NC STATE
UNIVERSITY

The Genomic Tools for Sweetpotato Improvement Project - GT4SP

Funded by:

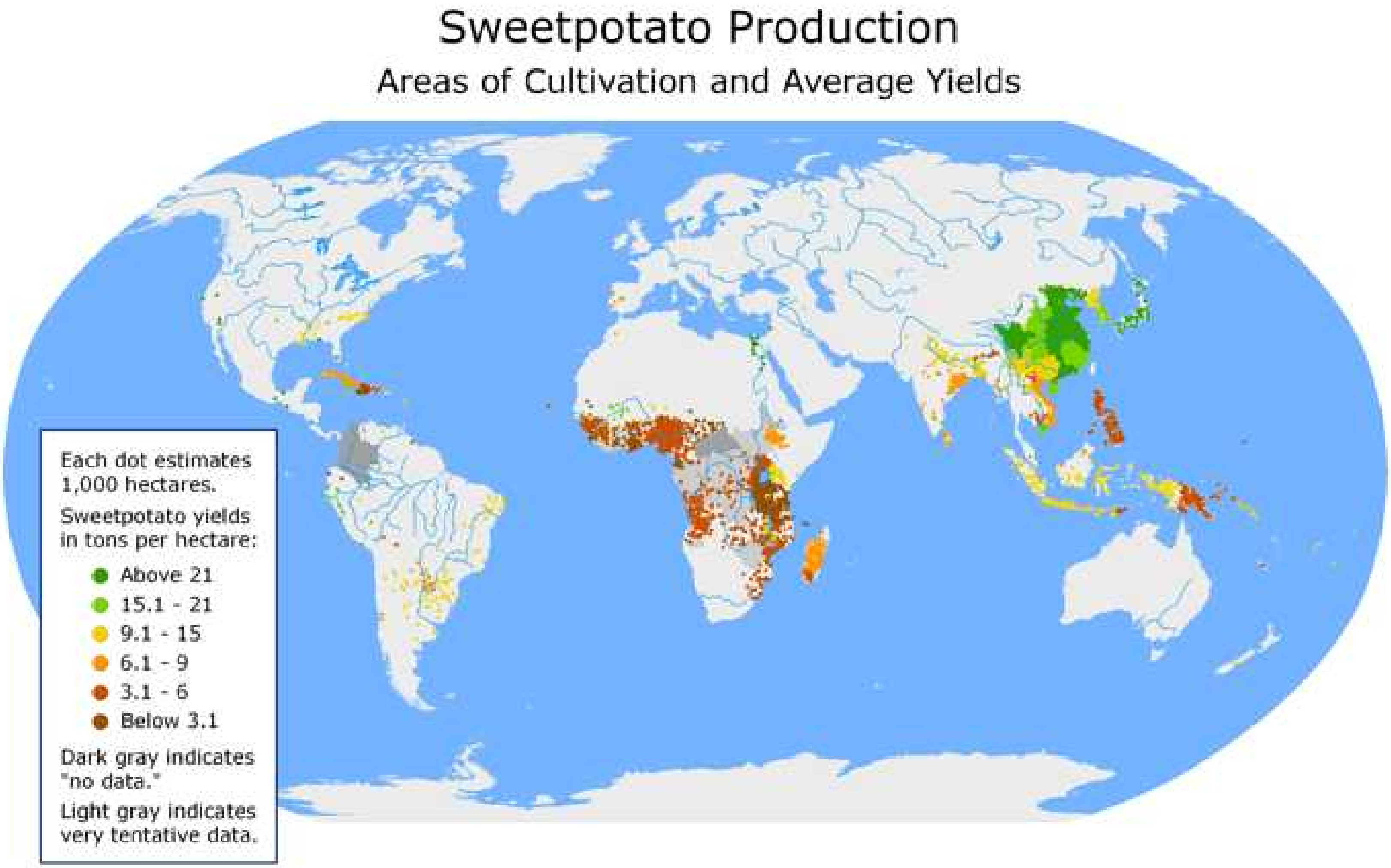
BILL & MELINDA
GATES foundation

Craig Yencho
Department of Horticultural Science
North Carolina State University
Raleigh, NC USA

SPHI Annual Technical Meeting
Villa Portofino Hotel, Kigali, Rwanda
Sept. 29 – Oct. 2, 2015

Global Sweetpotato Production

(2000 – 2006)



Source: International Potato Center: World Sweetpotato Atlas
https://research.cip.cgiar.org/confluence/display/WSA/Global+Sweetpotato+Cultivation

Covington

NCPUR06-020

NCDM02-180

Sweet Caroline and Illusion™ series

WE'RE PEELING THE POTATOES NOW...

HELLO!
COVINGTON®

Ending America's dependence on foreign vodka.

