Diploid Potato Breeding to Boost Potato Variety Enhancement Efforts in Maine

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20210121 REPORT

Diploid Potato Breeding

"Creating a new paradigm for potato breeding based on true seed"

USDA NIFA SCRI grant (2019-51181-30021)

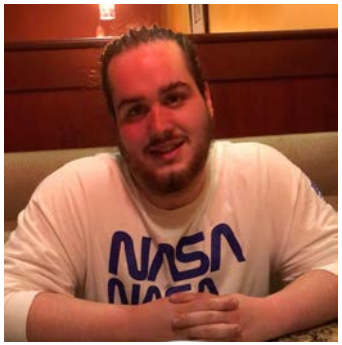
- ✓ More effective potato breeding
- ✓ Opportunities to improve existing varieties
- ✓ Increased flexibility for seed
- ✓ Rapid multiplication of new varieties

Converting potato to a diploid crop is an audacious undertaking

…but the potential payoffs are huge

Femi Alaba
(PhD Student)

Ben Moore
(Undergrad)



Lucas Heroux
(Undergrad)

Diana Spencer
(MS student)

Haploid Induction in Potato

Solanum tuberosum
(2*n* = 4*x* = 48)

X

“Haploid Inducer”

‘Phureja’
Solanum tuberosum
Group Andigena
(2*n* = 2*x* = 24)

(Hougas & Peloquin, *Nature* 1957;
Uijtewaal et al., *TAG* 1987)

Solanum tuberosum
Maternal Dihaploids
(2*n* = 2*x* = 24)

IVP35
IVP48
IVP101
PL-4

2019 Crosses



Cross	Female parent	HI parent	Dead seeds (%)	Spotted seeds (%)	Non-spotted seeds (%)
ME02	Atlantic	IVP48	5894 (46.4)	5249 (10.9)	1392 (42.7)
ME04	NY121	IVP48	2045 (74.6)	419 (15.3)	276 (10.1)
ME03	Caribou Russet	IVP48	2691 (50.8)	1670 (31.5)	933 (17.6)

Proposed Work

- Sorting TPS for dead, spotted, non-spotted
- *In vitro* germination of non-spotted TPS
- Grow *in vitro* cuttings in soil
- Leaf peel to count chloroplasts in guard cells to estimate ploidy
- Isolate DNA for whole genome sequencing
- Determine pollen viability
- Selfing to identify self-compatible primary dihaploids
- Phenotype tuber physiology and morphology
- Input data in Field Book

excellenceinbreeding.org

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2020 Report Summary

A number of limitations put in place to due to COVID-19 restrictions, but we still were able to perform all critical experiments.

1. Proposed 2020 crosses to Castle Russet, Saginaw Chipper, Dakota Trailblazer, Lamoka and NY121 were made successfully.
   - True potato seeds for 2020 crosses were extracted, counted, germinated in tissue culture for ploidy determination.
2. DNA extraction and genotyping of primary DH using the Potato v4 Infinium Array performed.
3. Primary DH from 2019 crosses were grown in soil for tuber evaluations.
   - 31 DH from ME02, 51 DH from ME03 and 82 DH from ME04 were grown and evaluated in the greenhouse. Of these, 116 set tubers (75.8%).
   - *Flowering evaluations were not performed due to limitations*
4. Field evaluations of primary DH from 2019 were performed at Aroostook Research Farms.
   - Total of 100 primary DH from cuttings were planted in the field during the heat wave. Of these, 55 (55%) survived and produced tubers.

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2020 Crosses

S/n	Female Parents (4x)	Male Parent (2x)	No. Plants	No. Pollinations	No. Berries	Seed Set (%)	Average Berries/Plant
1.	NY121	IVP48	5	405	279	68.8	56
2.	Castle Russet	IVP48	6	~1000	762	76.2	127
3.	Lamoka	IVP48	5	357	332	92.9	66
4.	Saginaw Chipper	IVP48	6	~1000	564	56.4	94
5.	Payette Russet	IVP48	6	~300	26	8.6	4
6.	Dakota Trailblazer	IVP48	6	~400	70	17.5	11
	Total		**34**	**~3462**	**2033**		

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2020 Crosses

Cross	Female parent	HI parent	Dead seeds (%)	Spotted seeds (%)	Non-spotted seeds (%)
ME05	Castle Russet	IVP48	62.77	27.36	9.88
ME06	Saginaw Chipper	IVP48	59.14	15.86	25.00
ME07	Dakota Trailblazer	IVP48	40.03	2.77	57.19
ME08	Lamoka	IVP48	50.99	7.84	41.18
ME09	NY121	IVP48	76.06	10.77	13.17

