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 2020 to Sept 2021
Date of This Report:	20Feb 2022
Annual Meeting Date(s):	13-14 December 2021 (originally Raleigh, NC, but changed to virtual meeting online due to Covid-19)

Brief summary of minutes of annual meeting (December 13-14, 2021 on-line virtual meeting). Attendees at the December 2021 annual NE1731 meeting were Craig Yencho (NC State), Mark Clough (NC State), Walter De Jong (Cornell U), Greg Porter (U ME), Han Tan (U ME), Mark Hutton (U ME), Paul Collins (USDA-ARS Orono, ME), Mark Reiter (VA Tech), Emmanuel Torres Quezada (VA Tech), Xinshun Qu (PA State), Luis Duque (PA State), Matt Kleinhenz (OH State), Marcio Resende (U FL), Leo Hoffman (U FL), Chris Hopkins (Black Gold), Jonathan Price (Sterman Masser Farms), John Lundeen (Potatoes USA), Bob Leiby (PA Coop Potato Growers), Daniel Yoder (Johnny's Selected Seeds), David DeKoeyer (AAFC Fredericton, NB), Erica Fava (AAFC Fredericton, NB), Mitchell Smith (NB Dept Ag).

Project Business

Greg Porter welcomed the group and called the meeting to order at 1:01 PM. The 2020 minutes (from the December 2020 meeting) were unanimously approved. The agenda was reviewed and additions and proposed changes to the agenda were requested. Introductions took place and committee chairs were appointed as follows: Resolutions – Walter De Jong and Mark Clough.

The group discussed site selection for the 2022 annual technical meeting – For two years running, we planned to have an in-person meeting in Raleigh, NC, and for two years running, have met over zoom instead because of the coronavirus pandemic. Porter suggested we try once again for an in-person meeting in Raleigh on Dec 12-13, 2022. All agreed.

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. To ensure continuity during the year of the project re-write, committee will remain unchanged for 2022, with the expectation that one or more new officers be appointed at the next annual meeting.

Administrative Advisor Report – Mark Hutton. Going forward, NERA, rather than NIFA, will be assuming primary oversight of northeast regional projects. This will include a mid-cycle review of all 5 year projects after 3 years. AA Hutton would like to nominate NE1731 for a national multistate award. Hutton relayed a story of how, at the recent Maine Potato Blossom Festival event in northern Maine that was attended by the President of the University of Maine, a grower approached the President and said "I'd like you to know that the potato variety Caribou Russet saved my farm". This was an excellent testimonial on the impact of our collective research effort.

Regarding the NE1731 project rewrite: we need to write a proposal, submit to Hutton by late January. He will review, and if satisfactory, submit to NE Multistate Committee for their approval.

National Institute of Food and Agriculture (NIFA) Report – Tom Bewick. Bewick tried to join our zoom meeting, but was denied entry without a passcode. He emailed to ask for the code, but we didn't notice until many hours later. We apologize!

Research presentations

Han Tan provided on update of the SCRI diploid potato project, a national effort to reinvent potato as an inbred diploid crop. KASP markers linked to the Sli locus have now been published. 50 dihaploids have been sequenced to date (20x coverage) to assess genetic diversity captured to date; surprising is that chromosome 10 has much less diversity than the other 11 chromosomes. Agronomically improved inbreds are being developed through recurrent selection. Clone W2x001-22-45 is homozygous for (earlier) maturity and Sli loci, making it a useful parent. Agronomic and economic studies are underway to evaluate future impact(s) of true potato seed (TPS) in the commercial potato seed system.

State Site Reports

FL – According to USDA-NASS, potato acreage was 21,000 acres in 2021, producing 5,300,000 cwt. Growing conditions were fair. There was one freeze event during 2021, which did not affect crop development.

The "Clean Waterways Act", created to overcome environmental issues related to the pollution of waterways, was signed into law in 2021. This act requires UF/IFAS (and other agencies) to develop annual research planning focused on agricultural runoff. This means that potato growers enrolled in BMP programs must follow UF/IFAS nutrient management recommendations. UF/IFAS has released N-fertilizer guidelines for potatoes based on tuber yield goals and is currently working on an update of P-fertilizer recommendations.

ME – estimated 55,500 acres for 2021, up about 5000 from 2020, likely because yields were low the past few years and contracted acres increased in response. Yields in 2021 were up, though, to 330-340 cwt/acre, from 269 cwt/acre in 2020. Industry about 60% fry and chips, 20% fresh, 20% seed.

NY – estimated 13,000 acres. USDA-NASS no longer reports potato acreage for NY. Similar to ME, abundant rainfall during tuber bulking increased yields in NY.

NC – currently has about 13,000 acres of potatoes, which will likely be less in 2022 due to cost of inputs and contract prices. Industry still about 70/30 - chip/table. Over Memorial Day weekend various trial locations received 7 to 15 inches of rain, with attendant consequences. At the Tidewater station flooding damaged 1/3 of the crop.

OH – USDA-NASS reporting changed after 2017, to the extent that acreage data is unreliable for all OH vegetables. OH has a few large chip growers and many small fresh market growers. B-sized potatoes are of increasing interest for some growers.

PA – Estimated 5000 acres. High yields in 2021, although better in southeast than north. Seeing some soft rot issues.

VA – estimated 3000 acres, based on own assessment (as in OH, NASS acreage data is not reliable). 45% chip/55% fresh market. Poor weather prevented harvest of regional yield trial, with rot evident in field.