THE BEST YAM VODKA ON EARTH®

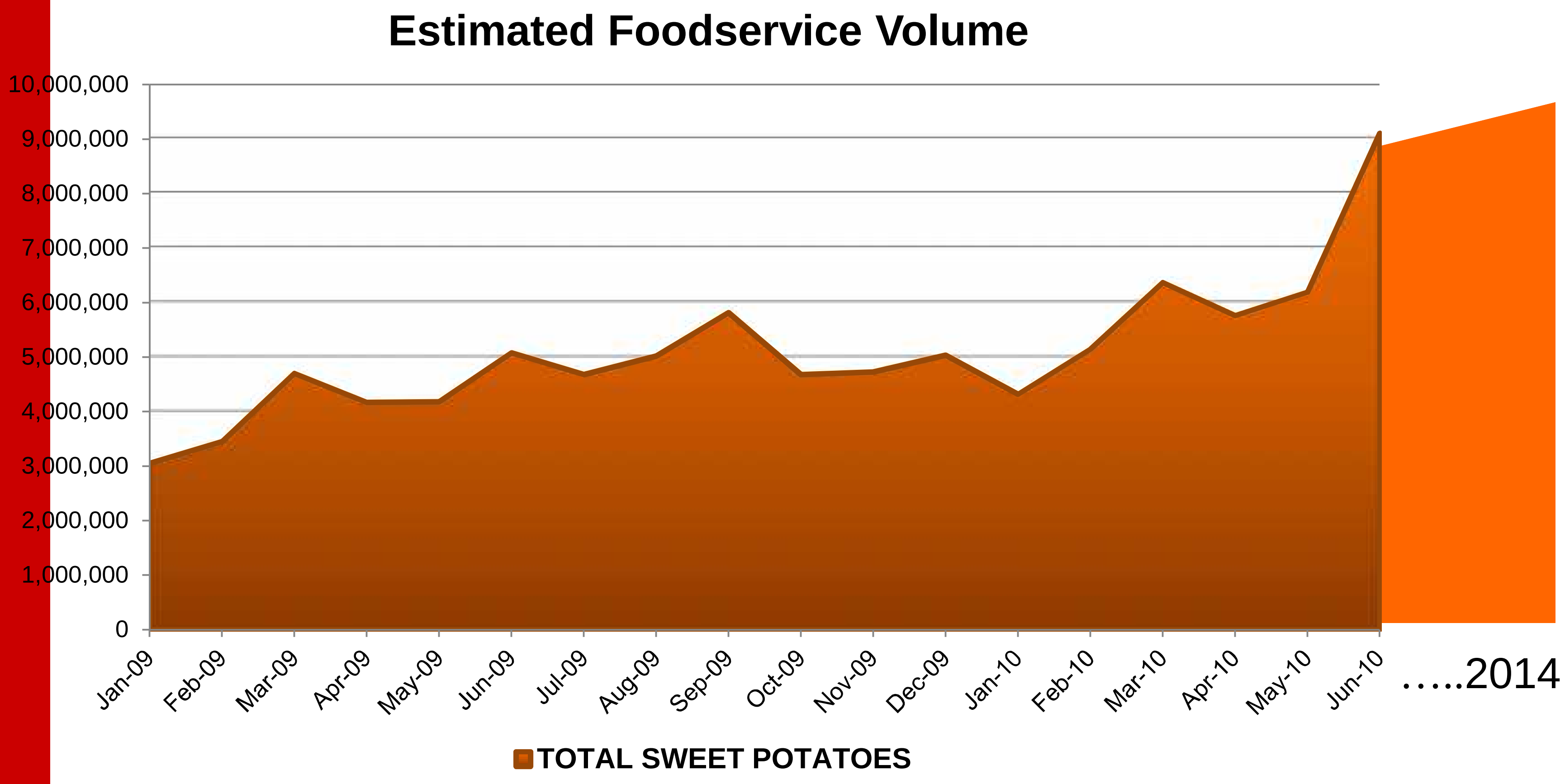
GOLD MEDAL WINNER — 2013 SAN FRANCISCO
WORLD SPIRITS COMPETITION!

