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The Genomic Tools for Sweetpotato Improvement Project – GT4SP

Bill & Melinda Gates Foundation
Seattle, WA

Beginning the Discussion

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Raleigh, NC USA

SASHA/GT4SP Annual Sweetpotato Breeders Meeting
Colline Hotel, Mukono, Uganda
June 2-5, 2015


Covington


NCPUR06-020

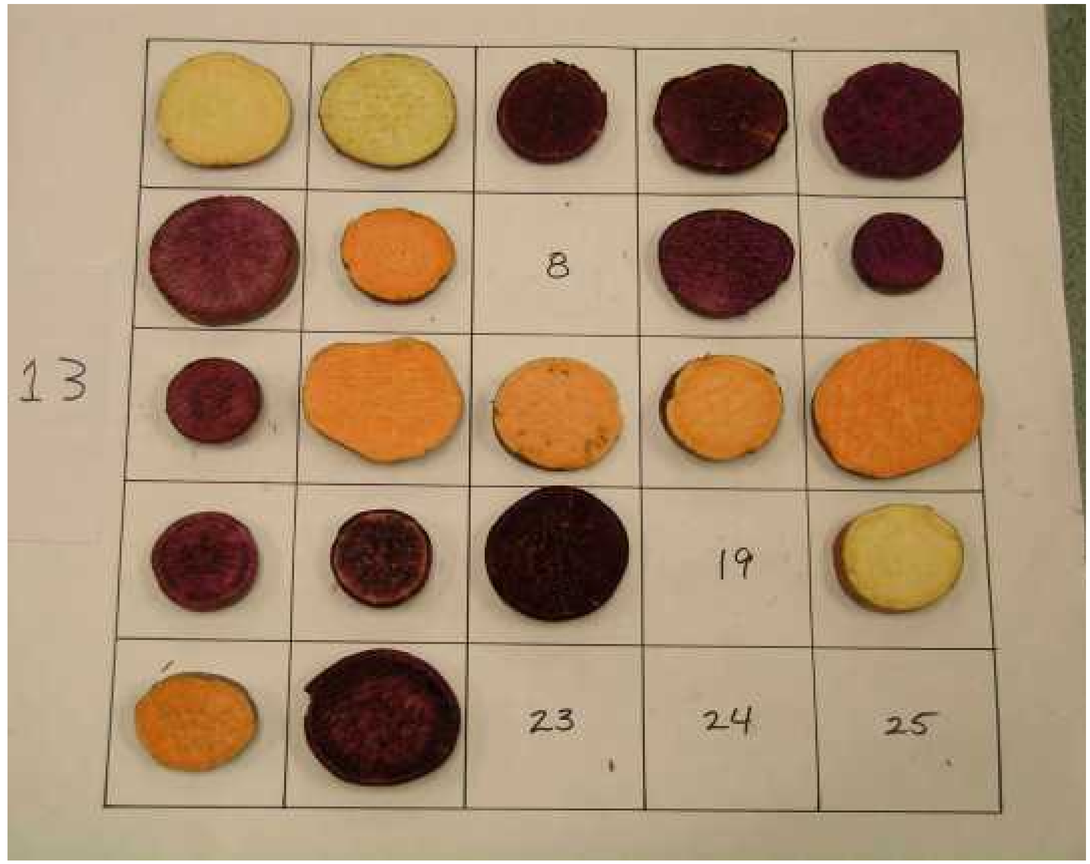

NCDM02-180


Sweet Caroline and Illusion™ series

L96-117 x NC415 –
Think about the opportunities in this cross…

Functional Food Products
- **Anthocyanins**
- **β-Carotene**
- **Phenolics**
- **Lower-glycemic index**

New flavors
Exciting colors
Different sugar, starch and texture profiles
Lower acrylamide levels?



The challenge is…
How do we decide what to develop and what tools do we use to get there?!

WE'RE PEELING THE POTATOES NOW...

HELLO! COVINGTON®

Ending America's dependence on foreign vodka.

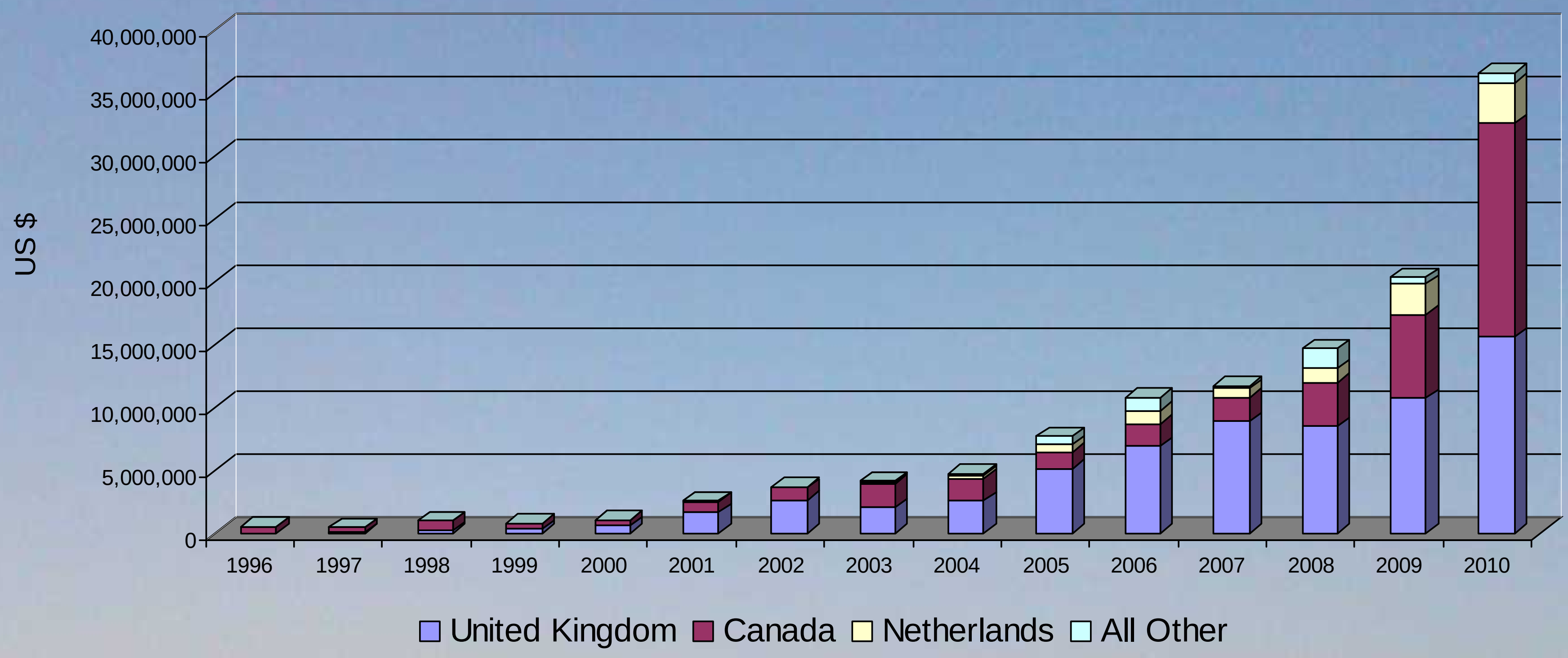
THE BEST YAM VODKA ON EARTH®

GOLD MEDAL WINNER – 2013 SAN FRANCISCO
WORLD SPIRITS COMPETITION!

