.3%



MG2

MG4

Received: 30 May 2021 | Accepted: 9 August 2021

DOI: 10.1002/tpg2.20156

The Plant Genome

SPECIAL ISSUE: ADVANCES IN GENOMIC SELECTION AND APPLICATION OF MACHINE LEARNING IN GENOMIC PREDICTION

Multivariate genomic analysis and optimal contributions selection predicts high genetic gains in cooking time, iron, zinc, and grain yield in common beans in East Africa

Renu Saradadevi[1,2] | Clare Mukankusi[3] | Li Li[4] | Winnyfred Amongi[3] | Julius Peter Mbiu[5] | Bodo Raatz[6,12] | Daniel Ariza[6] | Steve Beebe[6] | Rajeev K. Varshney[1,8,9] | Eric Huttner[7] | Brian Kinghorn[10] | Robert Banks[4] | Jean Claude Rubyogo[11] | Kadambot H. M. Siddique[1,2] | Wallace A. Cowling[1,2]

[1] The UWA Institute of Agriculture, The Univ. of Western Australia, Perth, Western Australia 6009, Australia

[2] UWA School of Agriculture and Environment, The Univ. of Western Australia, Perth, Western Australia 6009, Australia

[3] Alliance of Bioversity International & International Center for Tropical Agriculture (CIAT), PO Box 6247, Kampala, Uganda

[4] Animal Genetics and Breeding Unit, Univ. of New England, Armidale, New South Wales 2351, Australia

[5] Tanzania Agricultural Research Institute (TARI) Maruku, PO Box 127, Bukoba, Kagera, Tanzania

[6] Alliance of Bioversity International & International Center for Tropical Agriculture (CIAT), Cali, Colombia

[7] Australian Centre for International Agricultural Research, Canberra, Australian Capital Territory 2617, Australia

[8] Centre of Excellence in Genomics and Systems Biology, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad 502324, India

[9] State Agricultural Biotechnology Centre, Centre for Crop and Food Innovation, Murdoch Univ., Murdoch, Western Australia 6150, Australia

[10] School of Environmental and Rural Science, Univ. of New England, Armidale, New South Wales 2351, Australia

[11] Alliance of Bioversity International & International Center for Tropical Agriculture (CIAT), Nairobi, Kenya