COVINGTON SPIRITS LLC SNOW HILL, NC — COVINGTONVODKA.COM

Growth of Sweetpotato Fries

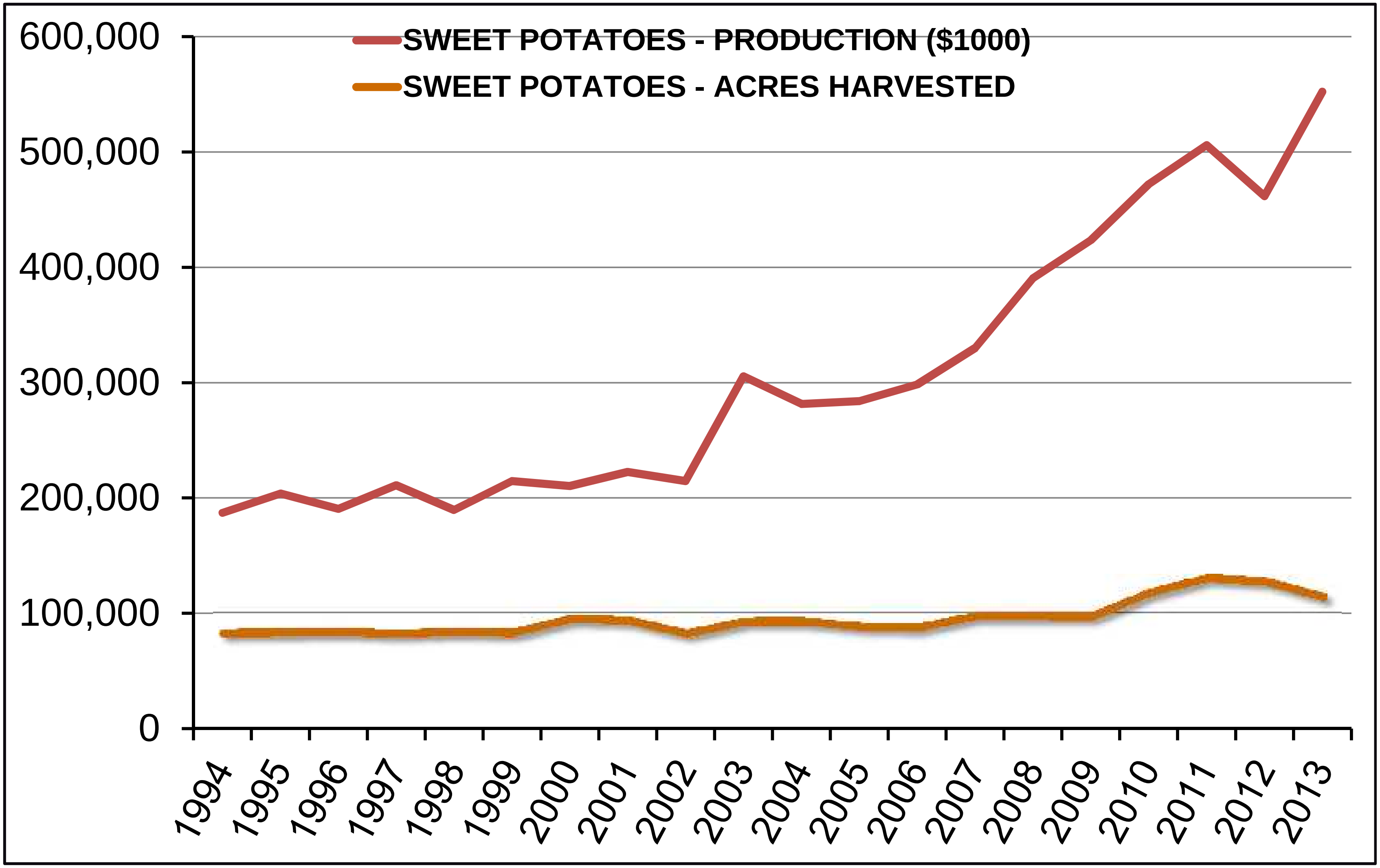
Jan.'09 – June '10

Impressive, but this represents < 2% of total fry market

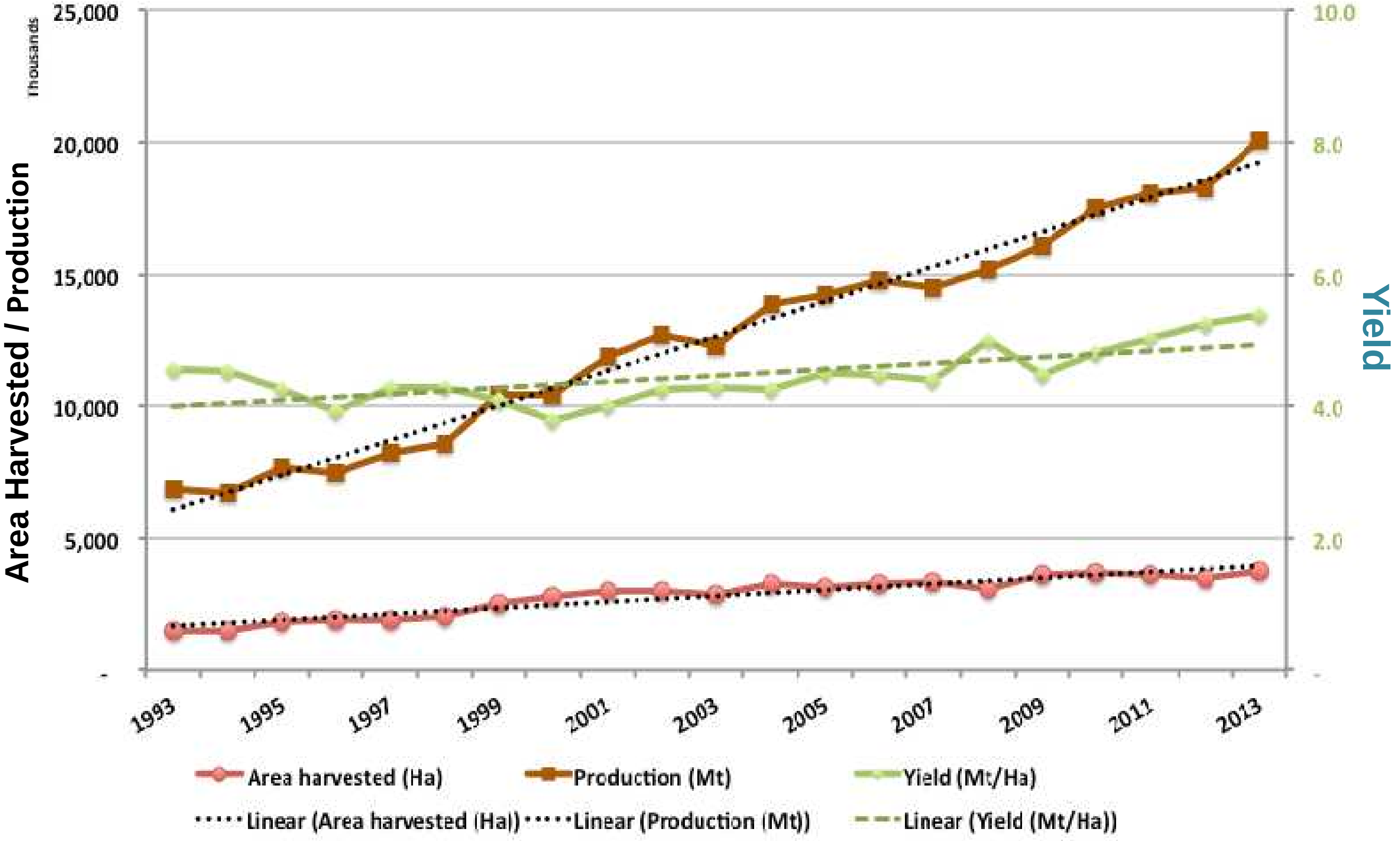


US Sweetpotato Growth

1994 - 2014



African Sweetpotato Production Trends 1993-2013



Source: FAOSTAT3.FAO.ORG (March 2015)

The SASHA Project – Sweetpotato Action for Security and Health, 2009-2014

Lead Institute: International Potato Center

BILL & MELINDA GATES foundation

Major Progress in 4 Key Areas

1. **Population Development & Varietal Selection**
2. **Seed Systems**
3. **Delivery Systems (proof-of-concept)**
4. **Management and Sweetpotato Support Platforms**

Focus 1 : Breeding & Varietal Development

New Populations

GOAL 1: Generate a radically expanded range of sweetpotato varieties that combine different quality characteristics with significant improvements in yielding ability

- **Generate populations to meet dominant needs of users**
- **All sites: High dry matter**