NB – Good growing season, 52,000 acres, 60% planted to processing potatoes. Wet weather in fall may lead to problems in potato storages.

Comments from Industry

John Lundeen (Research Director for Potatoes USA) provided an overview on potatoes USA research programs. In 2022 MD will start hosting a National Chip Processing Trial, to provide additional assessment of susceptibility to internal heat necrosis. For the National Fry Processing Trial: there is increasing industry emphasis on traits related to sustainability (e.g., water use efficiency).

Jonathan Price: commented that if eastern packers can purchase and re-pack higher quality potatoes grown out west, they will do so rather than pack lower quality potatoes grown in the east. In other words: high potato quality matters more than geographic origin.

Daniel Yoder: noted that there is an overall boom in the vegetable seed industry (not just potatoes). Johnny's only sells fresh market vegetable seed, with a preference for unique/specialty varieties. Specialty potato varieties that store well are of particular interest.

Chris Hopkins: smaller chip potatoes are needed by industry, but not at the cost of reducing overall yield. The ability to grow with less water and nitrogen is increasingly important.

Pathology Reports

Greg Porter recently emailed results from his ME common scab trial and reminded us that colleague Jay Hao is willing to screen clones for resistance to pink rot (in the field), soft rot (in the lab), and blackleg (in both greenhouse and field).

Xinshun Qu emailed the results of early and late blight testing from PA, as well as common scab trial results, before the meeting began. He has also started to evaluate transgenic potatoes, expressing candidate genes for resistance against early blight, late blight, and common scab, and initial results are promising.

Erica Fava reported that while growing conditions were good in NB, scab pressure was low in her test plot. NY165 exhibited the most resistance of any clone in her 2021 trial, better than Hindenburg. AAFC is currently negotiating for a new MOU with CFIA to test for resistance to wart.

12. Breeding/Genetics Reports

Maine. Planted 42,000 single-hills, saved 2%. Are currently genotyping 192 third year clones each year to construct a training population for genomic selection. Two clones entering SNAC trials in 2022: MSAFB609-12 will be tested in Northern SNAC trails while MSAFB635-15 will be tested at both Northern and Southern SNAC sites. Hamlin Russet, released in 2020, is being adopted in the West, thanks to NFPT trials; it had not garnered interest in the East. The red

clone NDAF113484B-1, a breeder's choice selection in 2021, is moving towards commercialization; more attractive skin and better cooking quality than Dark Red Norland. AF5280-5, a round white, performed well in most trials in 2021; competes well with Superior and is tolerant to pink rot and resistant to golden nematode. It is also moving towards commercialization. Breeder's choices for 2022 are AF6194-4 (round white), AF6289-2 (red), and MSAFB635-15 (chip).

New York. After the longest harvesting and grading season in memory, the program intends to reduce its footprint in 2022, in part by increasing threshold for fry color out of 43F cold storage (old standard: as light as Snowden. New standard: lighter than Snowden), and in part by discarding more clones that are susceptible to PVY (where markers are used to screen for resistance in third-year clones). Most promising clones currently in program are NY163 (lightest fry color of any clone yet developed at Cornell) and five offspring from a cross between NY148 and E48-2. All five have shown high yield, high specific gravity, and excellent fry color from cold storage. One of those five, NY168, as well as NY163, will be in SNAC trials in 2022. Breeder's choices are NY163 and NY171 (long white with purple splash around tuber eyes).

North Carolina. Craig Yencho provided an overview of both the sweet potato and potato breeding programs he oversees. As clonally propagated crops, the two programs have many parallels. 106,000 acres of sweet potatoes in NC, and about 13000 acres of potatoes. For potatoes, they plant in March and harvest in June/July. Focus is on breeding for heat tolerance, PVY resistance, and implementation of genomic selection. Both the potato and sweet potato programs are moving to multi-hill plots (rather than single-hill plots) in the first field year, to provide both more meaningful assessment of clone performance and accelerate seed production for subsequent years (for surviving clones). To date have genotyped 471 potato clones as a training population for genomic selection.

USDA-ARS. Paul Collins started as the new USDA breeder in January 2021 and is based on the U ME campus in Orono. Currently aims to plant 30,000 seedlings a year, with about 10% being diploid. Will continue predecessor Kathy Hayne's efforts to improve heart tolerance. In collaboration with Michigan State University, evaluated yield of 12 diploids (products of recurrent selection at MSU) in MI and ME. Found three that yielded more (Tukey's HSD) than the tetraploid checks Atlantic and Lamoka. Randomized complete block design, 3 replicates, 25 hill plots.

AAFC. David DeKoeyer is the new breeder in Fredericton. Program is undergoing a revamp, aiming to breed better varieties faster. Have recently begun to place a much larger emphasis on French fry varieties. AAFC runs variety trials all across Canada and is shifting to digital image analysis, an optical grader, and PotatoBase to modernize phenotyping and data storage, analysis, and management. Are using molecular markers to select for PVY, PVX and golden nematode resistance, and inoculations to screen for resistance to Fusarium and late blight. Have genotyped about 840 clones to date as a training population for genomic selection.