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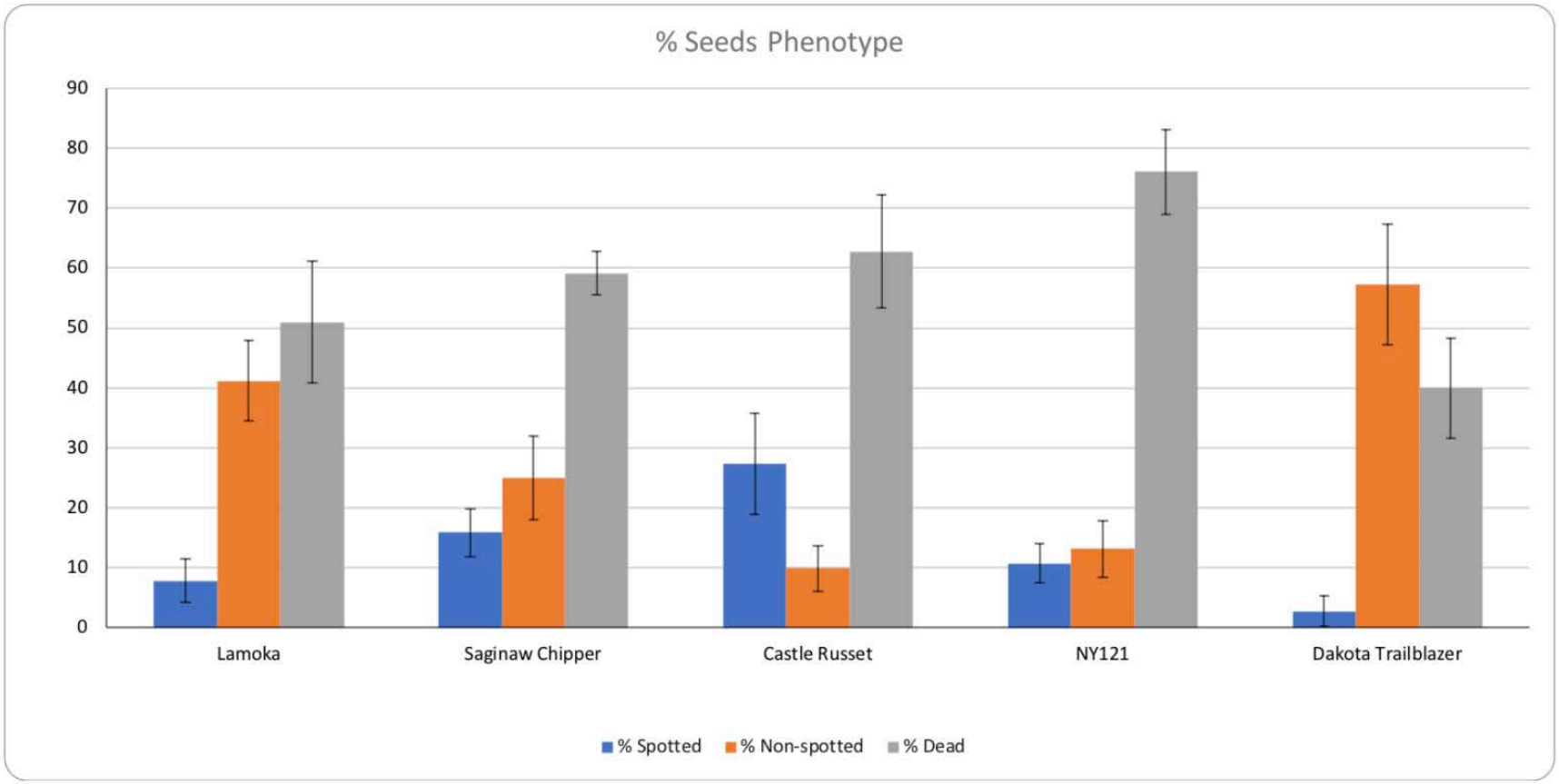
