MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
IN COOPERATION WITH THE MICHIGAN POTATO INDUSTRY COMMISSION

2004 MICHIGAN POTATO RESEARCH REPORT

Photo on Left
Left to Right: Ben Kudwa, First Last, First Last, First Last, Senator Alan Cropsey, First Last, First Last

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2004 MICHIGAN POTATO RESEARCH REPORT

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INTRODUCTION AND ACKNOWLEDGMENTS

The 2004 Potato Research Report contains reports of the many potato research projects conducted by MSU potato researchers at several locations. The 2004 report is the 36th volume, which has been prepared annually since 1969. This volume includes research projects funded by the Special Federal Grant, the Michigan Potato Industry Commission (MPIC), GREEEN and numerous other sources. The principal source of funding for each project has been noted at the beginning of each report.

We wish to acknowledge the excellent cooperation of the Michigan potato industry and the MPIC for their continued support of the MSU potato research program. We also want to acknowledge the significant impact that the funds from the Special Federal Grant have had on the scope and magnitude in several research areas.

Many other contributions to MSU potato research have been made in the form of fertilizers, pesticides, seed, supplies and monetary grants. We also recognize the tremendous cooperation of individual producers who participate in the numerous on-farm projects. It is this dedicated support and cooperation that makes for a productive research program for the betterment of the Michigan potato industry.

We further acknowledge the professionalism of the MPIC Research Committee. The Michigan potato industry should be proud of the dedication of this Committee and the keen interest they take in determining the needs and direction of Michigan's potato research.

Special thanks goes to Dick Crawford for the management of the MSU Montcalm Research Farm and the many details, which are a part of its operation. We also want to recognize Barb Smith and Lori Olin at MPIC for helping with the details of this final draft.

WEATHER

The overall 6-month average temperatures during the 2004 growing season were very similar to the 6-month average for the 2003 season, and were near the 15-year average (Table 1). There were no recorded temperature readings of 90 °F or above in 2004. There were 7 days in April and 2 in early May that the temperature was below 32 °F. The first daytime low, near 32 °F, during harvest occurred on September 30 with a recorded reading of 32.6 °F. There were four day time lows at or below 32 °F in October. The average maximum temperatures for July and August of 2004 were similar to the 15-year average (Table 1), but the average maximum temperature in September was 7 degrees warmer than the 15-year average.

Rainfall for April through September was 17.13 inches (Table 2). Rainfall recorded during the month of May was the highest recorded for that month in 15 years. Rainfall recorded during the month of September was the lowest recorded for that month in 15 years. Irrigation at MRF was applied 13 times from June 29th to August 30th averaging 0.70 inches for each application. The total amount of irrigation water applied during this time period was 9.05 inches.

Table 1. The 15-year summary of average maximum and minimum temperatures (°F) during the growing season at the Montcalm Research Farm.

	April		May		June		July		August		September		6-Month Average	
Year	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1990	NA	NA	64	43	77	55	79	58	78	57	72	47	NA	NA
1991	60	40	71	47	82	59	81	60	80	57	69	47	74	52
1992	51	34	70	42	76	50	76	54	75	51	69	46	70	46
1993	54	33	68	45	74	55	81	61	79	60	64	46	70	50
1994	57	34	66	43	78	55	79	60	75	55	73	51	71	50
1995	51	31	66	45	81	57	82	60	82	65	70	45	72	51
1996	50	31	64	44	75	57	76	55	80	59	70	51	69	50
1997	54	31	59	39	79	56	80	57	73	55	69	50	69	48
1998	60	37	75	51	77	56	82	58	81	60	76	52	75	52
1999	59	37	71	48	77	55	84	62	76	56	73	48	73	51
2000	56	34	70	49	75	57	77	56	79	57	70	49	71	50
2001	61	37	70	49	78	57	83	58	72	70	69	48	72	53
2002	56	36	63	42	79	58	85	62	81	58	77	52	73	51
2003	56	33	64	44	77	52	81	58	82	58	72	48	72	49
2004	**62**	**37**	**67**	**46**	**74**	**54**	**79**	**57**	**76**	**53**	**78**	**49**	**73**	**49**
15-Year Average	56	35	67	45	77	56	80	58	78	58	71	49	72	50

Table 2. The 15-year summary of precipitation (inches per month) recorded during the growing season at the Montcalm Research Farm.

Year	April	May	June	July	August	September	Total
1990	1.87	4.65	3.53	3.76	4.06	3.64	21.51
1991	4.76	3.68	4.03	5.73	1.75	1.50	21.45
1992	3.07	0.47	1.18	3.51	3.20	3.90	15.33
1993	3.47	3.27	4.32	2.58	6.40	3.56	23.60
1994	3.84	2.63	6.04	5.16	8.05	1.18	26.90
1995	3.65	1.87	2.30	5.25	4.59	1.38	19.04
1996	2.46	3.99	6.28	3.39	3.69	2.96	22.77
1997	2.02	3.13	3.54	2.80	2.71	1.46	15.66
1998	2.40	2.21	1.82	0.40	2.22	3.05	12.10
1999	5.49	5.07	5.82	4.29	5.46	4.03	30.16
2000	3.18	6.46	4.50	3.79	5.28	5.25	28.46
2001	3.28	6.74	2.90	2.49	5.71	4.43	25.55
2002	2.88	4.16	3.28	3.62	7.12	1.59	22.65
2003	0.70	3.44	1.85	2.60	2.60	2.06	13.25
2004	**1.79**	**8.18**	**3.13**	**1.72**	**1.99**	**0.32**	**17.13**
15-Year Average	2.99	4.00	3.63	3.41	4.32	2.69	21.32

GROWING DEGREE DAYS

Table 3 summarizes the cumulative, base 50°F growing degree days (GDD) for May through September, 2004. The total GDD for 2004 were 2,060 which is 196 GDD fewer than 2003, and second lowest in the 10-year average.

Table 3. Growing Degree Days* - Base 50°F.

Cumulative Monthly Totals					
Year	May	June	July	August	September
1995	202	779	1421	2136	2348
1996	201	681	1177	1776	2116
1997	110	635	1211	1637	1956
1998	427	932	1545	2180	2616
1999	317	865	1573	2070	2401
2000	313	780	1301	1851	2256
2001	317	808	1441	2079	2379
2002	319	903	1646	2214	2613
2003	330	762	1302	1922	2256
2004	245	662	1200	1639	2060
10-Year Average	278	781	1382	1950	2300

*1995-2004 data from the weather station at MSU Montcalm Research Farm (Michigan Automated Weather Network system Entrican, MI.)

PREVIOUS CROPS, SOIL TESTS AND FERTILIZERS

The general potato research area utilized in 2004 was rented from Steve Comden, directly to the West of the Montcalm Research Farm. This acreage was planted to field corn in the spring of 2003, harvested in the fall and the stubble was disked under. In the spring of 2004, the recommended rate of potash was applied and disked into the corn stubble. The ground was moldboard plowed for direct potato planting. The area was not fumigated prior to potato planting. Potato early die symptoms in 2004 were believed to have been the result of the leaching of starter fertilizer due to the heavy rainfall in the month of May and not necessarily related to components of the early die complex.

The soil test analysis for the general crop area was as follows:

	lbs/A			
pH	P_2O_5	K_2O	Ca	Mg
6.0	372 (186 ppm)	174 (87 ppm)	790 (395 ppm)	122 (61 ppm)

The fertilizers used in the general plot area are as follows. (Variances in fertilizers used for specific research projects are included in the individual project reports.)

Application	Analysis	Rate	Nutrients ($N-P_20_5-K_20$)
Broadcast at plow down	0-0-60	250 lbs/A	0-0-150
At planting	19-17-0	19 gpa	40-36-0
At emergence	46-0-0	135 lbs/A	62-0-0
1st Early side dress	46-0-0	197 lbs/A	91-0-0
2nd Late side dress (late varieties)	46-0-0	197 lbs/A	91-0-0

HERBICIDES AND PEST CONTROL

Hilling was done in late May, followed by a pre-emergence application of Sencor DF at 0.66 lb/A and Dual at 1.33 pints/A.

Admire was applied at planting at a rate of 13.6 oz/A. Dimetholate was applied once in mid June at 1 pint/A. Fungicides used were Bravo and Manzate over 13 applications.
Potato vines were desiccated with Reglone in late August and again in early September at a rate of 1 pint/A.

