

Progress Report to the Maine Potato Board Research Subcommittee January 31, 2019

Project Title:

Breeding New Varieties to Provide Marketing Opportunities and Improved Pest Resistance (2018 Growing Season)

Investigators:

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Executive Summary:

The University of Maine Potato Breeding Program uses traditional plant breeding to create, select, and develop new potato varieties for Maine and beyond. The objective is to develop and select new potato varieties which will provide marketing opportunities to the Maine Potato Industry and/or solve disease management problems. During 2018, our research effort by market category was: 50% russets and long-whites for processing and/or fresh market; 40% whites/yellows for chipping and/or fresh market; and 10% reds and specialty varieties. The Maine breeding program is the only eastern U.S. program with an emphasis on russets and long-whites with processing and fresh market potential. This report provides a summary of the 2018 activities.

Caribou Russet (AF3362-1) was named and released during 2015. It has been rapidly adopted by industry due to its dual-purpose potential, outstanding yields, bruise resistance, relatively low hollow heart incidence, moderate scab resistance, and reasonably good appearance. Pinto Gold (AF4659-12) was released during 2018. It is a yellow-fleshed “pinto-type”, fingerling/roaster, specialty variety with an interesting red and yellow skin pattern and excellent cooking quality. It has been well received by small-scale growers, gourmet markets, and home gardeners. Prior releases Sebec (AF0338-17) and Easton (AF3001-6) were named and released during 2014. While both of these varieties had some positive characteristics they both have failed to gain traction within commercial production and marketing systems.

We have many more promising clones in the development pipeline. Examples include: AF4124-7, AF4872-2, AF5071-2, AF5164-19, AF5406-7, AF5407-13, AF5492-6, AF5521-1, AF5661-13 and AAF10615-1 (russets for fry processing; several of these have dual-purpose potential); AF4157-6 (an early-maturing chipping clone); AF4648-2 (a mid-season fresh market clone with scab, PVY, late blight, pink rot, and golden nematode resistance; it can also chip quite well); AF5040-8 (a mid-season chipper with high yields and specific gravity); AF5429-3 (a mid-season chipper with very high yields and specific gravity, as well as verticillium wilt, blackspot, and golden nematode resistance); Other promising chippers that are advancing in the program are AF5563-5, AF5677-4, MSAFB605-4, MSAFB609-12, MSAFB635-15, and WAF10664-3; AF5280-5, AF5819-2, and NDAF102629C-4 (fresh market whites with scab resistance); AF4831-2 and NDAF113484B-1 (pretty reds with good skin color, good quality, and moderate scab resistance); and AF5245-1 (a medium-early, purple-skinned, white-fleshed clone with scab

resistance). We have several other reds and specialty types (e.g. purple or pink blush, purple skin, yellow-fleshed, and/or purple- and red-fleshed clones) in the development pipeline.

Priorities in the area of disease resistance are: late blight, scab, and PVY. Because of increasing concerns about PVY in the U.S. potato industry, we have dramatically increased our crossing and selection program for PVY resistance since 2011. Although these diseases are our top priorities, our work on disease and pest resistance also included efforts to develop varieties with resistance to: PLRV, powdery scab, verticillium wilt, fusarium dry rot, pink rot, soft rot, nematodes, bruising, internal defects, insects, etc. Marker-assisted selection for potato virus Y (PVY) and golden nematode resistance is now an integral part of the breeding program. We are now developing marker-assisted selection procedures for late blight resistance. Advanced clones in our program typically have resistance to several important potato pests. As an example, AF4648-2, a promising dual-purpose chipping and fresh market white, combines excellent common scab, golden nematode, and PVY resistance with moderate late blight, pink rot, and soft rot resistance. Progress in breeding for late blight and scab resistance has been dramatic. We currently have 64 late blight resistant clones moving through the selection process. This includes fourteen 3rd-year clones (14 of 80, 17.5%). Considering more advanced material, 46 of 88 (52.2%) 4th-year and older clones screened for late blight resistant clones showed moderate to good resistance. Fifty of 169 selections (29.6%) had scab resistance in our 2018 screening trial. Twenty-eight (16.5%) of 170 4th year and older clones tested showed evidence of PVY resistance when screened for the presence of DNA-based markers associated with PVY immunity associated with the Ry_{adg} or Ry_{sto} resistance genes. Twenty-five (14.7%) of 170 4th year and older clones tested showed evidence of golden nematode resistance when screened for the presence of the DNA-based markers associated with resistance (H1 marker). Clones with late blight, scab, and/or PVY resistance are present at an increasing frequency in our program and several are advancing toward commercialization. These clones will be moved forward based on field performance and either be developed for commercial release or used as breeding material to produce future commercially valuable cultivars with field resistance to late blight, PVY, and/or scab.

