Co-Implementing Trait Discovery and Marker QAQC in Dryland Crops- Insights from ADCIN

CGIAR Breeding Program optimization Community of Practice, 10th April 2025

Harish Gandhi,
Associate Program Director (a.i) & Breeding Lead, Dryland Crops Program, CIMMYT

Mohan Kumar Chejerla
Applied Geneticist, Dryland Crops Program, CIMMYT

Ronald Kakeeto
Senior Research Scientist
Team Leader - Sorghum Breeding, NaSARRI, Uganda

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Topics

Africa Dryland Crops Improvement Network (ADCIN)

Dryland Crops Network Workshop in Ghana, Jan 2023

Establishment of ADCIN

The Africa Dryland Crops Improvement Network was established in **August 2023**, after a consultation meeting in Senegal in February 2022 and a network members' meeting in Ghana in January 2023.

Diverse Scientific Collaboration

ADCIN includes over **~200 scientists** from **18 countries**, **3 CGIAR institutions,** bringing together experts from various agricultural disciplines.

ADCIN is about..

01 **Joint Crop Improvement Research**

A novel partnership approach between all partner institutions to jointly conduct crop improvement research and delivery of varieties.

02 **Leveraging Strengths**

Utilizing geographical locations, expertise, facilities, and local knowledge to enhance research outcomes.

03 **Distributed Decision-Making**

Following a distributed & consultative model of decision-making for all key areas: Market Segments, Product Profiles, Breeding Strategies.

04 **Roles and Capacity Development**

Defining roles & responsibilities of each institution; addressing capacity development needs in infrastructure & human resources.

"ADCIN is Governed by Steering committee"

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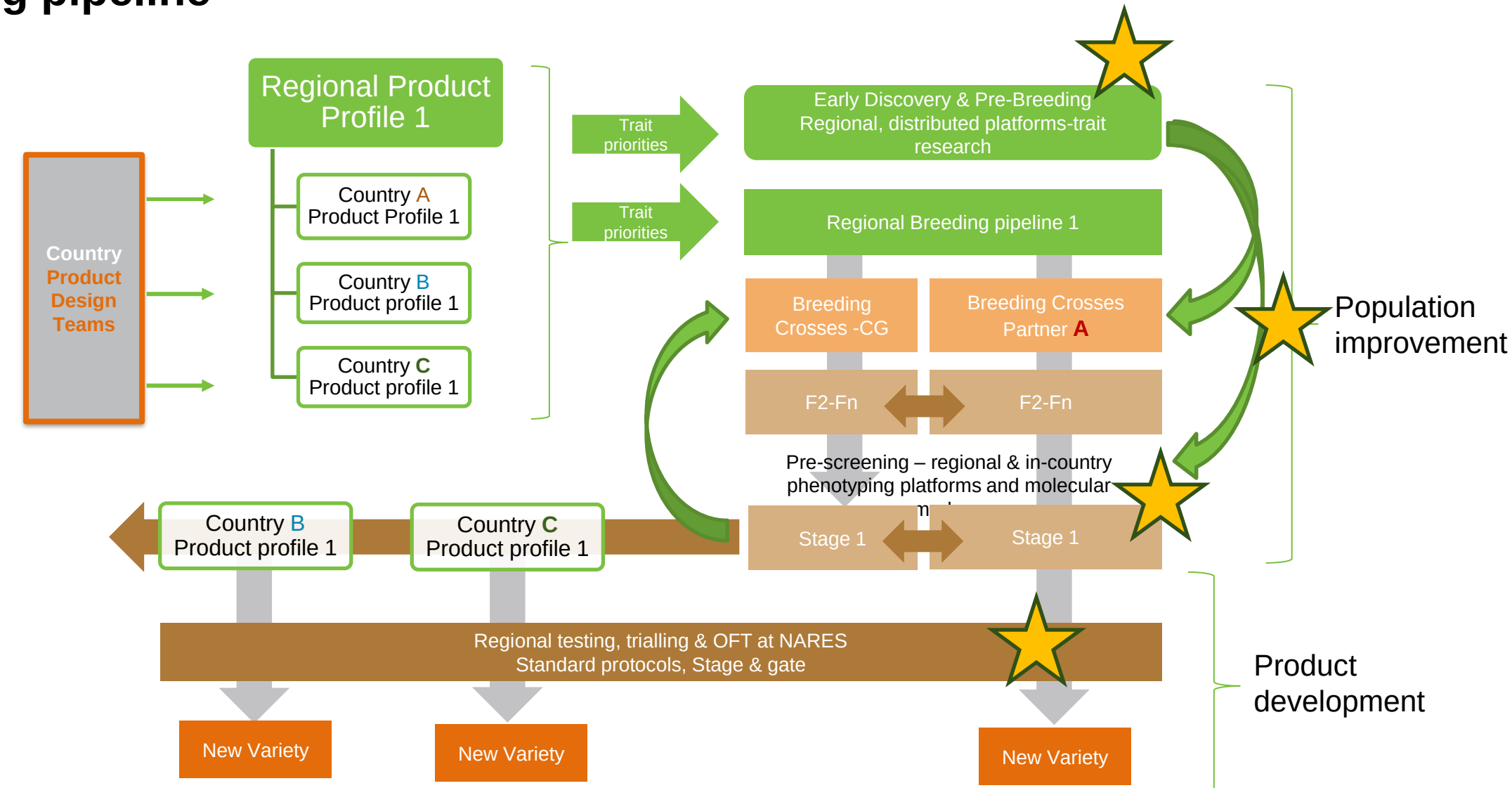
Shared breeding pipeline of network partners: Example schematic for one breeding pipeline



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From fragmented use to full integration of Marker applications in breeding pipelines managed by ADCIN

After interactions with breeders in ADCIN

Ad-hoc routine Marker application in breeding

F1 QAQC,
Parental QAQC, Fingerprinting founders & Stage-1

Trait deployment - less

Minimal/No trait marker deployment in breeding

Institutionalize Routine Marker Applications

Marker-based selection to support decision-making across breeding stages

F1 and parental line QAQC
Fingerprinting

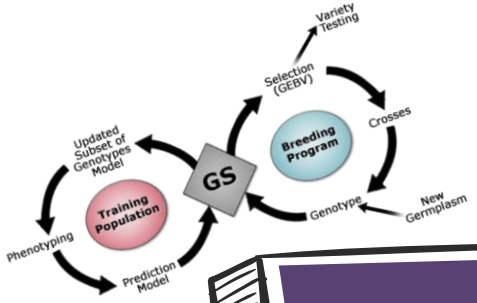
Strengthen Trait Pipelines

Trait validation to ensure reliable QTLs

Trait Package for deployment into breeding lines

Invest in upstream trait discovery

Native Trait Discovery Decision tree-ADCIN crops:



Native Trait Discovery

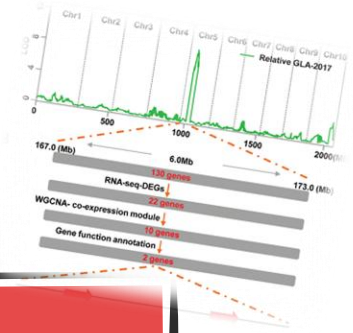
Evidence of Multiple Genomic region influencing the trait

Yes

Genomic Selection Model

1. Medium to high density genotyping
2. Re-training the model
3. Improving selection accuracies

No



Major effect QTLs discovery

- MABC
- Trait Introgression
- Trait Allele frequency
- MAS/ Forward breeding

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Target Traits for Dryland Crops in ADCIN

Sorghum

- Striga (Pre-emergence resistance)
- Striga (Post-emergence resistance)
- Stay green
- Anthracnose
- Fertility Restoration
- Midge
- Stemborer
- Nitrogen Use Effeciency
- Low Phosphorous/Aluminum

Pearl Millet

- Striga (Pre-emergence resistance)
- Striga (Post-emergence resistance)
- Downy Mildew
- Fertility Restoration
- Head Miner
- Drought

Finger Millet

- Blast
- Striga
- Drought

Groundnut

- Groundnut Rosette Disease (GRD)
- Late Leaf Spot
- Rust
- High Oleic Acid
- Seed Weight
- Seed Dormancy
- Drought

Pigeonpea

- Fusarium Wilt
- Pod Borers

Chickpea

- Fusarium Wilt
- Ascochyta Blight

"Traits are aligned with Target Product Profiles (TPP)"

‘Trait Champ’ to co-ordinate pre-breeding across network

For each Priority trait, the CG-NARES scientist is identified as a trait champ across DCP crops

Geneticists

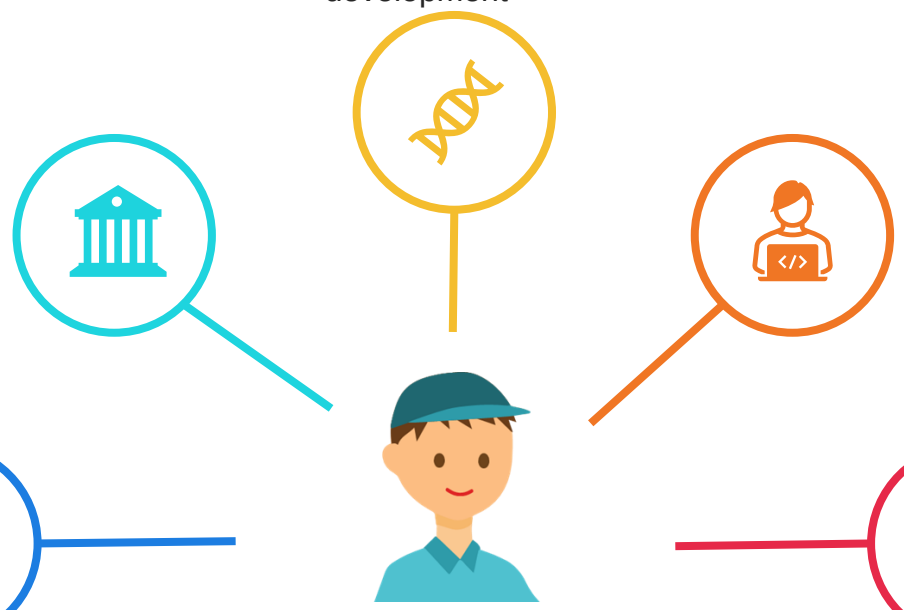
Conducting - trait validations & trait mapping from genotyping and phenotyping data for marker development

Collaborators (Universities/Institutes)

- Upstream research for trait packages
- Novel Variations eg: Wild introgression lines

Data Scientists

- Co-ordinating data analysis for trait mapping, GWAS
- Making sure all trait discovery experiments are in BMS



TRAIT CHAMP

Plant Health team

Co-ordinating and collecting of phenotype data from plant health trials, Mapping populations, stage-1 and above lines.

Breeders

- Identification of Donors for the traits,
- Core set Panel for GWAS
- Developing of mapping populations F2, RILs, BILs

Why Trait Champ??

Distributed Leadership

Distribution of responsibility of all the traits across the crops & regions through leadership.

Handoff trait package to Breeders for Deployment

Helps to develop the trait package (Markers, trait donors) that will be handed over to breeders for trait deployment in the breeding pipeline.

Leveraging expertise on trait

Leveraging the existing expertise and experience of several years, along with the skills and knowledge on the trait within ADCIN, helps the whole region.

Combines individual efforts into one regional effort

Individual partners effort on traits are combined and translated into one that helps for every breeding pipeline.

Leads and Co-ordinates trait discovery & validation in the network/region

Leads the co-ordination and execution of trait discovery and trait deployment experiments in the Network.

‘Trait Champ’s in WCA region for top priority traits for Sorghum, Pearl Millet and Groundnut

Crop: Sorghum
Trait: Midge
Trait Champ: Nofou Ouedraogo
Partner Institute: INERA

Crop: Groundnut
Trait: Groundnut Rosette Disease (GRD)
Trait Champ: Richard Oteng-Frimpong,
Partner Institute: SARI

Crop: Groundnut
Trait: Rust
Trait Champ: Issa Faye
Partner Institute: ISRA

Crop: Pearl Millet
Trait: Striga
Trait Champ: Armel Rouamba
Partner Institute: INERA

TRAIT CHAMP

Crop: Sorghum
Trait: Striga
Trait Champ: Fanna Maina
Partner Institute: INRAN

Crop: Sorghum
Trait: Anthracnose
Trait Champ: Rekiya Abdulmalik
Partner Institute: IAR

Crop: Groundnut
Trait: Early & Late Leaf spot disease ELS & LLS
Trait Champ: Aissatou Sambou
Partner Institute: ISRA

Crop: Pearl Millet
Trait: Downy Mildew
Trait Champ:- Elizabeth Zida
Partner Institute: INERA

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‘Trait Champ’s in ESA region for top priority traits for Dryland crops:

Cereals

Crop: Sorghum
Trait: Striga
Trait Champ: Tokuma Legesse,
Partner Institute: **EIAR**

Crop: Sorghum
Trait: Anthracnose
Trait Champ: Ronald Kakeeto
Partner Institute: **NARO**

Crop: Finger Millet
Trait: Blast
Trait Champ: Adane Gebreyohannes
Partner Institute: EIAR

Crop: Pearl Millet
Trait: Striga
Trait Champ: Tokuma Legesse
Partner Institute: EIAR

TRAIT CHAMP

Legumes

Crop: Groundnut
Trait: Groundnut Rosette Disease (GRD)
Trait Champ: Lutangu Makweti,
Partner Institute: ZARI

Crop: Groundnut
Trait: Early & Late Leaf spot disease ELS & LLS
Trait Champ: Justus Chintu
Partner Institute: DARS

Crop: Groundnut
Trait: Rust
Trait Champ: Joachim Madeni
Partner Institute: TARI

Crop: Pigeonpea
Trait: Fusarium wilt
Trait Champ:- Esnart Yohane
Partner Institute: DARS

Crop: Chickpea
Trait: Fusarium wilt
Trait Champ:- Dagnachew Besha
Partner Institute: EIAR

Crop: Chickpea
Trait: Fusarium wilt
Trait Champ:- Paul Kimurto
Partner Institute: Egerton University

Crop: Pigeonpea
Trait: Podborers
Trait Champ:- Rael Karimi
Partner Institute: KALRO

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Current status & way forward with Trait Champ…

Formulated trait champs for TPP traits

So far formulate and identified trait champions for top priority traits in each crop and regions based on TPP. Developing work plans on trait discovery work in the regions. Developing capacity building/training structures for trait champs

Capacity Development

Leadership trainings

Leadership training on co-ordination and execution since trait champ role involved working coordinating across the network.

Training on Trait discovery

Training on methods of trait discovery and marker trait validation experiments.

Genotype data interpretation

Training on various marker application workflows and interpreting the genotyping data

Stage & Gate process

Training on stage & gate process for trait deployment pipeline.

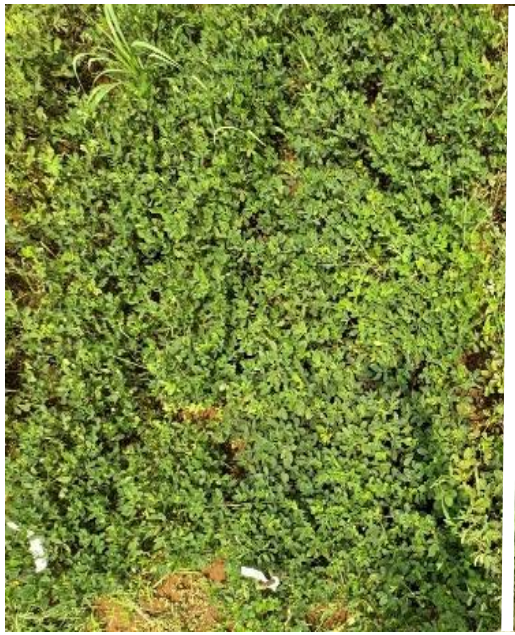
Impact/outcome with Trait Champ…

- Greater CG-NARES involvement in the network for pre-breeding and trait discovery
- Best way for coordinated activities on genomics in ADCIN

Groundnut : Trait validation of Late leaf spot with ISRA, Senegal

- *Aissatou Sambou (ISRA) & Daniel Fonceka (CIRAD)*

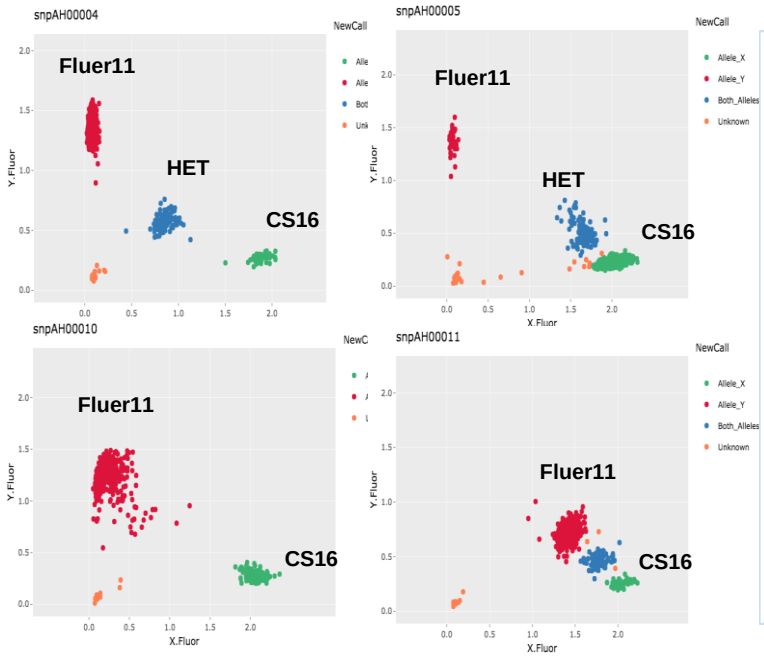
Leaf Spot screening trial at Nioro, Senegal, (WCA)



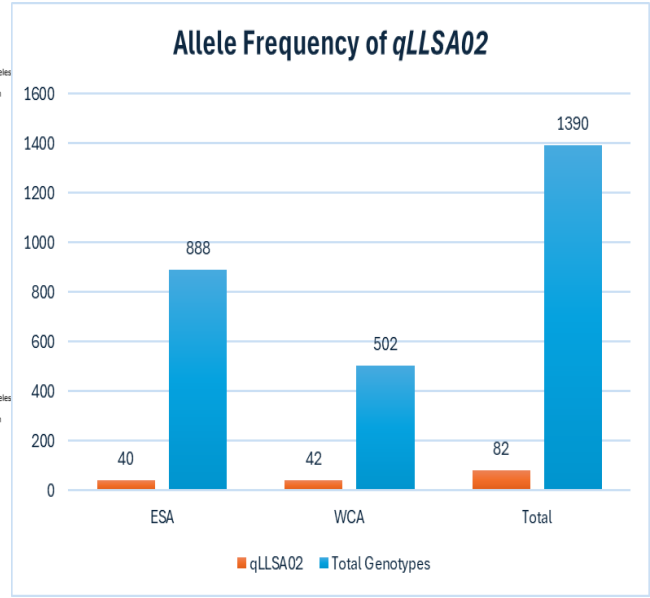
BC4F2 Fleur11 line carrying *QLLS-A02.1* is Resistant for LLS