Florida. The University of Florida has started a potato breeding program. The focus is on chipping potatoes adapted to FL (heat tolerant, high gravity). The program has requested clones from other potato breeders to use as parents, and have been pleasantly surprised that others are happy to share germplasm (this is not the case in many other crops). U FL has provided funding for a new single-row harvester and a PhD student, who will start next fall,

focusing on genomic selection. Currently using breeding program simulation software developed by John Hickey (AlphaSimR) to test various ideas of how to run the new program.

Update on the NE1731 website/database/data reporting. Mark Clough briefly walked us through some features of the NE1731 database hosted at neproject.medius.re. Comparing candidate varieties to standards is so simple now!

Seed orders, shopping list, new entries – Greg emailed all participants a list of 27 test clones and 11 standard varieties to be considered for evaluation. Yields were good in 2021, so seed supplies are abundant.

Breeder's choices (all sites must evaluate these):
AF6194-4 (round white)
AF6289-2 (red)
MSAFB635-15 (chip)
NY163 (chip)
NY171 (long white with purple splash)

Standard varieties to include in all NE1731 trials:
Atlantic
Dark Red Norland
Snowden
Superior
Yukon Gold

Eastern Region Potato Special Grant. Potato Special Grant was funded for 2021. As this is now awarded for two years at a time, no need to submit a proposal in 2022.

NE1731 project rewrite. We have been approved to submit a new multistate project proposal. Our proposal from five years ago has been emailed to many participants; updates requested by January 6. The group discussed the general project approach, rewrite process, and plans/goals for the next five-year period.

New funding opportunities. No new opportunities were discussed this year.

Old Business. Soon after the conclusion of this meeting we need to submit annual report and minutes; please provide input promptly when requested.

New Business. Consistent scoring of flesh and skin color would be facilitated by using widely available "paint chip" color cards. Kleinhenz has started to do this in Ohio, encourages others to consider same.

Committee Reports

Site Selection: next meeting will be in Raleigh NC, December 12-13, 2022. Coronavirus willing. Otherwise zoom, yet again.

Nominations: current committee will continue (Porter as Chair, Clough as deputy Chair, De Jong as secretary). Intent is to reformulate committee at next annual meeting.

Resolutions (approved unanimously):

Be it resolved on this 14th day of December 2021, that the NE1731 group expresses sincere appreciation to:

a) Mark Clough and Craig Yencho, North Carolina State University, for organizing this meeting and their willingness to host the meeting (yet again, third time in a row) next year;

b) Tom Bewick, USDA-NIFA, for his leadership in providing, maintaining, and administering NIFA funding of agricultural research;

c) Paul Ocaya and other members of the University of Maine technical and professional staff for their extensive efforts planting, rogueing, sampling, harvesting, packing, and shipping seed potatoes from the NE1731 seed potato nursery;

d) Mark Clough of North Carolina State University for his on-going database management and electronic data capture efforts on behalf of the NE1731 project;

e) Greg Porter, University of Maine; Craig Yencho, North Carolina State University; and Walter De Jong, Cornell University for continuing to serve their NE1731 project leadership roles;

f) Mark Hutton for his willingness to serve as our administrative advisor and provide timely and important information for the project;

g) John Lundeen (Potatoes USA), Jonathan Price (Sterman Masser Potato Farms) , Bob Leiby (PA Cooperative Potato Growers, Inc.), Daniel Yoder (Johnny's Selected Seeds) and Chris Hopkins (Black Gold Farms) for their insights into the industry and the value of the project;

h) Han Tan for serving as a liaison to our group for the Potato 2.0 project as they attempt to move potato breeding into a diploid format.

Other Business – none. Adjournment – 11:47 am on 14December 2021.

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 and pest resistance was conducted in ME, NY, NC, and USDA-ARS Beltsville, MD during 2021. During 2021, our programs generated 768 new tetraploid families (366,057 seeds) from crosses using parents with desirable quality, utilization, adaptation, and/or pest resistance traits. Progeny (65,511) from earlier crosses were field selected resulting in 2031 clones that will be further evaluated during 2022 under conditions with diverse abiotic and biotic stress in the eastern U.S. and beyond. These four programs focus on specific pest 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, soft rot, and scab resistance. During 2021, 269 ME crosses were made resulting 117,068 true seed for future selection and variety development. During the 2021 growing season ME evaluated 42,000 first-year generation clones selecting 850 (~ 2%) and 1259 second-year clones selecting 239(~19%). The selected clones will continue evaluation during 2022. NY emphasizes white-skinned chipping crosses, but also selects fresh market clones of varying skin and flesh colors. NY emphasizes resistance to golden nematode, but also is crossing for late blight, virus, white cyst nematode, and other resistances. All advanced NY clones were evaluated for resistance to the golden nematode during 2021 using an established bioassay. NY continues to select for improved chip quality from cold storage. For the fourth 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. Beginning in 2021/2022, the NY selection strategy will be to retain only chipping clones that chip better than Snowden from cold storage. Over time this will result in the release of new varieties with improved long-term storage chip quality. During 2021, 72 NY crosses resulted 142,250 true seed for future selection and variety development. NY evaluated 1,680 first-year clones during 2021 selecting 104 (~ 6%) and 1162 second-year clones selecting 250(~22%). Twenty-five advanced NY clones were evaluated in on-farm trials in NY during 2021. NY continues to conduct crosses using germplasm from outside of North America (e.g. Barbara, Gui Valley, Kameraz, Libertas, Nautilus, Rose Valley, Symfonia, Vida) to broaden the program's overall genetic base.