Project Objectives:

1. To breed, select, and develop new potato varieties for Maine which provide marketing opportunities and/or improved pest/disease resistance.

Grant Received:

\$35,000

Accomplishments to Date:

The University of Maine Potato Breeding Program uses traditional plant breeding to create, select, and develop new potato varieties for Maine and elsewhere. The objective of this research is to develop and select new potato varieties which will provide marketing opportunities to the Maine Potato Industry and/or solve disease management problems. Funding provided by the ME Potato Board and USDA-ARS has allowed us to incorporate marker-assisted selection for potato virus Y (PVY) resistance and golden nematode. We are now developing marker-assisted selection procedures for late blight resistance. During 2018, our research effort by

market category was as follows: 50% russets and long-whites for processing and/or fresh market; 40% whites/yellows for chipping and/or fresh market; and 10% reds and specialty varieties. The Maine breeding program is the only eastern U.S. program with an emphasis on russets and long-whites with processing and fresh market potential. Priorities in the area of disease resistance were: late blight, scab, and PVY. Because of increasing concerns about PVY in the U.S. potato industry, we have dramatically increased our crossing and selection program for PVY resistance since 2011. Although these diseases were our top priorities, our work on disease and pest resistance also included efforts to develop varieties with resistance to: PLRV, powdery scab, verticillium wilt, fusarium dry rot, pink rot, soft rot, nematodes, bruising, internal defects, insects, etc. This report provides a summary of the 2018 activities.

Progress on Russets/Long Whites: Caribou Russet (AF3362-1), a dual-purpose russet, was named and released during 2015. Plant Variety Protection (PVP) was obtained and it has been licensed by the Maine Potato Board. It has been rapidly adopted by industry due to its dual-purpose potential, outstanding yields, bruise resistance, relatively low hollow heart incidence, moderate scab resistance, and reasonably good appearance. Baked quality has been good. It may also be a suitable alternative to Shepody for out-of-field and short-term storage fry processing. Management of PVY in seed stocks is expected to be challenging for this variety. It is susceptible to internal heat necrosis in southern areas. Easton (AF3001-6) was named and released during 2013/2014. PVP was obtained and Easton was licensed by the Maine Potato Board. Despite positive traits such as outstanding fry color, high yields, good tuber type, relatively little hollow heart, and very good verticillium wilt resistance, Easton failed in commercial production due to late maturity, bruise, and rot susceptibility.

In the past, I have considered AF5312-1 and AF5468-5 to be promising fresh market russets; however, due to PVY susceptibility and poor symptom expression, AF5312-1 has been dropped from the program and AF5468-5 may soon follow. We currently have many other advanced russet/long-white clones in field and processing trials with McCain Foods and other processors. The most advanced and promising russets for fry processing are AF4124-7, AF4872-2, AF5071-2, AF5164-19, AF5406-7, AF5407-13, AF5492-6, AF5521-1, AF5661-13 and AAF10615-1. Several of these candidate varieties may also work as dual-purpose russets. Yield, tuber type, size profile, internal quality, bruise resistance, and fry processing characteristics are key selection criteria. Promising russet selections with processing potential have been entered into the industry-funded National Fry Processing Trials (NFPT) in ID, ME, ND, OR, WA, and WI. Clones that were particularly good performers in recent NFPT trials were AF5071-2, AF5406-7, AF5492-4, and AAF10615-1.