Fleur11 genotype is susceptible without QLLS-A02.1

SNPs (clustering) that are linked to *qLLA02* in Fluer11 x CS16 BC pop



Allele frequencies of QTL qLLA02 in CIMMYT-NARES breeding lines :



5% -ESA 8% -WCA

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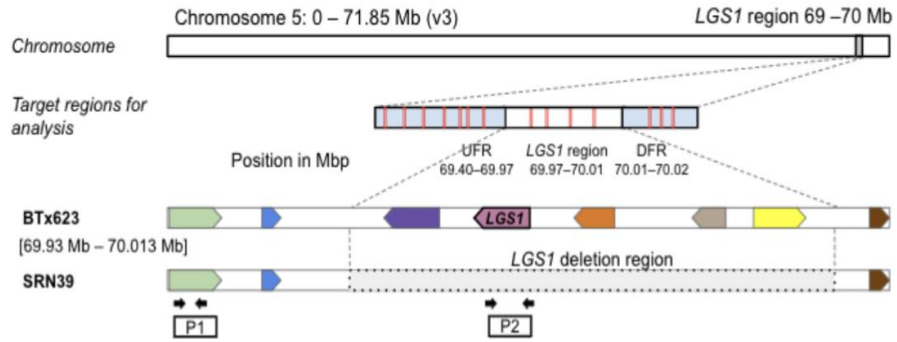
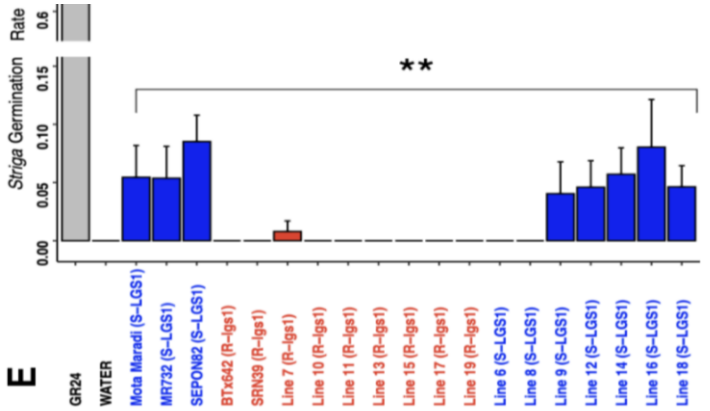
Sorghum: Trait validation of Sorghum-Striga *lgs1* with INRAN

Fanna Maina

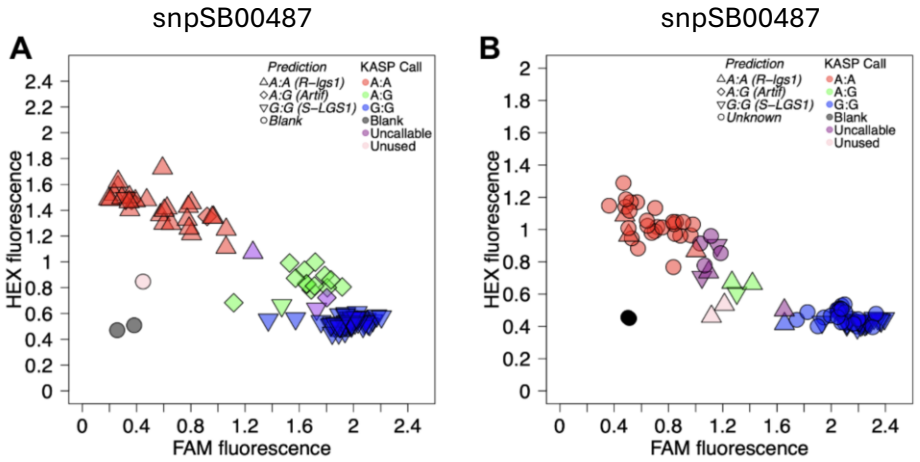
lgs1 gene for pre-emergence resistance to striga



Germination rate for progenies Mota Maradi x SRN39, including inbred lines after striga infestation



snpSB00487 SNP that is linked to *lgs1* gene



Genotypes: BTx623Population , El Mota, IRAT 204, Mota Maradi, MR732, and SRN39.

Genotypes: $F_{2:3}$ progenies of SRN39 × Mota Maradi.

Survival rate and biomass of sorghum plants after striga infestation

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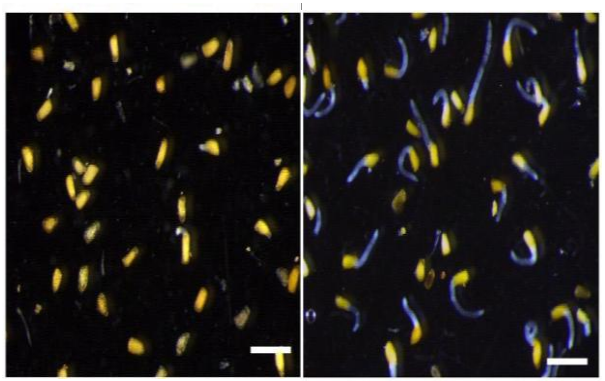
Sorghum :Trait discovery work on Sorghum-Striga for post-emergence and pre-emergence resistance with Kenyatta University

Pre-attachment Resistance response (R) to Striga infection in rhizotrons at 21 DAI

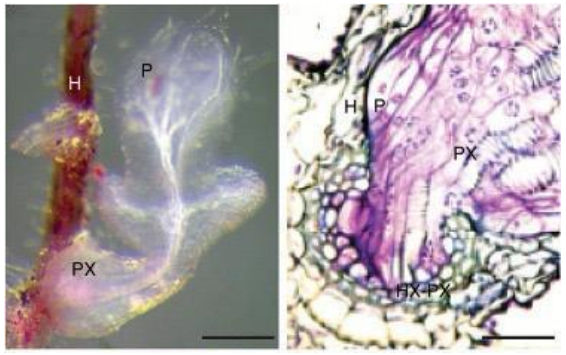


R (SRN39) S (IS3443)