2004 POTATO BREEDING AND GENETICS RESEARCH REPORT

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INTRODUCTION

At Michigan State University we are breeding potatoes for the chip-processing and tablestock markets. The program is one of four integrated breeding program in the North Central region. At MSU, we conduct a multi-disciplinary program for potato breeding and variety development that integrates traditional and biotechnological approaches. In Michigan, it requires that we develop high yielding round white potatoes with excellent chip-processing from the field and/or storage. We conduct variety trials of advanced selections and field experiments at MSU research locations (Montcalm Research Farm, Lake City Experiment Station, Muck Soils Research Farm and MSU Soils Farm), we ship seed to other states and Canadian provinces for variety trials, and we cooperate with Chris Long on 13 grower trials throughout Michigan. Through conventional crosses in the greenhouse, we develop new genetic combinations in the breeding program, and also screen and identify exotic germplasm that will enhance the varietal breeding efforts. With each cycle of crossing and selection we are seeing directed improvement towards improved varieties (e.g. combining chip-processing, scab resistance and late blight resistance). In addition, our program has been utilizing genetic engineering as a tool to introduce new genes to improve varieties and advanced germplasm for traits such as solids, insect resistance and disease resistance. We feel that these in-house capacities (both conventional and biotechnological) put us in a unique position to respond to and focus on the most promising directions for variety development and effectively integrate the breeding of improved chip-processing and tablestock potatoes.

The breeding goals at MSU are based upon current and future needs of the Michigan potato industry. Traits of importance include yield potential, disease resistance (scab, late blight and early die), insect (Colorado potato beetle) resistance, chipping (out-of-the-field, storage, and extended cold storage) and cooking quality, bruise resistance, storability, along with shape, internal quality and appearance. We are also developing potato tuber moth resistant lines as a component of our international research project. If these goals can be met, we will be able to reduce the grower’s reliance on chemical inputs such as insecticides, fungicides and sprout inhibitors, and improve overall agronomic performance with new potato varieties.

Over the years, key infrastructure changes have been established for the breeding program to make sound assessments of the breeding material moving through the program. These include the establishment and expansion of the scab nursery, the development of the Muck Soils Research Farm for late blight testing, the incorporation of no-choice caged studies for Colorado potato beetle assessment and the Michigan Potato Industry Commission (MPIC)-funded construction of the B.F. (Burt) Cargill Demonstration Storage adjacent to the Montcalm Research Farm.

PROCEDURE

I. Varietal Development

Each year, during the winter months, 500-1000 crosses are made using about 150 of the most promising cultivars and advanced breeding lines. The parents are chosen on the basis of yield potential, tuber shape and appearance, chip quality, specific gravity, disease resistance, adaptation, lack of internal and external defects, etc. These seeds are then used as the breeding base for the program. We also obtain seedling tubers or crosses from other breeding programs in the US. The seedlings are grown annually for visual evaluation (size, shape, set, internal defects) at the Montcalm and Lake City Research Farms as part of the first year selection process of this germplasm each fall. Each selection is then evaluated post harvest for specific gravity and chip processing. These selections each represent a potential variety. This system of generating new seedlings is the initial step in an 8-12 year process to develop new varieties. This step is followed by evaluation and selection at the 8-hill, 20-hill and 30-hill stages. The best selections out of the four-year process are then advanced for testing in replicated trials (Preliminary, Adaptation, Dates-of-Harvest, Grower-cooperator trials, North Central Regional Trials, Snack Food Association Trials, and other out-of-state trials) over time and locations. The agronomic evaluation of the advanced breeding lines in the replicated trials is reported in the annual Potato Variety Evaluation Report.

II. Evaluation of Advanced Selections for Extended Storage

With the Demonstration Storage facility adjacent to the Montcalm Research Farm we are positioned to evaluate advanced selections from the breeding program for chip-processing over the whole extended storage season (October-June). Tuber samples of our elite chip-processing selections are placed in the demonstration storage facility in October and are sampled monthly to determine their ability to chip-process from colder (42-48°F) and/or 50˚F storage. In addition, Chris Long evaluates the more advanced selections in the 10 cwt box bins and manages the 500 cwt. storage bins which may have MSU lines.

III. Germplasm Enhancement

To supplement the genetic base of the varietal breeding program, we have a "diploid" (2x = 24 chromosomes) breeding program in an effort to simplify the genetic system in potato (which normally has 4x chromosomes) and exploit more efficient selection of desirable traits. This added approach to breeding represents a large source of valuable germplasm, which can broaden the genetic base of the cultivated potato. The diploid breeding program germplasm base at MSU is a synthesis of seven species: *S. tuberosum* (adaptation, tuber appearance), *S. raphanifolium* (cold chipping), *S. phureja* (cold-chipping, specific gravity, PVY resistance, self-compatability), *S. tarijense* and *S. berthaultii* (tuber appearance, insect resistance, late blight resistance, verticillium wilt resistance), *S.*

microdontum (late blight resistance) and *S. chacoense* (specific gravity, low sugars, dormancy and leptine-based insect resistance). In general, diploid breeding utilizes haploids (half the chromosomes) from potato varieties, and diploid wild and cultivated tuber-bearing relatives of the potato. Even though these potatoes have only half the chromosomes of the varieties in the U.S., we can cross these potatoes to transfer the desirable genes by conventional crossing methods via 2n pollen.

IV. Integration of Genetic Engineering with Potato Breeding

Through transgenic approaches we have the opportunity to introduce new genes into our cultivated germplasm that otherwise would not be exploited. It has been used in potato as a tool to improve commercially acceptable cultivars for specific traits. Our laboratory has 12 years experience in *Agrobacterium*-mediated transformation to introduce genes into important potato cultivars and advanced breeding lines. We are presently using genes in vector constructs that confer resistance to Colorado potato beetle and potato tuber moth (*Bt-cry3A, Bt-cry1Ia1* and avidin), potato tuber moth, late blight resistance via the *RB* gene, lowering glycoalkaloids (*STG*), and drought resistance (*CBF1*). Furthermore, we are investing our efforts in developing new vector constructs that use alternative selectable markers and give us the freedom to operate from an intellectual property rights perspective. In addition, we are exploring transformation techniques that eliminate the need for a selectable marker (antibiotic resistance) from the production of transgenic plants.

RESULTS AND DISCUSSION

I. Varietal Development

Breeding

The MSU potato breeding and genetics program is actively producing new germplasm and advanced seedlings that are improved for cold chipping, and resistance to scab, late blight, and Colorado potato beetle. For the 2004 field season, progeny from over 600 crosses were planted and evaluated. Of those, the majority were crosses to select for round whites (chip-processing and tablestock), with the remainder to select for yellow flesh, long/russet types, red-skin, and novelty market classes. In addition to crosses from the MSU breeding program, crosses were planted and evaluated from collaborative germplasm exchange from other breeding programs including North Dakota State University, University of Minnesota, and the USDA/ARS program at the University of Wisconsin as part of the Quad state cooperative effort. During the 2004 harvest, 1055 selections were made from the 40,000 seedlings produced. Following harvest, specific gravity was measured and potential chip-processing selections were chipped out of the field. All potential chip-processing selections will be tested in January or March 2004 directly out of 42°F and 50°F storages. Atlantic (50°F chipper) and Snowden (45°F chipper) are chipped as check cultivars. Selections have been identified at each stage of the selection process that have desirable agronomic characteristics and chip-processing potential. At the 8-hill and 20-hill evaluation state, 220 and 90 selections were made, respectively. **Table 1** lists some of the potential lines for grower trials in year 2005.

Chip-Processing

About 60% of the single hill selections have a chip-processing parent in their pedigree. Of those selections chipped out of the field, about 85% have a SFA chip score of 1.5 or less. Based upon the pedigrees of the parents we have identified for breeding cold-chipping potato varieties, there is a diverse genetic base. We have at least eight cultivated sources of cold-chipping. Examination of pedigrees shows up to three different cold-chipping germplasm sources have been combined in these selections. Our promising chip-processing lines are MSG227-2 (scab resistant 45°F chipper), MSH095-4, MSJ036-A (scab resistant), MSH228-6 (moderate scab resistance), MSJ147-1, MSJ126-9Y (moderate scab resistance), MSJ316-A (moderate scab resistance), MSK061-4 (moderate scab resistance) and late blight resistant chipper MSJ461-1.

Dr. Joe Sowokinos, Univ. of Minnesota, has conducted biochemical analyses of our best chipping lines and has discovered that our lines differ from older varieties in their proteins (UGPase) involved in chipping. Some of these lines are MSJ147-1, MSG227-2 and MSJ126-9Y. Moreover, MSJ147-1 and MSJ126-9Y have the desirable levels of acid invertase to chip process from colder storage. His analysis will also allow us target specific crosses to find improved chip-processing varieties that will allow processing from colder storage temperatures.