[12] Current address: Vilmorin SA, la Menitré, France

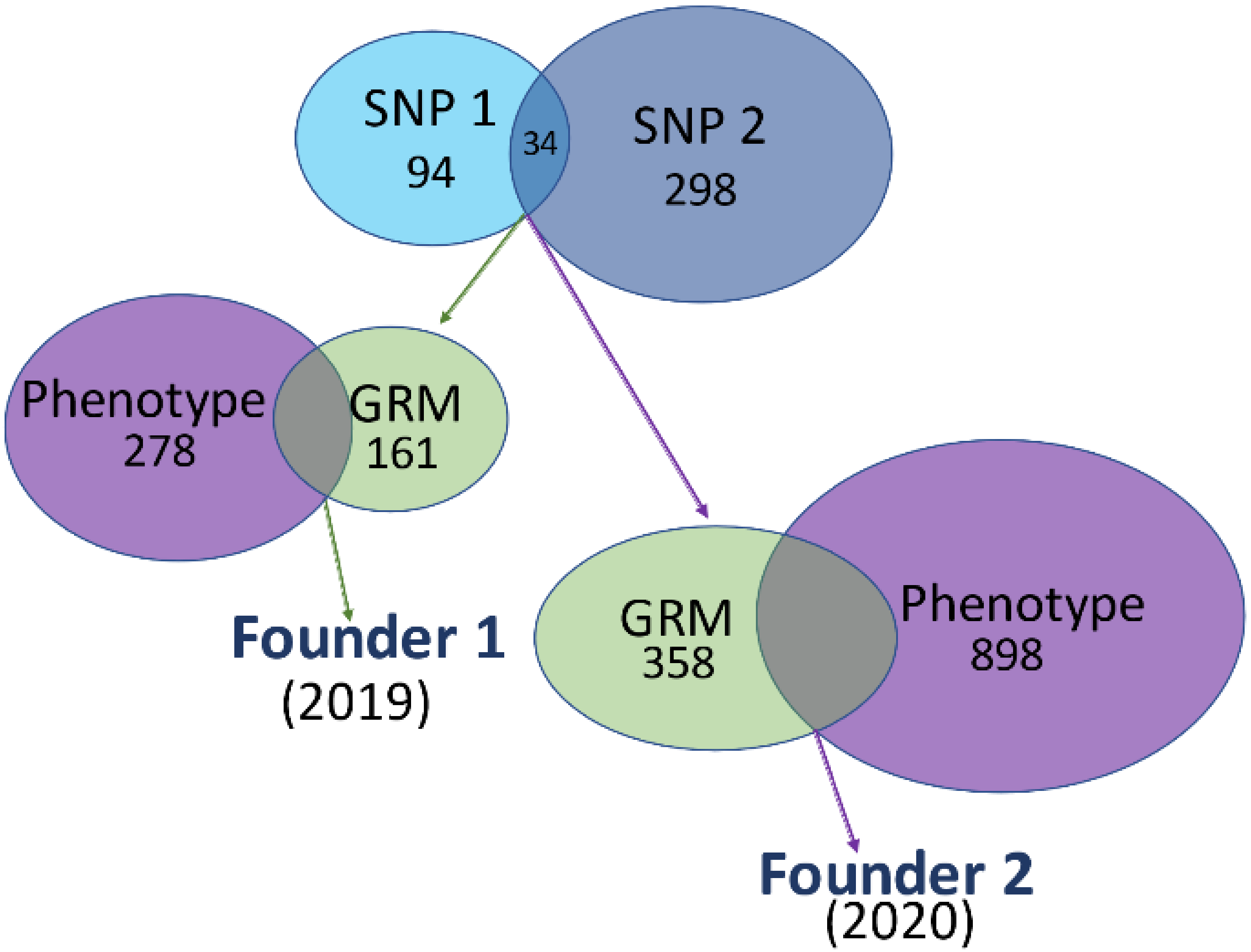
Read Paper

https://research.aciar.gov.au/rapidcookingbeans/publication/publications

Alliance Bioversity & CIAT

CGIAR

RCBP Founder Crossing



Founder 1:

GRM: 161 genotypes

Phenotype: 278 genotypes

Parents: 91

Founder 2:

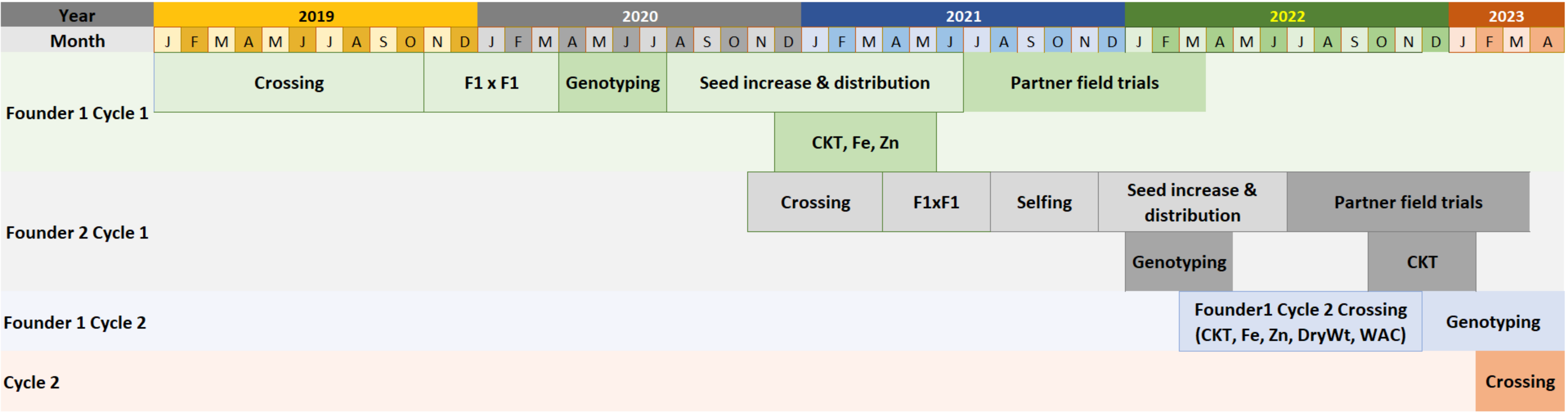
GRM: 358 genotypes

Phenotype: 898 genotypes

Parents: 88

Unique parents : 158

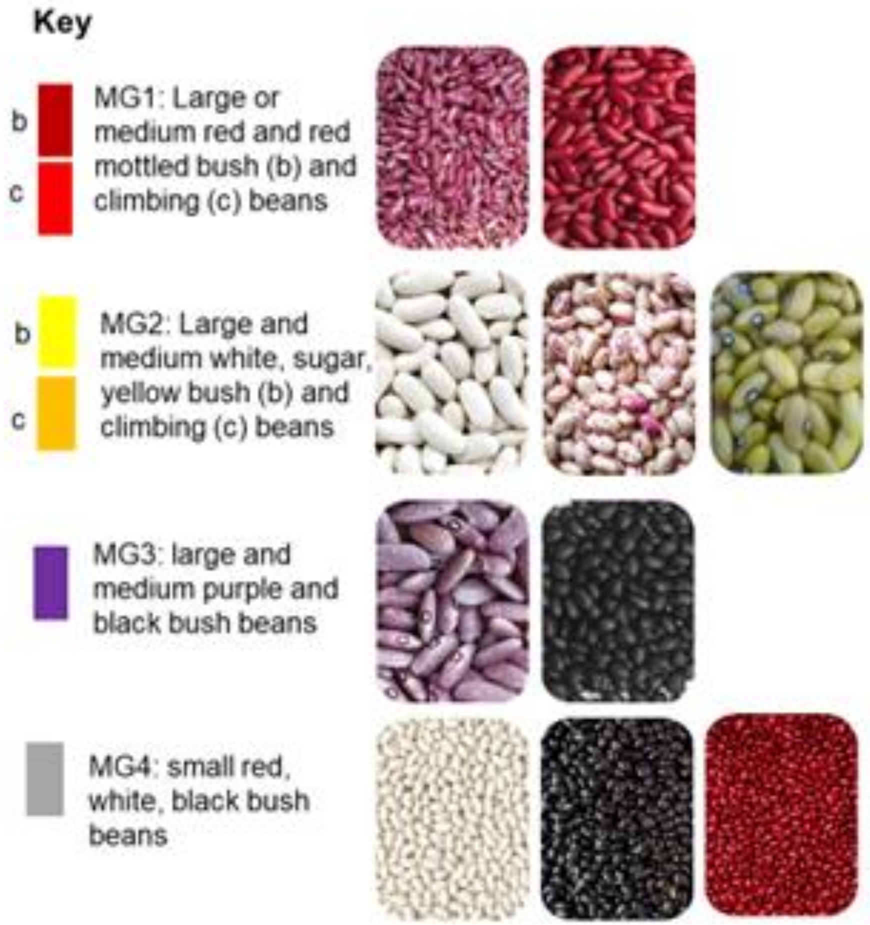
RCBP bean breeding 2019 - 2023

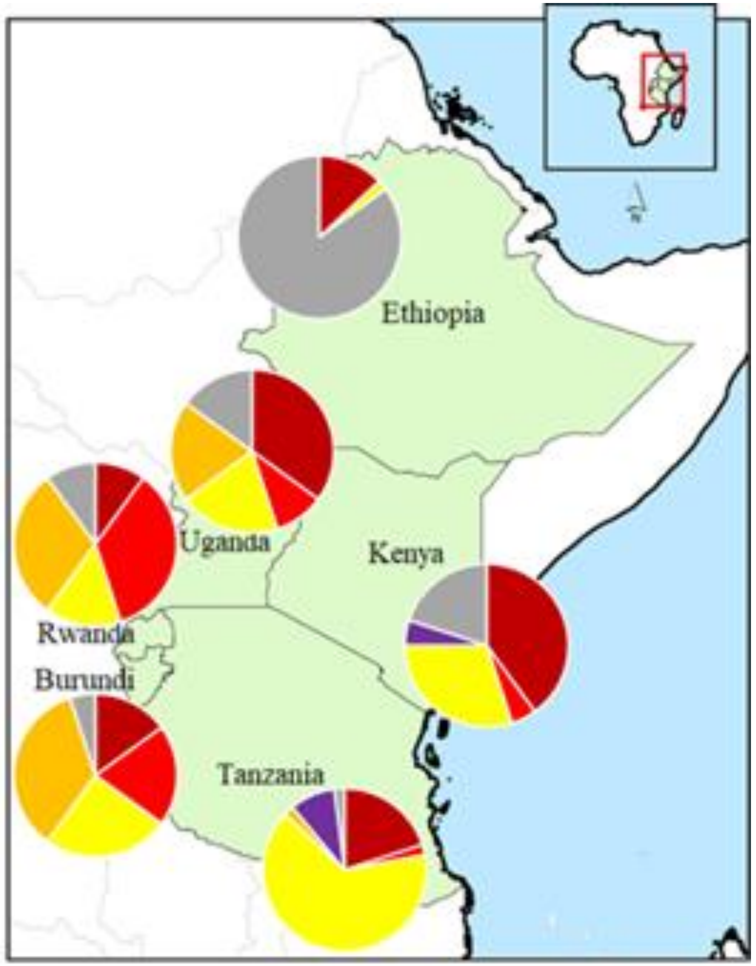


- ➢ One crossing program every year at AB-CIAT, Kawanda
- ➢ S_0 and F_2 progeny evaluated at 6 PCs every year
- ➢ Accumulate genotypic and phenotypic data over years

Add grain yield data from partners

- cycle 1 progeny field trials, test GY, seed colour





Combining Founder crosses– Fdr1 & Fdr2

Founder 1 Cycle 1 (2019)

Founder 2 Cycle 1 (2020)