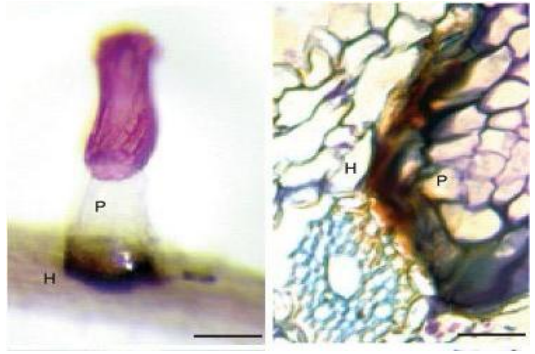
Post-attachment Resistance response (R) of to Striga infection in rhizotrons at 21 DAI

R (IS9830) R (IS14963) S (IS20016)

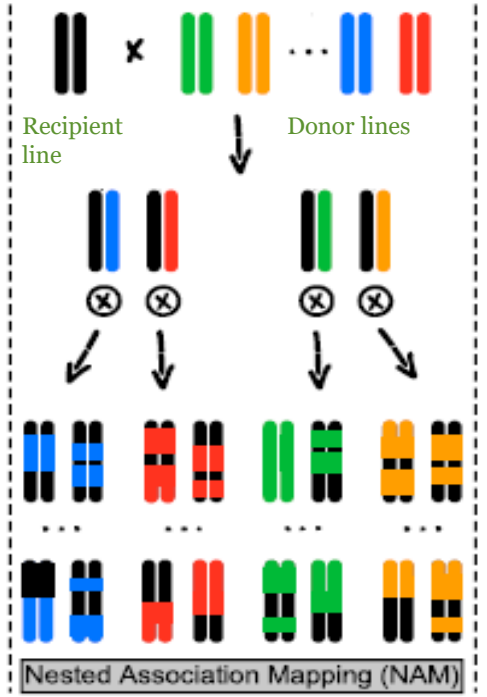
Susceptible genotype IS18829 showing well-established haustorium at the site of striga attachment



Resistance mechanisms of IS14963 showing a Hypersensitive Reaction (HR) at the site of infection



Nested Association Mapping



Collaborator:
Steven Runo (KU)

Trait champ:
Tokuma Legesse

- Many parental alleles get shuffled due to genetic recombination
- Maintains huge genetic diversity
- Discover the QTLs with good precision

S.No	Region	Recipient Line	Donor line
1	WCA	Soubatimi	N13, IS9830, IS2814, IS14963 and IS41724, SRN39, Farmida
2	WCA	SAMSORG-45	N13, IS9830, IS2814, IS14963 and IS41724, SRN39, Farmida
1	ESA	Macia	N13, IS9830, IS2814, IS14963 and IS41724, SRN39, Farmida

Source: Pest Manag Sci 2021; 77: 2894–2902 ; BMC Plant Biology (2021) 21:392

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Application of Molecular Markers for QA/QC in ADCIN

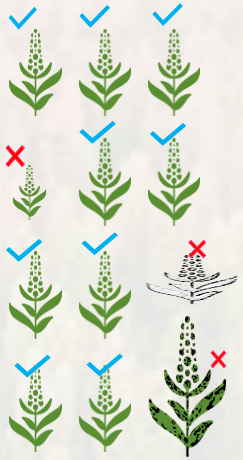
"Precision Breeding Starts with Purity"

- Breeding optimization for increased genetic gain requires quality assurance (QA) and quality control (QC) at key stages of the breeding pipelines.

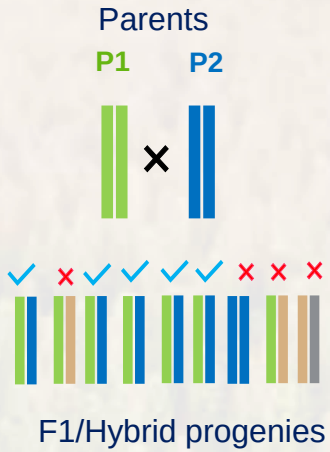
- ❑ Genetic purity of parental inbred lines
- ❑ F1 hybrids/breeding crosses
- ❑ Seed production activities

- Efficient and optimized, breeding programs adopts routine QAQC for maintaining integrity of genetic purity

i) Genetic purity of parental inbred lines



ii) F1 hybrids/breeding crosses



iil) Seed production activities

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Marker QAQC implementation in ADCIN by CIMMYT-NARES partnerships:

CG_NARES Breeders

- **Assembled MDG finger printing data of African lines (ESA & WCA) from CIMMYT-NARES programs**

Data Analytical team

- **Developed analytical pipeline for QAQC**
- **Routine support for data analysis**

EiB platform

- **Facilitated genotyping at Intertek lab for marker validations and test runs**

