APPENDIX D
SAES-422

Project/Activity Number:	NE1731
Project/Activity Title:	Collaborative Potato Breeding and Variety Development Activities to Enhance Farm Sustainability in the Eastern US
Period Covered:	Oct 2021 to Sept 2022
Date of This Report:	28Apr2023
Annual Meeting Date(s):	12-13 December 2022 (Raleigh, NC, hybrid meeting, in person and online)

Brief summary of minutes of annual meeting (December 12-13, 2022; hybrid meeting, in person and on-line).

Attendees at the December 2022 annual NE1731 meeting were Craig Yencho (NC State), Mark Clough (NC State), Bonny Olaka (NC State), Walter De Jong (Cornell U), Matt Falise (Cornell U), Greg Porter (U ME), Han Tan (U ME), Jessica Leahy (U ME), Mary Ellen Camire (U ME), Paul Collins (USDA-ARS Orono, ME), Doug Higgins (VA Tech), Xinshun Qu (PA State), Marcio Resende (U FL), Leo Hoffman (U FL), Lincoln Zotarelli (U FL), Pam Solano (U FL), Chris Clarke (USDA-ARS Beltsville MD), Chris Hopkins (Black Gold), Jonathan Price (Sterman Masser Farms), John Lundeen (Potatoes USA), David DeKoeyer (AAFC Fredericton, NB), Erica Fava (AAFC Fredericton, NB), Robyn Morgan (AAFC Fredericton, NB), Mitchell Smith (NB Dept Ag). Tommy Dixon (NB Dept Ag), Antoine Bedard (Patate Lac St-Jean), Jessica Shade (National Program Leader, NIFA).

Project Business

Greg Porter welcomed the group and called the meeting to order at 1:00 PM. The 2021 minutes (from the December 2021 meeting) were unanimously approved. The agenda was reviewed and additions and proposed changes were requested. Introductions took place and committee chairs were appointed as follows: Resolutions – Walter De Jong, Lincoln Zotarelli, and Craig Yencho; Site selection – Mark Clough, Xinshun Qu, Paul Collins.

The group discussed nominations for project officers – We have had a static leadership committee for many years (Porter, chair; Yencho, vice-chair; De Jong, secretary). Porter will be retiring in 2023, necessitating change. The following slate of officers was selected for 2022-2023: Walter De Jong, chair; Han Tan, vice-chair; and Paul Collins, secretary.

Administrative Advisor Report – Jessica Leahy. Jessica became our new AA in January 2022 and helped shepherd our 2022 project rewrite through the NERA system. We are grateful! Jessica's team can help submit annual report and minutes if assistance is needed.

National Institute of Food and Agriculture (NIFA) Report – Jessica Shade. Jessica is the National Program Leader for Plant Systems – Production, and along with Ann Stapleton, is the NIFA representative for our project. NIFA funds ag research, extension, and education, with a total budget for 2021 of 1.8 billion dollars, about half of which went to capacity programs (e.g., Hatch funds). Most competitive grants are awarded through AFRI. Jessica provided an overview of NIFA program priorities: climate change, nutrition security, enhanced market opportunities, DEIA (diversity, equity, inclusion, accessibility).

Research presentations

Chris Clarke gave a presentation about detecting and genomically characterizing *Streptomyces spp*, with a view towards combatting common scab of potato. Has found that quantifying the thaxtomin operon works well to predict level of disease in greenhouse pots, but not so well in the field, and not at all for organisms that cause netted scab. Has sequenced ~250 potato-associated *Streptomyces* isolates. In the process found three new species (bringing total to 15 species now known to cause pitted scab). Species group does not predict disease severity.

David DeKoeyer spoke about revitalizing potato wart resistance breeding in Canada. Wart spores can survive 40+ years so very difficult to control once you have it. 39 wart pathotypes are known, with 2, 6, and 8 important in Canada, and 1 also present. Most varieties from Newfoundland are resistant to pathotype 1 but 2 is becoming more common. Pathotypes 6 and 8 have been found on PEI. Russet Burbank is resistant to 1, while Goldrush and Prospect are resistant to 2, 6, 8. AAFC has been working to rejuvenate the five acre wart screening site in Avondale NFLD, e.g., installing fence to keep out moose. Have marker assays to detect Sen1, 2, 3, 4 resistance genes. Sen3 marker is more predictive with russet than non-russet germplasm.

Marcio Resende talked about the new potato breeding program at U FL. 2022 is the first year they conducted all steps of a potato breeding program (crossing, early generation selection, replicated trials of advanced clones). U FL has invested in infrastructure (cold storage, greenhouse, potato harvester).

Han Tan gave a presentation about his continuing efforts to capture genetic diversity of eastern potato germplasm at the diploid level by prickle pollination of tetraploids. Already has many dihaploids, is now working to improve male and female fertility and long day adaptation, as well as introgress self-compatibility. IVP48 has worked better for dihaploid extraction than IVP101.

Craig Yencho summarized lessons learned while trying to implement genomic selection in potato and sweet potato. Lessons are: 1) need to have appropriate resources to start (genome sequence, existing markers) 2) need to have a team (bioinformatics, genotyping, breeder) – no one person can do it all 3) need to be prepared to change structure of breeding program to accommodate collecting and using marker data 4) dosage sensitive markers work better for genomic prediction than markers that can only be scored as AA, AB and BB. NCSU is currently using marker data on year three clones to identify parents. Key struggle at present is weighting multiple traits for a single selection index.

State Site Reports

FL – Potato acreage has been on a downward trend, and the mix of varieties, once 80% chip/20% fresh, is shifting towards 50/50. Growing conditions were good, with somewhat low temperatures, which both raised specific gravities and increased length of growing season until crop maturity was achieved. Program intends to use Atlantic as a biomarker for harvest date, rather than an arbitrary days after planting number, to determine harvest date in the future. E.g., harvest when Atlantic is 90% senesced.

ME – perhaps 57,000 acres for 2022 (NASS estimate of 59,000 is deemed by industry to be too high). Yields in 2022 were even higher than the high yields of 2021, at about 345 cwt/acre.

Yields in university trials were the highest Greg Porter has ever seen. Industry about 60% fry and chips, 20% fresh, 20% seed. No late blight in 2022.

NY – estimated 12,000 acres. USDA-NASS no longer reports potato acreage for NY. Severe drought reduced yields throughout the state.

NC – currently has about 13,000 acres of potatoes, with industry still about 70/30 - chip/table. Planting typically in March, with harvest in June and July. Good growing season. Chip acreage is moving to irrigated land. NC had 17 yield trials in 2022, plan on 19 in 2023.

PA – Estimated 4500 acres, 60% chip/40% fresh. Hot and dry season reduced yield but quality still OK.

NB – Good growing season, 52,000 acres, 70% planted to processing potatoes, 18% to table potatoes, 12% seed. Crop is storing well. Russet Burbank had elevated hollow heart and sunburn this year. Overall yields about 330 cwt/acre.

QC – Report emailed to be shared with the group. Approximately 50000 acres, 50% fresh/40% process/10% seed. Cold, wet spring, small size profile, average yield, good quality.

Comments from Industry

Jonathan Price: expressed interest in creamer potatoes, especially those that are scab resistant. Most European creamer potatoes they have tested have been scab susceptible.

John Lundeen (Research Director for Potatoes USA) noted that at recent National Chip Program meeting, the default now is to trust breeders for EGSS and NCPT decisions, but for industry to be heavily involved when deciding which clones enter SNAC trials. Two key criteria for SNAC: clone needs to beat existing alternatives and show nationwide potential.