Pedigree relationship

Genomic relationship

CKT

Fe

Zn

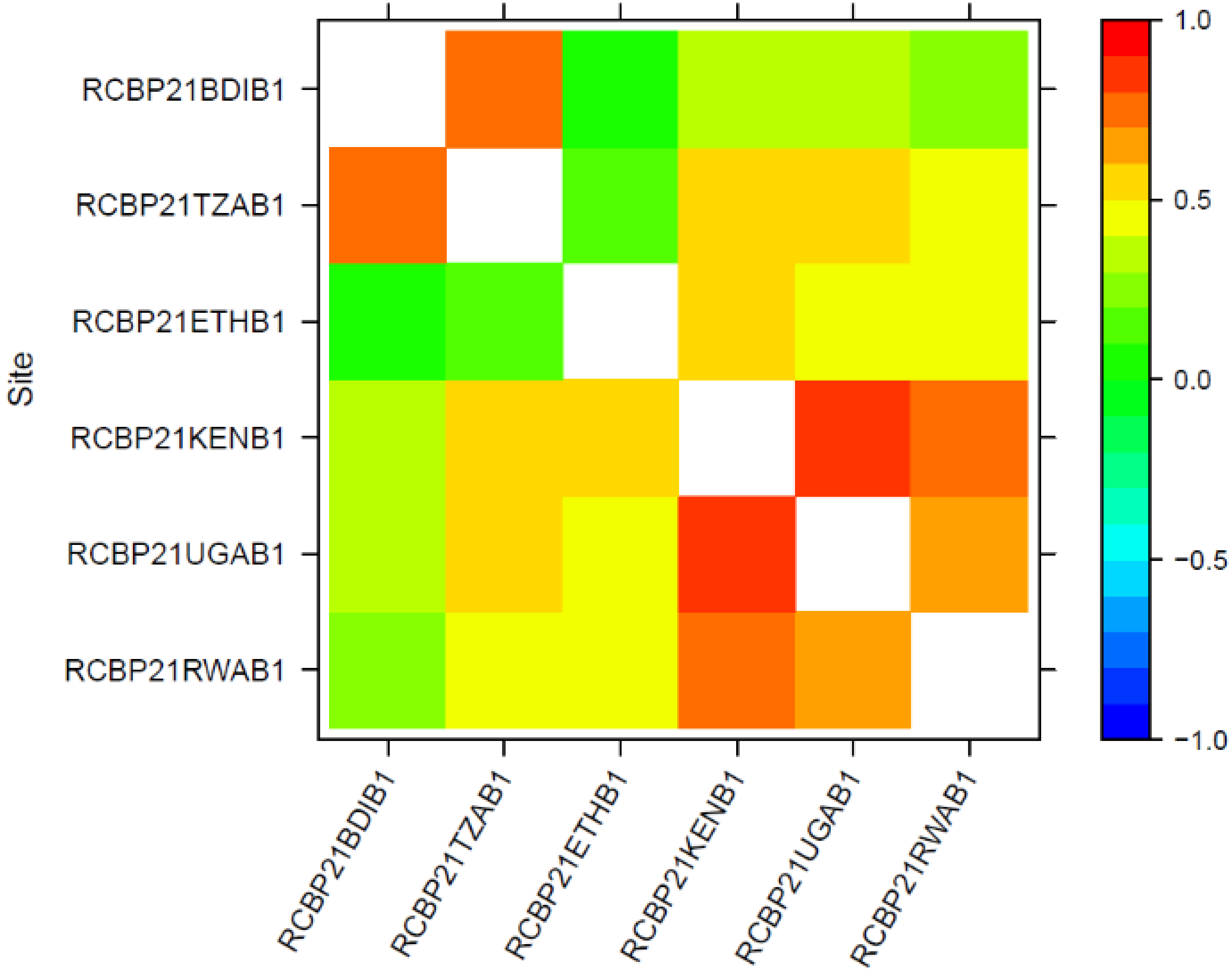
DryWt

WAC

Include GY from partner field trials → GY

HBLUP values for GY, CKT, Fe, Zn, DryWt, WAC for all Fdr1 and Fdr2 progeny

Genetic correlations between sites- Grain yield



- ➢ **No negative correlations**

Correlation of GEBVs among traits – Founder1 & 2

h2	GY					
GY	0.09	CKT20				
CKT20	0.31	0.21	Fe			
Fe	0.02	-0.01	0.35	Zn		