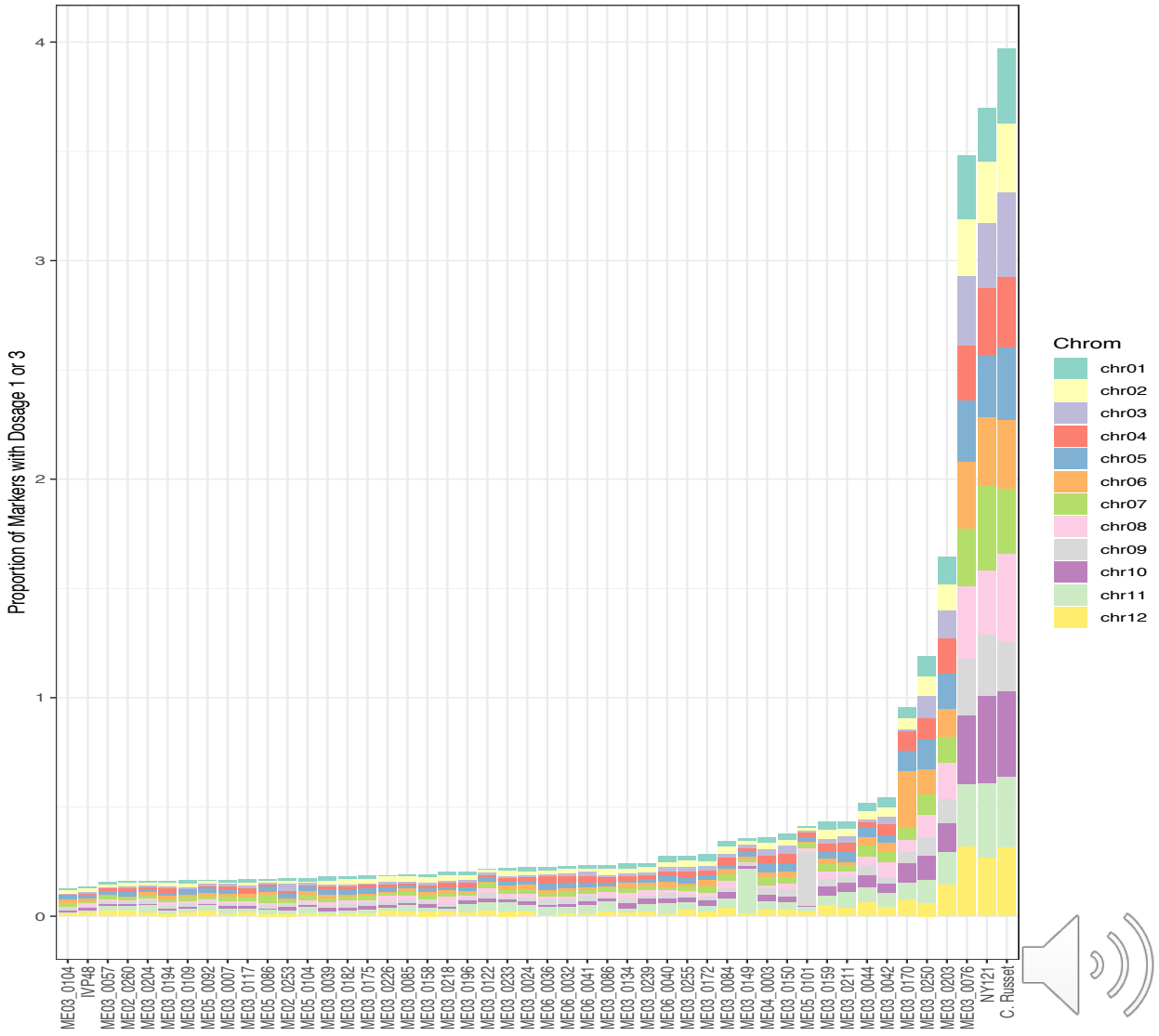
2020 Crosses