Tablestock

Efforts have been made to identify lines with good appearance, low internal defects, good cooking quality, high marketable yield and resistance to scab and late blight. Our current tablestock development goals now are to continue to improve the frequency of scab resistant lines, incorporate resistance to late blight along with marketable maturity and excellent tuber quality, and select more russet and yellow-fleshed lines. From our breeding efforts we have identified mostly round white lines, but we also have a number of yellow-fleshed and red-skinned lines, as well as long, russet type and purple skin selections that carry many of the characteristics mentioned above. We are also selecting for a dual-purpose russet, round white, red-skin, and improved Yukon Gold-type yellow-fleshed potatoes. Some of the tablestock lines were tested in on-farm trials in 2004, while others were tested under replicated conditions at the Montcalm Research Farm. Promising tablestock lines include MSE221-1 as a scab resistant tablestock, MSI049-A, a bruise resistant round white with red splashes around the eyes, and N084-11, a round white with a smooth round shape and bright skin. We have a number of tablestock selections with late blight resistance. These are MSK128-A, MSL006-AY, MSL072-C, MSL179-AY, MSM171-A and MSM224-1. MSL211-3 has late blight and scab resistance. In addition, all these clones performed well in the dry land trial at Montcalm Research Farm such as Boulder and Michigan Purple and MSJ461-1. MSE192-8RUS and MSA8254-2BRUS are two russet table selections that have scab resistance, while MSL794-BRUS has late blight resistance. MSI005-20Y and MSJ033-10Y are yellow-fleshed lines with smooth round appearance and high yield potential.

At the Great Lakes Expo the MPIC sponsored a booth where we helped promote the sale of Michigan Purple and Jacqueline Seed to the roadside stand and farm market operations.

Disease and Insect Resistance Breeding

Disease screening for scab has been an on-going process since 1988. Results from the 2004 MSU scab nursery indicate that 53 of 158 lines evaluated demonstrated little to no infection to common scab. In addition, 19 other MSU breeding lines showed moderate scab resistance. The limitation of breeding for scab resistance is the reliance on the scab nursery. The environmental conditions can influence the infection each year, thus multiple year data provides more reliable data. A laboratory-based screening process is currently under development that would use thaxtomin in tissue culture to expedite selection of material with potential scab resistance. In 2004, we expanded the scab nursery with an additional acre of land nearby. For three years we inoculated the field with *Streptomyces scabies* and grew scab susceptible cultivars. After 2003 we determined that the infection level was high enough to use for research. This expansion has allowed us to conduct early generation selection for scab resistance among our breeding material. We hope that this expanded effort will lead to more scab resistant lines advancing through the breeding program.

In the mid-1990's late blight re-emerged as the major fungal disease of potato in the US. Dr. Willie Kirk established foliar late blight testing at the Muck Soils Research Farm, Bath, Michigan. This location has become an excellent North American site for late blight testing because of the humid microclimate and isolation from major commercial potato production. As a result, late blight infection has been consistently achieved each year making breeding efforts to select late blight resistant germplasm very efficient. The breeding program has been able to identify advanced breeding lines with strong foliar resistance to late blight. In 2001 we released Jacqueline Lee, a yellow-fleshed tablestock potato with late blight resistance. We also have the late blight resistant lines MSI152-A and MSJ317-1, round white tablestock potatoes, and MSJ461-1, a round white chip-processor, being considered for release and commercialization. MSJ461-1, the chip-processing selection, has the same late blight resistance source Jacqueline Lee and was resistant to a US-17 genotype of *Phytophthora infestans* in New York this year. Our other promising late blight resistant lines that have been tested in replicated agronomic trials are MSJ317-1, MSI152-A, MSK136-2, MSL179-AY and MSL211-3 (see Potato Variety Evaluation Report for agronomic data). In each of these lines, the resistance is based on a single resistance source. If we rely on a single source of resistance, the varieties developed from this strategy may be overcome by *P. infestans* at some future date that we cannot predict. Therefore, the most effective breeding strategy is to combine resistance from different pedigrees to build a more durable resistance. Our efforts are now focusing on pyramiding the different resistance sources.

The Muck Soils Research Farm is also used for early generation selection for late blight, genetic studies involving late blight resistance, screening germplasm from other US breeding programs and Dr. Kirk-led fungicide x variety management studies to determine schemes to reduce fungicide usage when late blight resistant cultivars are grown. In 2004 we also screened our *RB*-transgenic potatoes for their foliar resistance to late blight.

With support from GREEEN, we also introduced an early generation Colorado potato beetle screen at the Montcalm Research Farm. In 2004 over 220 breeding lines from the MSU potato breeding program that had Colorado potato beetle resistant germplasm in their pedigree were evaluated at the Montcalm Research Farm Beetle Nursery. The beetle pressure was extremely high leading to complete defoliation in all susceptible check lines. Percent defoliation was visually estimated during the beetle infestation in June and July. The lines were then sorted into four categories: susceptible, reduced susceptibility, moderately resistant and resistant. The majority of the lines were susceptible, but 32, 32 and 26 lines were classified as reduced susceptibility, moderately resistant and resistant, respectively. The majority of the lines that were moderately resistant or resistant can be attributed to the expression of the *Bt-cry3A* gene or glycoalkaloid/leptine based mechanisms. The most resistant material was selected for further advancement in the breeding program and also for use in the next round of crossing to develop beetle resistant cultivars. Concurrently, a field cage (no-choice) experiment was conducted to evaluate 6 lines. With two years of data, the glandular trichome-based resistance was not different from the susceptible cultivar. The Bt-based resistance was very effective with complete mortality. The glycoalkaloid-based resistance affected beetle behavior: clipping of the petioles was observed in the cages. Avidin-based insect resistance is being studied in the lab. This resistance may be useful in combination with other host plant resistance factors.

It is a great challenge to achieve host plant resistance in a commercially acceptable line. We have some promising advanced selections with partial resistance to Colorado potato beetle. In addition, we have *Bt-cry3A* transgenic lines that could be commercialized if the processors renewed their acceptance and regulatory environment was modified to reduce costs.

II. Evaluation of Advanced Selections for Extended Storage: MSU Potato Breeding Chip-processing Results From the MPIC Demonstration Commercial Storage (October 2003 - June 2004)

The MSU Potato Breeding Program has been conducting chip-processing evaluations each year on potato lines from the MSU breeding program and from other states. For 5 years we have been conducting a storage study to evaluate advanced breeding lines with chip-processing potential in the Dr. B. F. (Burt) Cargill Potato Demonstration Storage facility directly adjacent to the MSU Montcalm Research Farm. In October 2003, tuber samples from 4 MSU lines plus three Frito Lay lines and Snowden in the Montcalm Research Farm trials were placed in the bin to be cooled to 49°F. Tubers from another 5 lines were placed in the bin that was to be cooled then held at 54°F. The first samples were chip-processed at MSU in October and then, each month until April 2004. Samples were evaluated for chip-processing color and quality.

Table 2 summarizes the chip-processing color of select lines over the 6-month storage season. In the 49°F bin, Snowden was the check variety. From October to April all lines chip-processed acceptably. In the 54°F bin Atlantic was used as check varieties and chip-processed acceptably until April. Liberator, MSH228-6 and MSJ461-1 also chip-processed acceptably. Only MSH112-6 did not chip-process and was dropped from the program. MSG227, UEC, and Liberator were in the 500 cwt storage bins. See Chris Long's storage report for those results and results from the box bins.

III. Germplasm Enhancement

In 2004, about 3% of the populations evaluated as single hills were diploid. From this breeding cycle, we plan to screen the selections chip-processing from storage. In addition, selections were made from over 4,000 progeny that was obtained from the USDA/ARS at the University of Wisconsin. These families represent material from South American potato species and other countries around the world that are potential sources of resistance to Colorado potato beetle, late blight, potato early die, and ability to cold-chip process. About 50 selections were made among the diploid material in 2004. Through GREEEN funding, we were able to initiate a breeding effort to introgress leptine-based insect resistance. From previous research we determined that the leptine-based resistance is effective against Colorado potato beetle. We will continue conducting extensive field screening for resistance to Colorado potato beetle at the Montcalm Research Farm and at the Michigan State University Horticulture Farm in 2005. In 2004 we made crosses with late blight resistant diploid lines derived from *Solanum microdontum* to our tetraploid lines. These progeny are being grown in the greenhouse and will be evaluated in 2005 for these late blight resistant and other agronomic characteristics.

IV. Integration of Genetic Engineering with Potato Breeding

Assessment of Natural (Glandular Trichomes and Glycoalkaloid-Based) and Engineered (*Bt-cry3A*) Potato Host Plant Resistance Mechanisms for Control of Colorado potato beetle: Caged no-choice studies.