NC's potato breeding program focuses on heat-stress tolerance 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 2021, 156 crosses resulted in 81,408 true seed. During the 2021 growing season NC evaluated 9,905 first generation clones selecting 630 (~6.4%) and 1028 second generation clones selecting 484 (47.1%). NC screened its 1028 2nd field year clones for the presence of DNA-based markers associated with potato virus Y (Ry_{adg} or Ry_{sto}) and golden nematode resistance (H1). The 2021 screening results showed that 276 (27%) carry the Ry_{adg} marker, 37 (4%) carry the Ry_{sto} marker and 423 (54%) carry the H1 marker. NC also screened 518 clones from twelve public US breeding programs for heat tolerance and adaptation to NC and the Southeastern US. In addition to NC, PA is now screening all ME 3rd and 4th year russet clones (78 during 2021) to help select for improved heat tolerance in our russet selections. FL initiated potato breeding during 2021 that will further strengthen our region's efforts to create heat-tolerant potato germplasm with adaptation to the Southeastern US.

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. USDA-ARS conducted 25 successful *2x-2x* diploid crosses resulting in 2493 seeds for future research as well as two *4x-2x* crosses resulting in 159 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 haploid inducer crossed to tetraploid potato (e.g. Atlantic, Caribou Russet, NY121, and five other tetraploid clones). ME currently has 436 primary dihaploid lines in tissue culture. These lines are being phenotyped by chloroplast counting and other methods. During 2021, 99 primary dihaploids derived from Caribou Russet (ME03), NY121 (ME04), Castle Russet (ME05), Saginaw Chipper (ME06), Dakota Trailblazer (ME07) and Lamoka (ME08) were planted in the field 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. In 2021, selected dihaploids from the previous year were crossed the diploid clone, W2x001-22-45 that harbors the dominant, *Sli*-based self-incompatibility inhibitor gene as well as, US-W4 which also contains a *Sli*-based inhibitor. Eight primary dihaploid lines were chosen as parents, but only line ME03_0042 successfully produced fruit. All F1 seeds from the successful crosses were sown but only crosses to W2x001-22-45 germinated. These F1 seedlings were transplanted in 2" pots for minituber production. Genetic studies are currently 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*. Further phenotyping and linkage mapping analyses are planned for 2022.

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 and can also reduce production costs. Screening trials in PA, evaluated our NE1731 and advanced breeding clones for early blight, late blight, and common scab resistance. During 2021, ME also conducted screening studies for susceptibility to important potato diseases (late blight, common scab, verticillium wilt, soft rot, pink rot, fusarium, potato virus Y, and potato leafroll virus). These data are used to select resistant varieties/breeding clones. NY's long-term effort at increasing the frequency of PVY resistance in its germplasm is bearing fruit. Eight of the 11 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). All 2nd year NC clones are screened for the presence or absence of PVY resistance genes (Ry_{adg} and R_{ysto}) as well as for golden nematode resistance (via the H1 DNA-based marker). As noted earlier 27, 4, and 41% tested positive for the respective resistance markers during 2021. 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 using genome-wide association studies. The candidate genes were cloned and transferred into disease susceptible varieties. The transgenic plants were evaluated for disease resistance in field trials during 2021. Experiments in ME are being used to identify clones with resistance to pink rot, fusarium, black leg, and softrot. Caribou Russet from the Maine breeding program and several diploid clones from USDA-ARS at Beltsville have shown high levels of resistance to blackleg and softrot'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. Eleven advanced clones were entered into tissue culture programs during 2021 leading to commercial seed production. Several advanced clones and newly released varieties are currently being evaluated in commercial scale trials on-farm for their potential across the US. Two of NY's recent chipping releases Waneta (NY138) and Lamoka (NY139) have been widely adopted by commercial growers. Based on 2021 certified seed acreage, Lamoka ranks 8th among US varieties in certified seed production (3108 acres) and has replaced Snowden (1874 seed acres in 2021) as the standard storage chipping variety across the US. Waneta has also been widely adopted (1511 acres of seed in 2021, 15th ranked in the US) for chipping 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, formerly NY152, was released for chipping during 2018 and has high yields, excellent chip color out of cold storage, potato virus Y and common scab resistance. National seed acreage increased to 629 during 2021, ranking it 31th in the U.S. just three years after its official variety release. Twenty-three 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 1476 acres (#16 in the US) during 2021. Caribou Russet's cash farm value to ME seed growers was ~$4.4 M during 2021 and the estimated cash farm value when this seed crop is planted, grown and harvested in 2022 is ~$41M. 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 2020 for early fry processing and russet fresh market. It has moderate scab resistance. Certified seed acreage rose to 90 acres (81st in the US) during 2021. AF5071-2 and AF5406-7 are advanced fry processing clones that are generating commercial interest. Thirty additional French fry clones are currently being evaluated by North American potato processors. Reveille Russet from TX recently completed testing in NE1731 regional trials and shows promise as a fresh market russet. It now ranks 23rd in US seed potato production 868 seed acres.