Progress on Whites and Chippers: Our program is an active participant in the National Chip Variety Trials (NCPT). The NCPT has 10 trial sites [CA, FL, MI, NC, ND, NY OR, TX, and WI(2)] representing major production areas of the U.S). The most promising clones from NCPT enter the Potatoes USA/Snack Food Association (SNAC) chipping trials in CA, FL, ID, ME, MI, MO, NC, ND, OR, PA, and WI, as well as the Potatoes USA NextGen/FastTrack chip evaluation program. Each year we submit ~15 promising chipping clones to NCPT for national evaluation. During 2018, five AF clones performed well in the NCPT trials and will advanced to more extensive testing during 2019. AF5429-3 was the top performing clone in the 2017 NCPT trials and advanced to the 2018 SNAC trials, but it was not well received in the 2018 trials and will not continue to be evaluated as part of SNAC. AF5040-8 completed testing in the SNAC chipping trials during 2018 and has performed well. AF5040-8 is in the FastTrack/NextGen

chipping program, mostly as a possible high gravity alternative to Atlantic in the SE states. It has Atlantic's specific gravity, but has much better internal quality and chip color than Atlantic.

AF4648-2 is primarily a fresh-market white, but it can chip well and has had good long-term chip color in research trials. It combines common scab, golden nematode, and PVY resistance with good tuber appearance, yields, specific gravity, internal quality, bruise resistance, fresh market quality, and chip quality. It also has moderate late blight, pink rot, and soft rot resistance. It does not chip well from cool storage and it is quite susceptible to powdery scab. AF4157-6 is a promising chipping clone that combines early maturity and good out-of-field chipping in the southern states with excellent storage chip color, including low sugars and the ability to chip from cool storage. It has relatively small tuber size, inconsistent yields, and is scab susceptible, but has moderate resistance to pink rot. AF5040-8 has been a good performer in the national chip trials (NCPT and SNAC) due to its high yields, high specific gravity, and good internal quality. It has had good yield in Mid-Atlantic and Southern trials, while providing specific gravity equal to or exceeding Atlantic. Its best market fit is for out-of-field chipping in the south, mid-Atlantic, and southeast coastal states. It has attractive tubers, high specific gravity, and cream to very pale yellow flesh. It is moderately susceptible to common scab. Other promising chippers include: AF5429-3 (very high yields, moderate specific gravity, excellent chip color, and resistance to golden nematode, verticillium wilt, and blackspot bruise); AF5563-5 (good yields, appearance, and chip color; large tubers, moderate gravity; moderate scab and bruise resistance); AF5677-4 (medium-late maturing, high yields, moderate to high specific gravity, good chip color, moderate late blight resistance, internal heat necrosis has been observed in a few trials); MSAFB605-4 (late maturing, high yields, fair tuber appearance, moderate to high specific gravity, good chip color, verticillium, scab, late blight and PVY resistance); MSAFB609-12 (medium-late maturing, moderate to high yields, good tuber appearance, moderate to high specific gravity, good chip color, late blight and PVY resistance); MSAFB635-15 (late maturing, high yields, fair tuber appearance, moderate to high specific gravity, good chip color, moderate verticillium, scab, and blackspot resistance); WAF10664-3 (mid-season, high yields, moderate gravity and good chip color).

AF4648-2, AF5280-5, and NDAF102629C-4 are attractive fresh market whites with high yields and good quality for fresh market. AF5280-5 is medium early and has a bright skin, high yields, low specific gravity, moderate scab resistance, large tuber size, and good internal quality. In addition to scab resistance, it has pink rot, bruise, and golden nematode resistance. NDAF102629C-4 is early maturing and has bright skin along with moderate scab, shatter, and blackspot resistance. Most of our fresh market candidates have good common scab resistance. These clones are advancing through the program and are being extensively trialed to determine which will merit entry into commercial trials and seed production. The top priority for fresh market selection is an early, scab-resistant white for fresh market use throughout the East as a better quality replacement for Superior. Other promising fresh market whites that will be tested again in 2019: AF5225-1 (high yields, cream flesh, light skin netting, internal heat necrosis has been observed in a few southern trials, verticillium and bruise resistance, scab susceptible) and AF5819-2 (mid-season, bright skin, high yields, moderate scab resistance).