The Colorado potato beetle, *Leptinotarsa decemlineata*, is the leading insect pest of potato (*S. tuberosum* L.) in northern latitudes. Host plant resistance is an important tool in an integrated pest management program for controlling insect pests. A field study was conducted in 2003 and 2004 to compare natural (glandular trichomes (NYL235-4) and glycoalkaloid-based (ND5822C-7)), engineered (*Bt-cry3A*: NO8.8, Atlantic NewLeaf, *Bt-cry1Ia1*: Spunta G2) host plant resistance mechanisms of potato for control of Colorado potato beetle. Six different potato lines representing 5 different host plant resistance lines were evaluated in caged studies (no-choice) at the MSU campus farms. Each cage with 10 plants represented one plot. The cages were arranged in a randomized complete block design consisting of three replications. Twenty egg masses were placed on the plants in each cage. Observations were recorded weekly for a visual estimation of percent defoliation by Colorado potato beetles, and the number of egg masses, larvae, and adults. The *Bt-cry3A* transgenic line and the combined resistance line were effective in controlling feeding by Colorado potato beetle adults and larvae. The high glycoalkaloid line had less feeding, but the beetles clipped the petioles, which led to greater defoliation in the first few weeks. Foliage re-growth occurred by the end of the season. The glandular trichome line suffered less feeding than the susceptible control. Spunta G2 was effective in limiting defoliation, but larval mortality was not as high as in the *Bt-cry3a* lines. Based on these results, the *Bt-cry3A* gene in combination with glandular trichome mechanism is an effective strategy that could be used to develop potato varieties for use in a resistance management program for control of Colorado potato beetle. The *Bt-cry1Ia1* all is effective against Colorado potato beetle. **Figure 1** shows the combined results of caged trial in 2003 and 2004.

Combining engineered and natural host plant resistance to *Phytophthora infestans* in cultivated potato

General susceptibility of potato cultivars to *Phytophthora infestans* (Mont.) de Bary is a major concern for potato production. The major resistance gene *RB* was cloned from *Solanum bulbocastanum* Dun. a diploid (2n=2x=24) Mexican species that is highly resistant to all known races of *P. infestans*. The objective of this work is to combine conventionally bred sources of resistance with the *RB* gene via *Agrobacterium* transformation. Our hypothesis is that by pyramiding engineered resistance with natural plant resistance we expect to obtain stronger and more durable resistance to potato late blight. Therefore, this study was undertaken to test the effectiveness of the *RB* gene on its own by transforming late blight-susceptible clones (Atlantic, and the breeding line MSE149-5Y), and to test the effectiveness of the gene in combination with natural late blight resistance by transforming resistant clones (Stirling, and the advanced breeding line MSJ461-1). The RB-transgenic potato lines were tested at the Muck Soils Research Farm and we identified 3 lines to be expressing the RB gene and have foliar late blight resistance.

Insecticidal activity of avidin against Colorado potato beetle larvae, *Leptinotarsa decemlineata* (Say)

The Colorado potato beetle, *Leptinotarsa decemlineata* (Say), is the most destructive insect pest of potato, *Solanum tuberosum* (L.) in eastern North America. The insect has adapted to every insecticide used to manage it. Avidin is a protein found in chicken egg whites that has demonstrated insecticidal properties against a number of Lepidopteran and Coleopteran pests. This protein protects the chicken embryo by sequestering biotin from disease causing organisms. Biotin is an essential co-enzyme required for all organisms, including insects. Biotin is a cofactor of a carboxylase which is required for many important processes like lipogenesis, gluconeogensis, fatty acid and amino acid catabolism. Without this co-enzyme, an insect’s growth is severely stunted, eventually leading to death. The gene for avidin production has been cloned and inserted into a few crops, including maize, tobacco and potato and has demonstrated resistance to a wide spectrum of insect pests. We have expressed avidin in two potato lines: MSE149-5Y, a susceptible potato line, and ND5873-15, a high glycolakaloid line. Detached leaf bioassays were performed on transgenic and non-transgenic clones of MSE149-5Y and ND5873-15 using Colorado potato beetle neonates and third instars. Survivorship and consumption were measured every 2d over a 12d period for neonates and avidin was effective in reducing growth and increasing larval morality.

USAID-funded International project to Develop Potato Tuber Moth Resistant Potatoes

Potato tuber moth, *Phthorimaea operculella* (Zeller), is the most serious insect pest of potatoes worldwide. The introduction of the *Bacillus thuringiensis* (Bt) toxin gene via genetic engineering offers host plant resistance for the management of potato tuber moth. The primary insect pest in Egyptian potato production, like many other countries in the Middle East, is the potato tuber moth. Recently it has emerged as a pest in Washington State and has also been a serious problem in Mexico.

Two transgenic 'Spunta' clones, G2 and G3, have been identified that produced high control levels of mortality in first instars of potato tuber moth in laboratory tuber tests (100% mortality), and field trials in Egypt (99-100% undamaged tubers). Reduced feeding by Colorado potato beetle first instars was also observed in detached-leaf bioassays (80-90% reduction). Field trials in the U.S. demonstrated that the agronomic performance of the two transgenic lines was comparable to 'Spunta'. In 2004 the Spunta lines were resistant to the potato tuber moth and the Colorado potato beetle in Washington State. We are currently working with USAID, Syngenta and South Africa to commercialize the Spunta-G2 and Spunta-G3 lines. We have also transformed Atlantic, Lady Rosetta and Jacqueline Lee with the *Bt-cry1Ia1 (*formally *cryV* gene).

V. Variety Release

We will be naming, releasing and protecting UEC in 2005. MSG227-2 (scab resistant chipper) and MSJ461-1 (late blight resistant chipper/tablestock) also show commercial potential. **Table 3** summarizes the commercial seed production of MSU lines in 2004.

VI. Development of a DNA-based Fingerprint System for Potato Varieties

The ability to quickly and accurately identify potato clones is important to potato breeding programs and to the potato seed industry and commercial growers. Since 1990, the Michigan State University Potato Breeding and Genetics Program has used an isozyme-based fingerprint system to identify potato cultivars. Isozyme analysis has been an economical and effective means of discriminating potato clones; however, they require fresh, healthy tuber or leaf tissue. DNA-based fingerprinting using simple sequence repeats (SSRs or microsatellites) has been shown to discriminate between potato clones. DNA can be extracted from freeze-dried tissue. The SSR fingerprinting system developed in our lab can be used as a practical fingerprint system for cultivated potato. This research was published in the American Journal of Potato Research in 2004.

Table 1. Potential Lines for 2005 On-Farm Grower Trials

	Pedigree		
Line	**Female**	**Male**	**Comments**
Processing			
MSG227-2	Prestile	MSC127-3	Scab resistant
MSH228-6	MSC127-3	OP	Scab tolerant
MSJ036-A	A7961-1	Zarevo	Scab tolerant chipper
MSJ080-1	MSC148-A	S440	High yield
MSJ147-1	Norvalley	S440	cold chipper
MSJ316-A	B0718-3	Pike	Scab tolerant chipper
MSJ461-1	Tollocan	NY88	Late blight resistant
MSK061-4	MSC148-A	ND2676-10	Scab tolerant chipper
MSK136-2	Greta	B0718-3	Late blight resistant
MSK498-1Y	Saginaw Gold	Brodick	Scab tolerant chipper
Tablestock			
BOULDER (MSF373-8)	MS702-80	NY88	Dryland production, large tubers
LIBERATOR (MSA091-1)	MS702-80	Norchip	Scab resistant, bright skin
MICHIGAN PURPLE	W870	Maris Piper	Bright purple skin, white flesh
MSA8254-2BRUS			Scab tolerant
MSE192-8RUS	A8163-8	Russet Norkotah	Scab resistant russet (Norkotah replacement)
MSE221-1	Superior	MS700-83	Scab tolerant, Superior-type
MSI005-20Y	MSA097-1Y	Penta	Yukon appearance
MSI049-A	Brodick	MSC121-7	Blackspot bruise resistant, red splashes
MSI152-A	Mainestay	B0718-3	Late blight resistant, round white
MSJ033-10Y	MSA097-1	Penta	Yellow, Scab resistant

Table 2.

