# **MSU Potato Breeding & Genetics Update**



David S. Douches

Kelly Zarka, Joe Coombs, Dan Zarka, Greg Steere, Matt Zuehlke, Kate Shaw, Jess Norling, Thilani Jayakody, Will Behling, Kaela Panicucci Dept. of Plant, Soil, and Microbial Sciences Michigan State University East Lansing, MI 48824

#### **Breeding and Selection Trials**

Trial	Entries	Remarks
Scab Variety Trial	210	
Scab Early Generation Trial	257	
Scab Diploid Breeding Evaluations	359	
On-Farm Scab Trial and Selection	32 families	5,000 single hills
On-Farm Red selection Trial	25 families	4,000 single hill
Tissue Culture Seed Increase	159	3,000 transplants
MRC Tuber Families	>300	40,000

## **Early Generation Selections and Seed**

Incre	Trial	Entries	Remarks
meree	30-Hill Selections	100	MSGG families
	12-Hill Selections	450	MSHH families (>95% PVYR)
	Single Hill Selections	850	MSII families
	Seed Increase	400	Promising selections
	NFT/GH Tuber Increase	40	Promising selections
	MRCTC Increase	130	Promising selections



### **Breeding for PVY Resistance**

Year	Family	PVYR Selections
Single 12-hill 30-hill	MSII MSHH MSGG	In testing 103 35
	MSFF	24
	MSEE	26
	MSDD	23
	MSCC	9
	MSBB	21



- MSU Germplasm has incorporated PVY Resistance in many market classes
  - Round whites, Red skinned, Yellow flesh, Specialty (pigmented).

#### Common Scab Selections On-Farm

Family Number Evaluated

MSII 25 families ~4500 ScabR pedigree seedlings





#### **Breeding for Scab Resistance**



### **Inoculated Late Blight Disease Trials**

 Foliar disease trials were inoculated with US-23





**RAUDPC Mean** 

# Bonafide (MSV093-1Y)

- McBride x MSP408-14Y
- Excellent yield
- Attractive, round shape
- Scab resistant
- Grower advocate



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## **Specialty Varietie**

- Blackberry
- Raspberry
- Colonial Purple
- Ruby Rose
- Spartan Rec

# **2021 Certified Seed Production at MSU**

#### - 46 Clones, 32,000 Minitubers

Line	Tubers	Remarks
Blackberry (MSZ109-10PP)	2500	
Mackinaw	2300	
Petoskey	2000	
Raspberry	2000	
Spartan Red #2 (Red Marker #2)	1200	
MSAA076-6	600	
MSAA217-3	500	
MSAA260-3	500	
MSBB058-1	500	
MSBB230-1	500	
MSBB238-1RY	500	
MSBB610-13	500	
MSBB626-11	400	
MSV093-1Y	1000	
MSV179-1	1500	

Line	Tubers	Remarks
MSW474-1	1400	
MSZ109-05RR	2200	
MSZ109-07PP	600	
MSZ242-13	500	
MSZ416-8RY	577	
DIA-MSU-UB015	1100	USAID-LB
Diamant	550	USAID-Check
Granola_UI	450	USAID-Check

# Potatoes USA National Chip Processing Trial (NCPT)

 The major goal of NCPT at its inception was to address the needs expressed by regional chip processors and growers to develop a more focused and efficient nationwide chip variety trialing and selection program.



NCSU Mark Clough

## **Specific Objectives**

- 1. Develop a high yield, late storage variety that will chip with good color and store later than Snowden.
- 2. Develop an *early bulking variety* that will be less susceptible to internal heat necrosis than Atlantic (more emphasis on Southern testing).
- 3. Develop scab resistant chip-processing potatoes.