Chris Hopkins: smaller chip potatoes are needed by industry, but not at the cost of reducing overall yield or specific gravity. The ability to grow with less water and nitrogen is increasingly important. Disease resistance is a plus if it allows growers to use less pesticides. Some Black Gold customers are asking them to plant on irrigated land, to reduce risk of supply failure. Thus the increased use of irrigation on potatoes in North Carolina (see NC state report above).

Pathology Reports

AAFC: Erica Fava, incidence of scab on susceptible clones in 2022 scab plots was low; data will be sent out soon.

U ME: Greg Porter, colleague Jay Hao continues to screen for pink rot and soft rot resistance. Pink rot data comes from a field trial, which shows good differentiation between clones. The breeding program runs *Verticillium* and *Fusarium* resistance trials. Greg has already distributed scab resistance trial results.

Penn State: Xinshun Qu, evaluated ~38 clones for resistance to common scab, early blight and late blight. Report has been sent out by email.

12. Breeding/Genetics Reports

Maine. Greg Porter will retire at the end of 2023. U ME hopes to hire a successor soon, to provide a year of overlap. Planted 45,000 single-hills, saved 2.7%. Program currently 50% russets / 40% round whites, chips, yellow flesh / 10% specialty. Disease resistance priorities are for late blight, potato virus Y, and scab. Use markers to identify clones with golden nematode and PVY resistance genes. Have begun to use Field Book app – has proven useful for field data collection, but not for grading line. Recent release of Caribou Russet: industry continues to be happy with it, seed acreage still going up. Although susceptible to internal heat necrosis, it has high yield and good quality, good tolerance to bruise and soft rot, and few internal defects. AF5280-5, a round white, performed well from FL to the Maritimes. AF6194-4 is another promising round white, with good resistance to common scab and PVY immune. AF5819-2 is high yielding, but eye depth and uniformity are possible issues. NDAF113484B-1 is a red with large tuber size and moderate scab resistance. A6289-2, a breeder's choice last year, is being dropped; not pretty enough. MSAFB609-12 is resistant to PVY and late blight; a chipping clone. MSAFB635-15 will be in SNAC trials in 2023, suitable for out-of-the-field chipping, and resistant to *Verticillium*, tolerant to pink and soft rot; specific gravity higher than Atlantic.

New York. Severe drought in 2022 – no rain entire summer in our unirrigated seed plots. Finding harvest help was the most difficult it has ever been. Planted 18000 seedlings. Deer pressure was high, which complicated making selections. Most promising clones currently in program are NY163 (lightest fry color of any clone yet developed at Cornell) and NY174 and NY177 (which will both be in SNAC trials in 2023). The set of chipping clone NY181 is relatively high, a trait we have been increasingly selecting for.

North Carolina. Now use five-hill plots in first field year. Selected 13% of chipping clones, lower percentage of tablestock. Intend to discard all PVY susceptible clones (based on marker analysis) going forward. NC470-03 will be in SNAC trials in 2024. Have used European clones to bring in Ry-sto resistance gene. Are trying to push harvest date to 90-95 days after planting to select for earlier maturities. Will get a new storage cooler soon, which will triple current storage space.

USDA-ARS. 60% chip/30% table/10% diploid. Planted 28000 single-hill plots, 448 12-hill plots, 15 40-hill plots, 34 100-hill plots, and are also evaluating 29 advanced clones. Working with U FL to study heat tolerance, NUE, and PUE.

AAFC. Working towards a four-hill system for first field year. 35000 seedlings in 2022 (mix of single and 3-4 hill plots). Field years 3 and 4 represent preliminary trials, while field years 5+ are national trials. Program is increasing emphasis on French fry varieties. Released six table varieties in 2022, one of which now has plant breeders' rights. Use a small plot-harvester from 3rd year on, which saves a lot of labor. Have optical sorters at all major national trial sites. Have begun to use genomic selection to choose parents. Using DArTag markers, find get acceptable DNA from tuber eyes. Use Potatobase for recordkeeping and like it.

Florida. Made 160 crosses, produced seedling tubers from 4000 clones, planted 7000 single-hill plots (and selected 115). Are using Field Book app for data collection and UAV imaging, too. For parents, are only using those that have yielded more than 330 cwt/acre in the past with a specific gravity above 1.075.

Update on the NE1731 website/database/data reporting. Data we submit to Mark Clough is posted publicly unless we ask that it not be. New feature in neproject.medius.re is that number of years and number of locations is shown when comparing varieties.

Seed orders, shopping list, new entries. Greg emailed all participants a list of 39 test clones and 12 standard varieties to be considered for evaluation. The cost of seed per hundredweight has been fixed at $75 for many years, with U ME covering the ever-increasing costs of production. Virus tests alone are $100 per clone. Going forward, to spread the costs more fairly, each breeding program will pay $200 per entry in the seed nursery.

Breeder's choices (all sites must evaluate these):
AF6565-8 (chip)
AF6601-2 (chip)
NDAF141Y-3 (red)
NY174 (chip)
NY177 (chip)
BNC559-1 (purple skin, white flesh)
BNC917-2 (purple skin, white flesh)

Standard varieties to include in all NE2231 trials:
Atlantic
Chieftain
Katahdin
Kennebec
Snowden
Superior
Yukon Gold

Eastern Region Potato Special Grant. We are currently in year 2 of 2 for the 2021 Potato Special Grant and will need to submit a proposal in Spring 2023. Plan is for the new breeder in Maine to assume responsibility as lead PI (just like Greg has done), as Maine is the largest potato producing state in the Northeast.

NE1731 project rewrite. We submitted a proposal early in 2022, which was approved. Our new project is now NE2231, and runs for five years (until 30 Sept 2027).

New funding opportunities. AFRI grants for conventional plant breeding – mentioned by Jessica Shade – are something we should look into.

Old Business. Greg has already collected data from us to write annual reports.

New Business. None.

Committee Reports

Site Selection: Chris Clarke (USDA-ARS) has graciously agreed to host our next meeting on 11-12 December 2023 in Beltsville, MD.

Resolutions (approved unanimously):

a. We recognize and congratulate Greg Porter for 40 years of excellent leadership and contribution to the potato industry, academia, and the time he dedicated as our project coordinator, and we wish him our best in retirement.

b. Craig Yencho, Emily Genther, and Mark Clough (NCSU) for hosting and assisting with the logistics of the meeting

c. Chris Clarke (USDA-ARS), David De Koeyer (AAFC), Marcio Resende (UFL), Ek Han Tan (Univ. of Maine) and Craig Yencho (NCSU) for giving presentations on their research to the project members

d. J. Leahy, Associate Director of the Maine Agricultural and Forest Experiment Station, for attending our meeting and providing guidance as our Administrative Advisor

e. Jessica Shade (National Program Leader for National Institute of Food and Agriculture/NIFA) for presenting an overview of the NIFA funding programs.

f. Mark Clough of North Carolina State University and Brad Halladay of Medius Ag for his on-going database management and electronic data capture efforts on behalf of the NE2231 project.

g. Walter De Jong from Cornell University for serving as the NE1731 Secretary.

h. All NE2231 presenters, potato breeders, agronomists, plant pathologists, industry, technical assistants, collaborators, and trial cooperators for their dedication to our group effort and their intellectual engagement in the process of potato improvement, selection, and variety development.

Other Business – none. Adjournment – 11:50 am on 13December 2022.