Applied Geneticists

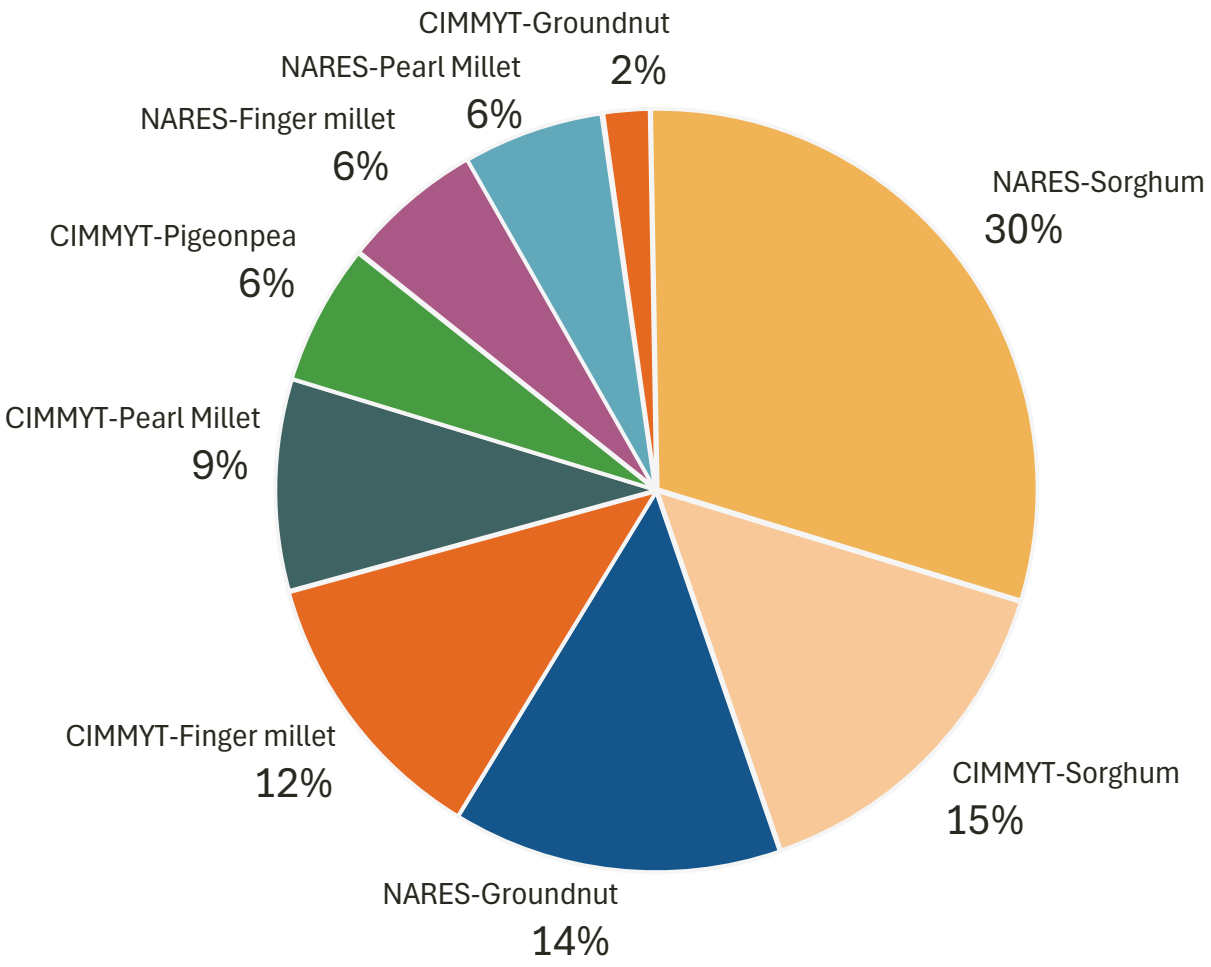
- **Developed RACI workflow for F1QAQC implementation**
- **Optimized to select highly informative markers for QAQC for African germplasm**
- **Routine decision support to breeders**

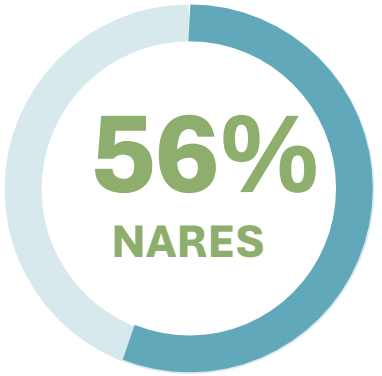
Deployment in CG_NARES

- **Adopted QAQC rapidly in the ADCIN network**

Status of QAQC Implementation in ADCIN

% QAQC sample submission by CG-NARES Network





5 Crops

12 Partners

23,000 QAQC Samples

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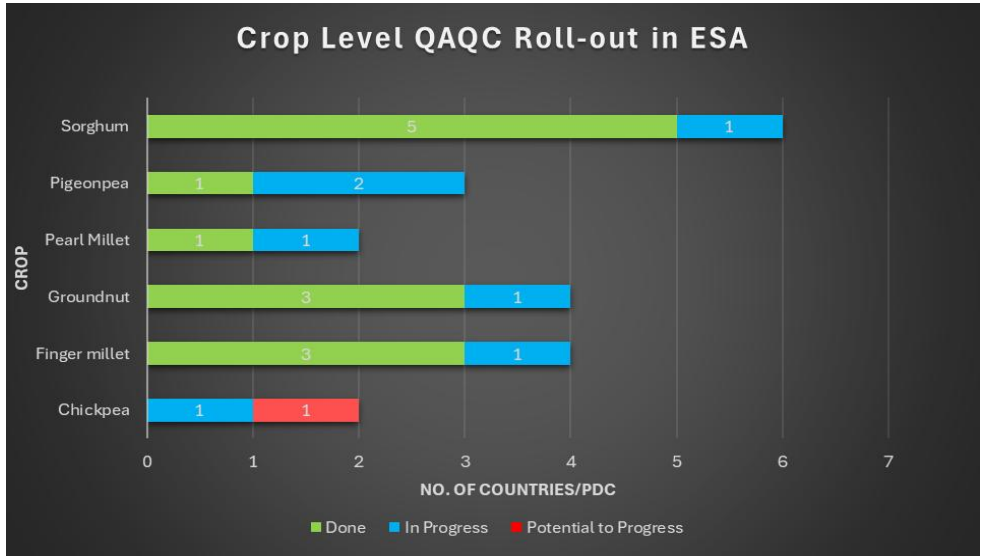
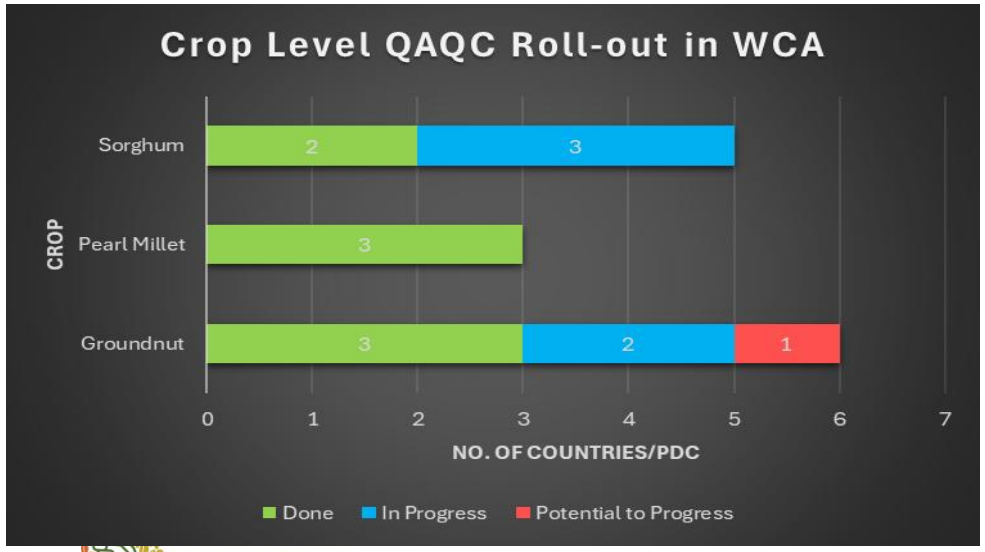
Molecular marker QAQC Adoption footprint in ADCIN