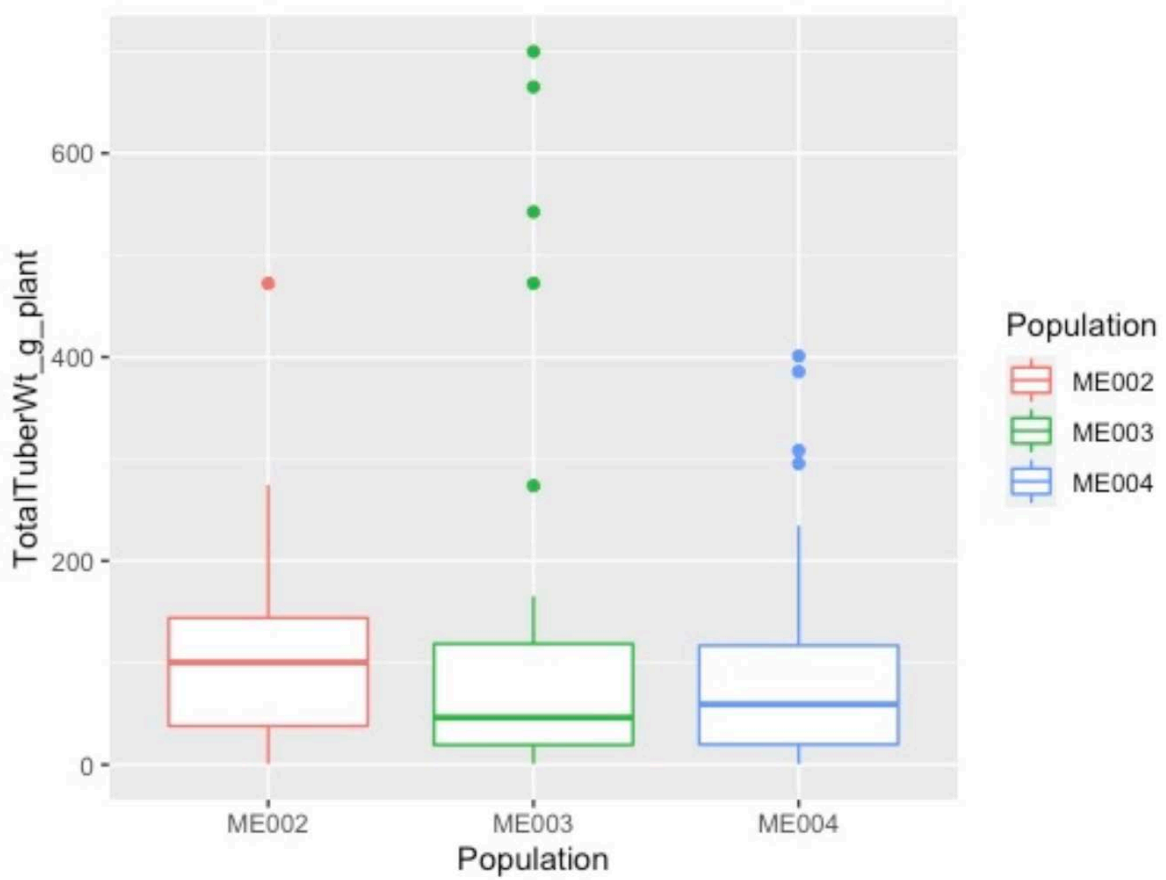
Genotyping Efforts

- Identified true diploids from ME03 and ME04 primary DH population.
- These are in the pipeline for whole genome sequencing and reconstruction as part of the SCRI project.



Tuber Evaluations

Tuber Evaluations



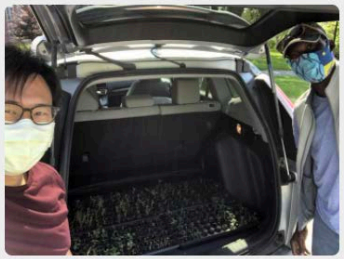
Field Trials

Outreach Efforts

Lab accounts @haploidgenomics @UMainePotato

Genome Elimination |
@haploidgenomics

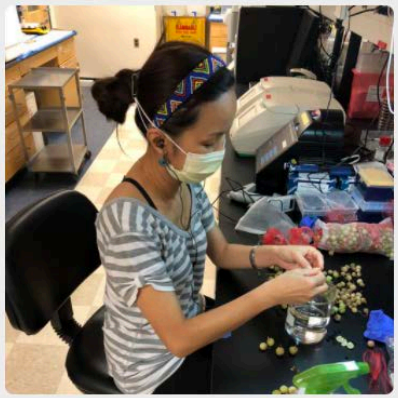
Field starts of primary dihaploids being loaded for transport to Aroostook Farms in Presque Isle, ME — hard work of grad student Femi @oaalaba and Lucas #pandemicplanting @UMainePotato @UMaine



May 27, 2020

Genome Elimination |
@haploidgenomics

Extracting seeds from the thousands of potato berries from our winter crosses is an art form, and MS student Diane has really mastered this in a few short weeks 🌱🧠#plantbreeding #potato @UMainePotato



Jun 2, 2020

Genome Elimination |
@haploidgenomics

Femi, Lucas and I finished planting our first batch of diploid potato/primary dihaploids in the field this year, in 93F heat at Aroostook Farms in Presque Isle, Maine 🥵@UMainePotato @UMaine, work supported partly by @MainePotatoes @USDA_NIFA

Jun 19, 202

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Acknowledgements

Current Lab Team:
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Kristen Brown-Donovan
Diana Spencer
Benjamin Moore
Lucas Heroux
Katie Tims
Kat Klebon
Thomas Bertsch

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Thank you