Project Accomplishments:

This multidisciplinary, regional project utilizes the potato breeding and variety development expertise in the eastern US to breed, select, and develop new potato varieties for growers at all scales of production. It encourages the pooling of regional resources and promotes increased communication within the potato community located in the northeast, mid-Atlantic and southeast. The overarching goal of this project is to identify new potato varieties for use in the Northeastern, mid-Atlantic and southeast US, which will contribute to a more sustainable and profitable potato industry. Many major US varieties, including Atlantic (the dominant out-of-field chipping variety in the US), Lamoka and Waneta (dominant out-of-storage chipping varieties in the US), and Caribou Russet (a popular and extensively-grown new russeted variety) are products of this coordinated eastern potato breeding and variety development effort.

This regional project has: 1) allowed potato breeders to share breeding materials and trial results; 2) facilitated potato germplasm selection and evaluation under diverse environmental conditions in the eastern US; 3) given research and extension personnel the opportunity to evaluate new selections from several potato breeding programs; 4) facilitated regional germplasm screening for specific characteristics at a single location (e.g. early blight, late blight, and common scab resistance in PA; scab and virus resistance in ME; nematode resistance in NY); 5) developed variety profiles

and cultural recommendations for potato selections that enter commercial production; and 6) resulted in the release and adoption of many important US potato cultivars .

Potato breeding for improved quality, stress tolerance, and pest resistance was conducted in FL, ME, NY, NC, and USDA-ARS (Orono, ME) during 2022. During 2022, our programs generated 789 new tetraploid families (494,528 seeds) from crosses using parents with desirable quality, utilization, adaptation, and/or pest resistance traits. Progeny (97,069) from earlier crosses were field selected resulting in 3289 clones that will be further evaluated during 2023 under conditions with diverse abiotic and biotic stress in the eastern U.S. and beyond. Our breeding programs focus on specific pest, climactic stress, and marketing issues, so that regional resources are used efficiently. For example, ME is the only breeding program in the region which focuses on russets and long whites for processing (50% russets, 40% fresh and chipping whites, 10% reds and specialty varieties). ME also emphasizes research on late blight, pink rot, potato virus Y (PVY), soft rot, and scab resistance. During 2022, 262 ME crosses were made resulting 127,638 true seed for future selection and variety development. During the 2022 growing season ME evaluated 45,392 first-year generation clones selecting 1215 (~ 2.7%) and 850 second-year clones selecting 208 (~24%). The selected clones will continue evaluation during 2023. In addition to selecting clones for adaptation to ME, ME sends all 2nd-year selections to NC and/or FL to assess heat tolerance and adaptation to stressful southeast (SE) growing conditions. PA also screens all ME 4th year russet clones to help select for improved heat tolerance. NY emphasizes white-skinned chipping crosses, but also selects fresh-market clones of varying skin and flesh colors. NY emphasizes resistance to golden nematode, scab, and PVY, but also crosses for late blight, white cyst nematode, and other resistances. All advanced NY clones were evaluated for resistance to the golden nematode during 2022 using an established bioassay. NY continues to select for improved chip quality from cold storage. For the fifth consecutive year, all NY chipping clones were screened for ability to chip from 43F storage. This increases selection pressure to further drive chip germplasm improvements for long-term storage chip quality. The NY selection strategy now requires that storage chipping clones must chip better than Snowden from cold storage. This is resulting in dramatic improvements in long-term storage chip quality within the NY program. During 2022, 111 NY crosses resulted 205,710 true seed for future selection and variety development. NY evaluated 14,700 first-year clones during 2022 selecting 807 (~ 5.5%) and 103 second-year clones selecting 25 (~24%). Fifteen advanced NY clones were evaluated in on-farm trials in NY during 2022. NY continues to conduct crosses using germplasm from outside of North America (e.g. Agata, Barbara, Bora Valley, Carola, Diamant, Kameraz, La Ratte, Morene, Olalla, and Vita) to broaden the program's overall genetic base.

Our potato breeding programs are focused on developing plant materials with greater resilience to heat stress and climate change; however, our USDA-ARS, NC, and FL programs are particularly suited to developing these new heat-stress-tolerant plant materials. NC's potato breeding program focuses on heat-stress tolerance, PVY resistance, and resistance to internal heat necrosis. In NC all crosses have pedigrees where either one or both parents has shown good adaptation for heat stress in the form of internal heat necrosis resistance as well as solids accumulation, tuber set and/or tuber bulking. During 2022, 147 NC crosses resulted in 67,650 true seed. During the 2022 growing season NC evaluated 5,750 first generation clones selecting 706 (~12.3%) and 630 second generation clones selecting 152 (24%). NC screens all of its field-selected clones for the presence of DNA-based markers associated with PVY (Ry_{adg} or Ry_{sto}) and golden nematode resistance (H1). Only clones with positive tests for the PVY resistance marker(s) are kept for future evaluation. NC continues to conduct crosses using germplasm from outside of North America (e.g. Pirola and Meduza) to broaden the program's overall genetic base. For the fresh market, NC's priority is finding a replacement for Dark Red Norland because of its low yield and variable skin color in

stressful SE environments. In addition to field screening 567 NC clones for heat tolerance, NC also screened 338 clones from the other eastern potato breeding programs to assess heat tolerance and adaptation to the SE. During 2021, FL initiated potato breeding that will further strengthen our region's efforts to create heat-tolerant potato germplasm with adaptation to the SE. During 2022, 80 FL crosses resulted 39,880 true seed for future selection and variety development. FL evaluated 5,895 first-year clones during 2022 selecting 54 (~ 0.9%) for continued evaluation in 2023.

In addition to developing improved tetraploid potato varieties, our programs are advancing future potato breeding by participating in national efforts to implement diploid potato breeding. Diploid potato breeding will simplify and accelerate the breeding and genetic improvement process. USDA-ARS conducted 102 successful *2x-2x* diploid crosses resulting in 15,055 seeds for future research. USDA-ARS evaluated 2,652 first-year diploid clones during 2022 selecting 46 (~ 1.7%) for continued evaluation in 2023. NY has used pollination with IVP101 to generate candidate dihaploids from Brodie, Andover, and NY164 and these have now been grown out for further evaluation and eventual use in diploid potato breeding. ME continues research on diploid potato breeding by developing primary dihaploid progeny using the IVP48 and IVP101 haploid inducers crossed to tetraploid potato (e.g. Atlantic, Caribou Russet, NY121, and fifteen other tetraploid clones). Haploid induction crosses were conducted using 10 advanced tetraploid breeding clones during 2022. A total of 237 berries were obtained that will yield seed for future research. Priority crosses in this set used tetraploid parents Sakai 35 (yellow-flesh, PVY resistance based on Ry_{chc}) and AF5707-1, AF5736-16, and AF5406-7 (all three are russets; two with late blight resistance). ME currently has more than 436 primary dihaploid lines in tissue culture. These lines are being phenotyped by chloroplast counting and other methods. During 2022, 339 primary dihaploids were field evaluated to assess plant growth and tuber quality. Selected individuals will be used for crosses to a male-fertile diploid parent in order to restore male fertility as well as to introduce self-compatibility. Phenotyping and genetic studies are underway to assess potato blackleg and soft rot disease (PBSR) resistance in the ME03 primary dihaploid population, derived from Caribou Russet. Preliminary data show that a number of ME03 primary dihaploid lines have promising resistance levels when inoculated with the PBSR-causing pathogen, *Dickeya dianthicola*.