- **East & Central Africa: virus-resistance, orange-fleshed, dual purpose for animal feed**
- **Southern Africa: drought resistance, orange-fleshed**
- **West Africa: non-sweet sweetpotato, orange & white-fleshed**

Focus 2 : Breeding & Varietal Development

New Breeding Methods

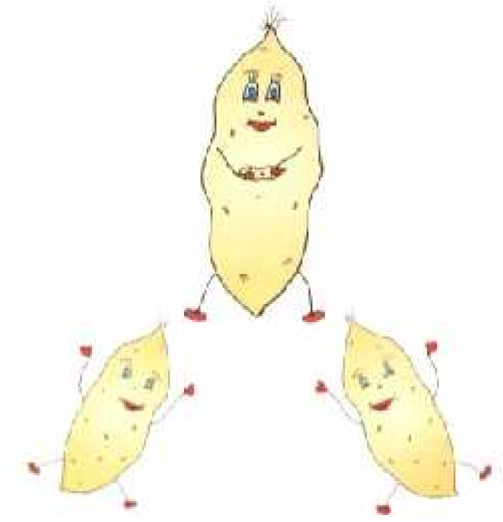
GOAL 2: Redesign sweetpotato breeding systems in Africa to produce varieties in fewer years (3-4) than currently (7-8 years) - “accelerated breeding”

- **More sites at the earliest stages of breeding to substitute for fewer sites over more seasons**
- **At least one site being the “tough”selection conditions; for instance, consistently drought stressed**
- **In February 2011, released 15 new, more drought tolerant OFSP in Mozambique**
- **Also released varieties using accelerated breeding in Malawi and Rwanda**

Focus 3 : Breeding & Varietal Development

GOAL 3: Exploitation of Heterosis –

Demonstration that heterosis exists for root and foliage weight… but not for quality traits?