Progress on Reds and Specialty Types. Pinto Gold (AF4659-12) was released during 2018. It is a yellow-fleshed "pinto-type", fingerling/roaster, specialty variety with an interesting red and yellow skin pattern and excellent cooking quality. It has been well received by small-scale growers, gourmet markets, and home gardeners. Growers have expressed a strong interest in

new red varieties that have smooth skin, attractive appearance when grown on our soils, and ability to hold their skin color in storage. Reds are a critical component of the seed potato market and new, well-adapted reds will provide opportunities for our seed growers, especially in VA, NC, FL, and other southern states. In addition to our own crosses, red seedling tubers are brought in from WI, ND, CO, and ID and are selected for appearance and yield under northern ME conditions. After two years of selection in northern ME, seed is sent to FL, NC, and central ME trials for additional selection under diverse soil and environmental conditions. This process should result in the development of new, widely adapted, red-skinned varieties. Several are showing good potential though it has been difficult to find the ideal combination of skin quality, yields, bruise/skinning resistance, and PVY tolerance. AF4831-2 is currently our most advanced red. It has pretty skin, relatively small oval tubers, moderate scab resistance, verticillium resistance, and good internal quality. NDAF113484B-1 is a pretty, mid-season, red with bright skin that holds its color well in storage. It is mid-season with moderate scab, shatter, and blackspot resistance.

We currently have several other promising specialty clones that should be of interest to small-scale growers. AF5245-1 is purple skinned with white flesh and moderate scab resistance. It is very attractive and has good yields, tuber size, and internal quality. It has much better purple skin color than Caribe, Purple Viking, and other standard purples. AF5412-3 has purple skin and flesh along with resistance to late blight, verticillium wilt, and net necrosis. AF5414-1 has red skin and flesh along with resistance to common scab, late blight, and net necrosis. AF5633-2 has round tubers, purple skin and flesh along with resistance to blackspot bruise and net necrosis. Promising red and specialty candidates that will be tested again in 2019: NDAF102696C-5 (red skin, pretty, small tubers for baby red market, moderate resistance to verticillium wilt and blackspot); AF5870-2 (yellow-fleshed, late maturity, bright skin, pretty, high yields, moderate scab and blackspot resistance); AF5891-1 (yellow-fleshed, pink splash on the skin, mid-season, pretty, high yields).

Progress of Disease Resistance: Advanced clones in our program typically have resistance to several important potato pests and/or physiological disorders. As examples, Caribou Russet has resistance to verticillium wilt, common scab, and powdery scab as well as excellent bruise resistance; AF4648-2, a promising chipper and tablestock clone, combines excellent golden nematode, scab and PVY resistance with moderate late blight, soft rot, and pink rot resistance. Priorities in the area of disease resistance are: late blight, scab, and PVY. Because of increasing concerns about PVY in the U.S. potato industry, we have dramatically increased our crossing and selection program for PVY resistance since 2011. Although these diseases are our top priorities, our work on disease and pest resistance also included efforts to develop varieties with resistance to: PLRV, powdery scab, verticillium wilt, fusarium dry rot, pink rot, soft rot, nematodes, bruising, internal defects, insects, etc. Marker-assisted selection for potato virus Y (PVY) and golden nematode resistance is now an integral part of the breeding program. We are now developing marker-assisted selection procedures for late blight resistance. Progress in breeding for late blight and scab resistance has been dramatic. We currently have 64 late blight resistant clones moving through the selection process. This includes fourteen 3rd-year clones (14 of 80, 17.5%). Considering more advanced material, 46 of 88 (52.2%) 4th-year and older clones screened for late blight resistant clones showed moderate to good resistance. Fifty of 169 selections (29.6%) had scab resistance in our 2018 screening trial. Twenty-eight (16.5%) of 170 4th year and older clones tested showed evidence of PVY resistance when screened for the presence of DNA-based markers associated with PVY immunity associated with the Ry_{adg} or

Ry_{sto} resistance genes. Twenty-five (14.7%) of 170 4th year and older clones tested showed evidence of golden nematode resistance when screened for the presence of the DNA-based markers associated with resistance (H1 marker). Clones with late blight, scab, and/or PVY resistance are present at an increasing frequency in our program and several are advancing toward commercialization. These clones will be moved forward based on field performance and either be developed for commercial release or used as breeding material to produce future commercially valuable cultivars with field resistance to late blight, PVY, and/or scab.

Breeding and Selection Approach: Crossing takes place at Aroostook Research Farm using parents from our program, Cornell University, Michigan State, North Dakota State University, University Wisconsin, and the USDA-ARS, as well as named varieties from North America, South America, and Europe. We generate true potato seed from the crosses and use these seeds to produce greenhouse seedling tubers. Excess greenhouse tubers are exchanged with the USDA-ARS Idaho, Colorado, North Dakota, and Wisconsin breeding programs to gain access to russets, reds, and chippers from their programs that will strengthen our program's ability to provide new varieties for the Maine industry. This type of exchange program improves the efficiency of potato breeding and variety development throughout North America.