Disease screening is an important part of potato variety development. Disease-resistant varieties generated by this project have the potential to greatly reduce growers' losses to devastating diseases such as late blight, pink rot, and PVY and can also reduce agricultural chemical use and production costs. Screening trials in PA, evaluated our NE1731 and advanced breeding clones for early blight (42 clones), late blight (252 clones), and common scab resistance (53 clones) tolerance. During 2022, ME also conducted screening studies for tolerance to important potato diseases (late blight, common scab, verticillium wilt, soft rot, pink rot, fusarium, PVY, and potato leafroll virus (PLRV). These data are used to select resistant varieties and parental clones. NY's long-term effort at increasing the frequency of PVY resistance in its germplasm is bearing fruit. Most advanced clones in the program carry a marker that is tightly linked to the Ry_{adg} gene for PVY resistance. All advanced NY clones are field screened for common scab resistance, while all are also screened for golden nematode resistance (via bioassay) and PVY resistance (via DNA-based marker). NC screens all of its field-selected clones for the presence of DNA-based markers associated with PVY (Ry_{adg} or Ry_{sto}) and golden nematode resistance (H1). Only clones with positive tests for the PVY resistance marker(s) are kept for future evaluation. ME also uses these DNA-based markers to select and advance PVY and golden nematode resistance potato germplasm. Through its plant disease research, PA has identified candidate genes associated with late blight, early blight and common scab tolerance using genome-wide association studies. The candidate genes were cloned and transferred into disease-susceptible varieties. The transgenic plants continued evaluation for disease resistance in field trials during 2022. Experiments in ME are being used to identify clones

with resistance to pink rot, fusarium, and PBSR. Caribou Russet from the Maine breeding program and several diploid clones from USDA-ARS at Beltsville have shown high levels of resistance to PBSR's causative organisms, *Dickeya dianthicola* and *Pectobacterium parmentieri*. These clones will be further investigated by genomic mapping. Dihaploid breeding populations under development in ME will facilitate this process.

Field trials were conducted from ME to FL to help select promising potato clones that are worthy of commercialization. Advanced clones from our project were introduced to growers through field days, presentations, publications, web sites, and direct contact with stakeholders. Nine advanced clones were entered into tissue culture programs during 2022 leading to commercial seed production for continued research and development. Several advanced clones and newly released varieties are currently being evaluated in on-farm commercial-scale trials for their potential use across the US. Two of NY's recent chipping releases Waneta (NY138) and Lamoka (NY139) have been widely adopted by commercial growers. Based on 2022 certified seed acreage, Lamoka ranks 8th among US varieties in certified seed production (3516 acres) and has replaced Snowden (1455 seed acres) as the standard storage chipping variety across the US. Waneta has also been widely adopted (1504 acres of seed in 2022, 17th ranked in the US) for chipping, fresh-cut fries, and fresh market. We estimate that the annual value of potato chip production from Lamoka and Waneta exceeds one billion dollars (~15% of U.S. chip production). Lady Liberty (NY152) was released for chipping during 2018 and has high yields, excellent chip color out of cold storage, PVY resistance, and common scab tolerance. National seed acreage totaled 443 during 2022, ranking it 37th in the U.S. just four years after its release. Twenty-six clones from the eastern states have been in the Potatoes USA fast-track chip program since 2011, and the programs supported under this grant have annually contributed up to 40% of clones in the Potatoes USA National Chip Processors Trials (NCPT).

Caribou Russet was released by ME during 2015 for fry processing and russet fresh market. It has been rapidly adopted due to high yields, scab and verticillium resistance, and excellent consumer quality. Certified seed acreage rose to 1874 acres (12th in the US) during 2022. Caribou Russet's cash farm value to ME seed growers was ~$6.6 M during 2022 and the estimated cash farm value when this seed crop is planted, grown, and sold in 2023 is ~$61M . It is also being evaluated and adopted in many other countries around the world. Hamlin Russet (tested as AF4124-7) was released by ME during 2021 for early fry processing and russet fresh market. It has moderate scab resistance. Certified seed acreage rose to 304 acres (#46th in the US) during 2022. AF5071-2, AF5406-7, AF5521-1, and AF5736-16 are advanced fry processing clones that are generating commercial interest, while 30 additional russeted French fry clones are currently being evaluated by North American potato processors.

For fresh market, NY released Upstate Abundance (NY150) and Algonquin (NY141) during 2017. Algonquin seed acreage totaled 49 during 2022, ranking it 118th nationally. It is a white skinned, white-fleshed fresh market variety with high yields and good tuber appearance as well as resistance to common scab and golden nematode. Upstate Abundance is a specialty white with very small, bright tubers. It has PVY, late blight, and golden nematode resistance as well as moderate common scab tolerance. It is being commercialized by specialty fresh market growers. Upstate Abundance seed acreage totaled 61 during 2022, ranking it 107th nationally. Genesee, another NY fresh market, round-white was produced on 112 seed acres during 2022 (ranked 75th). NY released Brodie (NY140) during 2018 as a dual-purpose table and chipstock variety with excellent marketable yields, attractive tuber skin and excellent fry color out of cold storage. US seed acreage was 17 in 2022, ranking it 174th nationally. It is the first U.S. cultivar with resistance to race Ro2 of the golden nematode and it is also resistant to race Ro1. Ro1 is the long-time golden nematode pest

in NY, while Ro2 is a newer race that has become increasingly difficult to manage in NY. ME released Pinto Gold (AF4659-12, 2.6 acres, 256th) in 2018. It is a pinto-type, yellow-fleshed 'roasting' variety that is being commercialized for small-scale local foods markets and has been favorably received in this high-value market. Other fresh market releases Red Maria (2010, 28 acres, 145th), a high-yielding red, Lehigh (2007, 307 acres, 45th), a widely-adapted yellow-fleshed variety, and Peter Wilcox (2007, 4 acres, 244th), a novel purple-skinned, yellow-fleshed variety continue to be utilized by fresh market growers. Lehigh has been quite successful as a fresh market variety due to its yellow flesh, high yields, common scab tolerance, and wide adaptation.

Each eastern breeding program submits its most promising advanced clones to the NE1731 regional project's seed nursery in ME. During 2022, the project distributed seed potatoes for 12 regional potato variety trials conducted in seven states and two Canadian provinces. Eleven standard varieties and 27 experimental clones were tested for yield, tuber quality, and pest resistance. All trials were grown using standard commercial cultural practices. Marketable yield, tuber quality and appearance, maturity, storage life and processing potential were evaluated and compared to commercial standards. The diverse environmental conditions present in the eastern U.S. allow us to quickly screen potato clones for stress sensitivity as well as for adaptation and suitability to specific growing areas and markets. Multi-site evaluation of early-generation clones speeds the breeding and selection process and enables us to identify both broadly- and specifically-adapted clones that will be useful to the U.S. potato industry and potato growers at all scales of production. FL continues to facilitate commercial adoption by conducting cultural management studies (e.g. seedpiece spacing, nitrogen fertilizer, and vine desiccation studies) on promising potato clones, so that growers receive the best possible production guidelines. FL research conducted during 2022 focused on seedpiece spacing and time of harvest management for candidate high-value creamer varieties. Considering yield and quality attributes the most promising NE1731 clones by market type were: chipping (MSAFB635-15, NY163, and NY165); fresh market whites (AF5280-5 and AF5819-2); russet and long-whites (AF5071-2, AF5406-7, and AF5521-1), reds and specialty (NDAF113484B-1). Similar variety trials will be conducted during 2023 to further select clones to advance to commercial trials. Each regional trial site reports results to their local stakeholders and submits their data to the project website coordinator located in NC. The data are entered into a searchable database so that results are accessible to stakeholders and researchers anywhere in the world.