A) Working with two heterotic genepools, on average for first hybrid population:

- **22.9% root yield jump (dry matter basis)**
- **7.8% more biomass production.**

B) Potential of further yield jumps by selecting the best "hybrid family parents"

- **up to 100% more root yield (dry matter basis)**
- **up to 85% more biomass production.**
  - ***These 2nd hybrid populations now underway in Uganda, Mozambique, and Peru***

Focus 4 : Management & Sweetpotato Support Platforms

GOAL 4 : Research organized around breeding platforms that integrate and support the work of institutional partners in each sub-region

- **Provide technical backstopping**
  - Special emphasis on Alliance for a Green Revolution (AGRA) supported national breeding programs and PhD training programs (ACCI & WACCI)
- **Assure clean germplasm exchange**
- **Assure gender-sensitive design and implementation**
- **Assure comparable data collection** between countries engaged in the breeding and germplasm exchange
- **Facilitate information exchange**

Each Platform with Quality Lab and Clean-up Capacity

Near Infrared Spectrometer enables rapid assessment of major macro- and micronutrients

Screen houses essential for maintaining stocks of disease free vines as primary foundation material

Current Status of Sweetpotato

- The importance and potential of SP has become widely recognized across the globe.
- Many public and private organizations recognize the superior nutritional value in SP compared to many other staple crops and investments are increasing.
- SASHA “1” has been very successful – new breeding programs (4-6), new varieties (18+), 3 region SSP’s established, NIRS technology introduced, seed systems, virus studies, value-added POC’s, etc.
- SASHA “2”, SPHI, etc. recently launched.
  - See http://sweetpotatoknowledge.org/

In short…..A lot of people are more interested in sweetpotato than ever before!!!

However….genomic resources for sweetpotato are noticeably lacking!!

Sweetpotato Genomics Convening

A “Vision” for SP Improvement in SSA

BMGF, Seattle, WA June 3-5, 2013

With the help of the SASHA project, sweetpotato is poised for significant growth in SSA.

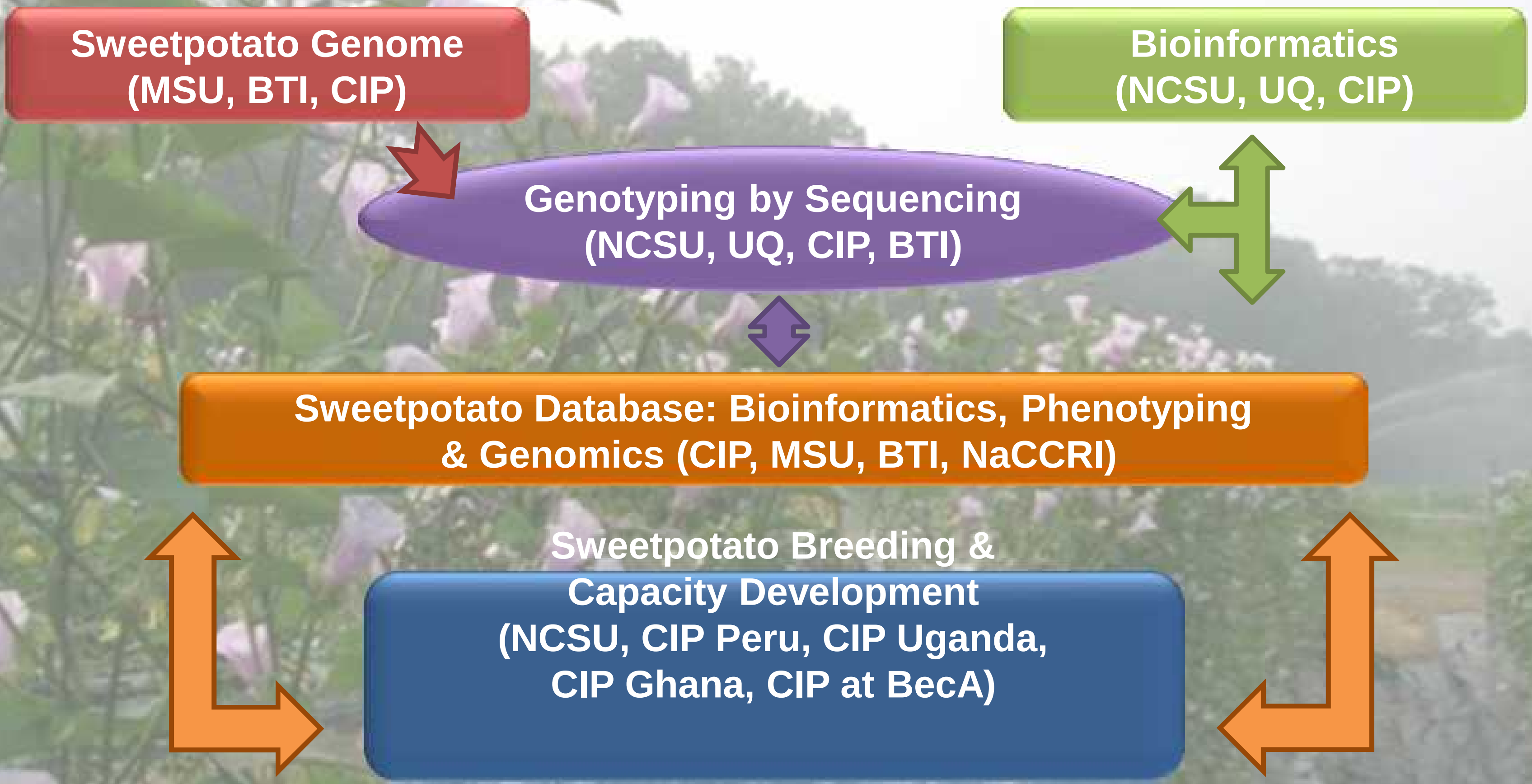
However, to fully realize SP’s true long-term potential, we need to invest in modern breeding tools, and integrate them into applied breeding efforts connected to improved seed systems and market-based value-chains.