The University of Maine Potato Breeding Program plants ~50,000 single-hills at Aroostook Research Farm during each season (this represents ~50% of the initial screening of potato clones conducted in the eastern U.S.). These single-hill plots were derived from greenhouse tubers grown during the previous year (by our program, the USDA-ARS Aberdeen, North Dakota State University, Colorado State University, and the University of Wisconsin) and represent the first year of field selection to produce new potato varieties. Each single hill is a candidate new potato variety developed from crossing two parents with desirable characteristics (e.g. PVY resistance, market quality, etc). At harvest, clones from the single hills (~1200, typically 2-3%) are selected for further evaluation based on their yield and appearance. The ~1200 clones selected from the single hills are evaluated in year#2 in our 8- and 12-hill plots. Those that are selected during the 2nd field year (~300 clones) are screened again during year #3 in ME (northeast conditions) and NC (southeast climatic conditions). The whites and reds are also screened in FL (southeast climatic conditions). Late blight susceptibility is determined by screening this 3rd-year material in PA. Only the clones with outstanding yields, market quality, and/or pest resistance are kept at each stage. Seed is multiplied in year #3 so that the top performers can enter 4th year replicated yield trials (ME) and regional performance trials (FL, NC, VA, MD, PA, and OH); also the National Chip Variety Trials, NCPT which has 10 trial sites [CA, FL, MI, NC, ND, NY OR, TX, and WI(2)] representing major production areas of the U.S.). The most promising of these enter the Potatoes USA/Snack Food Association (SNAC) chipping trials in CA, FL, ID, ME, MI, MO, NC, ND, OR, PA, and WI. Promising russet selections with processing potential enter the National Fry Processing Trials (NFPT in ID, ME, MI, ND, OR, WA, and WI). Over the course of six years of field selection the clones are evaluated for yield, quality, disease resistance, bruise susceptibility, processing characteristics,

Potato Breeding and Variety Development Project

Cross Desirable Parents in Greenhouse (FY minus 2)	Market classes (50% russets, 40% whites, 10% reds/specialties) Disease resistance priorities (scab, late blight, PVY, others) Crossing at Orono and Presque Isle (ARF)
Produce Seedling Tubers in Greenhouse (FY minus 1)	Seedling Tuber Production in Two ARF Greenhouses
1 st -year Selection Plots in Presque Isle, single hills (FY1)	~50,000 new candidate varieties each year (~1200 saved each year for future study)
2 nd -year Selection Plots in Presque Isle, 8 or 12 hills (FY2)	Fry color evaluations begin (~1200 candidate varieties/year)
3 rd -year Selection Plots in FL, NC, and ME (Presque Isle and Exeter), 20 hills (FY3)	Selection in four different environments (FL, NC, ME1, ME2) improves ability to detect widely-adapted, reliable candidate varieties (~300/year) Processing quality evaluations continue Late blight resistance screening begins DNA-based markers used to test for PVY and GN resistance
Replicated Yield & Quality Trials, ME; screening trials in other states (FY4)	Yield and quality trials expand to multiple sites in ME (ARF, St. Agatha, Exeter) and beyond (~100/year) Screening begins in National Chip Processing Trials (NCPT) Introduction to fry processing companies
Replicated Yield & Quality Trials, ME and other states (FY5)	DNA-based marker testing continues Disease screening: late and early blight, VW, scab, PVY, PLRV/NN, fusarium, pink rot, and soft rot) Screening begins in National Fry Processing Trials (NFPT) Virus removal and clean seed multiplication may begin
Advanced Replicated Yield & Quality Trials, ME; Eastern Regional Trials; Trials in Other Areas; Commercialization Trials; Seed Production (FY6 and beyond)	Extensive yield and quality trials continue in ME (ARF, St. Agatha, Exeter) and beyond (~20/year) Snack Food Association Chip Variety Trials (SFA/USPB) NCPT and NFPT trials continue Grower, chip and fry processing company trials Continued disease screening and DNA-based marker screening Virus removal and clean seed multiplication may begin