COVINGTON SPIRITS LLC SNOW HILL, NC – COVINGTONVODKA.COM

NC Sweet Potato Exports

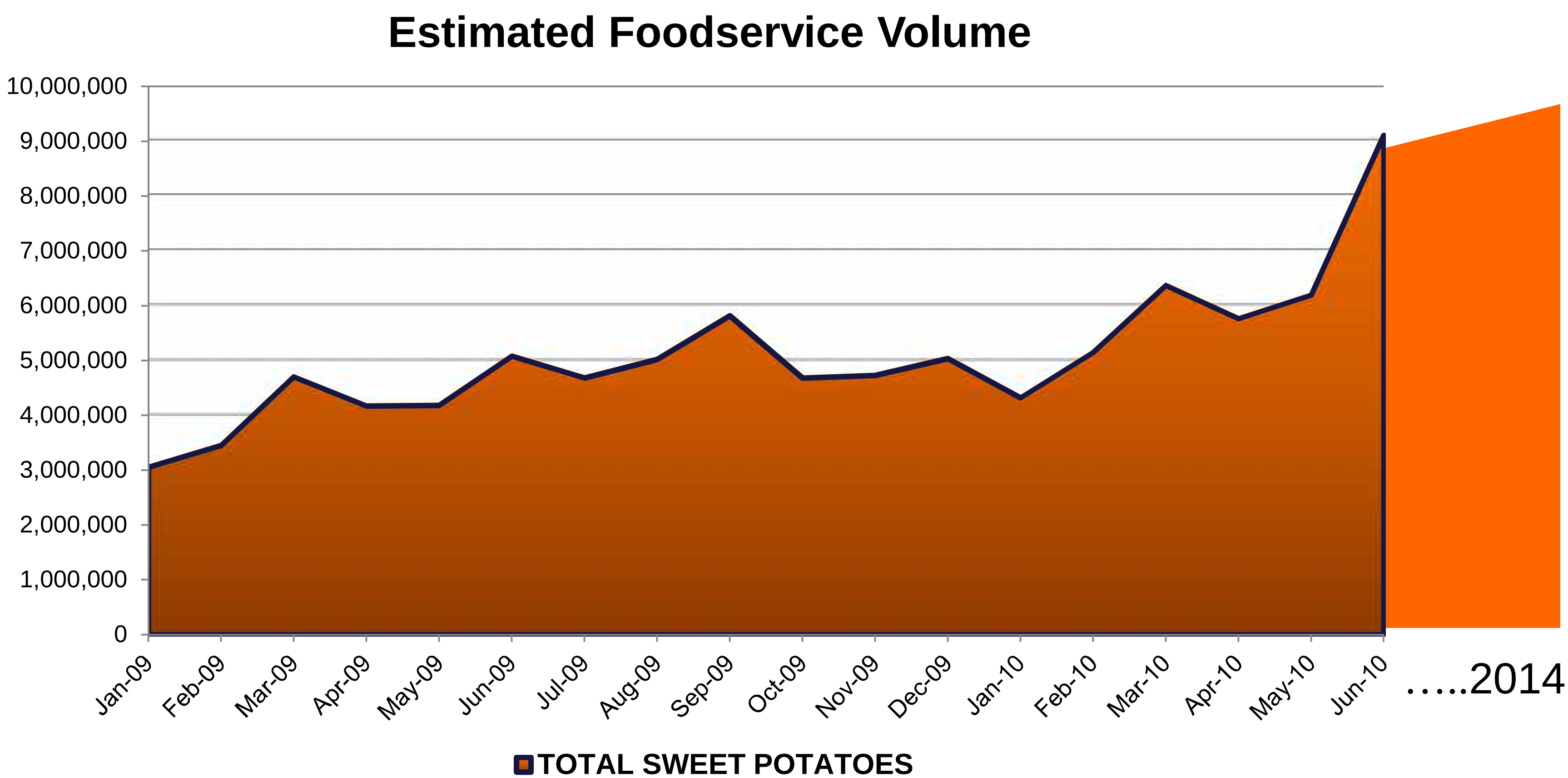
Exports now account for between 10% and 20% of production



Growth of Sweetpotato Fries

Jan.’09 – June ‘10

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



More types of SP varieties = more traits to evaluate

1997 (total traits evaluated = 28)	2014 (total traits evaluated > 50)
Yield (Total, No. 1, canner’s, jumbos, culls)	Yield (Total, No. 1’s, petites, canners, jumbos, culls)
Maturity (E, M, L)	Maturity (E, M, L)
Storage root shape and appearance (6 traits)	Storage root shape and appearance (6 traits)
Skin color and texture	Skin color and texture
Flesh color – O, W	Flesh Color – O, W, Y, P
Dry Matter Content	Dry Matter Content - Starch, amylose:amylopectin
Skinning	Skinning
Taste – Baking test (6 traits)	Taste – Baking test (6 traits), plus glucose, sucrose, fructose, maltose, total sugars
Storage	Storage – Internal beak-down, browning potential
Disease resistance – FW, SSR, RKN	Disease resistance – FW, SSR, RKN, FLD Screen, SPFMV
Sprouting behavior	Chip and fry tests (2-3x/yr)
	Anthocyanin profiling
	Sprouting behavior
	Cut root piece potential