A “Vision” for MAB Breeding in SSA

Breeding pipeline investments should include:

- **Genomic Resources –**
  - A reference genome – the 1st!
  - Marker development – we are way behind the curve….
  - A robust set of SNP markers and a low-cost genotyping platform
  - Advanced laboratory sequencing linked with developing country phenotyping and breeding activities
  - 2x and 6x mapping, training and test populations
- **Bioinformatics, analytics and database resources –**
  - Stand-alone and web-based bioinformatics resources
  - Sweetpotato database, data collection and phenotyping options
  - New analysis resources
- **Human Resources and Capacity Development** –
  - Continue to assemble and develop a dynamic team of breeders and allied disciplines
  - Training in the use of traditional and genomic breeding methods
  - Effective communication and collaboration
  - Multi-institutional training and capacity development

The Genomic Tools for Sweetpotato Improvement Project – GT4SP



Sweetpotato Genome
(MSU, BTI, CIP)

Bioinformatics
(NCSU, UQ, CIP)

Genotyping by Sequencing
(NCSU, UQ, CIP, BTI)

Sweetpotato Database: Bioinformatics, Phenotyping & Genomics (CIP, MSU, BTI, NaCCRI)

Sweetpotato Breeding &
Capacity Development
(NCSU, CIP Peru, CIP Uganda,
CIP Ghana, CIP at BecA)

An ambitious project to sequence sweetpotato and develop modern breeding tools for a food crop that sustains million of people in SSA.

Collaborators: Boyce Thompson Institute at Cornell, Michigan State University, University of Queensland, Australia; The International Potato Center, Peru; BioSciences East and Central Africa, Kenya; National Crops Resources Research Institute, Uganda;

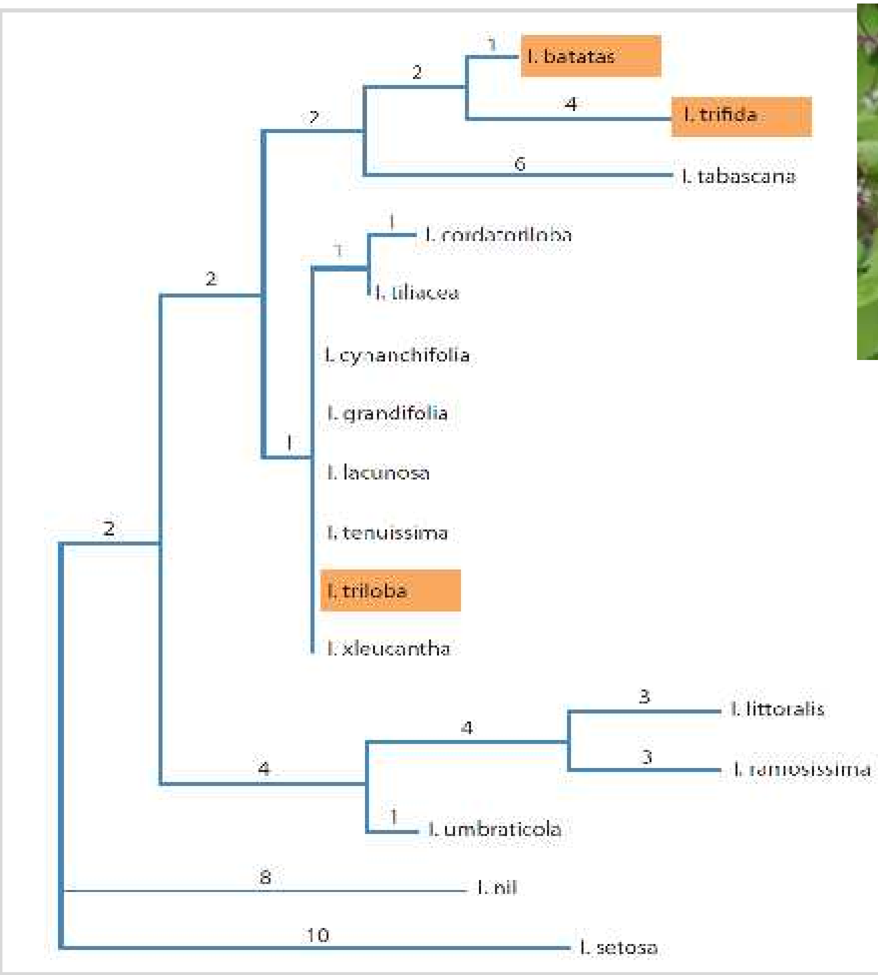
GTSPI Start-up Meeting, San Diego, CA Jan. 7-9, 2015