and other attributes. It takes six to eight field seasons of selection and evaluation of the advanced materials at multiple trials sites to identify potato clones that show enough promise to warrant seed production for commercial-scale evaluation. Because each step of the process from crossing through initial field selection to multi-site testing of advanced materials takes

place during each growing season, our program generates a steady stream of promising candidate potato varieties than have the potential to benefit the potato industry. It can be thought of as a conveyor belt with many (~50,000 per year) potential varieties entering the front end and a handful of new candidate varieties with commercial potential coming out the end each year. The progression on clones and selections by field selection year is presented in Table 1. We work with growers and processors to commercially test the most promising clones and determine which merit commercial release.

Crosses conducted in the Aroostook Research Farm greenhouse and at Orono during spring 2018 resulted in 328 families and ~184,400 true potato seed (TPS). The top priorities represented in the 2018 crosses were improved russet, processing, and chipping clones, especially with late blight, scab, and/or virus resistance. Seedling tubers (52,275) from prior ME crosses and from germplasm exchanges with other breeding programs (WI, CO, USDA-ARS, and ND) were planted in the field and selected for performance under ME growing conditions. We selected 1474 (2.8%) for continued evaluation in 2019. By category the selections were as follows: 673 (46%) round to oblong white- or yellow-skinned potatoes for fresh and/or chipping markets; 208 (14%) red- or purple-skinned potatoes for fresh market; and 593 (40%) long-tuber-type whites and russets for fresh and/or processing markets. The selection of red- or purple-skinned potatoes (5 to 14% since 2013) is a marked change for the program and reflects grower interest in developing red-skinned varieties with excellent appearance under ME and Eastern conditions.

A total of 249 second-year clones were selected during 2018 (249 out of 1530, 16.3%). Of these selections, 75 (30%) were russets or long whites. There were 156 (63%) round-white or yellow-fleshed selections and 18 (7%) were red-skinned or specialty clones. Many of these clones were derived from parents with late blight, PVY, and/or other key disease resistance traits. The 249 selected second-year clones will be advanced to 3rd year testing during 2019 in ME, FL, NC and PA.

Thirty-two of 70 (46%) advanced selections (6th year or older clones) were retained for further evaluation in ME and elsewhere. The advanced clones that have been selected are distributed as follows: 17 russets and long whites (53%), 10 chippers, fresh market, yellows, or dual-purpose whites (31%), and 5 reds, purples, and specialty types (16%). Five have late blight resistance (16%), 19 have scab resistance (59%), and three are PVY immune (9%) based on DNA-based marker data.

Thirty-nine of 57 (68%) intermediate selections (5th year clones) were retained for further evaluation next year. These were distributed as follows: 19 russets and long whites (49%), 18 round-whites or yellow-fleshed (46%), and 2 red-skinned or specialty clones (5%). Nineteen have late blight resistance (49%), twenty-three have scab resistance (59%), and sixteen are PVY immune (41%) based on DNA-based marker data.

Fifty-six of 99 (57%) 4th year clones were retained for further evaluation next year. These were distributed as follows: 24 russets and long whites (43%), 25 round-whites, yellows, and chippers (45%), and 7 colored-skinned or specialty clones (12%). Twenty-three (41%) have late blight resistance, 21 (38%) have scab resistance, and seventeen (30%) are PVY immune based on DNA-based marker data.

Eighty-four of 337 (25%) 3rd year clones were retained for further evaluation next year. These were distributed as follows: 32 russets and long whites (38%), 42 round-whites and yellows (50%), and 10 colored skinned or specialty clones (12%). Fourteen (17%) have late blight resistance and 35 (42%) are from crosses with PVY resistant or immune parents. Scab resistance has not been formally tested at this stage though susceptibility has been used to discard clones at this stage.

Table 1 Selected clones by field year, market type, and known resistances to late blight, scab, or PVY.