# Key Components of the Coordinated Breeding Effort

- Early stage evaluation of key chip processing traits
- Coordinated national trials
- Sharing of elite parents among programs
- Centralized web-based database of breeder trial results (NCSU, now MediusAg-VDM).
- Centralized labs to put potato lines into tissue culture and remove virus.
- Coordinated scab resistance screening of advanced breeding lines.
- Annual meeting to discuss results and take action
  - Integrate with USPB/SFA SNaC trials

**National Chip Processing Trial 2010-2022**  $\otimes$  $\bigotimes$  $\otimes$  $\otimes$  $\otimes$  $\bigotimes$  $\otimes$  $\otimes$ Cooperating Breeding Programs Testing Location 

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# National testing of early generation selections

- Breeders submit early generation breeding lines for Tier 1 evaluation across all sites
- Data is summarized and breeders select lines for Tier 2 evaluation
- Best Tier 2 lines are considered to Fast Track
- SNaC Trial and Next Gen testing are coordinated with advancing Fast Track material

# **Key Traits of Chip Processing Varieties**

- Yield
- Quality traits
  - Solids
  - Chip color
  - Low defects
  - Shape/appearance
  - Early bulking and/or long term storage
- Scab resistance
- Long-term storage quality
- Internal Heat Necrosis (IHN) resistance
- Breeder merit score summarizes the potential for advancement in NCPT



## **Interpreting NCPT Data: Breeder Merit Score**

- Based upon index of yield, SG, chip quality, tuber shape, flesh color
- Breeder merit scale (1-4)
  - 1 = Outstanding
  - 2 = Keep
  - 3 = Marginal
  - 4 = Drop
- Atlantic and Snowden perform well each year
- Additional assessments by Kathy Haynes and Jeff Endelman

## **NCPT Overall Merit Summary**

- Overall Merit Summary
  - Based on Clone's Merit Score of 1 or 2 (Outstanding and Keep)
- Merit Summaries organized by
  - Tier 1 Overall
  - Tier 1 Fresh Sites
  - Tier 1 Storage Sites
  - Tier 2 Overall
  - Tier 2 Fresh Sites
  - Tier 2 Storage Sites

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**NCPT Overall Merit Summary** 