Sweetpotato genome sequencing

Strategy: Sequencing the closely related wild ancestors that are diploid and homozygous

- Examples: potato, wheat, cotton, strawberry

I. triloba NSP0323



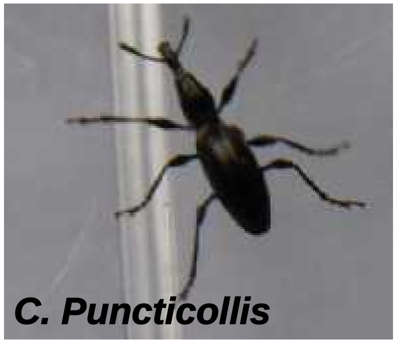
I. trifida NSP0306

NC STATE
UNIVERSITY

NaCRRI

Development of High Yielding Multiple Resistant Sweetpotato Germplasm

Impact of sweetpotato weevils (SPW) in SSA

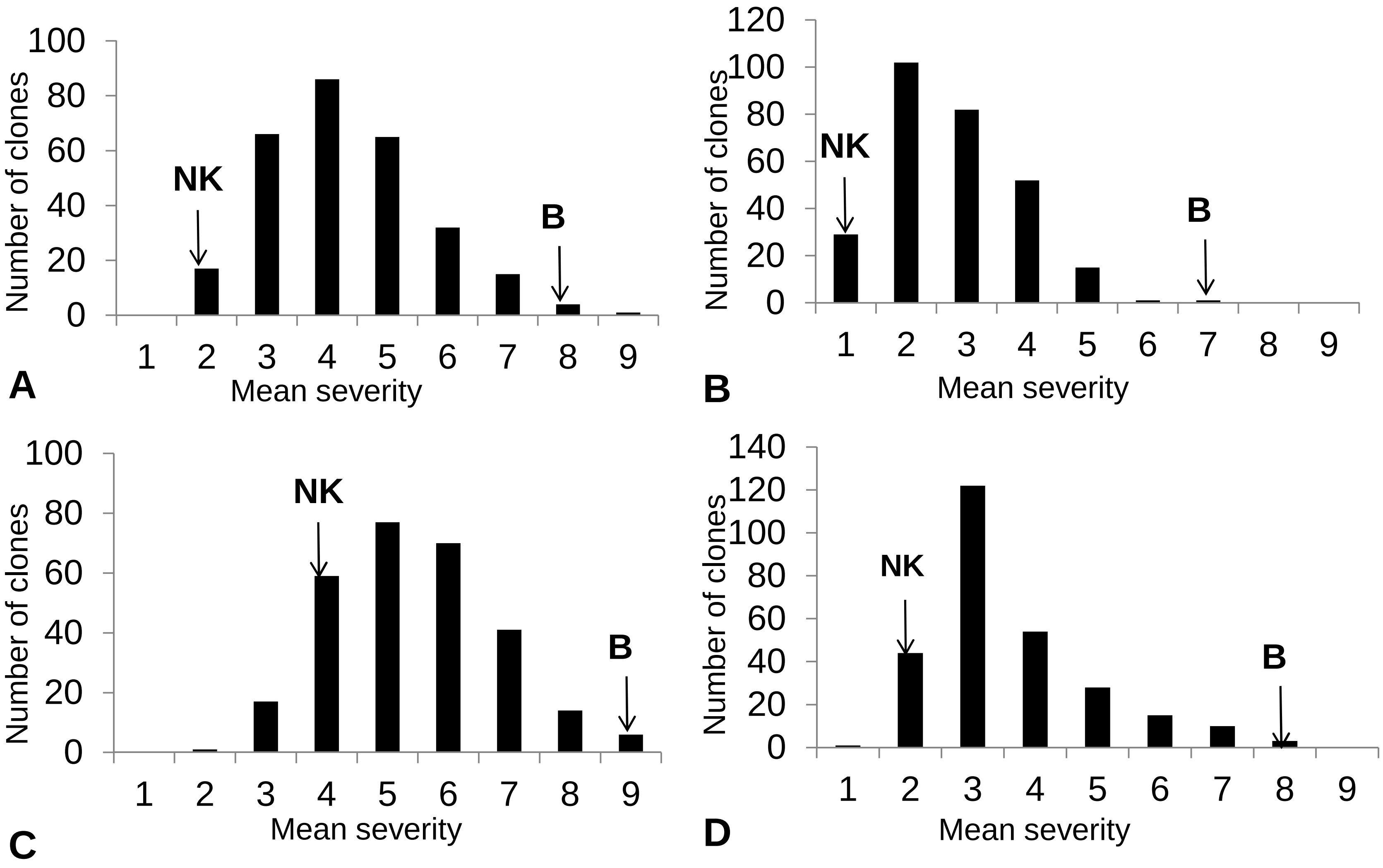


- Yield losses of 67-100%
- Oviposition and feeding
- Pathogenic microbial accumulation
- Sesquiterpenes
- Impeded translocation of phytochemicals
- **Difficult to manage**