Our project web site and searchable database continues to grow in size and utility. The database has now migrated to the more powerful and user-friendly Variety Data Management (VDM) platform (https://neproject.medius.re/). The web site provides current contact information for project cooperators and recent research reports, as well as access to our searchable regional variety database and a dynamic summary generator for all released varieties. This new database can provide side-by-side comparative data for potato clones and varieties as well as advanced analytical tools. It is a valuable tool for researchers, Extension, and stakeholders.

New varieties and descriptions.

This project seeks, through activities coordinated across many Northeastern states, to develop potato varieties with improved agronomic, disease-resistance, and nutritional characteristics. It is anticipated that improved potato cultivars will help maintain the viability of rural economies, reduce dependence on pesticides, and contribute substantially toward maintaining a secure, safe and nutritious food supply.

Advanced Experimental Potato Clones Showing Particular Promise in 2022 include:

- **AF5071-2** (AF3011-29 x AF3051-2), a late maturing, russet with good fry quality, fair tuber appearance, and high yields. Specific gravity is higher than Russet Burbank and fry color from storage has been good. Fry color uniformity is very good. It is moderately susceptible to scab and hollow heart, but has moderate verticillium, blackspot, and shatter resistance. It was a strong performer in the Potatoes USA National Fry Processing Trials.
- **AF5280-5** (ND7791C-1 x ND860-2), an early, round to oblong white with good yields, large tubers, moderate-low gravity, good chip color, and good appearance. It could go for early fresh market. It has good scab, bruise, hollow heart, pink rot, fusarium, and golden nematode resistance. AF5280-5 is a good prospect to replace Superior in eastern markets.
- **AF5406-7** (AF3317-15 x Silverton Russet), a late-maturing russet with good yields, large tubers, and resistance to late blight, scab, blackspot, shatter, verticillium, fusarium, and pink rot. It will most likely be useful for processing market, but may also work for fresh market. It was a strong performer in the Potatoes USA National Fry Processing Trials.
- **AF5412-3** (BCO01044-2 x Adirondack Blue), a mid-season, purple-skinned and purple-fleshed specialty clone with large oblong tubers, fair appearance. Large tubers are prone to off shapes. It has late blight and verticillium resistance. Shatter bruise susceptibility is a concern.
- **AF5521-1** (AF4320-7 x AF2291-10), a dual-purpose russet with large long-blocky tubers, medium-late maturity, high yields, high gravity, excellent fry color, and outstanding fry color uniformity. It is resistant to golden nematode and moderately resistant to early blight, shatter, and blackspot. It was a strong performer in the Potatoes USA National Fry Processing Trials.
- **AF5736-16** (AF3317-15 x Dakota Trailblazer), a dual-purpose russet with long, blocky, tubers, large size profile, and late maturity . It has high yields when given a long season, high gravity, excellent fry color, and outstanding fry color uniformity. It has moderate resistance to scab, late blight, blackspot, softrot, and verticillium. It has had growth crack problems in some ME trials. It is currently being evaluated in the Potatoes USA National Fry Processing Trials.
- **AF5819-2** (Dakota Crisp x AF4552-5), a medium-maturing fresh market clone with bright skin, round tubers, high yields, low specific gravity, moderate scab resistance, medium-sized tubers, and good internal quality. It also has pink rot, softrot, and shatter resistance.
- **AF6194-4** (Waneta x AF4648-2), a medium-maturing fresh market clones with bright skin, high yields, moderate specific gravity, moderate scab resistance, large tubers, and good internal quality. It also has resistance to PVY, bruise, and golden nematode.
- **AF6206-3** (AF4386-16 x Lamoka), a medium-late-maturing chipper with high yields, good chip color, low internal defects incidence, and high specific gravity. It has shatter bruise tolerance, moderate scab resistance, and golden nematode resistance.
- **AF6206-5** (AF4386-16 x Lamoka) a medium-late-maturing chipping clone with high yields, low internal defects incidence, excellent chip color, and high specific gravity. It has moderate external defects incidence being especially prone to growth cracks. It has bruise tolerance, moderate scab resistance, and golden nematode resistance.
- **AF6565-8** (WAF10139-19 x MSR127-2), a medium-maturing chipper with high yields, very good chip color, low internal heat necrosis incidence, and moderate to high specific gravity. Hollow heart incidences has been a concern in several trials. It has PVY resistance.
- **AF6601-2** (NY121 x Lamoka), a medium-maturing chipper with high yields, low internal defects incidence, good chip color, and moderate to high specific gravity. It has PVY, golden nematode, and late blight resistance along with good bruise tolerance.

- **MSAFB635-15** (NYH15-5 x MSS297-3), a medium-late maturing chipper with high yields, high specific gravity, good chip color, netted skin, and fair tuber appearance. It has moderate resistance to verticillium, scab, and shatter. MSAFB635-15 has potential for chipping in both southern and northern areas, but is probably best suited to out-of-field chipping. This clone is being evaluated in the Potatoes USA National SNAC chipping trials
- **NC470-3** (Marcy X BNC182-5), a round to oblong PVY-resistant (Ryadg) chipper that has late vine maturity. It has good out-of-field chip color, as well as moderate early and late blight resistance. It is also resistant to PVY. Specific gravity is typically within 2 to 4 points of Atlantic. Marketable yields in NC have averaged 103% of Atlantic and 93% of Snowden. This clone will be evaluated in the future Potatoes USA National SNAC chipping trials as soon as seed can be made available. NC470-3 was also evaluated in two, small commercial chipping trials during 2022.
- **NDAF113484B-1** (ND060570B-1R x ND8555-8R), an attractive, mid-season, red with bright skin that holds its color well in storage. It has white flesh and mid-season maturity with moderate scab, shatter, and blackspot resistance. Tubers size and yields are typically similar to those of Dark Red Norland. It has had low hollow heart incidence, but has had internal heat necrosis problems in several southern and mid-Atlantic trials.
- **NY163** (E50-8 x E48-2), a medium-late maturing chipping clone with moderate to high specific gravity. It has round to oblong tubers with a lightly textured skin. Yields have been high in many NY trials and are typically similar to Atlantic. Specific gravity averages about 0.004 less than Atlantic. It has exceptionally good chip color from storage and chips well from cold storage. It has low incidence of external defects and low hollow heart incidence. It has moderate scab resistance and is resistant to golden nematode (Ro1). It recently completed evaluation in Potatoes USA National SNAC chipping trials throughout the US.
- **NY165** (NY148 x F48-4), a mid-season, moderate to high specific gravity, chip stock clone. It has round to oblong tubers with slightly netted skin. Yields have been high in many NY trials; however, specific gravity may not be high enough for commercialization outside the northeast. Chip color from storage is very good. It has moderate scab resistance and is resistant to golden nematode (Ro1) and PVY. It is recently completed evaluation in Potatoes USA National SNAC chipping trials throughout the US.
- **NY174** (NY148 x E48-2), a full-season, moderate to high specific gravity, chip stock clone. It has round to oblong tubers with slightly netted skin. Yields have been high in many NY trials averaging 119% of Atlantic (8 trials). Low levels of internal and external defects have been observed to date. Chip color from storage is very good. It has moderate scab resistance and is resistant to golden nematode (Ro1) and PVY. It will be tested in the 2023 Potatoes USA National SNAC chipping trials throughout the US.
- **NY177** (NY148 x E48-2), a mid- to late-season, high specific gravity, chip stock clone. It has round to oblong tubers with slightly netted skin. Yields have been high in many NY trials averaging 119% of Atlantic (6 trials). Low levels of internal and external defects have been observed to date. Chip color from storage is very good. It has moderate scab resistance and is resistant to golden nematode (Ro1) and PVY. It will be tested in the 2023 Potatoes USA National SNAC chipping trials throughout the US.