#### Tier 2, 48 Entries in 2021: Overall Sort

2021 National Chip	-Process	ing Trial (NCPT) Overall N	lerit Ranking Summary fo	or the Replicated (	Tier 2)	Trial												Overall	
									Merit						L	oc Adjuste	ed	Loc	Scab
								l	ocatio	n					Fresh	Storage	Overall	Adj	Severity
Line	Tier	Female	Male	Program	CA	FL	NC	ΤХ	MI	NY	ND	OR	WI	Ν	Count	Count	Count	Merit	(1-5)
NYR107-4	2	NY148	E48-2	CU-NY	2	2	2	2	2	1	2	2	2	9	8	9	17	17.0	3.0
MSAFB635-15	2	NYH15-5	MSS297-3	U-ME	2	2	1	2	2	1	2	1	2	9	7	8	15	15.0	2.3
NYR107-6	2	NY149	E48-3	CU-NY	0	1	1	2	2	2	2	1	2	9	4	9	13	13.0	2.1
MSAFB609-12	2	NY148	MSQ086-3	U-ME	0	2	1	2	1	0	2	2	2	9	5	7	12	12.0	2.8
MSBB222-1	2	Snowden	MSQ086-3	MSU-MI	0	2	1	2	2	1	2	0	2	9	5	7	12	12.0	2.8
NYR107-11	2	NY150	E48-4	CU-NY	0	2	ND	ND	ND	2	ND	ND	ND	3	2	2	4	12.0	ND
Lamoka	2			Check	ND	2	1.5	0.66	2	0	1	1.33	2	8	4	6	10	11.8	3.5
AF6165-9	2	BEACON CHIPPER	AF290-5	U-ME	2	2	1	0	ND	ND	ND	ND	ND	4	5	0	5	11.3	3.4
MSBB058-1	2	NY148	MSR127-2	MSU-MI	2	2	0	1	2	0	2	0	2	9	5	6	11	11.0	2.6
WAF15204-4	2	W5955-1	Nicolet	U-ME	ND	ND	ND	ND	2	2	0	0	2	5	0	6	6	10.8	2.0
MSBB079-2	2	MSS927-1	MSR127-2	MSU-MI	0	1	0	2	2	2	2	0	1	9	3	7	10	10.0	2.1
MSBB230-2	2	NY148	MSQ089-1	MSU-MI	0	2	1	1	0	0	2	2	2	9	4	6	10	10.0	2.8
NYORN41-5	2	A00188-3C	Pallida CPC	OSU-OR	2	1	0	0	2	0	2	1	2	9	3	7	10	10.0	2.4
NYR1-7	2	Andover	Lady Liberty	CU-NY	2	2	1	1	1	1	0	1	1	9	6	4	10	10.0	2.8
W15125-4	2	Atlantic	W10670-3	UW-WI	2	1	1	0	2	0	2	0	2	9	4	6	10	10.0	2.8
W15NYR11-13	2	NY158	NYF31-3	UW-WI	0	2	0	2	2	0	0	2	2	9	4	6	10	10.0	2.8
Snowden	2			Check	2	2	0.66	0	2	0	0	0.66	2	9	5	5	9	9.3	2.1
AF6200-4	2	SEBEC(AF0338-17)	TUNDRA	U-ME	2	2	0	0	2	0	0	1	2	9	4	5	9	9.0	3.0
AF6237-3	2	WAF10131-19	TUNDRA	U-ME	0	2	0	2	ND	ND	ND	ND	ND	4	4	0	4	9.0	2.5
MSAA232-4	2	Lamoka	Manistee	MSU-MI	2	2	0	1	2	0	0	2	0	9	5	4	9	9.0	3.1
MSBB047-1	2	Lamoka	MST096-2Y	MSU-MI	2	1	0	1	0	1	2	0	2	9	4	5	9	9.0	2.3
MSBB610-13	2	NY148	MST096-2Y	MSU-MI	2	1	0	0	2	1	1	0	2	9	3	6	9	9.0	1.8
NYR102-3	2	NY154	E48-2	CU-NY	0	2	ND	ND	ND	ND	ND	ND	ND	2	2	0	2	9.0	ND
MSCC168-1	2	Atlantic	MST424-6	MSU-MI	0	2	1	2	1	1	1	0	0	9	5	3	8	8.0	2.3
NYR3-5	2	Andover	NY154	CU-NY	0	2	1	0	1	0	2	0	2	9	3	5	8	8.0	3
Pike	2			Check	ND	2	0	ND	1.5	0.5	0	0	2	7	2	4	6	7.7	2.4
Atlantic	2			Check	2	2	1	0	1	0	0	0	1	9	5	2	7	7.0	3.6
AF6550-2	2	NDAF102629C-4	AF5040-8	U-ME	2	1	1	1	2	0	0	0	0	9	5	2	7	7.0	2.1
CO12293-1W	2	CO02024-9W	ND7519-1	CSU-CO	0	2	1	0	1	0	1	2	0	9	3	4	7	7.0	3.3
COOR13270-2	2	CO02321-4W	CO02024-9W	OSU-OR	0	2	0	0	1	0	1	1	2	9	2	5	7	7.0	3.8
W14NYQ9-2	2	Eva	NY153	UW-WI	2	2	0	0	1	1	1	0	0	9	4	3	7	7.0	2.7