Field Selection Year	Clones	# of Clones	Market Type (#, %)	Clones with Known Disease Resist.		
				Late Blight	Scab	PVY Immune
1 st	single hills	1474	673 (46%) whites, yellows 208 (14%) reds, specialties 593 (40%) russets, longs			
2 nd	8- or 12-hills	249	156 (63%) whites, yellows 18 (7%) reds, specialties 75 (30%) russets, longs			
3 rd	60-hills	84	42 (50%) whites, yellows 10 (12%) reds, specialties 32 (38%) russets, longs	14		
4 th	Prelim. YT	56	25 (45%) whites, yellows 7 (12%) reds, specialties 24 (43%) russets, longs	23	21	17
5 th	Intermed. YT	39	18 (46%) whites, yellows 2 (5%) reds, specialties 19 (49%) russets, longs	19	23	16
≥6	Advanced YT	32	10 (31%) whites, yellows 5 (16%) reds, specialties 17 (53%) russets, longs	5	19	3

Tissue Culture and Minitubers. Tissue culture, minitubers, N1 or N2 seed of the following advanced clones are available from the Maine Seed Potato Board or will become available after the 2019 harvest: Sebec (AF0338-17), Easton (AF3001-6), Caribou Russet (AF3362-1), Pinto Gold (AF4659-12), AF4138-8, AF4124-7, AF4157-6, AF4172-2, AF4648-2, AF4872-2, and AF5040-8. So far this year, two clones have been through virus removal and entry into tissue culture at the University of Wisconsin or Michigan State University: AF5312-1 (fresh market

russet) and AF5429-3 (high yielding chipper). Eight additional clones have been submitted to these labs for virus removal and entry into tissue culture: AF4831-2 (red-skinned, fresh market), AF5071-2 (fry processing russet), AF5245-1 (purple-skinned, fresh market), AF5280-5 (fresh market russet), MSAPB605-4 (chipping), MSAPB609-5 (chipping), MSAPB635-15 (chipping), and NDAF113484B-1 (red-skinned, fresh market). Sebec, AF4157-6, AF4296-3, AF4648-2, and AF5040-8 are or have been part of the Fast-Track seed production program of the US Potato Board and/or the US Potato Board/SCRI acrylamide project. This program produces minitubers and start-up seed production for processing trials.

Licensing/Royalties/Commercialization. Until recently, most releases have been public releases (the exception was Reeves Kingpin, licensed initially to McCain Foods). Policies of U.S. Breeding Programs have changed dramatically with Plant Variety Protection and most are now protected and require licensing and royalties. Most future releases from the Maine Breeding Program are likely to be via licensing with favorable terms for Maine growers and/or companies. The Maine Potato Board, University, and stakeholders have worked together to develop a release plan for our varieties. We have named and released Sebec (AF0338-17), Easton (AF3001-6), and Caribou Russet (AF3362-1) since 2013/2014. Plant variety protection (PVP) was obtained for these varieties and all three varieties were licensed from the University by the Maine Potato Board. More varieties will be released in the coming years as long as they show commercial potential. Most are expected to involve PVP; however, depending on the market class and/or expected scale of production public releases may also be used.

Example Recent Maine Releases and Promising Selections. Selections that have performed particularly well in the 2018 ME Breeding Program and Maine regional and advanced trials were:

Chipping

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| AF4157-6 | Early maturing with moderate to high yields, excellent chip color, good gravity, bruise resistance. It may work well from the field in the South and from storage in the north. Small tuber size and scab susceptibility are weaknesses. It can have good yields for an early, but has been inconsistent. |
| AF5040-8 | Mid-season, high yields, high gravity, cream to light yellow flesh, good internal quality and chip color. Susceptible to scab. Because of its high specific gravity, AF5040-8 is a possible alternative to Atlantic in the South and mid-Atlantic states. |
| AF5429-3 | Medium-late maturity, high yields, medium-high gravity, good chip color, large tubers. Verticillium and blackspot resistance, susceptible to scab. |
| Other | Promising chipping candidates that will be tested again in 2019: AF5563-5 (good yields, appearance, and chip color; large tubers, moderate gravity; moderate scab and bruise resistance); AF5677-4 (medium-late maturing, high yields, moderate to high specific gravity, good chip color, moderate late blight resistance, internal heat necrosis has been observed in a few trials); MSAPB605-4 (late maturing, high yields, fair tuber appearance, moderate to high specific gravity, good chip color, verticillium, scab, late blight and PVY resistance); MSAPB609-12 (medium-late maturing, moderate to high yields, good tuber appearance, moderate to high specific gravity, good chip color, late blight and PVY resistance); MSAPB635-15 (late maturing, high yields, fair tuber appearance, moderate to high specific gravity, good chip color, moderate verticillium, scab, |

and blackspot resistance); WAF10664-3 (mid-season, high yields, moderate gravity and good chip color).