Region	Crop	Country	PDC	Coments
ESA	Sorghum	Kenya	CIMMYT	Done
ESA	Sorghum	Uganda	NARO	Done
ESA	Sorghum	Tanzania	TARI	Done
ESA	Sorghum	Ethiopia	EIAR	Done
ESA	Sorghum	Kenya	KALRO	Done
ESA	Sorghum	Zambia	ZARI	In Progress
WCA	Sorghum	Burkina Faso	INERA	Done
WCA	Sorghum	Nigeria	IAR	Done
WCA	Sorghum	Senegal	CIMMYT	In Progress
WCA	Sorghum	Mali	IER	In Progress
WCA	Sorghum	Togo	ITRA	In Progress
ESA	Groundnut	Tanzania	TARI	Done
ESA	Groundnut	Uganda	NARO	Done
ESA	Groundnut	Kenya	CIMMYT	Done
ESA	Groundnut	Malawi	DARS	In Progress
WCA	Groundnut	Ghana	SARI	Done
WCA	Groundnut	Mali	IER	Done
WCA	Groundnut	Togo	ITRA	Done
WCA	Groundnut	Senegal	CIMMYT	In Progress
WCA	Groundnut	Nigeria	IAR	In Progress
WCA	Groundnut	Senegal	ISRA	Potential to Progress
ESA	Finger millet	Kenya	CIMMYT	Done
ESA	Finger millet	Tanzania	TARI	Done
ESA	Finger millet	Zambia	ZARI	Done
ESA	Finger millet	Uganda	NARO	In Progress
ESA	Pearl Millet	Kenya	CIMMYT	Done
ESA	Pearl Millet	Zambia	ZARI	In Progress
WCA	Pearl Millet	Senegal	CIMMYT	Done
WCA	Pearl Millet	Burkina Faso	INERA	Done
WCA	Pearl Millet	Niger	INRAN	Done
ESA	Pigeonpea	Kenya	CIMMYT	Done
ESA	Pigeonpea	Kenya	KALRO	In Progress
ESA	Pigeonpea	Malawi	DARS	In Progress
ESA	Chickpea	Ethiopia	EIAR	In Progress
ESA	Chickpea	Kenya	EU	Potential to Progress

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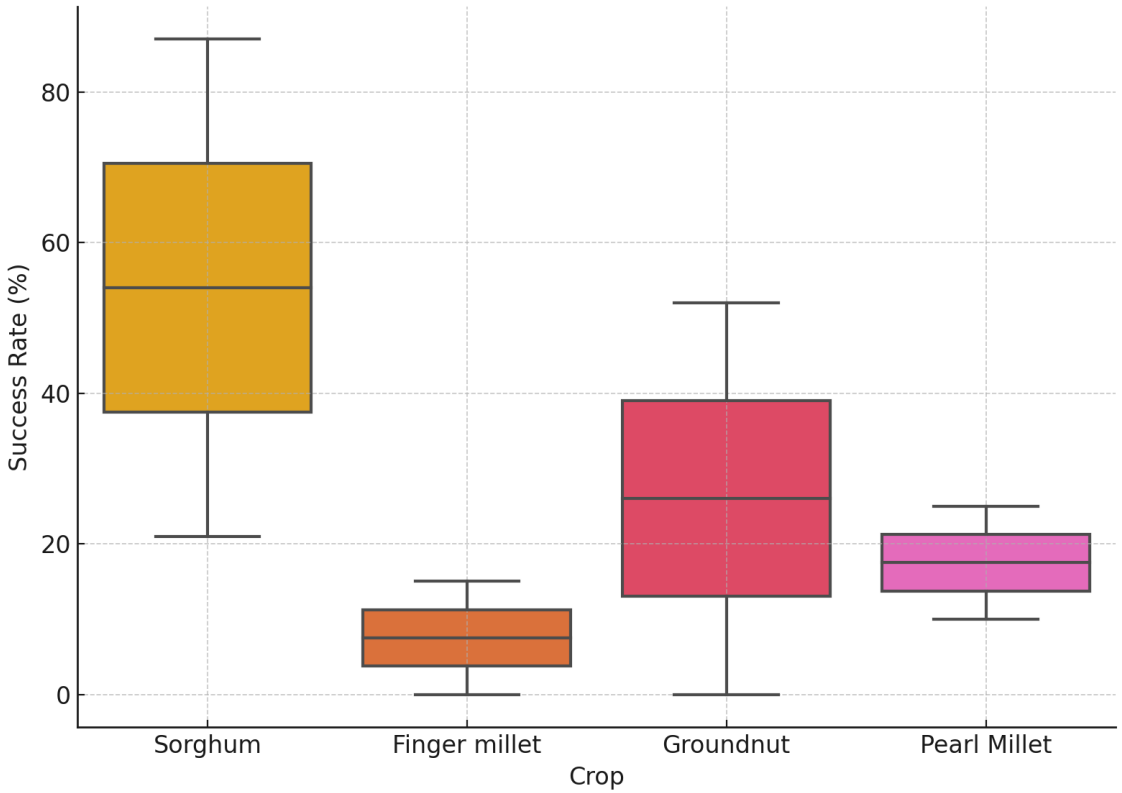
QAQC % Success rates across the Dryland crops in ADCIN

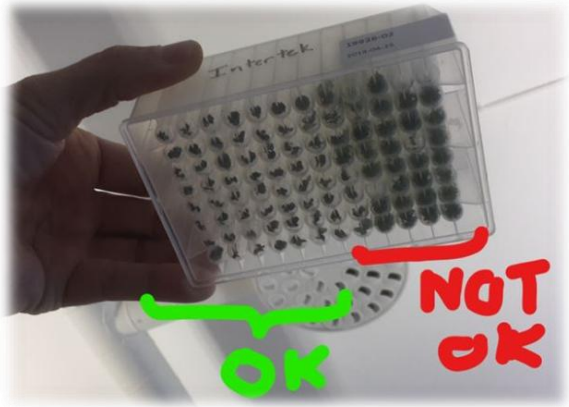


- QAQC % success rates vary across DCP crops due to differences, self- vs. cross-pollinated, Flower morphology
- Breeders are leveraging QAQC feedback to augment operational practices
- Breeders are increasing breeding crosses based on success rates to meet the stage-1 lines for testing
- Impact: by routine molecular QAQC.
- Developing Dashboard for QAQC to continuously monitor & improve.