Short-term Outcomes:

1. Eastern potato growers need new potato varieties which are highly productive and less susceptible to stress, diseases, and insects than current varieties. This regional potato breeding and trial network produces new potato varieties and evaluates their potential to serve fresh, processing, and specialty potato markets in the East. These new varieties will improve grower

profitability by increasing yields, enhancing market quality, and/or decreasing costs associated with pests. Farm gates receipts for Eastern potatoes exceed $460M per year. Potatoes can cost more than $3000 per acre to produce and devastating diseases such as pink rot and/or late blight can totally destroy the crop. Resistant varieties greatly decrease the risk of losses and, in the case of late blight resistance and plant viruses, can reduce production costs by reducing the number of chemical sprays applied to protect the crop. Several areas in NY could not produce potatoes without the golden nematode resistant varieties developed as part of this and other research projects. Potato virus Y (PVY) has become increasingly difficult to control and seed producers have lost millions of dollars to this pest in recent years. All of our breeding programs develop new plant materials with resistance or tolerance to one or more of these important plant pests. As noted above, several of our advanced selections that are in or heading toward commercialization trials are resistant to one or more important pests. Internal heat necrosis (IHN) is a common stress-related defect in the mid-Atlantic and southeastern U.S. While several of our trial sites help our programs screen for this defect, NC provides an excellent screening site for selecting more stress-tolerate potato varieties. In addition to field screening 567 NC clones for heat tolerance during 2022, NC also screened 338 clones from the other eastern potato breeding programs to assess heat tolerance and adaptation to the SE.

2. Field trials were conducted from ME to FL to help select promising potato clones that are worthy of commercialization. Advanced clones from our project were introduced to growers through field days, presentations, publications, web sites, and direct contact with stakeholders. Over the years, the eastern regional project has resulted in the release of many commercially important potato varieties (e.g. Algonquin, Atlantic, Andover, Brodie, Caribou Russet, Harley Blackwell, Keuka Gold, Lady Liberty, Lamoka, Lehigh, Marcy, Peter Wilcox, Pike, Pinto Gold, Red Maria, Upstate Adundance, Waneta, etc.). Two of NY's recent chipping releases Waneta (NY138) and Lamoka (NY139) have been widely adopted by commercial growers. Based on 2022 certified seed acreage, Lamoka ranks 8th among US varieties in certified seed production (3516 acres) and has replaced Snowden (1455 seed acres) as the standard storage chipping variety across the US. Waneta has also been widely adopted (1504 acres of seed in 2022, 17th ranked in the US) for chipping, fresh fries, and fresh market. We estimate that the annual value of potato chip production from Lamoka and Waneta exceeds one billion dollars (~15% of U.S. chip production). Lady Liberty (NY152) was released for chipping during 2018 and has high yields, excellent chip color out of cold storage, PVY resistance, and common scab tolerance. National seed acreage totaled 443 during 2022, ranking it 37th in the U.S. just four years after its release. Twenty-six clones from the eastern states have been in the Potatoes USA fast-track chip program since 2011, and the programs supported under this grant have annually contributed up to 40% of clones in the Potatoes USA National Chip Processors Trials (NCPT).

3. Caribou Russet was released by ME during 2015 for fry processing and russet fresh market. It has been rapidly adopted due to high yields, scab and verticillium resistance, and excellent consumer quality. Certified seed acreage rose to 1874 acres (#12th in the US) during 2022. Caribou Russet's cash farm value to ME seed growers was ~$6.6 M during 2022 and the estimated cash farm value when this seed crop is planted, grown, and sold in 2023 is ~$61M . It is also being evaluated and adopted in many other countries around the world. Hamlin Russet (tested as AF4124-7) was released by ME during 2021 for early fry processing and russet fresh market. It has moderate scab resistance. Certified seed acreage rose to 304 acres (#46th in the US) during 2022. AF5071-2, AF5406-7, AF5521-1, and AF5736-16 are advanced fry processing clones that are generating commercial interest, while 30 additional russeted French fry clones are currently being evaluated by North American potato processors. Reveille Russet from TX completed testing in NE1731 regional trials during 2021 and shows promise as a fresh market

russet. It now ranks 22nd in US seed potato production at 873 acres.

4. As evidenced above, the advanced clones and releases from the Eastern project continue to be commercially evaluated and adopted by farmers and our industry stakeholders. Recent Eastern releases were grown on 3373 ME and NY seed acres during 2022 with a seed value of ~$11.8M. The resulting seed crop has the potential to plant 33,731 acres in 2023 with a ware value estimated at $109.6M. Nationally, varieties released by our long-term project since 2007 were grown on 8240 seed acres during 2022 with an approximate seed value of $28.8M and potential 2023 ware production value of $267.8M. Several varieties developed though our collective efforts are in the top 100 U.S. varieties based on seed acreage, including (acres, rank): Lamoka (3516, 8), Caribou Russet (1874, 12), Waneta (1504, 17), Lady Liberty (443, 37), Lehigh (307, 45), Hamlin Russet (304, 46), Keuka Gold (121, 72), Genesee (112, 75), Reba (107, 79), Eva (84, 92), and Harley Blackwell (78, 98). Atlantic, released in 1971 by USDA-ARS Beltsville and selected by a predecessor of this project, remains the top publically-released, out-of-field chip potato variety in the US (2308 acres, rank 10th in US).

5. The project places special emphasis on breeding and selecting clones with resistance to late blight, early blight, scab, golden nematode races Ro1 and Ro2, and PVY. Advanced clones in our programs typically have resistance to several important potato pests and/or physiological disorders. As an example, Caribou Russet has resistance to verticillium wilt, common scab, soft rot, and powdery scab as well as excellent bruise resistance. Cornell releases typically have golden nematode resistance and scab tolerance, plus many recent releases also have resistance to PVY and late blight. Upstate Abundance (NY150), released in 2017, has resistance to late blight, common scab, PVY, and golden nematode. Brodie (NY140) was released during 2018 and is the first U.S. cultivar with resistance to golden nematode race Ro2 and it is also resistant to race Ro1. Ro1 is the long-time golden nematode pest in NY, while Ro2 is a newer race that has become increasingly difficult to manage. Golden nematode, a serious pest found in NY and in other countries, cannot be effectively managed without resistant varieties. All NY round whites, and most of the NY colored crosses, segregate for resistance to golden nematode Ro1 or Ro2, as do many crosses from the ME, NC and USDA programs. Marker-assisted selection for PVY and golden nematode resistance is now an integral part of our breeding programs. All advanced clones in the ME, NY, and NC potato breeding programs have been tested for the presence of DNA-based markers associated with PVY resistance. Our programs also use DNA-based markers (i.e. the H1 marker) to select for resistance to golden nematode. Disease screening trials in PA, evaluated varieties and advanced breeding clones for early blight, late blight, and common scab resistance. ME also conducts screening studies for susceptibility to important potato diseases (e.g. verticillium wilt, common scab, softrot, pink rot, fusarium, PVY, etc.). NY screens all of its advanced clones for common scab (field screening) and golden nematode (bioassay) resistance. These data are used to select resistant varieties/breeding clones. Disease resistant varieties generated by this project have the potential to greatly reduce growers' losses to devastating diseases such as late blight and can also reduce production costs.