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									Merit						L	.oc Adjuste	ed	Loc	Scab
								l	ocatio	n					Fresh	Storage	Overall	Adj	Severity
Line	Tier	Female	Male	Program	CA	FL	NC	ТΧ	MI	NY	ND	OR	WI	Ν	Count	Count	Count	Merit	(1-5)
NYR107-11	2	NY150	E48-4	CU-NY	0	2	ND	ND	ND	2	ND	ND	ND	1	2	2	4	10.0	ND
NYR107-4	2	NY148	E48-2	CU-NY	2	2	2	2	2	1	2	2	2	5	8	9	17	9.0	3.0
NYR107-6	2	NY149	E48-3	CU-NY	0	1	1	2	2	2	2	1	2	5	4	9	13	9.0	2.1
MSAFB635-15	2	NYH15-5	MSS297-3	U-ME	2	2	1	2	2	1	2	1	2	5	7	8	15	8.0	2.3
MSAFB609-12	2	NY148	MSQ086-3	U-ME	0	2	1	2	1	0	2	2	2	5	5	7	12	7.0	2.8
MSBB222-1	2	Snowden	MSQ086-3	MSU-MI	0	2	1	2	2	1	2	0	2	5	5	7	12	7.0	2.8
MSBB079-2	2	MSS927-1	MSR127-2	MSU-MI	0	1	0	2	2	2	2	0	1	5	3	7	10	7.0	2.1
NYORN41-5	2	A00188-3C	Pallida CPC	OSU-OR	2	1	0	0	2	0	2	1	2	5	3	7	10	7.0	2.4
Lamoka	2			Check	ND	2	1.5	0.66	2	0	1	1.33	2	5	4	6	10	6.3	3.5
MSBB058-1	2	NY148	MSR127-2	MSU-MI	2	2	0	1	2	0	2	0	2	5	5	6	11	6.0	2.6
MSBB230-2	2	NY148	MSQ089-1	MSU-MI	0	2	1	1	0	0	2	2	2	5	4	6	10	6.0	2.8
W15125-4	2	Atlantic	W10670-3	UW-WI	2	1	1	0	2	0	2	0	2	5	4	6	10	6.0	2.8
W15NYR11-13	2	NY158	NYF31-3	UW-WI	0	2	0	2	2	0	0	2	2	5	4	6	10	6.0	2.8
MSBB610-13	2	NY148	MST096-2Y	MSU-MI	2	1	0	0	2	1	1	0	2	5	3	6	9	6.0	1.8
WAF15204-4	2	W5955-1	Nicolet	U-ME	ND	ND	ND	ND	2	2	0	0	2	5	0	6	6	6.0	2.0
AF6200-4	2	SEBEC(AF0338-17)	TUNDRA	U-ME	2	2	0	0	2	0	0	1	2	5	4	5	9	5.0	3.0
MSBB047-1	2	Lamoka	MST096-2Y	MSU-MI	2	1	0	1	0	1	2	0	2	5	4	5	9	5.0	2.3
NYR3-5	2	Andover	NY154	CU-NY	0	2	1	0	1	0	2	0	2	5	3	5	8	5.0	3
COOR13270-2	2	CO02321-4W	CO02024-9W	OSU-OR	0	2	0	0	1	0	1	1	2	5	2	5	7	5.0	3.8
MSAA076-6	2	MSR127-2	MSS297-3	MSU-MI	0	1	0	0	2	1	0	0	2	5	1	5	6	5.0	2.6
W15NYR11-8	2	NY158	NYF31-3	UW-WI	0	1	0	0	2	1	0	0	2	5	1	5	6	5.0	3.6
Snowden	2			Check	2	2	0.66	0	2	0	0	0.66	2	5	5	5	9	4.7	2.1
NYR1-7	2	Andover	Lady Liberty	CU-NY	2	2	1	1	1	1	0	1	1	5	6	4	10	4.0	2.8
MSAA232-4	2	Lamoka	Manistee	MSU-MI	2	2	0	1	2	0	0	2	0	5	5	4	9	4.0	3.1
Pike	2			Check	ND	2	0	ND	1.5	0.5	0	0	2	5	2	4	6	4.0	2.4
CO12293-1W	2	CO02024-9W	ND7519-1	CSU-CO	0	2	1	0	1	0	1	2	0	5	3	4	7	4.0	3.3
MSBB018-1	2	Dakota Diamond	MSR169-8Y	MSU-MI	0	2	0	0	0	0	1	1	2	5	2	4	6	4.0	ND
W15200-3	2	Hodag	Lamoka	UW-WI	0	2	0	0	2	0	0	0	2	5	2	4	6	4.0	2.5
MSCC168-1	2	Atlantic	MST424-6	MSU-MI	0	2	1	2	1	1	1	0	0	5	5	3	8	3.0	2.3
W14NYQ9-2	2	Eva	NY153	UW-WI	2	2	0	0	1	1	1	0	0	5	4	3	7	3.0	2.7
AOR13124-6	2	MSR061-1	A03440-2C	OSU-OR	2	1	0	0	0	0	0	2	1	5	3	3	6	3.0	2.2
NDTX1482YB-1W	2	Eva	Missaukee	TAMU-TX	0	0	1	2	0	1	1	1	0	5	3	3	6	3.0	3.3

# Variety Data Management Managed and Hosted by Medius Ag, Brad Halladay

- https://potatoesusa.mediusag.conmedius.g
- National Chip Processing Trials
- SNaC Chip Trials
- NexGen Trials



## **Key Points of Progress**

- Since the inception of the trial in 2010, almost 1,000 different potato entries, including reference varieties, have been evaluated.
- The data for all the lines tested are summarized on searchable, centralized databases housed at NCSU and now MediusAg VDM.
- More than 40 promising new breeding lines from the trials have been fast-tracked for larger-scale commercial trials and processor evaluation
  - High risk/reward strategy
- Nine varieties named and commercialized