For fresh market, 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 42 in 2020, ranking it 118nd 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 New York, while Ro2 is a newer race that has become increasingly difficult to manage in New York. NY also released Upstate Abundance (NY150) and Algonquin (NY141) during 2017. Algonquin seed acreage totaled 51 during 2021, ranking it 111th nationally. It is being grown for fresh market and is a white skinned, white fleshed variety. It has 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 potato virus Y (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 29 during 2021, ranking it 142nd nationally. The University of Maine released Pinto Gold (AF4659-12) in 2018. It is a pinto-type, yellow-fleshed 'roasting' variety is also being commercialized by small-scale local foods markets and has been favorably received in this high-value market. Other fresh market releases Red Maria (2010), a high-yielding red, Lehigh (2007), a widely-adapted yellow-fleshed variety, and Peter Wilcox (2007), 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 and wide adaptation.

Each eastern breeding program submits its most promising advanced clones to the NE1731 regional project's seed nursery in ME. During 2021, the project distributed seed potatoes for 12 regional potato variety trials conducted in seven states and two Canadian provinces. Eleven standard varieties and 16 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 broad 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. Considering yield and quality attributes the most promising clones by market type were: chipping (MSAFB609-12, MSAFB635-15, NY163, and NY165); fresh market whites (AF5280-5 and AF5819-2); russet and long-whites (AF5071-2, and AF5406-7), reds and specialty (NDAF113484B-1). Similar variety trials will be conducted during 2022 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 a more powerful and the user-friendly Variety Data Management 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 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.

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 2020 include:

- **AF4648-2** (NY132 x Liberator), a mid-season, round to oblong white with good yields, moderately-high gravity, bruise resistance, very good chip color, and good appearance. It could go for chipping or fresh market. It has good scab resistance and is resistant to golden nematode and PVY. It has moderate pink rot and late blight resistance.
- **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.

- **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.
- **AF5819-2** (Dakota Crisp x AF4552-5), is a medium maturing fresh market clones with bright skin, 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), is 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.
- **MSAFB609-12** (NY148 x MSQ086-3), is a medium-ate maturing chipper with moderate to high yields, moderate to high specific gravity, good chip color, smooth skin, and fair to good tuber appearance. It has resistance to late blight, PVY, golden nematode, pink rot, fusarium, and shatter bruise. MSAFB609-12 has potential for chipping from northern areas. This clone will be evaluated in the 2022 Potatoes USA National SNAC chipping trials (northern storage areas only).
- **MSAFB635-15** (NYH15-5 x MSS297-3), is a medium-late maturing chipped 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 will be evaluated in the 2022 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 moderate scab and late blight resistance. 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.
- **NDAF113484B-1** (ND060570B-1R x ND8555-8R), a pretty, 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). Yields are typically similar to those of Dark Red Norland.
- **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 0.005 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 relatively low hollow heart incidence (4% across 11 trials). It has moderate scab resistance and is resistant to golden nematode (Ro1). It is currently being evaluated 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). It is currently being evaluated in 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. Annual farm gate receipts for eastern potato production exceed 460 million dollars, therefore the impact of a successful new potato cultivar can mean many millions of dollars to the industry over time. Potatoes can cost more than $2500 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, can reduce production costs by reducing the number of chemical sprays applied to protect the crop from the pest. Several areas in NY could not produce potatoes without the golden nematode resistant varieties developed as part of this and other research projects. 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 and helps our programs select more stress-tolerate potato varieties. During 2021, NC screened > 500 advanced and preliminary clones from 11 state and 2 USDA-ARS potato breeding programs for resistance to IHN.

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 2021 certified seed acreage, Lamoka ranks 8th among US varieties in certified seed production (3108 acres) and has replaced Snowden (1874 seed acres in 2021) as the standard storage chipping variety across the US. Waneta has also been widely adopted (1511 acres of seed in 2021, 15th ranked in the US) for chipping 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, formerly NY152, was released for chipping during 2018 and has high yields, excellent chip color out of cold storage, potato virus Y and common scab resistance. National seed acreage increased to 629 during 2021, ranking it 31th in the U.S. just three years after its official variety release. Twenty-three 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 1476 acres (#16th in the US) during 2021. Caribou Russet's cash farm value to ME seed growers was ~$4.4 M during 2021 and the

estimated cash farm value when this seed crop is planted, grown, and sold in 2022 is ~$41M . 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 90 acres (#81st in the US) during 2021. AF5071-2 and AF5406-7 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 just completed testing in NE1731 regional trials and shows promise as a fresh market russet. It now ranks 33rd in US seed potato production at 435 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 3127 ME and NY seed acres during 2021 with a seed value of ~$10.9M. The resulting seed crop has the potential to plant 31,274 acres in 2022 with a ware value estimated at $101.6M. Nationally, varieties released by our long-term project since 2007 were grown on 7369 seed acres during 2021 with an approximate seed value of $25.8M and potential ware production value of $239.4M. Several varieties developed though our collective efforts are in the top 100 U.S. varieties based on seed acreage, including (acres, rank): Lamoka (3108, 8), Waneta (1511, 15), Caribou Russet (1476, 16), Lady Liberty (629, 31), Lehigh (283, 48), Reba (126, 71), Hamlin Russet (90, 81), Eva (88, 83), and Genesee (73, 92). 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 (2360 acres, ranks 9th 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 potato virus Y (PVY). Advanced clones in our programs typically have resistance to several important potato pests and/or physiological disorders. As examples, 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 potato virus Y and late blight; Upstate Abundance (formerly NY150), released by Cornell in 2017, has resistance to late blight, common scab, potato virus Y, and golden nematode; Brodie (tested as NY140) was released by Cornell University 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 in NY. 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 potato virus Y (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. 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, softrot, pink rot, fusarium, etc.). 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. USDA-ARS conducted 25 successful *2x-2x* diploid crosses resulting in 2493 seeds for future research as well as two *4x-2x* crosses resulting in 159 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 haploid inducer crossed to tetraploid potato (e.g. Atlantic, Caribou Russet, NY121, and five other tetraploid clones). ME currently has 436 primary dihaploid lines in tissue culture. These lines are being phenotyped by chloroplast counting and other methods. Additionally, whole genome sequencing libraries were generated and Illumina genomic sequencing is being performed. These populations will be useful for future breeding and for studies on inheritance of important potato diseases, such as late blight, potato virus Y, and soft rot.