2003-2004 Demonstration Storage Chip Results
Michigan State University Potato Breeding and Genetics
Montcalm Research Farm
Chip Scores: SFA Scale[†]

		Sample Dates:					
	Date:	11/4/2003	12/2/2003	1/6/2004	2/12/2004	3/11/2004	4/7/2004
Line	**Temp:**	55 °F	54 °F	50 °F	50 °F	49 °F	51 °F
FL1833		1.5	1.0	1.5	1.5	ND	ND
FL1867		1.0	1.0	1.0	1.0	1.5	1.0
FL1922		1.0	1.0	1.0	1.0	1.0	1.0
MSG227-2		1.0	1.5	1.5	1.0	1.0	1.0
MSJ080-1		1.0	1.5	1.5	1.5	1.5	1.5
MSJ147-1		1.0	1.0	1.5	1.0	1.0	1.5
SNOWDEN		**ND**	**1.0**	**1.0**	**1.0**	**1.0**	**1.5**
UEC		1.0	1.0	1.0	1.0	1.0	1.5
	Temp:	55 °F	54 °F	54 °F	54 °F	54 °F	51 °F
ATLANTIC		**1.5**	**1.0**	**1.5**	**1.5**	**1.5**	**1.5**
LIBERATOR		1.5	1.0	1.0	1.0	1.0	1.0
MSH112-6		2.0	2.5	2.0	2.0	2.0	1.0
MSH228-6		1.0	1.0	1.5	1.0	1.5	1.5
MSJ461-1		1.5	2.0	1.5	1.0	1.5	1.5

[†] Snack Food Association Chip Score

Ratings: 1 - 5
1: Excellent
5: Poor
ND: No Data
Chip scores were from two-slice samples from five tubers of each line collected at each sample date.

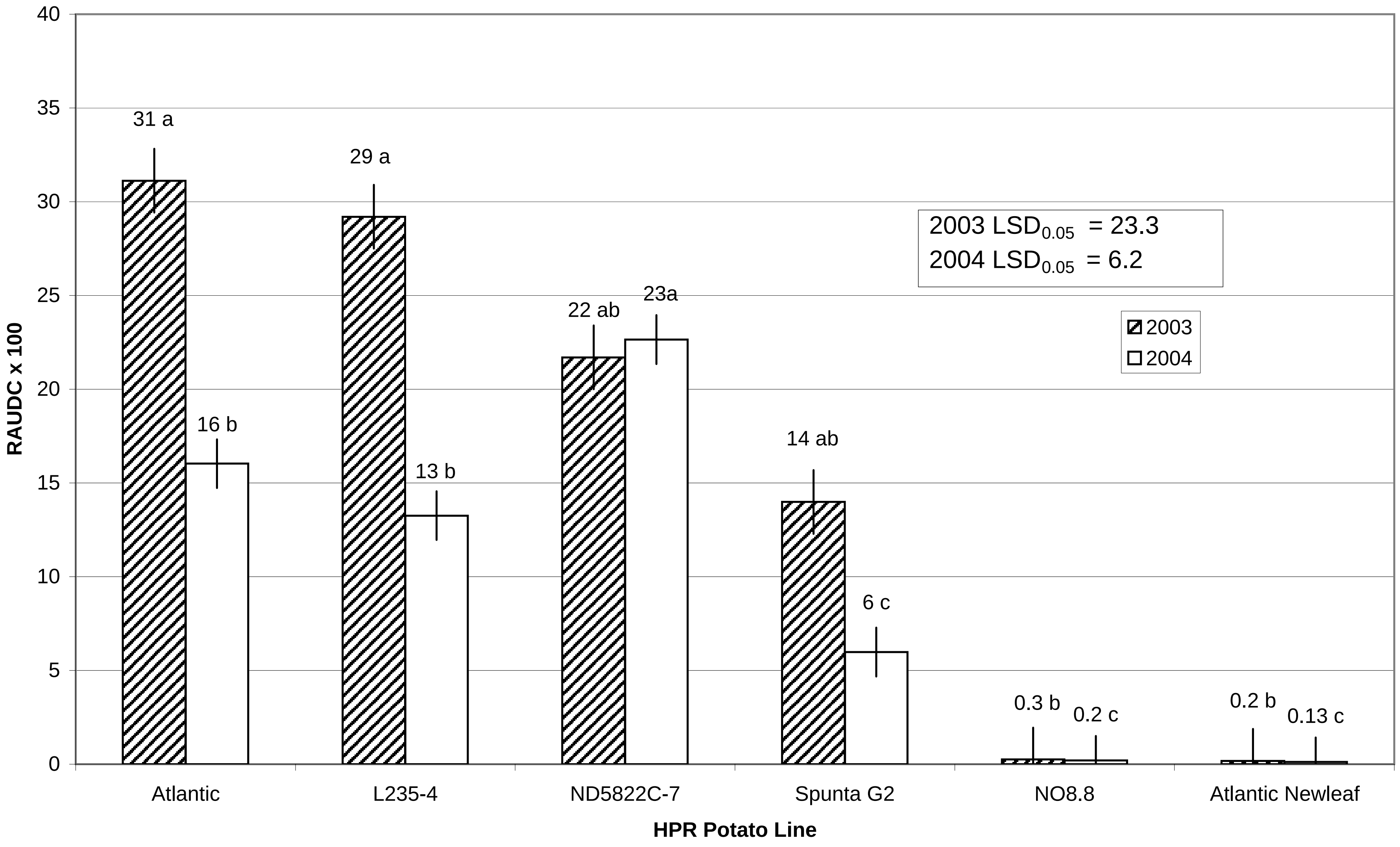
Table 3. Potato Seed Inventory 2004
MSU Potato Breeding Program Introductions
Availability of Michigan Certified Seed
A Cumulative Inventory

LINE	MINI-TUBERS (UNITS)	FY1 (CWT)	FY2 (CWT)	FY3 (CWT)	FY4 (CWT)
Jacqueline Lee (MSG274-3)	7901	3	-	100	-
Liberator (MSA091-1)	5153	27	748	4150	-
Michigan Purple	4986	106	1422	-	1080
MSE192-8RUS	3247	-	-	-	-
MSE202-3RUS	635	-	-	-	-
MSF099-3	-	-	-	67	-
MSG227-2	388	-	-	1950	-
MSH067-3	573	-	-	-	-
MSH095-4	617	-	-	-	-
MSI152-A	2280	5	-	-	-
MSJ461-1	7274	4	88	-	-

Information listed above is a cumulative count from Golden Seed Farms, Haindl & Hanson Farms, Iott Seed Farms Inc., Krueger Seed Farm, Marker Farms, Makarewicz Seed Farm, Sklarczyk Seed Farm, and Skogman Seed.
Table courtesy of Chris Long.

Fig. 1

Colorado Potato Beetle Field Cage Trial Relative Area Under the Defoliation Curve (RAUDC) of HPR Potato Lines



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2004 POTATO VARIETY EVALUATIONS

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INTRODUCTION

Each year we conduct a series of variety trials to assess advanced potato selections from the Michigan State University and other potato breeding programs at the Montcalm Research Farm. The evaluation also includes disease evaluation in the scab nursery and foliar and tuber late blight evaluation at the Muck Soils Research Farm. The objectives of the evaluations are to identify superior varieties for fresh market or for processing and to develop recommendations for the growing of those varieties. The varieties were compared in groups according to the tuber type and skin color and to the advancement in selection. Each season, total and marketable yields, specific gravity, tuber appearance, incidence of external and internal defects, chip color (from field, 42°F and 50°F storage), as well as susceptibilities to late blight (foliar and tuber), common scab, and blackspot bruising are determined.

PROCEDURE

Eleven field experiments were conducted at the Montcalm Research Farm in Entrican, MI. They were planted as randomized complete block designs with two to four replications. The plots were 23 feet long and spacing between plants was 12 inches. Inter-row spacing was 34 inches. Supplemental irrigation was applied as needed. The field experiments were conducted on new potato ground that was in corn the previous year.

The round white tuber types were divided into chip-processors and tablestock and were harvested at two dates (Date-of-Harvest trial: Early and Late). The other field experiments were the Russet, North Central Regional, Adaptation (tablestock and chip-processors), and Preliminary (tablestock and chip-processors), Transgenic and two water management trials. In each of these trials, the yield was graded into four size classes, incidence of external and internal defects in > 3.25 in. diameter or 10 oz. potatoes were recorded, and samples for specific gravity, chipping, disease tests, bruising, and cooking tests were taken. Chip quality was assessed on 25-tuber samples, taking two slices from each tuber. Chips were fried at 365°F. The color was measured visually with the SFA 1-5 color chart. Tuber samples were also stored at 45°F and 50°F for chip-processing out of storage in January and March. Advanced selections are also placed in the Commercial Demonstration Storage for monthly sampling. The scab nursery at the MSU Soils Farm and the late blight trial at the Muck Soils Research Farm are used for scab and foliar late blight assessment of lines in the agronomic trials.