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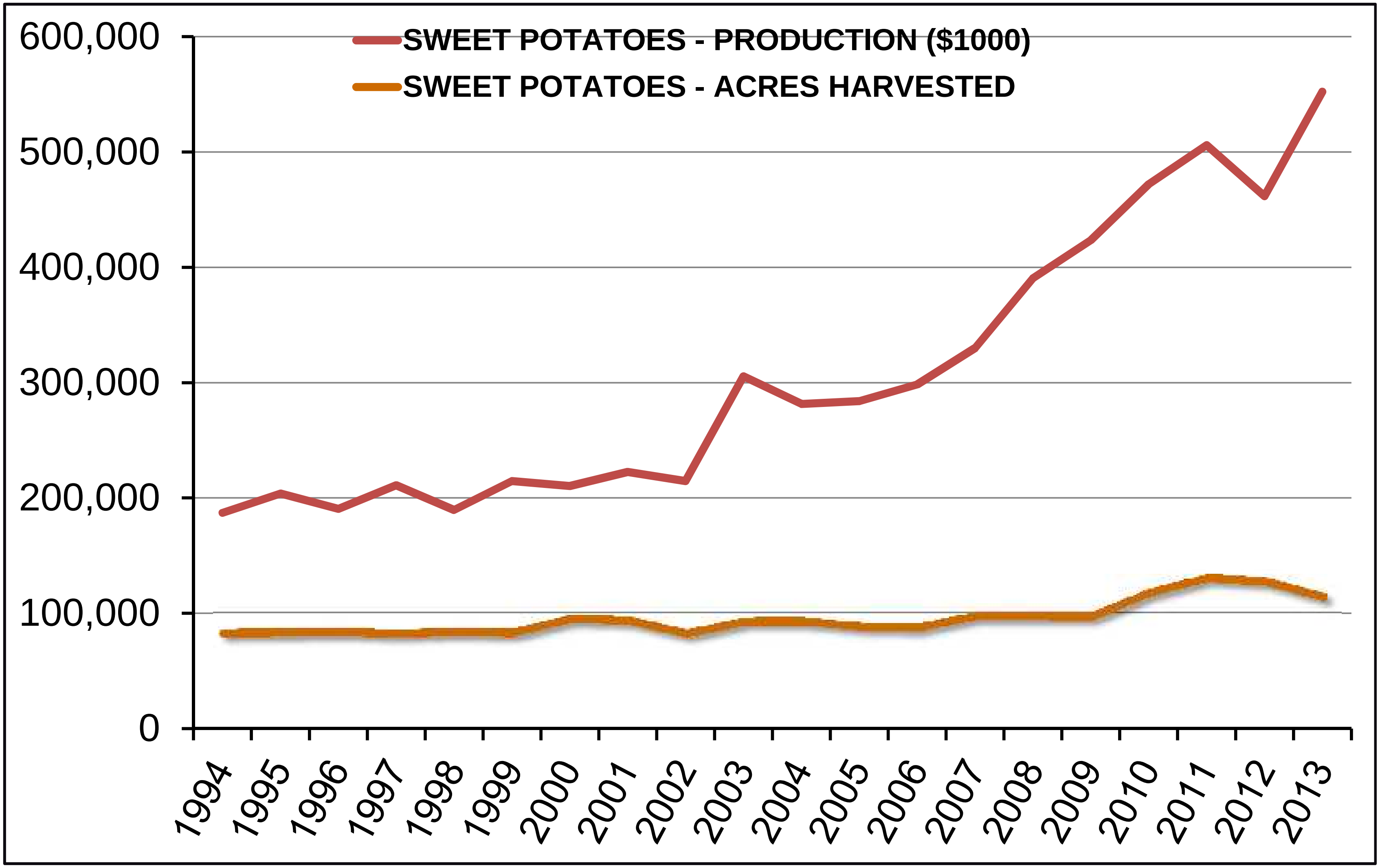
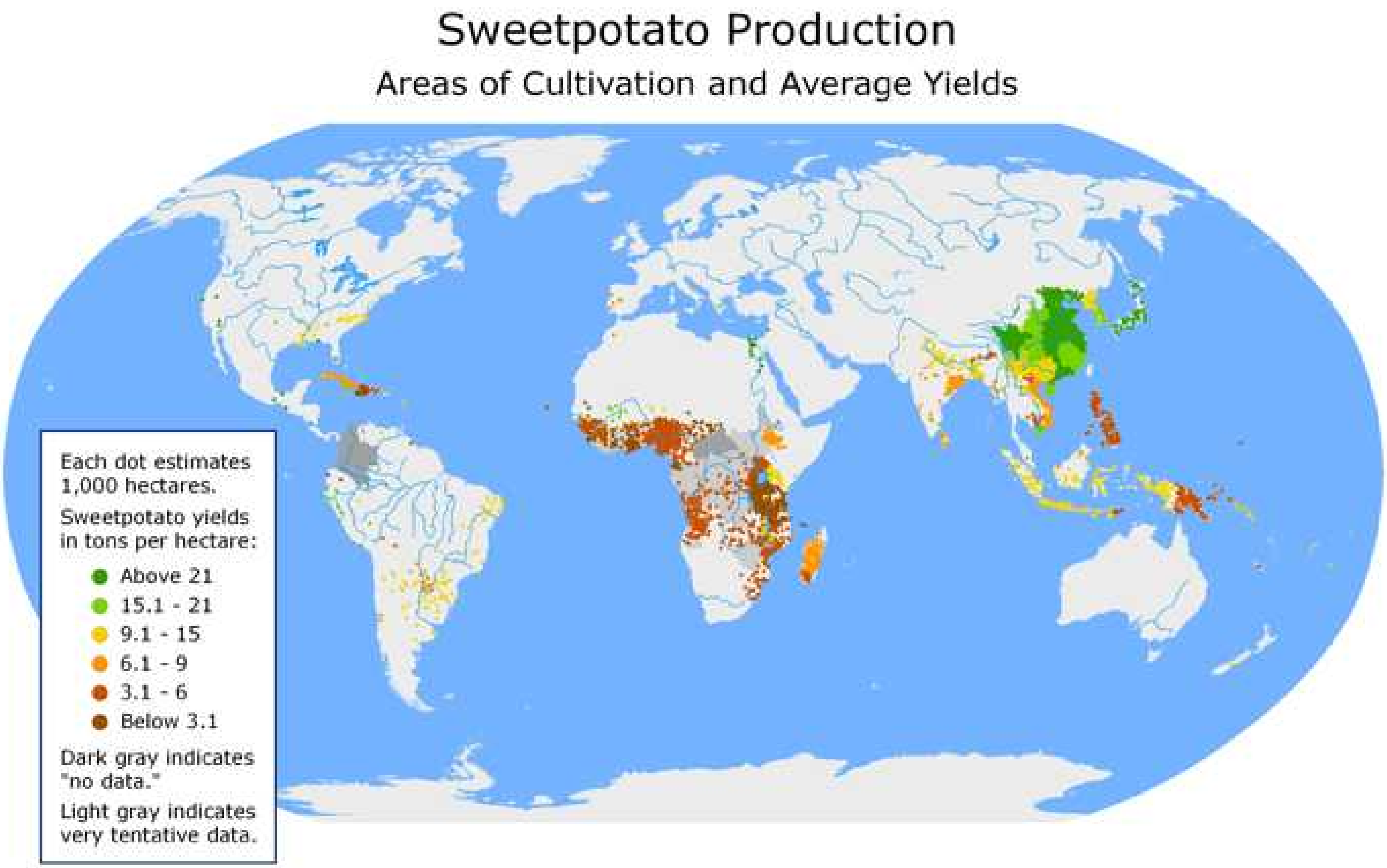
US Sweetpotato Growth

1994 - 2014



Global Sweetpotato Production

(2000 – 2006)



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

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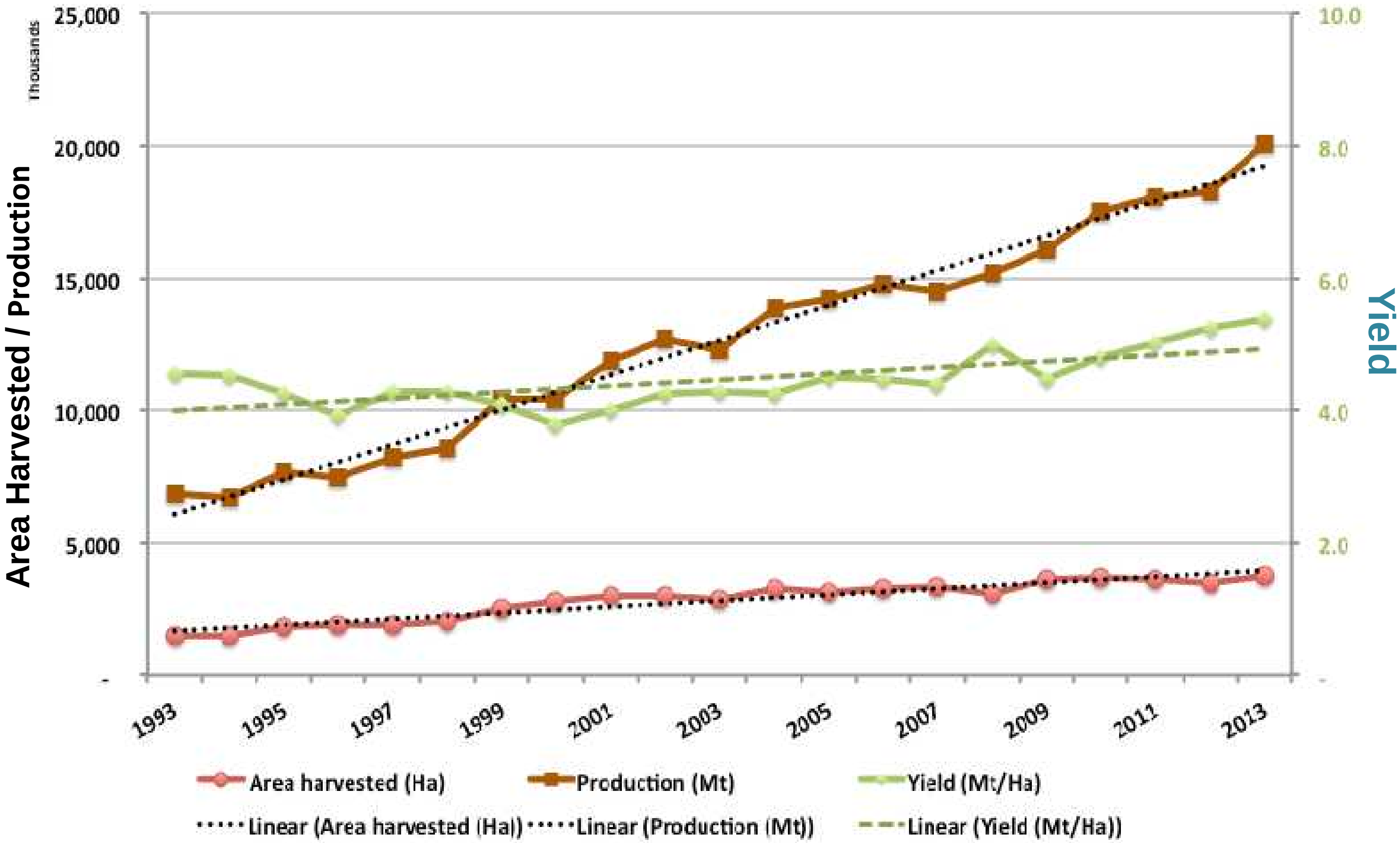
African Sweetpotato Production Trends 1993-2013