7. Our project web site and searchable database continues to grow in size and utility. The database has now migrated to a more powerful and the user-friendly Variety Data Management 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 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.

Outputs:

1. Cultivars released this year:

- Our group did not release any new cultivars during 2021; however, commercialization of our recent releases continued as is summarized above.

2. Publications:

Refereed Journal Papers

Andrade, M.H.M.L., A.L.B.R. da Silva, L.G. Pesantes, C.T.Christensen, and L. Zotarelli. 2021. Seed piece spacing for early-maturing table-stock potato grown under subtropical conditions. Am. J. Potato Res. https://doi.org/10.1007/s12230-021-09838-z

Brown-Donovan, K.M., G.A. Porter, and E.H., Tan. 2021. Late blight resistance profiles of elite potato germplasm in the United States. American Journal of Potato Research doi: 10.1007/s12230-021-09837-0

Christensen, C.T., L. Zotarelli, K.G. Haynes, and J. Colee. 2021. Quantifying *Solanum chacoense* root morphology responses to limited nitrogen supply using in vitro, hydroponic, and field monolith methods. Am. J. Potato Res. 98:246-254. DOI: 10.1007/s12230-021-09829-0

Curland, R.D., A. Mainello, K.L. Perry, J. Hao, A.O. Charkowski, C.T. Bull, S. Johnson, N. Rosenzweig, G.A. Secor, and C.A. Ishimaru. 2021. Species of *Dickeya* and *Pectobacterium*

associated with 2015-2016 outbreaks of soft rot and blackleg of potato in Northeastern and North Central United States. Microorganisms 9(8):1733. DOI: 10.3390/microorganisms9081733.

De Jong, W.S., D.E. Halseth, R.L. Plaisted, X. Wang, K.L. Perry, X., Qu, K.M. Paddock, M. Falise, B.J. Christ, and G.A. Porter. 2020. Waneta, a variety with excellent chip color out of cold storage, long tuber dormancy, and resistance to the golden cyst nematode. American Journal of Potato Research 97:580-585.

Ge, T., H. Jiang, E.H. Tan, S.B. Johnson, R.P. Larkin, A.O. Charkowski, G. Secor, and J. Hao. 2021. Pangenomic analysis of *Dickeya dianthicola* strains reveals the outbreak of blackleg and soft rot of potato in USA. Plant Disease doi: 10.1094/PDIS-03-21-0587-RE

Ge, T., H. Jiang, S.B. Johnson, R.P. Larkin, A.O. Charkowski, G. Secor, and J. Hao. 2021. Genotyping *Dickeya dianthicola* causing potato blackleg and soft rot outbreak associated with inoculum geography in the United States. Plant Disease xx-xxx. DOI: 10.1094/PDIS-10-20-2138-RE.

Ge, T., S.B. Johnson, R.P. Larkin, L Luo, X. Liu, and J. Hao. 2021. Interaction between *Dickeya dianthicola* and *Pectobacterium parmentieri* in potato infection under field conditions. Microorganisms 9(2): 316. DOI: 10.3390/microorganisms9020316.

Hao, J., and K. Ashley. 2021. Irreplaceable role of amendment-based strategies to enhance soil health and disease suppression in potato production 9:1660. DOI: 10.3390/ microorganisms9081660.

Krupek, F.S., P.J. Dittmar, S.A. Sargent, L. Zotarelli, and D.L. Rowland. 2021. Impact of early potato desiccation method on crop growth, skinning injury, and storage quality maintenance. Am. J. Potato Res. doi:10.1007/s12230-021-09836-1

Lee, W.C., L. Zotarelli, D.L. Rowland, and G. Liu. 2021. Evaluation of potato varieties grown in hydroponics for phosphorus use efficiency. Agriculture, 11(7), 668. https://doi.org/10.3390/agriculture11070668

Levina, A.V., O. Hoekenga, M. Gordin, C., Broeckling, and W.S. De Jong. 2021. Genetic analysis of potato tuber metabolite composition: genome-wide association studies applied to a non-targeted metabolome, Crop Science 61:591-603. https://doi.org/10.1002/csc2.20398

Mishra, S., J. Dee, W. Moar, J. Dufner-Beattie, J. Baum, N.P. Dias, A. Alyokhin, A. Buzza, S.I. Rondon, M. Clough, S. Menasha, R. Groves, J. Clements, K. Ostlie, G. Felton, T. Waters, W.E. Snyder, and J.L. Jurat-Fuentes. 2021. Selection for high levels of resistance to double-stranded RNA (dsRNA) in Colorado potato beetle (*Leptinotarsa decemlineata* Say) using non-transgenic foliar delivery. Sci Rep 11, 6523. https://doi.org/10.1038/s41598-021-85876-1

da Silva Pereira, G., Mollinari, M., Schumann, M.J., Clough, M.E., Zeng, Z.B., and G.C. Yencho, 2021. The recombination landscape and multiple QTL mapping in a *Solanum*

tuberosum cv. 'Atlantic'-derived F_1 population. Heredity 126**,** 817–830. https://doi.org/10.1038/s41437-021-00416-x