Fresh market whites

- AF4648-2 Mid-season maturity with good yields, chip color, gravity, and bruise resistance. This clone is common scab, golden nematode, and PVY resistant with moderate resistance to late blight and pink rot. Susceptibility to greening and powdery scab can present problems at times.
- AF5280-5 Medium early, bright, high yields, low specific gravity, moderate scab resistance, large tubers, good internal quality. Scab, pink rot, bruise, and golden nematode resistance.
- Other Promising fresh market whites that will be tested again in 2019: AF5225-1 (high yields, cream flesh, light skin netting, internal heat necrosis has been observed in a few southern trials, verticillium and bruise resistance, scab susceptible); NDAF102629C-4 (early, bright skin, moderate scab, shatter, and blackspot resistance); AF5819-2 (mid-season, bright skin, high yields, moderate scab resistance)

Russets or Long Whites

- Caribou R. Tested as AF3362-1. A medium-late maturing, dual-purpose russet with fair to good appearance, long to oblong tubers, low external defects, moderate specific gravity, and good fry color. It has high yields, moderate to large tuber size, and good internal quality (except for internal heat necrosis in southern areas). It has moderate scab resistance and is resistant to shatter and blackspot bruise.
- AF4124-7 A mid-season russet with large tuber size and good processing quality. Yield, gravity, and internal quality have been good. It is moderately resistant to common scab, blackspot bruise, and fusarium, but is moderately susceptible to verticillium wilt.
- AF5071-2 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.
- AF5406-7 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 markets.
- Other Promising russet and long-white candidates that will be tested again in 2019: AF4872-2 (russet, good yields and excellent processing quality, some oblongs, it is probably best suited to fresh-cut fry production); AF5164-19 (russet, good yields, possible dual purpose, susceptible to common scab, but resistant to verticillium and fusarium); AF5407-13 (russet, long tubers, dual-purpose, medium-late, medium to high gravity, moderate scab, verticillium, and blackspot resistance); AF5468-5 (russet, long tubers, good yields, fresh market, resistant to scab, fusarium, and verticillium); AF5492-6 (russet, long-oblong tubers, dual-purpose, medium-late, medium to high gravity, resistant to scab); AF5521-1 (russet, long tubers, processing, mid-season, medium to high gravity, excellent fry color, susceptible to scab, moderate verticillium and blackspot resistance); AF5661-13 (russet, long-oblong tubers, dual-purpose, mid-season, medium to

high gravity, moderate resistance to scab and blackspot); AAF10615-1 (light russeting, long-oblong tubers, processing, outstanding fry color, mid-season, high specific gravity, resistant to PVY and moderate verticillium and blackspot bruise).

Reds and Specialty

- Pinto Gold Test as AF4659-12, this is a yellow-fleshed “pinto-type” specialty variety with a interesting red and yellow skin pattern. It produces small, fingerling-type tubers that are excellent roasted, boiled, or fried.
- AF4831-2 Bright red skin with a smooth, attractive skin finish, small tubers that tend to be oval to oblong, white flesh, good cooking quality, medium to medium-late vine maturity. It has moderate resistance to scab, verticillium wilt, and blackspot bruise. Short tuber dormancy.
- AF5245-1 Purple skin, white flesh, moderate common scab resistance, small tubers
- NDAF113484B-1A pretty, mid-season, red with bright skin that holds its color well in storage. It is mid-season with moderate scab, shatter, and blackspot resistance)
- Other Promising red and specialty candidates that will be tested again in 2019: AF5412-3 (purple flesh, late blight and verticillium resistance, off shapes are common); AF5414-1 (reddish flesh, scab resistance, moderate late blight resistance, dull red skin and slightly deep eyes); AF5633-2 (purple flesh, round tubers, blackspot resistance); NDAF102696C-5 (red skin, pretty, small tubers for baby red market, moderate resistance to verticillium wilt and blackspot); AF5870-2 (yellow-fleshed, late maturity, bright skin, pretty, high yields, moderate scab and blackspot resistance); AF5891-1 (yellow-fleshed, pink splash on the skin, mid-season, pretty, high yields).