6. In addition to developing improved tetraploid potato varieties, our programs are advancing future potato breeding by participating in national efforts to implement diploid potato breeding. Diploid potato breeding will simplify the breeding and genetic improvement process and should speed future potato improvement. During 2022, USDA-ARS conducted 102 successful *2x-2x* diploid crosses resulting in 15055 seeds for future research. NY has used pollination with IVP101 to generate candidate dihaploids from Brodie, Andover, and NY164 and these have now been grown out for further evaluation. ME continues research on diploid potato breeding by developing primary dihaploid progeny using the IVP48 and IVP101 haploid

inducers crossed to tetraploid potato (e.g. Atlantic, Caribou Russet, NY121, and fifteen other tetraploid clones). ME currently has more than 436 primary dihaploid lines in tissue culture and field evaluated 339 primary dihaploids during 2022 to assess plant growth and tuber quality. Selected individuals will be used in future crosses to a male-fertile diploid parent in order to restore male fertility. Phenotyping and genetic studies are underway to assess potato blackleg and soft rot disease (PBSR) resistance in the ME03 primary dihaploid population, derived from Caribou Russet. Preliminary data show that a number of ME03 primary dihaploid lines have promising resistance levels when inoculated with the PBSR-causing pathogen, *Dickeya dianthicola*. These dihaploid populations will be useful for future breeding and for studies on inheritance of important potato diseases, such as late blight, PVY, and soft rot.

7. Our project web site and searchable database continues to grow in size and utility. The database has now migrated to the more powerful, user-friendly Variety Data Management (VDM) platform (https://neproject.medius.re/). The web site provides current contact information for project cooperators and recent research reports, as well as access to our searchable regional variety database and a dynamic summary generator for all released varieties. This new database can provide side-by-side comparative data for potato clones and varieties as well as advanced analytical tools which help stakeholders and researchers determine which advanced clones are worthy of commercialization trials.

Outputs:

1. Cultivars released this year:

- Our group did not release any new cultivars during 2022; however, commercialization of our recent releases continued as is summarized above.

2. Publications:

Refereed Journal Papers

Fan G, Wang Q, Xu J, Chen N, Zhu W, Duan S, Yang X, De Jong WS, Guo Y, Jin L, Li G. 2022. Fine mapping and candidate gene prediction of tuber shape controlling *Ro l*ocus based on integrating genetic and transcriptomic analyses in potato. *International Journal of Molecular Sciences* 23:1470. https:// doi.org/10.3390/ijms23031470

Haynes KG, Qu XS, Bamberg J. 2022. Germplasm release: true potato seed (TPS) from a late blight resistant, long-day adapted diploid potato population that is segregating for early blight resistance. *American Journal of Potato Research* 99:321-325.

Hoopes G, Meng X, Hamilton JP, Achakkagari SR, de Alves Freitas Guesdes F, Bolger ME, Coombs JJ, Esselink D, Kaiser NR, Kodde L, Kyriakidou M, Lavrijssen B, van Lieshout N, Shereda R, Tuttle HK, Vaillancourt B, Wood JC, de Boer JM, Bornowski N, Bourke P, Douches D, van Eck HJ, Ellis D, Feldman MJ, Gardner KM, Hopman JCP, Jiang J, De Jong WS, Kuhl JC, Novy RG, Oome S, Sathuvalli V, Tan EH, Ursum RA, Vales MI, Vining K, Visser RGF, Vossen J, Yencho GC, Anglin NL, Bachem CWB, Endelman JB, Shannon LM, Strömvik MV, Tai HH, Usadel B, Buell CR, and Finkers R. 2022. Phased, chromosome-scale genome assemblies of tetraploid potato reveals a complex genome, transcriptome, and predicted proteome landscape underpinning genetic diversity. *Molecular Plant* 15: 520-536.
https://doi.org/10.1016/j.molp.2022.01.003.

Krupek F, Zotarelli L, Sargent SA, Rowland DL, and Dittmar P. 2022. Vine desiccation timing strategies for enhanced harvest and storage quality of early-maturing potato cultivars. *Potato Research.* https://doi.org/10.1007/s11540-022-09550-3

Xue WY, Haynes KG, Clarke CR, and Qu XS. 2022. Genetic dissection of early blight resistance in tetraploid potato. *Frontiers in Plant Science* 13:851538.

Xue WY, Haynes KG, and Qu XS. 2021. Resistance to *Phytophthora infestans* clonal lineage US-23 in potato cultivars and its relationship with early blight resistance and tuber yield. *Plant Disease* 105:3956-3966.

Published Abstracts

Ekbataniamiri F, Ge T, Johnson SB, Larkin R, and Hao J. 2022. Investigating surface water in association with potato blackleg and soft rot. American Journal of Potato Research 100: #28. DOI: 10.1007/s12230-022-09868-1. (abst)

Zhang X, Ge T, Fan X, Chim BK, Johnson SB, Porter G, and Hao J. 2022. Impact of inoculation methods on potato tuber responses to *Dickeya dianthicola* infection. 2022 Annual Meeting of American Phytopathological Society, August 5 – 10, 2022. Pittsburg, PA. (abst)

Zotarelli L, Wade T, England GK, and Christensen CT. 2022. Development of nitrogen fertilizer strategies using yield goal for chipping potatoes. 11th World Potato Congress. Dublin, Ireland. P-008. p.127. https://wpc2022ireland.com/wp-content/uploads/2022/07/Abstract-Book-WPC-2022_01.07.pdf (abst)

Other Publications

Andrade, M.H.L., L.G. Pesantes, C.T. Christensen, L. Sharma, L. Zotarelli. 2022. Seed spacing recommendations for table-stock potato cultivars in Florida: HS1446, 09/2022. EDIS 2022 (6). https:// doi.org/10.32473/edis-HS1446-2022

De Jong, W.S. and M. Falise. 2022. Cornell potato breeding program annual report. 18 pp.

Clough, M. and G.C. Yencho. North Carolina Potato Variety Trial and Breeding Report 2022. 47 pp. (available online at https://potatoes.cals.ncsu.edu/)

Clough, M. and G.C. Yencho. North Carolina Potato Variety Trial and Breeding NE1731 State Report 2022. 12 pp. (available online at https://potatoes.cals.ncsu.edu/)

Kleinhenz, M.D., J.M. Speicher, and S.D. Walker. 2022. 2022 Ohio Potato Germplasm Evaluation Report, Horticulture and Crop Science Series No. 887 November 2022, XX pp

Porter, G.A., P. Ocaya, B. MacFarline, and B. Plummer. 2022. Potato variety trial results in Maine, 2021 growing season. SFA Research Report (posted on www and distributed to industry), 2021-01, 32 pp. Also available at https://neproject.medius.re

Porter, G.A. and P. Ocaya. 2022. Progress report on advanced potato variety testing and potato PVY research - 2021 Growing Season. Report to the Maine Potato Board, February 2022, 9 pp.

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Qu XS, Xue WY, Peck MW. 2022. Evaluation of potato cultivars and breeding lines for resistance to late blight in Pennsylvania, 2021. *Plant Disease Management Reports* 16:V030.

Qu XS, Xue WY, Peck MW. 2022. Evaluation of potato cultivars and breeding lines for resistance to early blight in Pennsylvania, 2021. *Plant Disease Management Reports* 16:V029.

Qu XS, Xue WY, Peck MW. 2022. Field evaluation of potato cultivars and breeding lines for resistance to common scab in Pennsylvania, 2021. *Plant Disease Management Reports* 16:V031

Torres Quezada, E. 2022. Virginia potato variety trial report, 2022. Eastern Shore Agricultural Research and Extension Center, 26 pp.

Zotarelli, L. and P. Solano. 2022. Florida potato variety trial report, 2022. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, Volume 12.