Rens, L.R., L. Zotarelli, A.L.B.R. da Silva, Ferreira, C.J.B., C.A. Tormena, D.L. Rowland, and K.T. Morgan. 2021. Managing water table depth thresholds for potato subirrigation. Agricultural Water Management, 259:107236. https://doi.org/10.1016/j.agwat.2021.107236

Tooley, B.E., E.B. Mallory, G.A Porter, and G. Hoogenboom. 2021. Predicting the response of a potato-grain production system to climate change for a humid continental climate using DSSAT. Agricultural and Forest Meteorology. 307 (2021) 108452

Published Abstracts

Andrade. M., L. Gomez-Pesantes, L. Zotarelli, and G. England. 2020. Tuber yield and size distribution as function of seed piece spacing for table-stock potatoes. Abstract of Am. Soc. of Horticultural Sciences Annual Meeting. HortScience 55(9):S281.

Andrade. M. and L. Zotarelli. 2020. Comparison of spatial models for potato breeding trials. Abstract of Am. Soc. of Horticultural Sciences Annual Meeting. HortScience 55(9):S23.

Bortolozzo, F., R. Mwatuwa, L. Zotarelli, A.L.B.R. Silva, and T. Wade. 2020. Potato yield and net return of n-fertilizer rate and timing for seepage and subsurface drain-tile irrigation. Abstract of Am. Soc. of Horticultural Sciences Annual Meeting. HortScience 55(9):S360.

Ge, T., S. Johnson, R.P. Larkin, A.O. Charkowski, and J. Hao. 2020. Pathogen synergism of blackleg disease on potato. DOI: 10.1094/PHYTO-110-12-S2.207.

Other Publications (Book Chapters)

Jansky S.H., W.S. De Jong, D.S. Douches, K.G. Haynes, and D.G. Holm. 2021. Cultivar Improvement with Exotic Germplasm: An Example from Potato. In: The Wild Solanums Genomes. D. Carputo, R. Aversano, M.R. Ercolano, Eds. Springer, Cham, Switzerland. pp 215-230. DOI: 10.1007/978-3-030-30343-3_12

Other Publications

De Jong, W.S. and M. Falise. 2021. Cornell potato breeding program annual report. 33 pp.

Clough, M. and G.C. Yencho. North Carolina Potato Variety Trial and Breeding Report 2021. 41 pp. (available online at https://potatoes.cals.ncsu.edu/)

Ge, T. 2021. Characterization of *Dickeya dianthicola* and *Pectobacterium parmentieri* causing blackleg and soft rot on potato. University of Maine, Ph.D.dissertation.

Kleinhenz, M.D., and S.D. Walker. 2021. 2021 Ohio potato germplasm evaluation report, in Cooperation with the Northeast (NE-1731) Regional Project, The Ohio State University Horticulture and Crop Science Series No. 886, Nov. 2021. 51 pp.

Li, K. 2021. Determining effects of management on potato early dying and soil microbiome and assessing risk of fungicide resistance in *Verticillium dahliae*. University of Maine, M.S. thesis.

Liu, G., X. Fu, L. Zotarelli, S.A. Sargent, K.W. Migliaccio, and Y. Li. 2020. How to fertigate plant vines via center pivots for commercial potato production in Florida. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida EDIS Publication HS1361. https://edis.ifas.ufl.edu/hs1361

Porter, G.A., P. Ocaya, B. MacFarline, and B. Plummer. 2021. Potato variety trial results in Maine, 2020 growing season. SFA Research Report (posted on www and distributed to industry), 2020-01, 22 pp. Also available at https://neproject.medius.re

Porter, G.A. and P. Ocaya. 2021. Progress report on potato PVY research - 2020 Growing Season. Report to the Maine Potato Board, submitted February 2021, 5 pp.

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Qu X.S., W.Y. Xue, and M.W. Peck. 2021. Field evaluation of potato cultivars and breeding lines for resistance to late blight in Pennsylvania, 2020. Plant Disease Management Reports 15:V033.

Qu X.S., M.W. Peck, and X.Y. Xue. 2021. Evaluation of fungicides for control of potato early blight in Pennsylvania, 2020. Plant Disease Management Reports 15:V034.

Qu X.S., M.W. Peck, and X.Y. Xue. 2021. Evaluation of foliar fungicides for control of potato late blight in Pennsylvania, 2020. Plant Disease Management Reports 15:V035.

Qu X.S., W.Y. Xue, and M.W. Peck. 2021. Field evaluation of potato cultivars and breeding lines for resistance to early blight in Pennsylvania, 2020. Plant Disease Management Reports 15:V036.

Torres Quezada, E. and M. Reiter. 2021. Virginia potato variety trial report, 2021. Eastern Shore Agricultural Research and Extension Center, 27 pp.