### Comments

- Some Northern selections show promise in Southern locations.
  - Adding <u>Early Generation Southern Selection</u> in 2017 to feed NCPT
- Promising lines are being fed into the National SNaC and NexGen trials
- Leveraging USDA grants and State funding to accomplish goals
- Leveraging genome-wide SNP markers to map traits and clarify pedigree relationships

#### **Climate Resilient Potatoes**

- What are the effects of increased temperatures and reduced water on potato productivity?
- Heat Stress Study
- Water Stress Study



Statistically significant temperature trends (p=0.05) for the month of February, over the period 1895-2016.

#### **Potato Heat Stress Greenhouse**





#### **Potato Water Stress Structure**



## **PRI Studies at Montcalm Research Center**

- Four Heat Stress Treatments (Timing)
  - Control No Heat
  - Heat 1 Early-tuber bulking
  - Heat 2 Early-Mid-tuber bulking
  - Heat 3 Late-Mid-tuber bulking
  - Heat 4 Late-tuber bulking
- Two potato varieties
  - Mackinaw
  - Snowden
- RCBD, 3 replications of 3-row blocks, 20 ft plots
- Planted 5/18/21, Harvested 10/28/21, 168 Days

# **PRI Studies at Montcalm Research Center**

- Water Stress Treatments
  - Control No Reduction
  - Water Stress Treatment 50% Reduction of Water (Rain, irrigation)
- Four potato varieties
  - Mackinaw
  - Manistee
  - Lamoka
  - Snowden
- RCBD, 3 replications of 3-row blocks, 20 ft plots
- Planted 5/18/21, Harvested 10/28/21, 168 Days

#### **Breeding Potatoes for Climate Resilience**



#### **Agronomic Yield and Grading Data**

#### ANOVA p-values

			Prob > F													
Trial	Source	DF	TOTAL cwt/a	US#1 cwt/a	Specific Gravity	US#1 %	В %	Α%	A1 %	A2 %	OV %	PO %	HH %	VD %	IBS %	BC %
Heat Stress	Treatment	4	0.008	0.049	0.000	0.922	0.895	0.922	0.384	0.397	NA	0.626	0.023	0.408	NA	0.539
Heat Stress	Line	1	0.558	0.700	0.002	0.849	0.656	0.849	0.437	0.439	NA	0.459	0.010	0.003	NA	0.195
Heat Stress	Line*Treatment	4	0.745	0.595	0.505	0.152	0.182	0.152	0.374	0.575	NA	0.278	0.023	0.579	NA	0.539
Water Stress	Treatment	1	0.230	0.168	0.893	0.289	0.369	0.289	0.019	0.153	NA	0.568	0.385	0.630	NA	0.646
Water Stress	Line	3	0.062	0.032	0.003	0.011	0.091	0.011	0.026	0.003	NA	0.032	0.014	0.001	NA	0.162
Water Stress	Line*Treatment	3	0.194	0.138	0.484	0.397	0.541	0.397	0.206	0.618	NA	0.785	0.269	0.805	NA	0.885

#### **Heat Stress Yield Effects**



Means within each effect with the same letter are not significantly different as determined by Tukey's HSD or Student's t-test (alpha = 0.05).

#### **Heat Stress Specific Gravity Effects**



Means within each effect with the same letter are not significantly different as determined by Tukey's HSD or Student's t-test (alpha = 0.05).

#### **Water Stress Yield Effects**



Means within each effect with the same letter are not significantly different as determined by Tukey's HSD or Student's t-test (alpha = 0.05).

#### Dihaploids Extracted from Cultivated Potato at MSU (Past 8 Years)

- <u>Dihaploidization</u> is a critical genetic sieve to remove deleterious alleles carried in tetraploid parents
- Dihaploids from 40 tetraploid varieties and breeding lines
- Over 500 dihaploid selections in the breeding pool







ATL.M.198

ATL.M.188

ATL.M.120

- Key traits:
  - Chip-processing
  - Specific gravity
  - Scab resistance
  - PVY resistance
  - PLRV resistance
  - PVX resistance
  - Late blight resistance
  - Golden nematode resistance