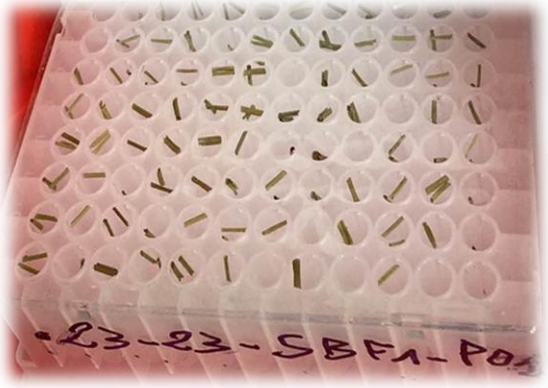
How we improved in leaf sampling protocols

Before….

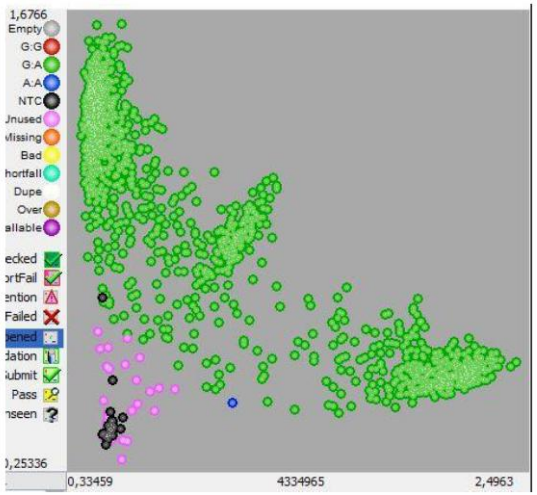
Inconsistent sampling



Spilling of tissue sampling

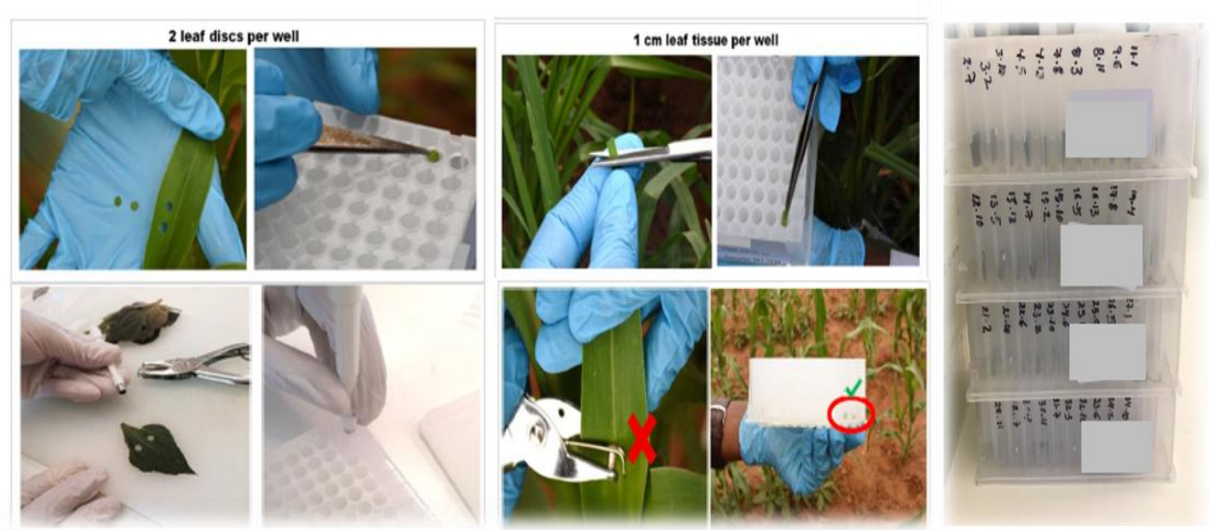


Lab Feed back: Poor SNP clustering due to uneven DNA concentration

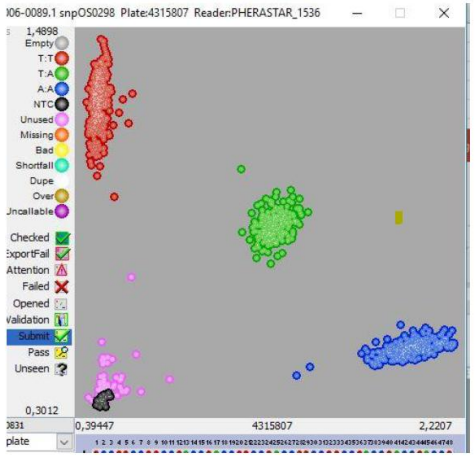


After Training and following good SOPs

Standardized procedures



Good SNP clustering to interpret the calls



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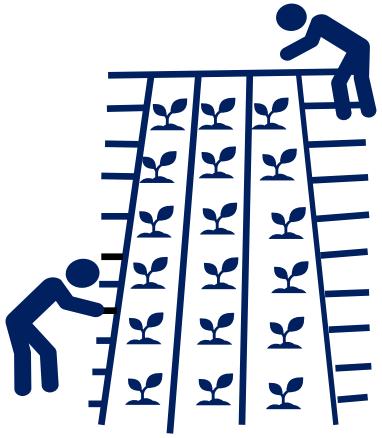
NARO (Sorghum) Success story in implementing marker QAQC in CG-NARES network breeding pipelines:



Conventional way in field

Conventionally, laborious and time-consuming process to select true to type plants in the field for breeders, yet not efficient sometimes

		F1QAQC				Parental line QAQC			
First Year	-->	Total F1s Genotyped	Successful F1s	Failed F1s	% Success	Total parents	Successful lines	Failed lines	% Success
		109	52	57	50	27	24	3	88
Second Year	-->	Total F1s Genotyped	Successful F1s	Failed F1s	% Success	Total parents	Successful lines	Failed lines	% Success
		203	176	27	87	19	19	0	100

- ✓ Molecular markers QAQC is much precise & efficient way of selection
- ✓ Through QAQC able to maintain high level of genetic purity standards in the breeding

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Summary

- Trait Champs lead and ensure trait discovery, validation, and deployment are co-owned across the CGIAR–NARES network.
- Trait champions accelerate the translation of upstream trait discoveries into downstream breeding gains.
- Ad-hoc, marker-assisted QAQC is now a routine tool in the breeding pipelines, ensuring genetic purity in: Parental inbred lines, F1 crosses
- Collectively, this accelerates genetic gain in dryland crops—delivering better varieties faster

Thank you for your interest!

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