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

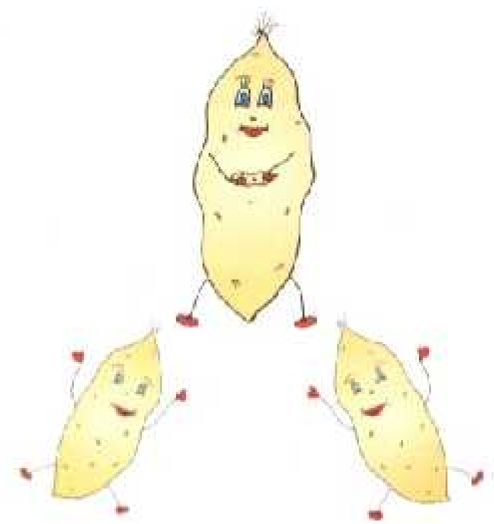
GOAL 2: Redesign sweetpotato breeding systems in Africa to produce varieties in fewer years (3-4) than currently (7-8 years) - “accelerated breeding”

- **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***
  - **In Uganda, distinct populations formed using molecular markers**

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 is becoming 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" and Sweetpotato for Profit and Health Initiative (SPHI) 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.

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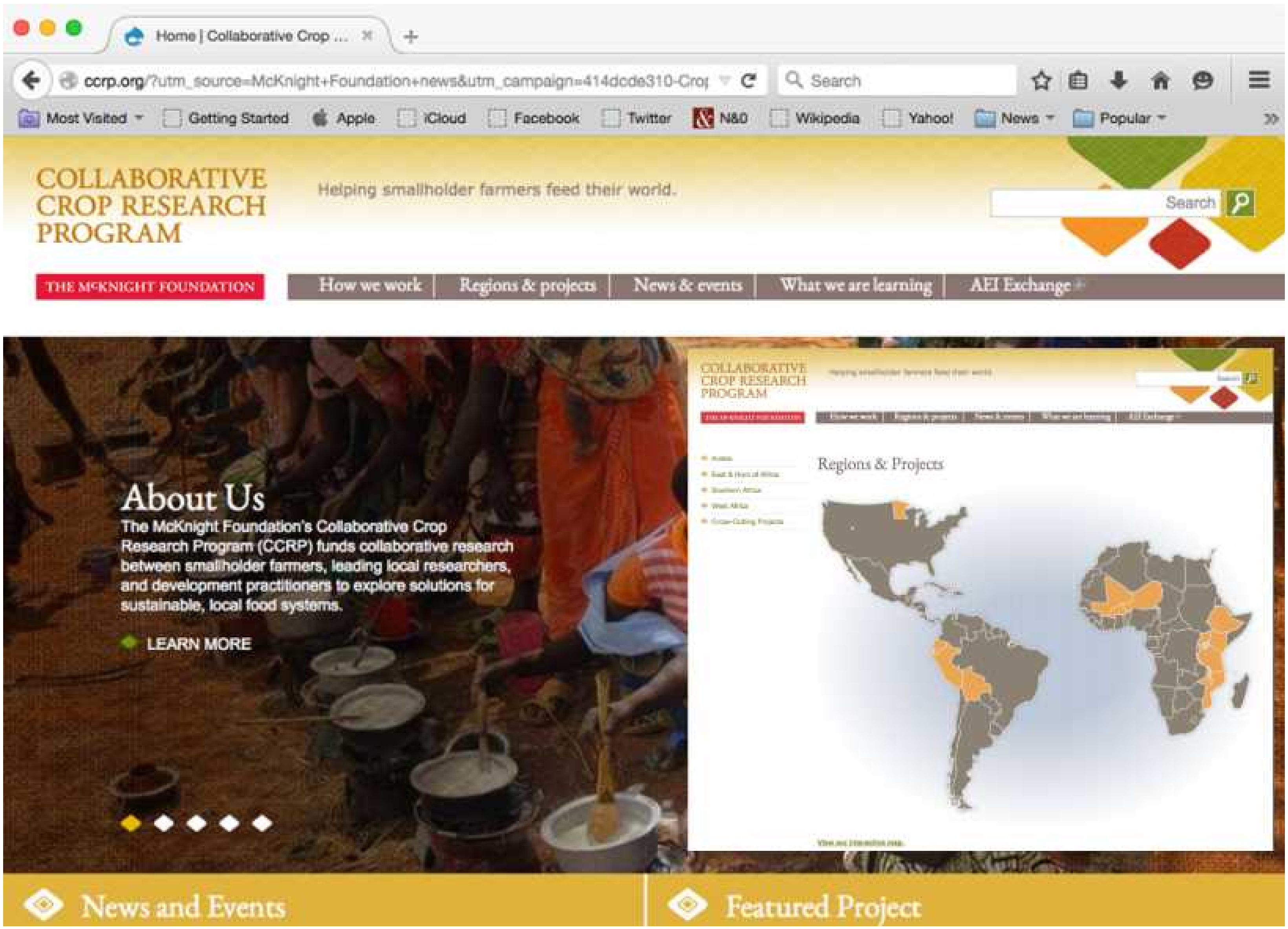
A "Vision" for MAB Breeding in SSA

Breeding pipeline investments should include:

- **Genomic Resources –**
  - A reference genome
  - 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 –**
  - Improved web-based bioinformatic resources
  - New 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

McKnight Foundation
Collaborative Crop Research Program, Est. 1993



McKnight Foundation
Collaborative Crops Research Program

- **Promote crop research partnerships between developing and developed countries**
  - **Developing country partners lead**
  - **Long-term projects - 8-10 years**
  - **Promotes capacity building and increased scientific infrastructure**
- **NARO/NCSU/NRI Partnership (1996 – 2015)**
  - **Development of high yielding, high dry matter, orange-fleshed cultivars with increased resistance to viruses and insects.**
  - **Lead PIs, Drs. Robert Mwanga, Gorrettie Ssemakula, NARO**
    - **Drs. Craig Yencho, NCSU and Phil Stevenson, NRI**