Zotarelli, L., T. Wade, G.K. England, C.T. Christensen. 2021. "Nitrogen fertilization guidelines for potato production in Florida: HS1429, 12/2021". EDIS 2021 (11). https://doi.org/10.32473/edis-HS1429-2021

Zotarelli, L., P.J. Dittmar, P.D. Roberts, J. Desaeger, B. Wells. 2021. Chapter 14. Potato Production: HS733/CV131, rev. 4/2021, EDIS 2021 (33). https://doi.org/10.32473/edis-cv131-2021

PRESENTATIONS:

Clough, M. and C. Yencho. 2021. NC potato breeding and variety trials. Northeastern regional potato meeting (via ZOOM). Dec 12, 2021.

Clough, M. and C. Yencho. 2022. NC potato breeding and variety trials. Eastern shore agricultural conference. January 27, 2022.

Clough, M. and C. Yencho. 2022. NC potato breeding and variety trials. Annual NC Potato Association Meeting. May 16, 2022.

Hao, J. 2022. Understanding the outbreak of blackleg and soft rot of potato in NE US. PEI Potato Conference, Prince Edward Island, Canada, via Zoom. Mar. 30, 2022. Invited presentation.

Hao, J. 2022. Multi-tactic Strategies in Managing Potato Diseases. Feb. 15, 2022. Online via Zoom.

Heroux, L.K., J. Hao, G. Porter and E.H. Tan. 2022. Disease phenotyping with *Dickeya dianthicola* isolate ME30, a causative agent of potato blackleg soft rot disease. July 19, 2022, Potato Association of America Annual Meeting, Missoula, MT.

Porter, G.A. and P. Ocaya. 2022. Progress report on potato variety trials and PVY research - 2021 Growing Season. Report to the Maine Potato Board, Presque Isle, ME. March 9, 2022.

Porter, G.A., P. Ocaya, and K. Brown. 2022. Progress report on Maine potato breeding program – 2021 growing season. Report to the Maine Potato Board, Presque Isle, ME. March 9, 2022.

Porter, G.A., P. Ocaya, and K. Brown. 2021. Progress report on potato variety research and potato breeding at the University of Maine - 2021 Growing Season. Report to the NE1731 Eastern Regional Technical Committee, web-based meeting hosted by NCSU. December 12 and 13, 2021.

Qu, XS. 2022. Potato Research in PA and Penn State 2021. Mid-Atlantic Fruit and Vegetable Convention, Hershey, PA, February 3, 2022.

Qu, XS. 2022. Potato Research at Penn State, 2022. Potato Twilight field Meeting, Northampton County, PA, September 20, 2022.

Zhang X, Ge T, Fan X, Chim BK, Johnson SB, Porter G, and Hao J. 2022. Impact of inoculation methods on potato tuber responses to *Dickeya dianthicola* infection. 2022 Annual Meeting of American Phytopathological Society, August 5 – 10, 2022. Pittsburg, PA.

TOURS, FIELD DAYS, WORK SHOPS, TRADE SHOWS (INCLUDE DATES):

Clough, M. 2021. Annual NC Potato Association Field Tour – 5/15/22

Hao, J. 2022. Potato plant pathology research. Maine Potato Research Field Day, Aroostook Research Farm, Presque Isle, ME. Aug. 17, 2022.

Porter, G.A. 2022. Potato breeding and variety development research. Maine Potato Research Field Day, Aroostook Research Farm, Presque Isle, ME. Aug. 17, 2022

Qu, XS. 2022. Potato Variety Demonstration Show, Penn State's Ag progress Days, Russell E. Larson Agricultural Research Center, Centre County, PA, August 9-11, 2022.

Qu, XS. 2022. Northampton Variety Demonstration Show, Country View Farm, Northampton County, PA, September 20, 2022.

Sharma, L., L. Zotarelli, S.K. Sidhu, F.R. Bortolozo. 2022. Determination of potassium requirement for potato. Handouts for UF/IFAS potato field day. 1p. 04/13/2022

Sharma, A.L., L. Zotarelli, C.T. Christensen, L. Sharma. 2022. Determination of sulfur requirement for potato. Handouts for UF/IFAS potato field day. 1p. 04/13/2022

Torres Quezada, E. 2022. Virginia potato variety trial report, 2022. Vegetable and Strawberry Field Day - Wednesday, June 22, 2022 | 8:30 am 5:00 pm at the Eastern Shore AREC, Virginia Tech, Painter, VA.

Zotarelli, L., M. Resende, L. Hoffmann, C.T. Christensen, P. Solano. 2022. UF/IFAS Potato Breeding Program. Handouts for UF/IFAS potato field day. 1p. 04/13/2022

NEWSPAPER, RADIO, TELEVISION MEDIA ARTICLES:

Porter, G.A. 2022. E.W. Scripps Television Stations and Newsy online news. Interviewed by Chris Conte, June 7, 2022 for a news piece on developing new climate change tolerant potato varieties. Piece aired on-line in June 2022.

Porter, G.A. 2022. Bangor Daily News (print and online news). Interviewed by Paula Brewer (Bangor Daily News), May 4, 2022. "An Aroostook farm is helping UMaine create climate-resistant potatoes". May 9 print edition plus online (link not available).

Porter, G.A. 2022. Climate Central and the Bangor Daily News (print and and online news). Interviewed by Caitlin Looby (Climate Central), March 10, 2022 and Lori Valigra (Bangor Daily News), April 6, 2022. "The looming threat for Maine's iconic potato industry". April 25 print edition plus online at https://bangordailynews.com/2022/04/25/business/warming-temperatures-drove-maines-potato-boom-theyre-also-a-threat-joam40zk0w/

Porter, G.A. 2022. Wall Street Journal and online news. Interviewed by Jennifer Levitz, March 11, 2022. "Idaho needs potatoes, so Maine is chipping in". This article was also spun off into a Boston Globe article featured online: Westward Ho! Maine potatoes travel far after western drought - The Boston Globe

Porter, G.A. 2022. Compilation of interview materials developed by University of Maine was featured by World Economic forum showcasing efforts to improve the potatoes tolerance to climate change. https://www.weforum.org/videos/24543-new-potatoes-bred-to-adapt-to-climate-change

Porter, G.A. 2022. NewsCenter Maine –TV and online news. Appeared on NewsCenter Maine TV and web-based news and was interviewed by Stephen Armstrong, news producer, February 17, 2022. "2021 Maine potato harvest was highly successful and is opening new business opportunities". https://www.newscentermaine.com/article/money/economy/2021-maine-potato-harvest-highly-successful-opening-new-business-opportunities/97-cd5c1b0e-af0b-422a-a18e-a15a13ea87d7

Porter, G.A. 2021. Maine Public –TV and online news. Appeared on Maine Public News Portland, ME news show and was interviewed by Robbie Feinberg, November 26, 2021. "UMaine researcher are trying to create climate change resistant potatoes".

Porter, G.A. 2021. NBC News. Appeared on TV and online news following interview by Dustin Wlodkowski, NBC 10 , Boston, MA, November 23, 2021. "UMaine develops climate change resistant potatoes".

Porter, G.A. 2021. Bangor Daily News newspaper and online news following an interview by Sam Schipani, November 18, 2021. "UMaine is creating a super potato".

Porter, G.A. 2021. NewsCenter 2-TV, Presque Isle, ME. Appeared on NewsCenter 2, Portland, ME news show and was interviewed by Hannah Yechive, July 12, 2021. "Condition of the Maine potato crop, water supply, and market conditions".