Zn	0.08	0.15	0.62	0.46	DryWt	
DryWt	-0.37	0.06	-0.30	-0.25	0.66	WAC
WAC	-0.39	-0.16	0.15	-0.22	-0.05	0.17

CKT goes up when GY increases

Fe and Zn high in small seeded beans

Yield is high in small seeded beans

Iron and zinc go up together

Genetic correlations between traits have major impacts on predicted genetic gain in all traits!!

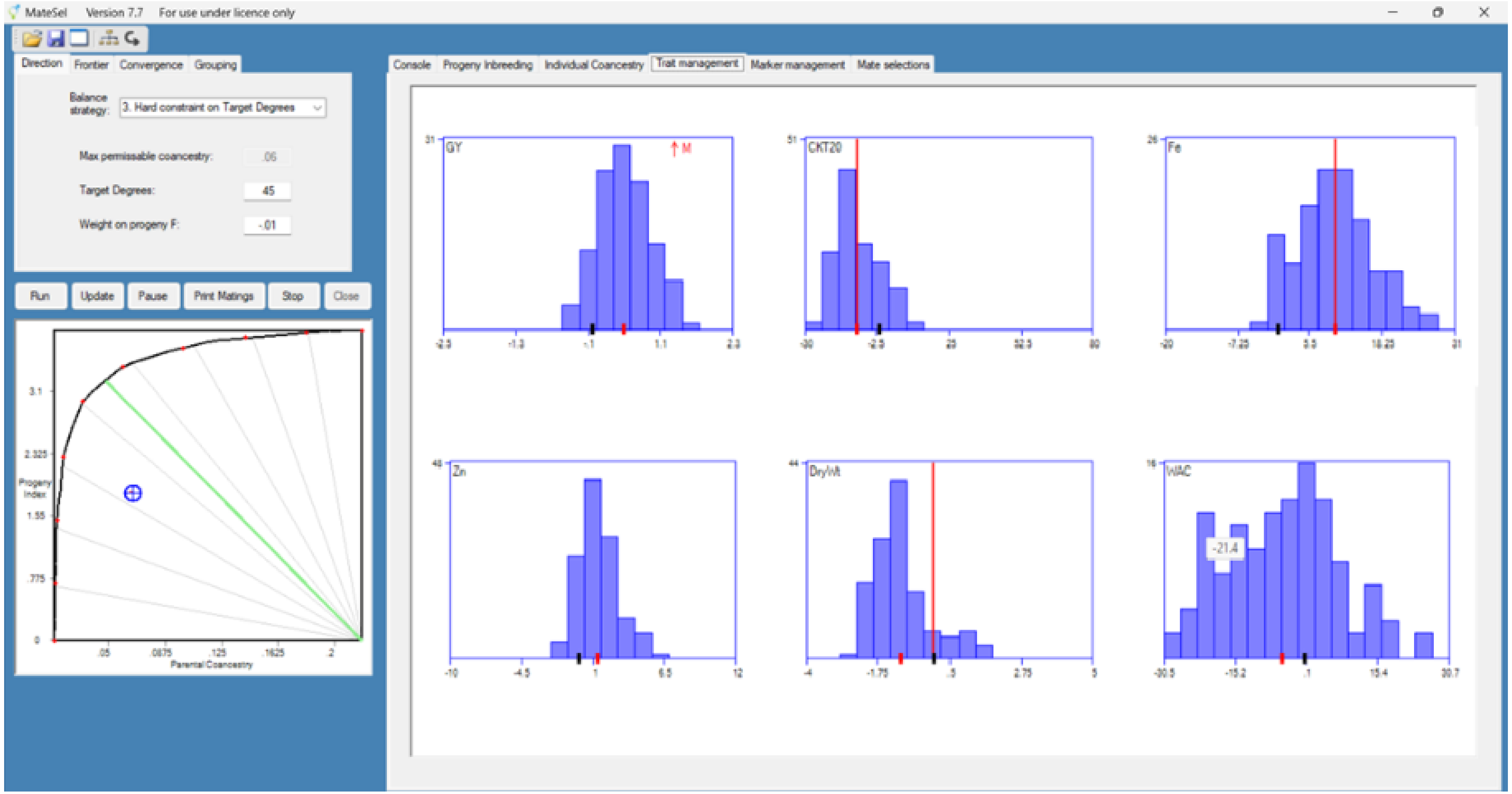
Predictions from OCS in MateSel show that:

- GY decreases when CKT is given high weight
- Fe and Zn decrease when CKT is given high weight
- Seed DryWt decreases when Fe, Zn, GY are given high weights

A compromise is needed! MateSel allows the user to manage predicted progeny distributions:

- Minimise loss in seed DryWt in the population
- Achieve desired gains in Fe, Zn and GY while reducing CKT to a reasonable level

MateSel output: Founder 1 & Founder 2 cycle 2



Predicted change	
GY	0.3 g $plant^{-1}$
CKT	-10 min
Fe	13 ppm
Zn	1 ppm
DryWt	-1 g
WAC	2 %

Summary

Cycle 1 & 2 progeny show strong predicted genetic gain

- CKT reduces by 9 % (cycle 1) and 10 % in cycle 2
- Fe increases by 4 % (cycle 1) and 6 % in cycle 2
- Zn increases by 3 % (cycle 1 & 2)

What we don't know

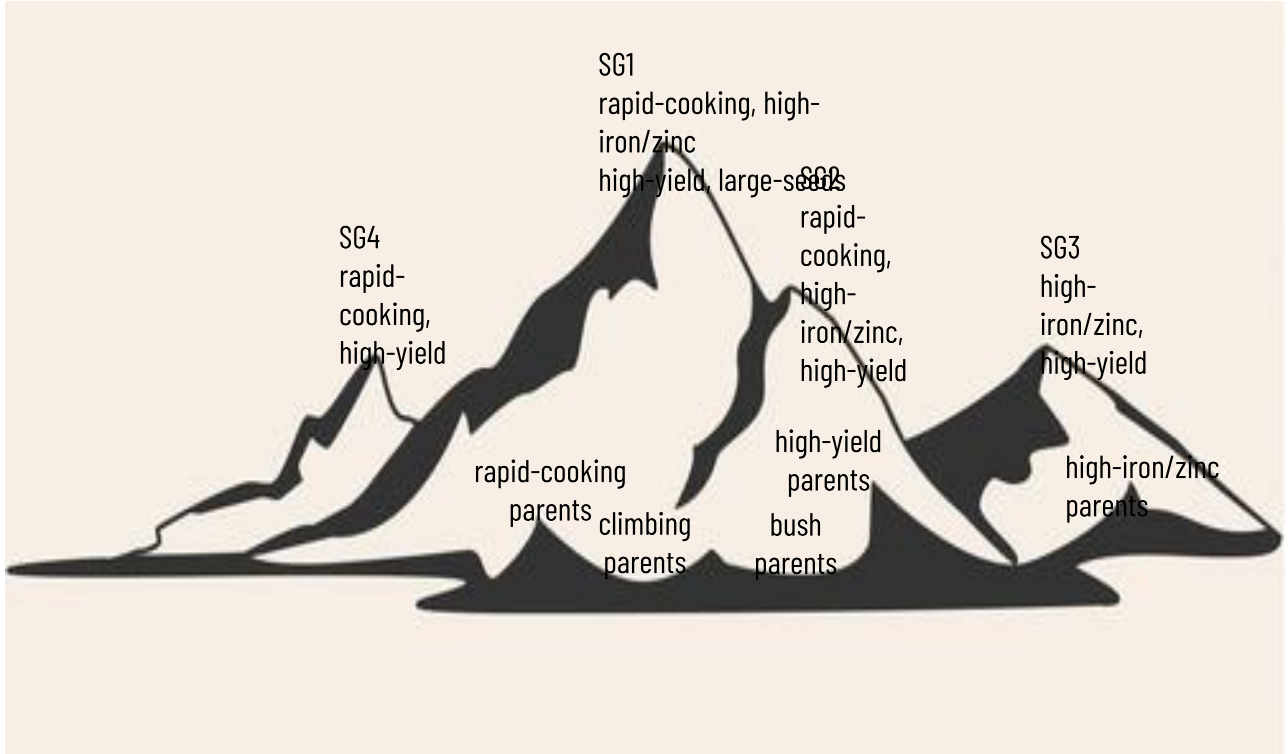
- Rate of genetic gain over cycles (next year)
- % genetic gain compared with benchmark varieties (next year)