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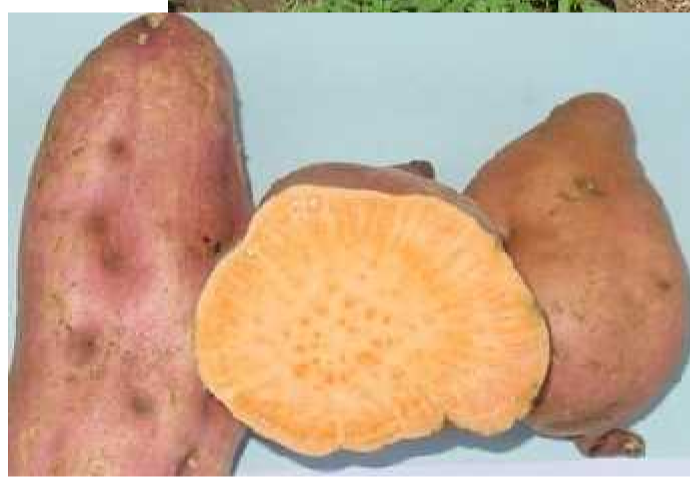
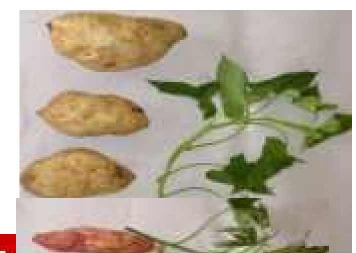
Development of High Yielding Multiple Resistant Sweetpotato Germplasm





Sweetpotato production constraints in Uganda

A

B

C

D

NC State Sub-contract

Sweetpotato Genetic Mapping