RESULTS

A. Round White Varieties:

Chip-processors (Tables 1 and 2)

There were 20 entries that were compared at two harvest dates. Atlantic, Snowden and four Frito Lay clones were used as checks. The plot yields were below average in the early harvest (100 days), but specific gravity values were very high due to the cool summer temperatures in July and August. Most lines increased between 30-70 cwt/a in yield for the second harvest date (140 days). We attribute the lower yields to the loss of fertilizer from the heavy spring rains. The results are summarized in **Tables 1 and 2**. Hollow heart and vascular discoloration were the prevalent internal defects. *Note that this year we changed the format of the data table so that the internal defects are presented as percentages rather than as a count.* Atlantic, Boulder, MSH067-3 and UEC showed the highest incidence of hollow heart between the two harvest dates. Vascular discoloration was only frequent in the later harvest, with MSH095-4 and Snowden being the highest. In the early harvest trial, the best yielding chipping lines were Atlantic, MSH112-6, and MSJ147-1. We have dropped MSH112-6 because it has poor chipping quality. MSJ147-1 is showing promise as a chipper out of colder storage temperatures and tissue culture plants have been distributed to the industry for larger scale testing. In the later harvest, MSJ147-1 has been consistently in the top group for the past few years. MSJ461-1, Boulder and MSF099-3 also yielded well, but Boulder had an abundance of off-types and hollow heart for the first time in 2004. MSJ461-1 is a promising chip-processing line with strong foliar resistance to late blight. MSF099-3 is dropped because of scab susceptibility. Liberator, MSG227-2 and FL1922 offer scab resistance. UEC, Liberator, MSJ461-1 and MSG227-2 are in the 500 cwt bins of the Commercial Demonstration Storage this year.

Tablestock (Tables 1 and 2)

Only two tablestock clones were tested in the Date of Harvest Trials in 2004. The russets are in a separate trial and the reds, along with other round whites and yellows are found in the North Central and Adaptation trials. The descriptions of Michigan Purple and Jacqueline Lee are below.

Variety Characteristics

LIBERATOR - a MSU selection for chip-processing with strong scab resistance. Yield and specific gravity over the past 7 years were comparable to Snowden. It has performed well in other states (Nebraska, Pennsylvania and California). It was in the national SFA and the North Central regional trials. Liberator was released in 2001 and is in the 2003 and 2004 Commercial Demonstration Storage.

UEC – an unknown eastern chip processing line thought to be from USDA-Beltsville. It has high yield potential and scab tolerance along with excellent chip-processing quality. It is in the 500 cwt 2002, 2003 and 2004 Commercial Demonstration Storage bins. It is being considered for naming and release in 2005.

MSG227-2 – a MSU chip-processing selection with strong scab resistance. It has a specific gravity acceptable for chip-processing, excellent chip quality and cold-chipping potential. The tubers are smooth-shaped with a flattened round appearance that is attractive. It has chip-processed well from the 42°F MPIC demonstration storage studies. It has yielded well in some on-farm trials. It is in the 2004 500 cwt storage bins. This line will be considered for release in 2006.

MSJ147-1 – a full season storage chipper that also has some early sizing. It has excellent chip-processing quality and a large percentage of A-size tubers. It has performed well in on-farm trials.

MSH228-6 – a chip-processing line with moderate scab resistance. It has a good type and has performed well in on-farm trials.

MSH095-4 - a mid-season maturing line with excellent chip quality and bruise susceptibility equal to Snowden. It had not yielded well in the past few years at Montcalm Research Farm or the on-farm trials. It is intermediate in scab tolerance between Atlantic and MSG227-2.

MSJ461-1 – an MSU chip-processing selection with strong foliar resistance to late blight and maturity similar to Snowden. It has excellent chip-processing quality, smooth round shape and above average yield, but an intermediate specific gravity in most years. The chips show few defects. It is in the 2004 500 cwt storage bins. It has good tablestock quality too.

MICHIGAN PURPLE - a tablestock selection with an attractive purple skin. This selection has high yield potential and the tubers have a low incidence of internal defects. The vine maturity is mid-season to mid-early. Do not let the tubers oversize. A thin skin makes this variety a challenge market on a large scale without making adjustments in harvest, washing and grading process. We regard this as a variety that can compete in the red market. It has great potential in the roadside stand and farm markets.

JACQUELINE LEE – an MSU oval/oblong tablestock selection with a high tuber set. The tubers have the bright skinned, smooth and attractive appearance that is typical of many European cultivars. The tubers have very low incidence of internal defects and good baking quality. It is our best tasting potato! The strength of this selection is also its strong foliar resistance to the US8 genotype of late blight. Vine maturity is similar to Snowden. There is interest in California to market this variety. It has great potential in the roadside stand and farm markets.

C. Russet Varieties (Table 3)

The russet trial had 21 lines evaluated in 2004. GoldRush and Russet Burbank and Russet Norkotah were the standard varieties in the trial and the results are summarized in **Table 3**. Scab resistance was prevalent among the lines tested. Internal quality was high except for vascular discoloration in Keystone Russet. Specific gravity measurements were above average with Russet Burbank and GoldRush having 1.084 and 1.076 readings. The yield of the overall trial was below average for 2004. Off type and cull tubers were found in all lines tested, but the frequency was generally low in 2004. In general, the highest yielding lines also had the latest vine maturity in the trials. Gemstar, Keystone Russet and Silverton Russet show the most promise, however, the varietal choice should take into account whether a new variety is a symptomless carrier of PVY. MSA8254-2BRUS is a high yielding MSU selection that has yielded well in on-farm trials. MSL794-BRUS had foliar late blight resistance, but did not exhibit strong resistance to scab. Stampede Russet has a very attractive type, but has a low yield. MSE192-8RUS has similar features. Millenium Russet was the most blackspot bruise susceptible line tested in the trial.

D. North Central Regional Trial (Table 4)

The North Central Trial is conducted in a wide range of environments (11 locations) to provide adaptability data for the release of new varieties from North Dakota, Minnesota, Wisconsin, Michigan and Canada. Twenty-three breeding lines and 7 check varieties were tested in Michigan. The results are presented in **Table 4**. The range of yield was very wide (412 cwt – 61 cwt) which is typical for this trial each year. Moreover, the yields were below average this year, while the specific gravity readings were very high. This year we sorted the table into round white, reds and russet sections. This grouping will allow more meaningful comparisons to be made when looking at the table. The MSU lines MSJ317-1, MSI152-A, MSH095-4 and MSH031-5 were the Michigan representatives included in the North Central Trial. Both MSJ317-1 and MSI152-A round white tablestock selections have nice type and both have foliar late blight resistance. We are dropping MSH031-5 and will continue to evaluate MSH095-4. The chipper W1773-7 shows high yield potential, while FV12486-2 and CV89023-2R have excellent red color. Gemstar and V1102-1 were the best-performing russet lines.

E. Adaptation Trial (Tables 5A and 5B)

The Adaptation trial was divided into chip-processing and tablestock trials. Three cultivars (Snowden, Pike and Atlantic) and 25 advanced breeding lines are reported in the chip-processing trial. The trial was harvested after 140 days and the results are summarized in **Table 5A**. As in 2003, MSJ036-A was the highest yielding line. It also has a high specific gravity reading and scab resistance. The tuber type of MSJ036-A is also round and attractive. Other lines in the trial that show promise are MSK128-A and MSK136-2 which have foliar late blight resistance. MSM051-3, MSK061-4, MSK476-1 and MSJ126-9Y offer scab resistance with chip-processing from the MSU program. W2128-8 also showed scab resistance in 2004. The Cornell University line NY126 is a yellow-fleshed line with good type.

In the tablestock trial Onaway and Yukon Gold were the check varieties and 18 advanced breeding lines and new varieties are summarized in the table. The trial was harvested after 133 days and the results are summarized in **Table 5B**. Two red-skinned entries were tested. Dakota Jewel did not yield well in 2004, but the type and red color are attractive. Keuka Gold, a light yellow fleshed variety (NY101) from Cornell University was the highest yielding line. There are a number of promising late blight resistant lines to note: MSM224-1, MSL072-C, MSM171-A, MSM137-2, MSM183-1Y and MSL211-3. MSI049-A was the high yielding line and was also a strong performing line in the dry land trial with blackspot bruise resistance and moderate late blight resistance. MSK136-2 is a round white selection with chip-processing and strong foliar resistance to late blight. MSI005-20Y and MSJ033-10Y are scab tolerant yellow-fleshed selections that shows promise.