Frequency Distribution of Mean Sweetpotato Weevil Severity

‘New Kawogo’ (NK) x ‘Beauregard’ (B) mapping population at NaCRRI (A), NgeZARDI (B), NaSARRI (C), and overall mean across sites and seasons (D)

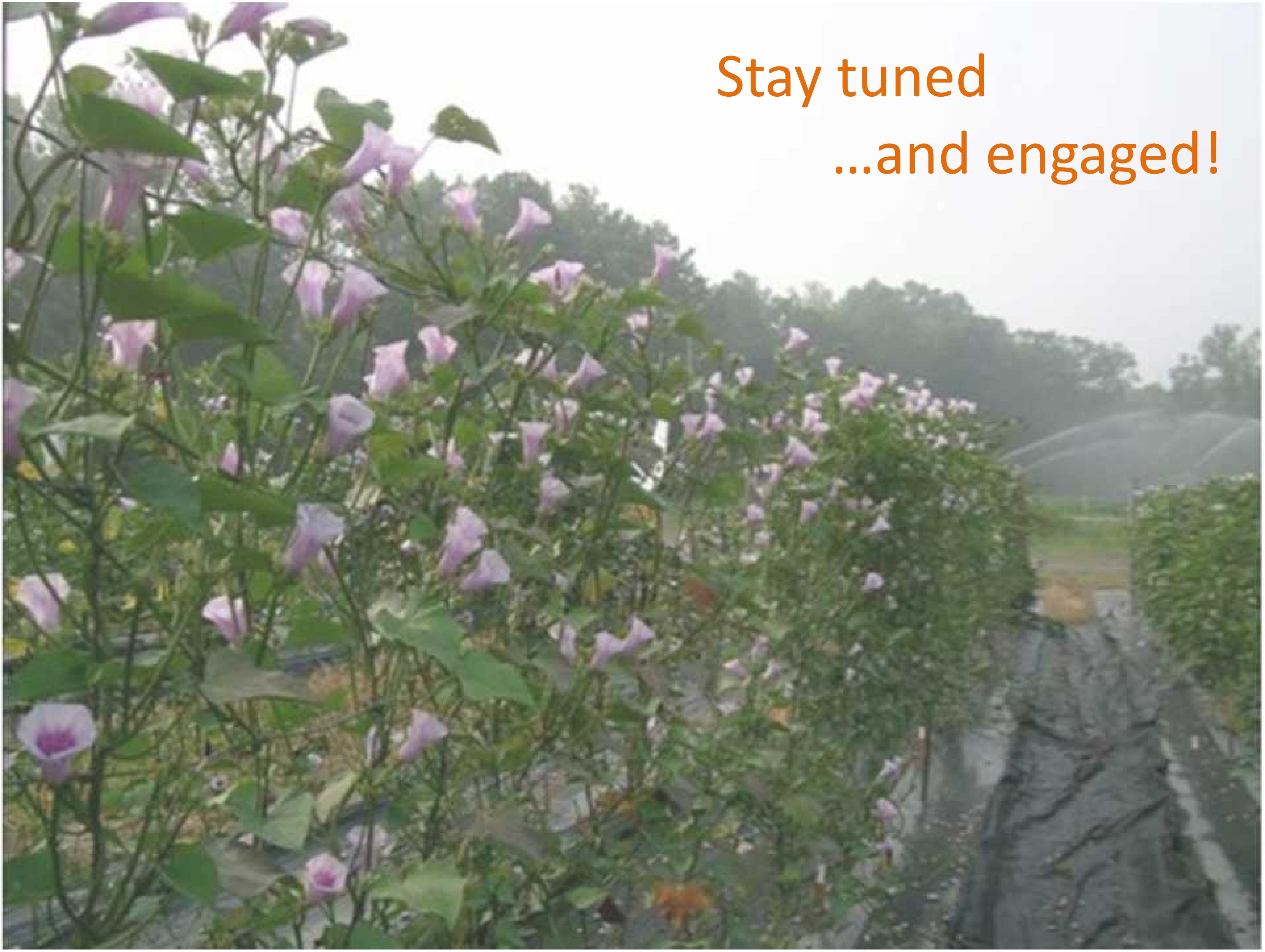
Transgressive segregants = 25



Outcomes

- An MAB breeding pipeline that utilizes up- and down-stream breeding methods
- Genomic selection technologies integrated with the SASHA accelerated breeding program
- A new generation of sweetpotato breeders, and a new cadre of molecular geneticists and bioinformatics scientists interested in using the new tools to study sweetpotato.
- Linkage of genomic-based breeding to address the demand of new varieties and “products” will yield maximum long-term ROI on current SP crop improvement investments in SSA.

- Note: We can’t expect “omics” to solve all our breeding problems. Conventional breeding will still be the workhorse, but it will offer new solutions for difficult traits.



Stay tuned

…and engaged!