Dr. Jim Cervantes, Dr. Benard Yada
Dr. Gorrettie Ssemakula, Dr. Robert Mwanga,
Ken Pecota, Craig Yencho

NaCRRI

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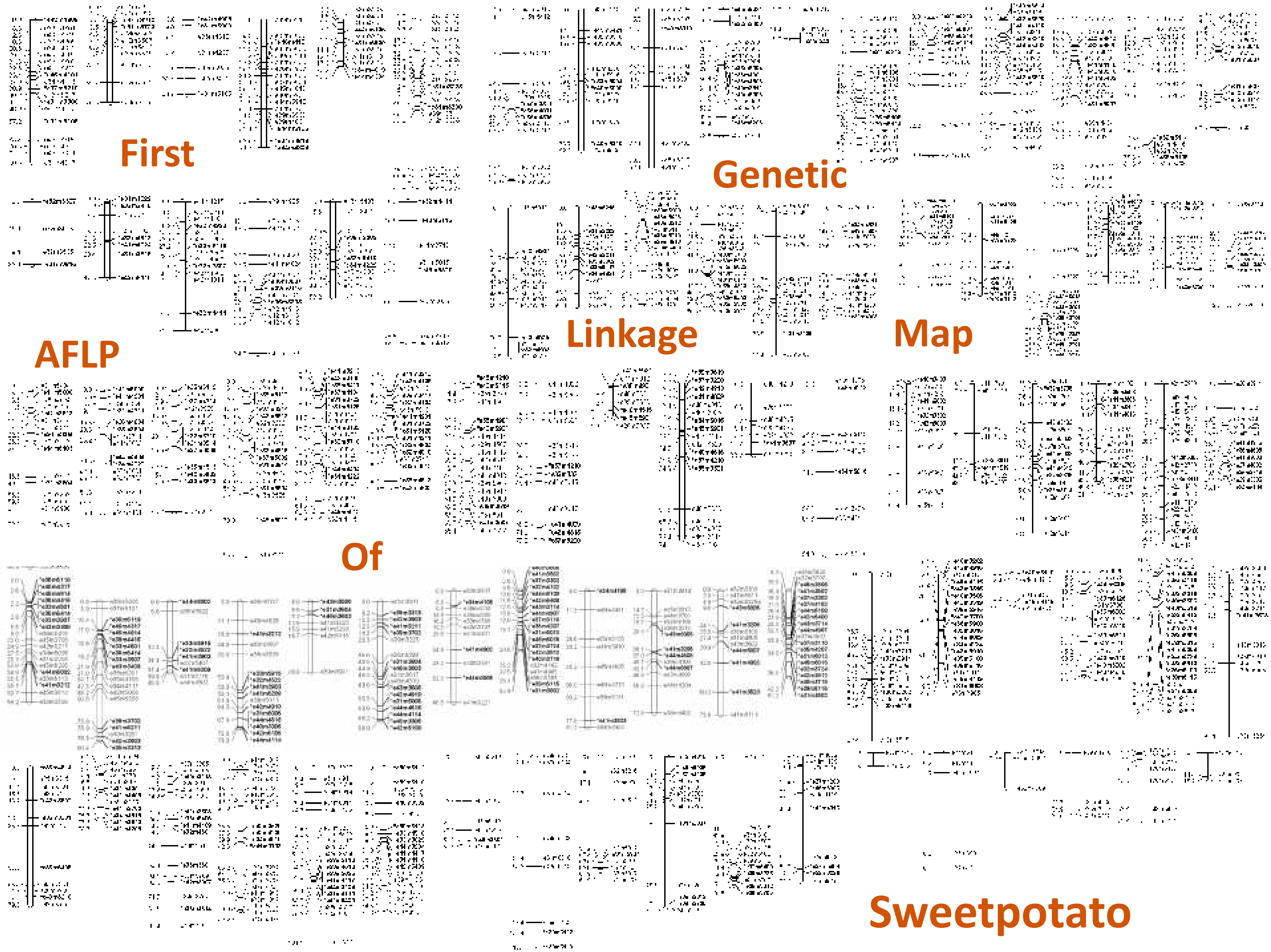
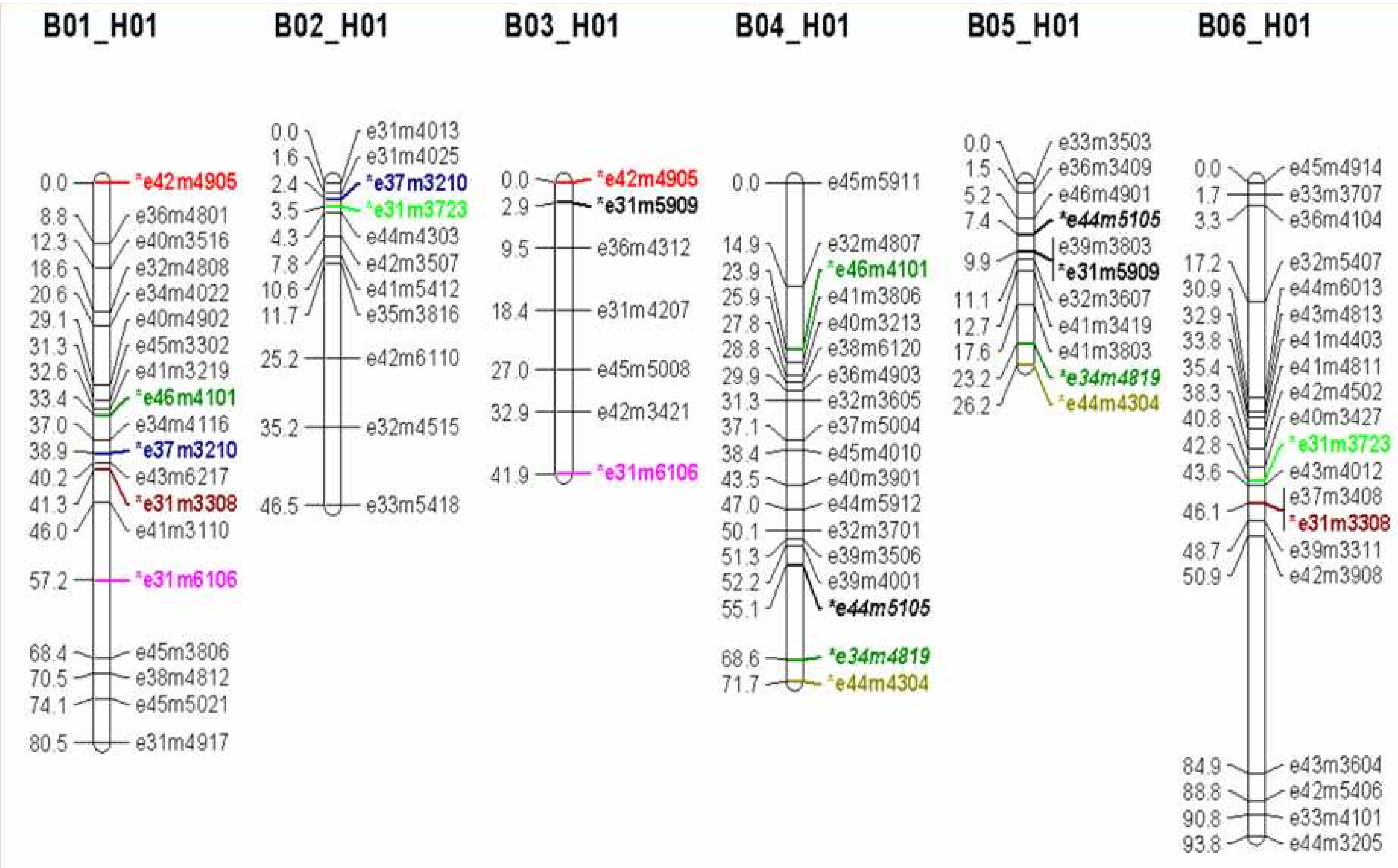
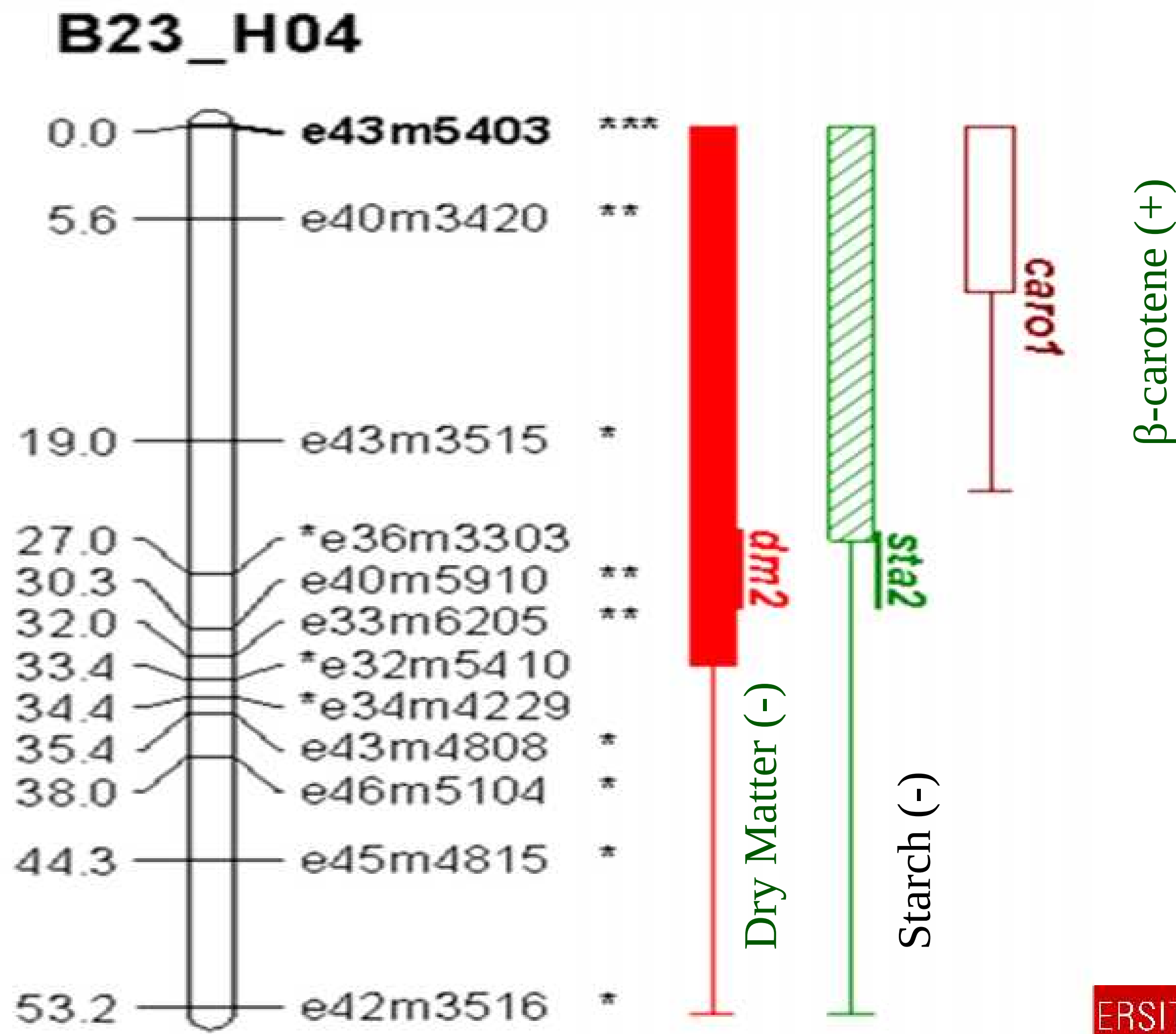
First AFLP Genetic Linkage Map Of Sweetpotato