Future goals

- Annual recurrent selection cycles
- Accumulate genotypic, pedigree and phenotypic data over cycles
- Combined analysis every year (with help from UNE)
- Target seed size for each market?
- Include seed colour in decisions of crossing parent

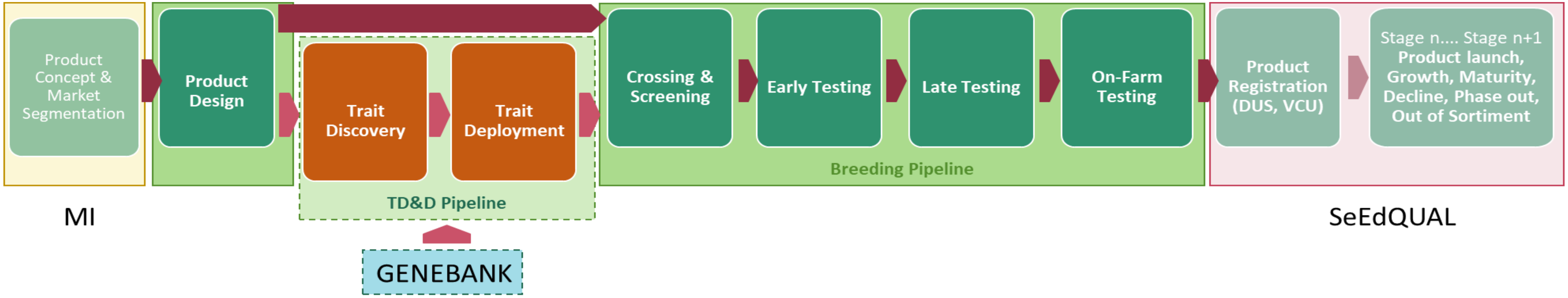
Advancement towards variety release

Selection groups in ACIAR/CROP/132 (rapid cooking bean project, RCBP)



Cycle	1	2	3	4	5
%reduction in cooking time	5-10	10-15	15-20	20-25	25-30
Years in advancement and testing system and reach farmer	6	6	6	6	6
Actual year varieties reach the farmer	2025	2027	2029	2031	2033

Field testing with partners



Training within the project

- BMS: Field book download and upload
- Single site single trait with spatial designs
  - Identifying errors in data and optimising spatial model
- Multi-site field data and multi-year lab data BLUEs analysis
- NRM, GRM, H-matrix (ABLUP, GBLUP, HBLUP)
- Multi-trait analysis, Index calculation (Desire)
- Optimal Contribution Selection: OCS (MateSel)

Acknowledgments

THEME

Leveraging Genetic Innovation for Resilient African Food Systems in the wake of Global Shocks

#APBAConf2023

APBA
African Plant Breeders Association

MOHAMMED VI POLYTECHNIC UNIVERSITY

APBA CONFERENCE 2023
OCTOBER 23-26
UM6P, MOROCCO

*Scan the **QR-Code** or visit the link below to register*

apbaconf2023.um6p.ma/register

african plant breeders association
www.africanplantbreeders.org

Thanks!