Atlantic 4x control

#### Backcross Breeding to Introgress Self-compatibility (SC) into *Solanum tuberosum* Dihaploids (cultivated

germplasm poo



SC Donor



SC F<sub>1</sub>





SC F<sub>1</sub>BC<sub>1</sub>





SC F<sub>1</sub>BC<sub>4</sub> Lines

Selfing

# MSU Diploid Advanced Selections Agronomic Trial

700



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**MSU Diploid Advanced Selections Multi-Site Agronomic Trial** 



Line ordered by Total Yield cwt/a (descending)

# **Diploid BC clones**

#### Total Yield (kg)



Total Yield (kg), 10 plant plots



Diploid GWAS trial harvest 2021

https://youtu.be/p1\_xLXA2pIM

# Transferring beetle resistance into cultivated



Atlantic

(S check)

#### Introducing host plant resistance into cultivated



Montcalm Research Center 2020

USDA8380-1 (R check)

#### Introgression of VER x EBN1 hybrids into MSU cultivated diploids • VER x EBN1 hybrids exhibit low

- VER x EBN1 hybrids exhibit low fertility initially. Normal fertility is restored after crossing to cultivated diploids.
- The use of S. verrucosum bridge crosses provides direct access







MSII1827-1 ((VER x CPH) x USW4)

MSII1828-2

MSII1827-1

#### Silencing of the Vacuolar Invertase in MSU potato lines and Kalkaska (Can we fix sugar problem in Obtained construct from UW-Maclison (Dr. Jiming Jiang)

- Proof of Concept Variety: MSE149-5Y (MSU potato breeding program) easy to transform via Agrobacterium
- Target Variety: Kalkaska (MSU potato breeding program)

difficult to transform via

Agrobacterium



Kalkaska (MSJ036-A)

## **Agronomic Yield Trials**

	Yield (	cwt/a)	Pe	Percent By Weight (%)					Quality (%)					
Line	US#1	Total	US#1	Bs	As	OV	PO	SPGR	HH	VD	IBS	BC		
Kal.91.03	290	382	75	25	75	0	0	1.082	0	10	0	0	2016	
Kalkaska	365	438	83	17	83	0	0	1.080	5	5	0	0	2016	
Kal.91.03	335	399	84	16	84	0	0	1.083	0	3	0	0	2017	
Kalkaska	348	401	86	13	86	1	0	1.087	0	5	0	0	2017	
Kal.91.03	313	390	79	20	79	0	0	1.082	0	7	0	0	Mean	
Kalkaska	356	420	85	15	85	0	0	1.084	3	5	0	0	Mean	

2019 – Block trial at MRC, Samples in MPIC Demonstration Storage and MSU Campus Storage



Kal.91.03

Kalkaska Cr

## **Conclusions and Future Opportunities**

- Kal91.03 event has excellent long term cold storage potential
- Silencing vacuolar acid invertase in Kalkaska corrected the sugar accumulation in storage
- Agronomic performance comparable in replicated trials in Michigan
- Segregating progeny carrying silencing construct suggests breeding potential of the silencing events
- Candidate for commercial deregulation through USDA/APHIS

#### XERICO Drought Tolerance Technology for Potato A trait for climate change

- Transformations using the XERICO gene coupled with drought inducible promoter in a commercially important potato variety
- Greenhouse studies to verify function
- Field trials to assess agronomic traits



# 2019-21 XERICO Field Trials

at MSU

- Test trait in potato in situ
- No yield penalty
- Increase in starch content



#### **Tetraploid potato tuber protein screen**



ADC Trial Controls								
Potato Variety	Average Protein Content (mg protein/ 100g FW)							
Petoskey	845.32							
Manistee	796.84							
Lamoka	768.35							
Atlantic	760.64							
Mackinaw	704.41							
Snowden	650.12							

#### **Diploid potato tuber protein screen**



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#### PotatoesUSA





#### **MSU Potato Breeding and Genetics Program**

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Kate Shaw	Azamat Sardarbekov	Norma Manrique
Kelly Zarka	Chen Zhang	Paul Collins
Matt Zuehlke	Emily Pawa	Sarah Lee
Monica Hufnagel	Felix Enciso	Susan Otieno
Sylvia Morse	Maher Alsahlany	Swathi Nadakuduti
Thilani Jayakody	Natalie Kaiser	
Will Behling	Nick Garrity	



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