Linkage groups of ‘Beauregard’





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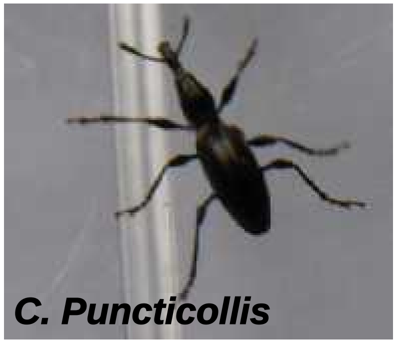
Impact of sweetpotato weevils (SPW) in SSA



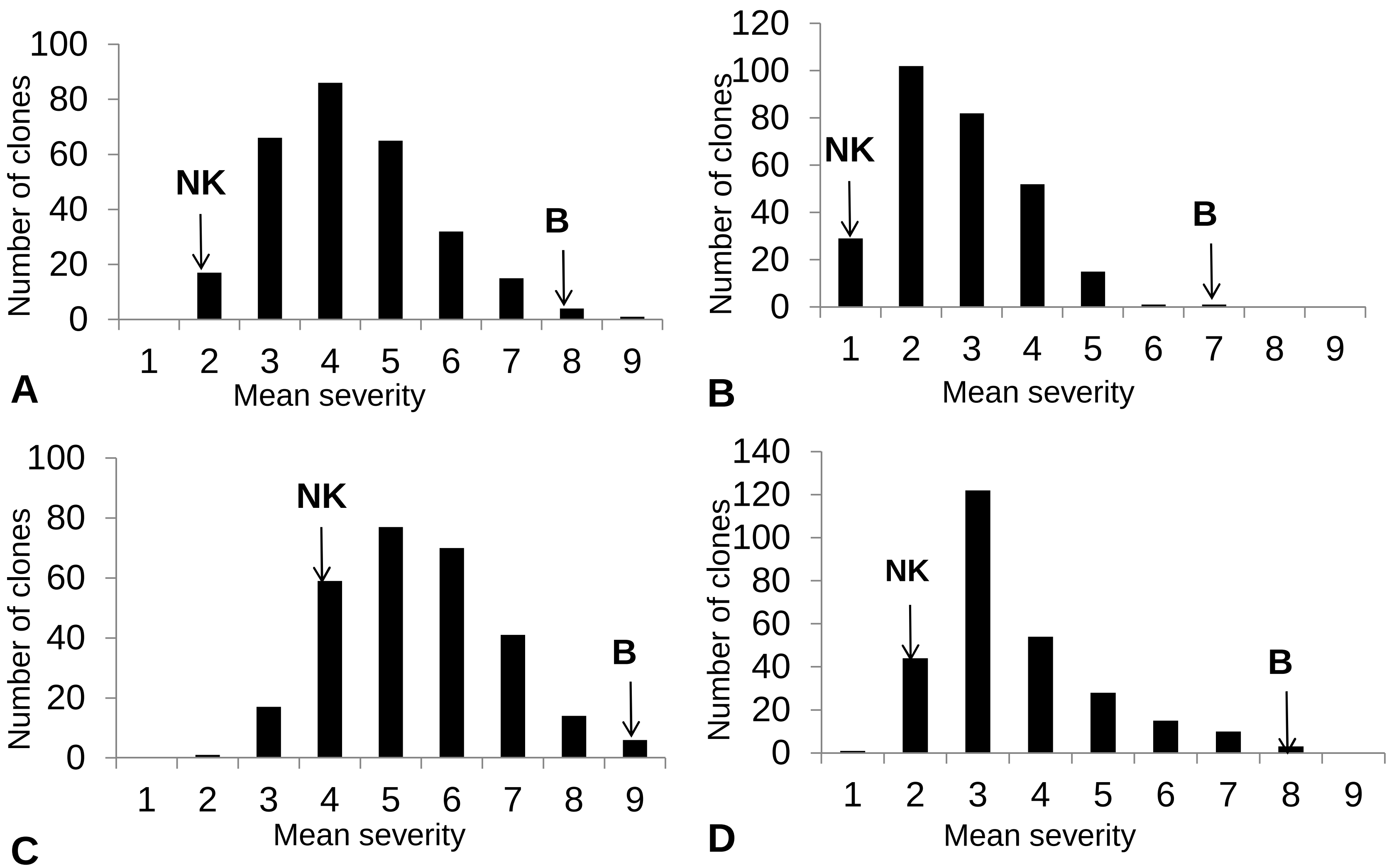
- Yield losses of 67-100%
- Oviposition and feeding
- Pathogenic microbial accumulation
- Sesquiterpenes
- Impeded translocation of phytochemicals
- **Difficult to manage**



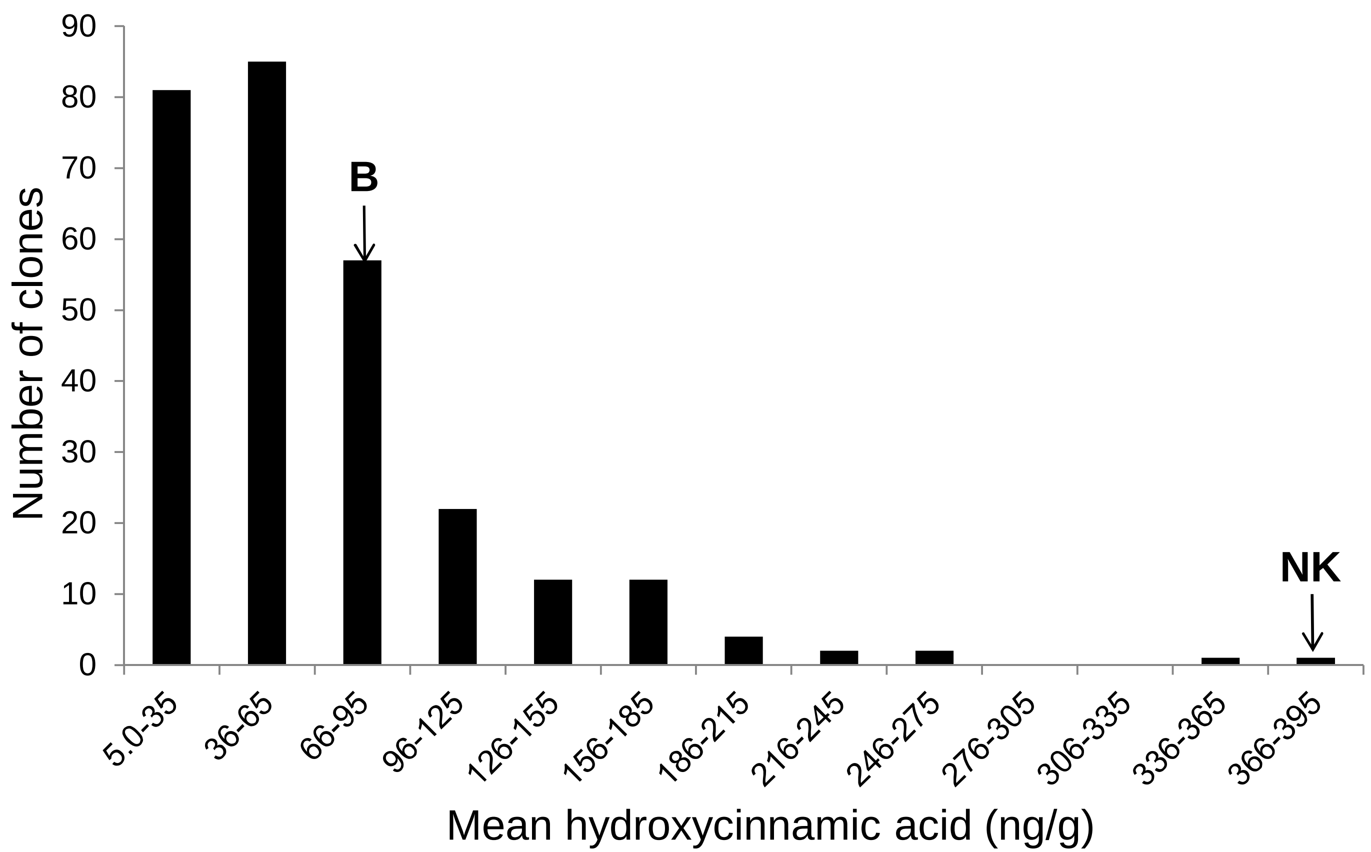
Frequency Distribution of Mean Sweetpotato Weevil Severity

‘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



Distribution of mean storage root hydroxycinnamic acid ester content in the progeny and parents of the ‘New Kawogo’ (NK) x ‘Beauregard’ (B) across sites



- Broad sense heritability $H^2 = 0.49 \pm 0.0471$
- Weak correlation of HCA with field SPW (r=0.103; P=0.015)

Association of SSR marker loci with the best linear unbiased predictions of overall mean across-sites and seasons sweetpotato weevil severity of genotypes

Marker	Total variance (%)	Most significant allele	R^2	ProbF
IBS11	22.3	IBS11NKB253	0.0443	0.032
IbE5		IbE5B218	0.0311	0.033
IbL16		IbL16NK183	0.0446	0.028
IbO5		IbO5NKB181	0.0233	0.038
J116A		J116ANKB210	0.0806	0.000

A Vision for Sweetpotato Improvement in Africa:

Modern Breeding Tools
Increased Potential, Improved Genetic Gain, Reduced Hunger and Poverty

Craig Yencho
NC State University
Bill and Melinda Gates Fdn.
Seattle, WA
June 3-5, 2013