Zotarelli, L., T. Wade, G.K. England, and C.T. Christensen. 2021. Nitrogen fertilization guidelines for potato production in Florida. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida EDIS Publication HS1429. Available at https://edis.ifas.ufl.edu/publication/hs1429

Zotarelli, L. and P. Solano. 2021. Florida potato variety trial report, 2021. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, Volume 12. Available at https://hos.ifas.ufl.edu/extension/variety-trials/

PRESENTATIONS:

Alaba, O., L. Heroux, B. Moore, M. Davis, G.A. Porter, and E.H. Tan. 2021. Estimating the efficacy of potato haploid induction system from seed abortion rates. Potato Association of America Annual Meeting (Virtual Meeting, 2021)

Clough, M. and C. Yencho. 2019. NC Regional Potato Growers Talks, Dec 8th 2020.

Hao, J.J. 2020. Multi-facet perspectives in understanding blackleg and soft rot of potato. Inner Mongolia Agricultural University, via Zoom. Dec. 19, 2020.

Heroux, L., O. Alaba, J. Hao, G.A. Porter, and E.H. Tan. 2021. Leveraging primary dihaploid potato genetics to investigate *Dickeya dianthicola* resistance in Caribou Russet. Potato Association of America Annual Meeting (Virtual Meeting, 2021)

Ge, T. and J. Hao. 2021. Diversified bacteria associated with blackleg and soft rot of potato in Northeastern America. Annual Maine Potato Conference, online, January 11, 2021.

Li, K. and J. Hao. 2021. Managing potato early dying using soil fumigation and pesticides. Annual Maine Potato Conference, online, January 11, 2021.

Moore, B, K. Klebon, and E.H. Tan. 2021. In planta Minichromosome Engineering. UMaine Student Symposium (Virtual Meeting, 2021)

Porter, G.A. and P. Ocaya. 2021. Progress report on PVY research - 2020 Growing Season. Report to the Maine Potato Board, Presque Isle, ME. March 10, 2021.

Porter, G.A. and P. Ocaya. 2021. Potato virus Y management and 2021 research update. University of Maine Cooperative Extension on line video presentation. March 2021.

Porter, G.A., P. Ocaya, and K. Brown. 2021. Progress report on Maine potato breeding program – 2020 growing season. Report to the Maine Potato Board, Presque Isle, ME. March 10, 2021.

Porter, G.A., P. Ocaya, and K. Brown. 2021. Breeding potatoes and 2020 potato breeding program research update. University of Maine Cooperative Extension on line video presentation. March 2021.

Qu, X.S. 2021. Pennsylvania potato variety trials 2020 and promising varieties, Mid-Atlantic Fruit and Vegetable Convention, Hershey, PA, February 11, 2021.
Spencer, D., C. Hatton, and E.H. Tan. 2021. Genome instability induced by centromere-mediated genome elimination in the early *Arabidopsis* embryo
Polyploidy in Development, Evolution and Disease (MDIBL, 2021)

Tims, K. and E.H. Tan. 2021. Examining student attitudes towards genetic engineering and the Bioengineered (BE) food label. USDA Agricultural Marketing Services (AMS) and Marketing and Regulatory Programs (MRP) Conference (Virtual Conference, 2021)

Tan, E. H., O. Alaba, O., L. Heroux, D. Spencer, D., and B. Moore, B. 2021. Diploid potato breeding to boost potato breeding and enhancement efforts in Maine. UMaine Extension Workshop (Virtual Meeting, 2021)

Zhang, X. and J. Hao. 2021. Screening potato clones for pink rot resistance. Annual Maine Potato Conference, online, January 11, 2021.

Zotarelli L. and J.M. Oliveria. 2021. Water conservation and nutrient management on vegetable production: a case study of Florida. I International Week of Agronomy. State University of Maringa, CAJOL Academic Center, Maringa, Brazil. Virtual Meeting. 10/27/2021.

Zotarelli L. 2020. Potato and broccoli breeding programs focus on improved varieties for eastern USA. Original title: "Melhoramento genético de batata e brócolis para a Costa Leste dos Estados Unidos". I Workshop Internacional sobre Melhoramento Genético e Produção de Sementes de Hortaliças. Embrapa Hortaliças, Brasilia, Brazil. Virtual Meeting. 11/16/2020.

TOURS, FIELD DAYS, TRADES SHOWS:

Clough, M. 2021. NC Virtual Field Day. June 9th 2021

De Jong, W.S. 2021. Twilight grower meeting at site of on-farm chip potato trial, 5 August 2021, Arkport, NY

NEWSPAPER, READIO, TELEVISION MEDIA ARTICLES:

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".

Tan, E.H. 2021. News article on Morning Ag Clips 2021 https://www.morningagclips.com/new-umaine-research-hub-to-focus-on-potato-virus-y/

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".

Porter, G.A. and E.H. Tan. 2021. NewsCenter 2, Portland, ME. Appeared on "NewsCenter 2 News" and was interviewed by Hannah Yechive, March 2021. "Potato breeding and genetic tools for potato breeding". https://www.newscentermaine.com/article/news/community/umaine-professors-trying-to-develop-potato-varieties-using-new-dna-based-tools/97-4e8e267f-c482-49a4-9e76-67882344b7c2

Porter, G.A. 2020. WAGM-TV, Presque Isle, ME. Appeared on "WAGM TV News" and was interviewed by Kathy McCarty, December 9, 2020. "Genetic tools for potato breeding: our recent grant and application to potato improvement". https://www.wagmtv.com/2021/01/07/researchers-using-potato-dna-to-develop-new-varieties/

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