F. Preliminary Trial (Tables 6A and 6B)

The Preliminary trial is the first replicated trial for evaluating new advanced selections from the MSU potato breeding program. The division of the trials was based upon chip-processing and tablestock utilization. Thirty-one advanced selections and three check varieties were reported chip-processing Preliminary trial. The chip-processing trial is summarized in **Table 6A** was harvested after 133 days. Most lines chip-processed well from the field. Specific gravities were high, but yield was below average. The top yielding line was MSN251-1Y, a yellow-fleshed line with scab resistance, but is late maturing. Another promising line is MSN105-1 which has both scab and late blight resistance. MSM185-1 has scab resistance and some moderate resistance to the Colorado potato beetle. MSN144-2 has some scab tolerance and high yield potential. **Table 8B** summarizes the tablestock lines. Interestingly, many have foliar late blight resistance. This trial was also harvested and evaluated after 133 days. Nine of the 17 lines were late blight resistant. Despite the late blight resistance, the vine maturities were not late in all cases. Seven different late blight resistance sources were also represented. The most promising lines combining tablestock qualities and late blight resistance are MSL179-AY, MSN228-5, MSL183-AY and MSM417-A. MSL179-AY also stood out in the 2003 trial. MSN188-1 is selection with purple splashes that may suit the roadside markets. NDMS7994-1RUS is a scab resistant russet selection to test further. MSN084-3 is a selection with bright, round tubers. It is a cross between Boulder and Chaleur.

G. Trangenic Trial (Table 7)

A field trial was conducted to evaluate Bt-cry1Ia1 transgenic potato lines. The results are summarized in **Table 7.** Spunta G2 and Spunta G3 have good agronomic performance and good type. Two Bt-Atlantic lines were in the trial, but were dropped because of their poor vine growth. Four of the five Bt-Lady Rosetta line performed as well as the non-transgenic Lady Rosetta, but the performance of these Lady Rosetta and the Bt-lines were poor and susceptible to hollow heart.

H. Water Management Trials (Tables 8A and 8B)

In 2003 and 2004 a series of field trials were conducted to compare the agronomic performance of varieties and lines when grown with and without irrigation. In 2004 20 clones were compared. In the irrigated trial, agronomic performance was typical of other irrigated trials at the Montcalm Research Farm. In the non-irrigated trial, yields were about 60%, vine maturity ratings were half, frequency of hollow heart was reduced and specific gravity was similar compared to the irrigated trial. Percent of US #1 potatoes for Michigan Purple, Boulder, Atlantic and MSJ080-1 were similar between irrigated and non-irrigated treatments.

I. Potato Scab Evaluation (Table 9)

Each year a replicated field trial at the MSU Soils Farm is conducted to assess resistance to common and pitted scab. We are using a modified scale of a 0-5 ranking based upon a combined score for scab coverage and lesion severity. Usually examining one year's data does not indicate which varieties are resistant but it should begin to identify ones that can be classified as susceptible to scab. Our goal is to evaluate important advanced selections and varieties in the study at least three years to obtain a valid estimate of the level of resistance in each line. **Table 9** categorizes many of the varieties and advanced selections tested in 2004 at the MSU Soils Farm Scab Nursery over a three-year period. This disease trial is a severe test. The varieties and lines are placed into six arbitrary categories based upon scab infection level and lesion severity. A rating of 0 indicates zero infection. A score of 1.0 indicates a trace amount of infection. A moderate resistance (1.2 – 1.8) correlates with <10% infection. Scores of 4.0 or greater are found on lines with >50% infection and severe pitted lesions. In 2004 the scab disease incidence at the nursery was typical compared to other years, and the data were separated into three categories (Resistant = 0.0-1.0; Moderately Resistant = 1.3 – 1.8; and Susceptible = 2 or higher).The check varieties Russet Burbank, GoldRush, Superior, Onaway, Pike, Red Pontiac, Yukon Gold, Atlantic and Snowden can be used as references (bolded in **Table 9**). In general, most russet lines were scab resistant. This year's results indicate that we have been able to breed numerous lines for the chip-processing and tablestock markets with resistance to scab. Most notable scab resistant MSU lines are Liberator, MSG227-2, MSE192-8RUS, MSE202-3RUS, MSE221-1, MSH228-6, MSK409-1, MSL211-3, MSN251-1Y, MSJ126-9Y, MSJ033-10Y, MSK061-4, MSK476-1, and MSJ036-A. The greater number of MSU lines in the resistant and moderately resistant categories indicates we are making progress in breeding more scab resistant lines for the chip-processing and tablestock markets. Scab results from the disease nursery are also found in the Trial Summaries (**Tables 2-6B**).

J. Late Blight Trial (Table 10)

In 2004, a late blight trial was conducted at the Muck Soils Research Farm. Over 100 entries were evaluated in replicated plots. The field was planted on June 23 and inoculated July 30 with a combinations of isolates (see Table 10 for isolates), and ratings were taken throughout August. Most lines were highly susceptible to the US-8 genotype of late blight. Included in this trial are the varieties and lines from the MSU trials at the Montcalm Research Farm. The partial results are summarized in **Table 10**. The first column lists the lines classified as resistant, while the second column lists select varieties that are susceptible. The late blight differential lines LBR8 and LBR9 were resistant in 2004 as in previous years (not shown in table). Twenty-eight MSU lines were highly resistant to late blight. Resistance of the MSU lines is derived from Tollocan (a Mexican variety), B0718-3 (USDA clone), AWN96518-2 (USDA clone), Stirling (Scottish variety), NY121 (Cornell University clone) and Jacqueline Lee (MSU variety). These resistant progeny indicate that we can continue to breed for resistance using this group of resistant clones. Some of the most promising late blight resistant clones are MSJ461-1, MSL159-AY, MSL179-AY, MSM171-A, MSL794-BRUS, MSL211-3, MSN105-1, MSN251-1Y, MSI152-A and MSK136-2. We find these late blight resistant lines valuable because many of them also have marketable maturity. Some of these lines also have other desirable traits such as scab tolerance resistance and/or chip-processing quality. Tuber late blight resistance is being evaluated on many of the selections with foliar late blight resistance.

K. Blackspot Susceptibility (Table 11)

Increased evaluations of advanced seedlings and new varieties for their susceptibility to blackspot bruising have been implemented in the variety evaluation program over the past decade. Based upon the results collected over the past three years we decided to eliminate the check sample from our bruise assessment. Therefore a composite bruise sample of each line in the trials was collected. The sample consisted of 25 tubers (a composite of 4 reps) from each line at the time of grading. The 25 tuber sample was held in 50°F storage overnight and then was placed in a hexagon plywood drum and tumbled 10 times to provide a simulated bruise. The samples were peeled in an abrasive peeler in October and individual tubers were assessed for the number of blackspot bruises on each potato. These data are shown in **Table 11**. The bruise data are represented in two ways: percentage of bruise free potatoes and average number of bruises per tuber. A high percentage of bruise-free potatoes is the desired goal; however, the numbers of blackspot bruises per potato is also important. Cultivars which show blackspot incidence greater than Atlantic are approaching the bruise-susceptible rating. In addition, the data is grouped by trial, since the bruise levels can vary between trials. Conducting the simulated bruise on 50°F tubers is helping to standardize the bruise testing. We are observing less variation between trials since we standardized the handling of the bruise sample. However, these results become more meaningful when evaluated over 3 years that reflects different growing seasons and harvest conditions. In 2004 the bruise levels were higher other years. The most bruise resistant lines this year were FL1922, Keystone Russet, Stampede Russet, MSA8254-2BRUS, GoldRush, MSK409-1, MSK437-A, Dakota Jewel, MSN125-2, MSN084-3, MSL183-AY, MSI049-A, BTX1544-2W/Y, MSJ317-1, NDTX4271-5R and MSE192-8RUS. The most susceptible lines were MSEE018-1, ND2470-27, MSM183-1Y, MSL007-B, NY132, Millenium Russet, MSH095-4, UEC, FL1833, Snowden and Atlantic.

Table 1

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

DATE OF HARVEST TRIAL: EARLY HARVEST
MONTCALM RESEARCH FARM
AUGUST 11, 2004 (100 DAYS)