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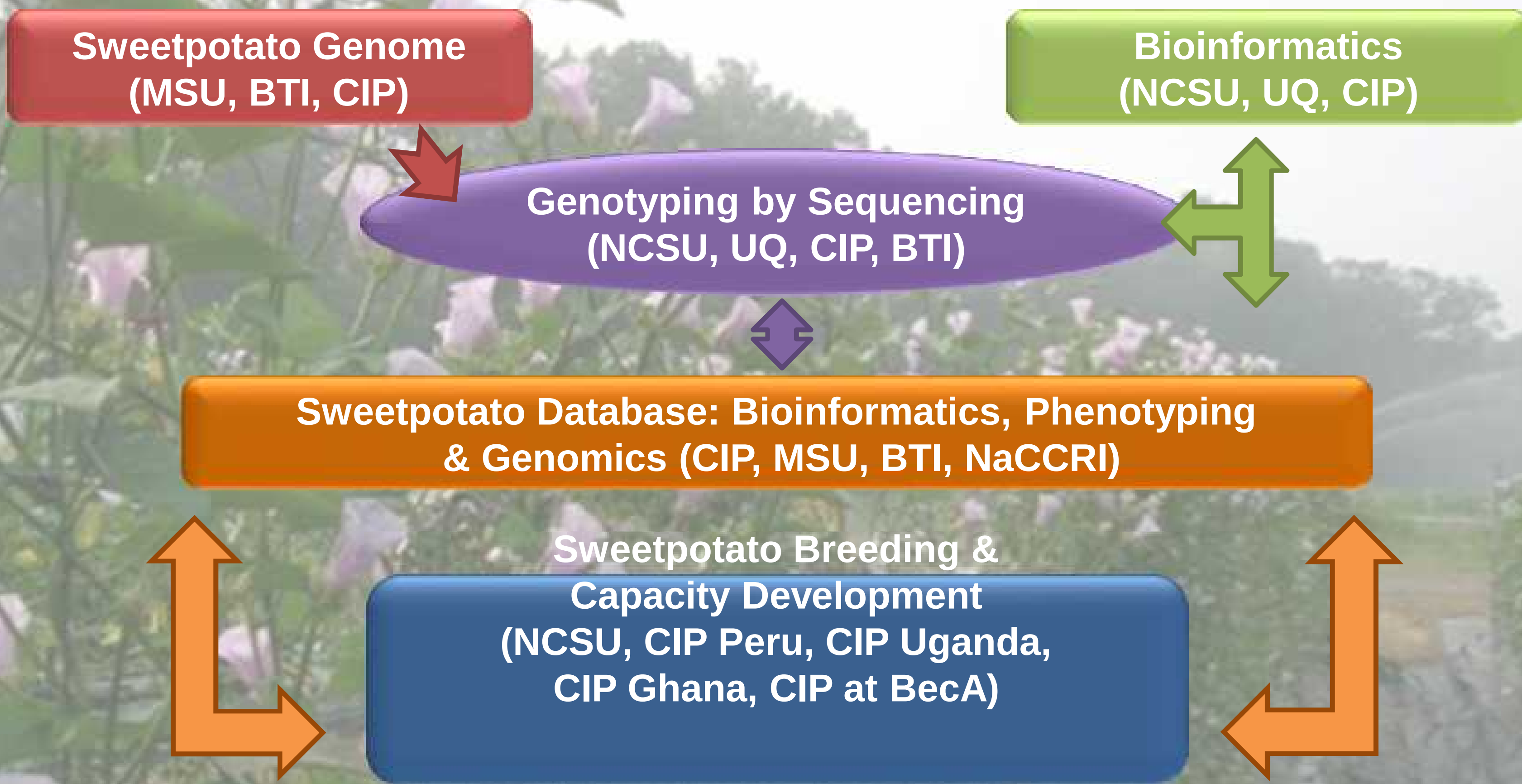
The Genomic Tools for Sweetpotato Improvement Project – GT4SP



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

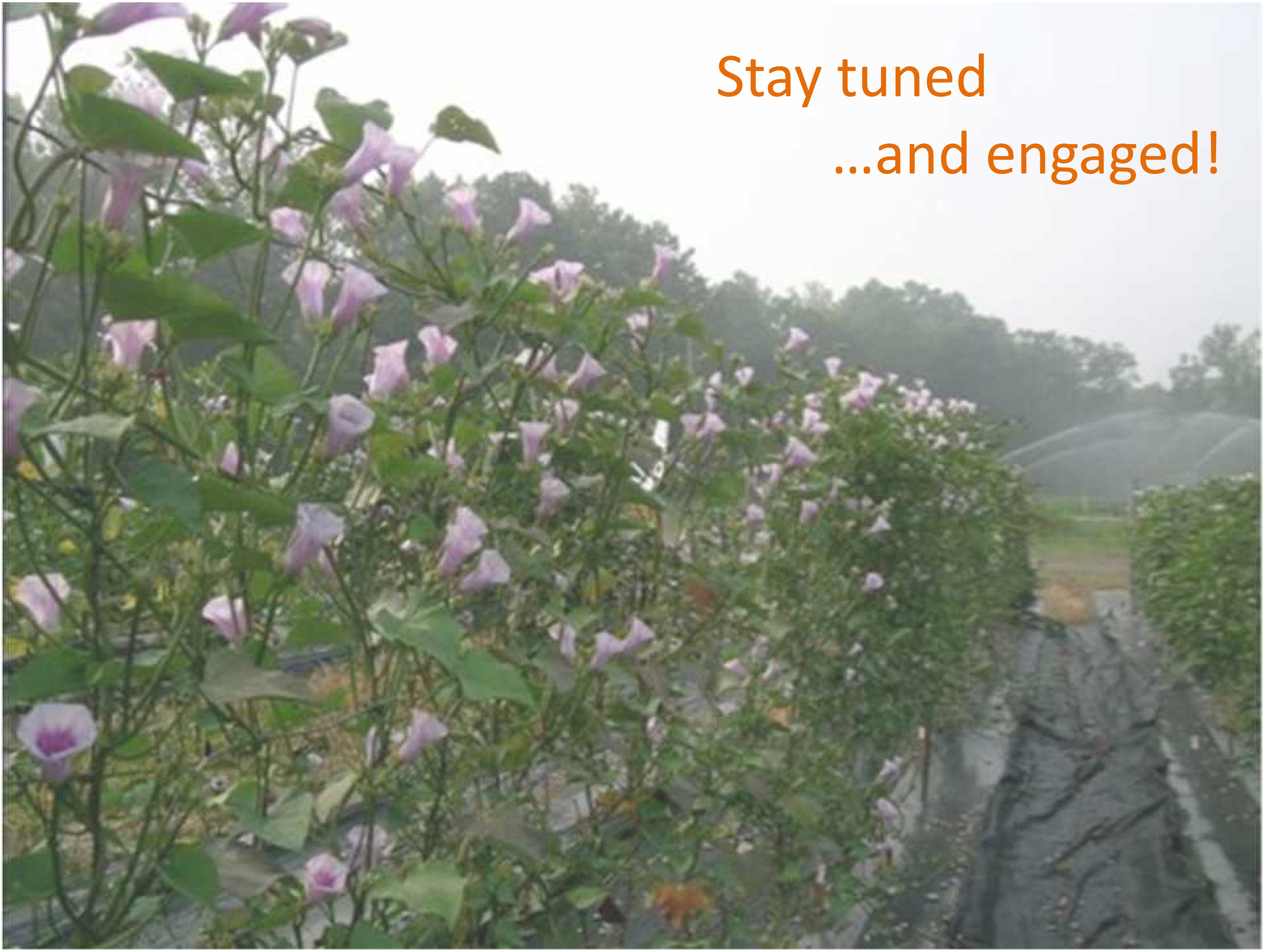
Collaborators: Boyce Thompson Institute at Cornell, Michigan State University, University of Queensland, Australia; The International Potato Center, Peru; BioSciences East and Central Africa, Kenya; National Crops Resources Research Institute, Uganda;

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.

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


Stay tuned
...and engaged!