										PERCENT (%)				3-YR AVG
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[3]				US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	CWT/A
ATLANTIC	**275**	**295**	**93**	**7**	**87**	**6**	**0**	**1.103**	**1.0**	**23**	**0**	**5**	**0**	**264**
MSH112-6	262	305	86	9	85	0	5	1.097	1.5	0	0	0	0	270*
MICHIGAN PURPLE	243	266	92	7	88	4	1	1.078	2.5	3	0	0	0	265
MSJ147-1	240	278	87	13	87	0	0	1.095	2.0	0	0	0	0	271*
FL1833	238	252	94	6	91	3	0	1.098	1.5	0	0	0	0	263*
SNOWDEN	**235**	**275**	**85**	**14**	**85**	**0**	**0**	**1.095**	**1.5**	**5**	**0**	**0**	**0**	**213**
BOULDER	223	244	92	2	81	11	6	1.080	2.0	28	0	0	5	229
UEC	222	240	92	8	90	2	0	1.091	2.0	5	0	0	0	225
MSJ080-1	221	250	88	10	85	4	2	1.082	1.0	10	0	3	0	235*
FL1879	221	236	94	6	90	4	0	1.090	1.5	8	3	0	0	238*
MSF099-3	217	249	87	13	84	3	0	1.098	1.0	3	0	0	0	219
MSH095-4	207	235	88	11	87	1	1	1.094	2.0	0	5	0	0	224
MSH067-3	205	217	95	5	92	3	0	1.096	1.5	13	0	0	0	200*
MSJ461-1^{LBR}	198	254	78	22	78	0	0	1.087	1.5	0	5	0	0	191
MSH094-8	195	222	88	10	86	2	2	1.094	1.5	5	5	0	0	177
MSH228-6	194	223	87	12	87	0	1	1.090	1.0	0	5	0	0	181*
MSG227-2	194	229	85	15	85	0	0	1.090	2.0	5	3	0	0	197
B0766-3	172	205	84	16	84	0	0	1.093	2.0	15	0	0	0	-
JACQUELINE LEE^{LBR}	168	298	57	43	57	0	0	1.087	2.5	0	0	0	0	185
LIBERATOR	163	192	84	16	84	0	0	1.093	1.0	0	0	0	3	194
FL1922	151	174	87	12	85	1	1	1.085	1.5	0	5	0	0	171*
FL1867	135	155	87	9	87	0	4	1.093	2.0	13	0	0	0	187*
MEAN	208	241						1.091						
$LSD_{0.05}$	36	41						0.003						

* Two-Year Average

^{LBR} Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

Planted May 3, 2004

Table 2

DATE OF HARVEST TRIAL: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 20, 2004 (140 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]						3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	CWT/A
ATLANTIC	**350**	**363**	**96**	**3**	**87**	**9**	**1**	**1.104**	**1.0**	**28**	**10**	**0**	**3**	**2.4**	**4.0**	**340**
MSJ147-1	320	353	91	9	88	2	0	1.094	1.0	5	13	0	0	1.8	3.8	302*
BOULDER	317	359	88	2	67	22	10	1.083	1.0	35	0	0	8	1.8	3.5	353
MSJ461-1[LBR]	292	349	84	15	82	2	1	1.086	1.0	0	5	0	0	1.8	4.0	297
MSF099-3	283	314	90	9	85	5	1	1.098	1.0	3	0	0	3	2.5	3.5	311
MICHIGAN PURPLE	281	303	93	6	90	3	2	1.078	1.0	3	10	0	0	3.3	2.5	315
FL1833	277	289	96	3	81	15	1	1.099	1.0	10	10	0	0	2.0	3.5	289*
SNOWDEN	**275**	**315**	**87**	**11**	**83**	**4**	**2**	**1.095**	**1.0**	**5**	**25**	**0**	**0**	**1.9**	**3.5**	**270**
UEC	273	289	94	5	83	12	1	1.092	1.0	5	8	0	0	1.5	4.0	324*
MSG227-2	261	286	91	8	87	4	1	1.093	1.0	13	3	0	0	0.8	4.0	280
MSH094-8	259	279	93	7	90	3	0	1.097	1.0	10	8	0	0	2.0	3.3	265
MSH228-6	253	275	92	7	89	3	1	1.095	1.0	8	10	0	0	1.3	4.3	270*
FL1879	248	259	96	4	93	3	0	1.092	1.0	5	18	0	0	2.5	2.3	306*
MSJ080-1	241	267	90	8	82	8	2	1.084	1.0	20	10	0	0	2.3	3.5	300*
MSH095-4	216	235	92	8	91	1	0	1.094	1.0	5	28	3	0	2.5	2.8	280
MSH067-3	213	233	91	5	80	11	4	1.097	1.0	28	0	0	0	2.7	3.5	252*
B0766-3	212	240	88	11	85	4	1	1.096	1.0	20	3	0	0	1.8	3.8	-
JACQUELINE LEE[LBR]	194	321	60	39	60	0	1	1.091	1.0	0	10	0	0	2.7	3.5	237
LIBERATOR	188	222	85	14	84	1	1	1.091	1.0	3	13	0	0	0.3	3.3	249
FL1922	167	193	86	11	84	2	3	1.086	1.0	0	8	0	0	1.0	3.0	199*
FL1867	160	183	88	10	87	1	3	1.093	1.0	10	0	0	0	1.5	3.0	196*
MEAN	251	282						1.092								
LSD$_{0.05}$	45	48						0.003								

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: August 12, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 3, 2004

Table 3

RUSSET and LONG TYPES TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 15, 2004 (135 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[2]						3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]	CWT/A
GEMSTAR (A9014-2RUS)-NCR	320	400	80	17	75	5	3	1.093	15	3	0	0	0.8	4.3	-
KEYSTONE RUSSET	303	343	88	10	68	20	2	1.073	3	40	0	0	0.5	4.0	301*
A8254-2BRUS	271	397	68	27	61	7	4	1.084	15	3	0	0	0.0	4.3	291*
SILVERTON RUSSET	269	307	88	13	66	23	2	1.080	0	5	0	0	0.0	4.5	193
A9305-10	258	344	75	21	71	4	4	1.086	0	15	0	0	1.5	4.5	255*
V1102-1-NCR	234	283	83	16	76	7	1	1.085	0	8	0	0	1.0	1.5	-
MSL794-BRUS[LBR]	226	283	80	17	70	9	3	1.085	0	3	0	0	2.0	3.8	-
A8893-1	213	322	66	31	65	1	3	1.087	3	8	0	0	0.5	3.5	-
A95409-1	200	285	70	27	66	4	3	1.090	0	0	0	0	1.8	3.0	212*
MSE202-3RUS	191	254	75	21	67	8	3	1.084	15	3	0	0	1.0	4.3	213
WALLOWA RUSSET	191	255	75	21	63	12	4	1.093	5	23	0	0	3.0	3.5	-
MILLENIUM RUSSET	178	268	66	27	65	1	7	1.086	3	3	0	0	0.3	3.8	-
GOLDRUSH	**176**	**256**	**69**	**30**	**63**	**6**	**2**	**1.076**	**0**	**13**	**0**	**0**	**0.0**	**2.0**	**198**
MSL025-ARUS	165	283	58	41	56	2	1	1.079	0	15	0	3	0.8	4.0	-
RUSSET BURBANK-NCR	**147**	**265**	**56**	**40**	**55**	**1**	**5**	**1.084**	**0**	**3**	**3**	**0**	**0.8**	**3.0**	**195**
AC89536-5RUS	138	263	52	46	50	3	2	1.084	5	18	0	0	0.3	3.0	210
RUSSET NORKOTAH-NCR	**126**	**220**	**58**	**41**	**58**	**0**	**1**	**1.082**	**0**	**5**	**0**	**0**	**1.3**	**1.3**	**-**
ND7882b-7RUS-NCR	125	246	51	47	49	1	2	1.080	3	5	3	0	-	1.0	-
MSE192-8RUS	124	208	59	34	57	3	7	1.076	0	3	0	0	1.0	2.8	183
AC STAMPEDE RUSSET-NCR	94	157	60	39	57	3	2	1.064	0	3	0	0	0.5	2.3	-
MN99460-21-NCR	61	149	41	58	41	0	1	1.082	0	0	3	0	2.3	1.3	-
MEAN	191	276						1.083							
$LSD_{0.05}$	72	76						0.005							

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: < 4oz.; A: 4-10oz.; OV: > 10oz.; PO: Pickouts.

[2] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

[3] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[4] MATURITY RATING: August 28, 2003; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

Planted May 3, 2004

Table 4

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 6, 2004 (126 DAYS)

										PERCENT (%)						
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[3]						
ENTRY	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	MERIT[6]
ROUND WHITES:																
W1773-7	283	342	83	16	82	1	1	1.101	1.0	0	3	0	0	1.8	4.0	3
USDA02-20066	272	325	84	15	83	1	1	1.084	2.5	8	10	0	3	-	5.0	
NORVALLEY	**260**	**314**	**83**	**15**	**82**	**1**	**2**	**1.085**	**1.5**	**0**	**5**	**0**	**0**	**1.5**	**2.5**	**1**
ATLANTIC	**271**	**309**	**87**	**6**	**74**	**13**	**7**	**1.098**	**1.0**	**45**	**3**	**0**	**0**	**2.4**	**3.3**	
SNOWDEN	**259**	**290**	**89**	**9**	**86**	**4**	**2**	**1.098**	**1.5**	**10**	**13**	**0**	**0**	**1.9**	**4.0**	**2**
W2128-8	221	288	77	21	76	0	2	1.101	1.5	0	3	0	0	0.7	3.3	
USDA02-20312	237	286	83	16	83	0	1	1.098	1.5	5	13	0	0	-	3.8	
MSJ317-1^{LBR}	238	270	88	9	87	1	2	1.085	1.0	10	10	0	0	2.5	5.0	
MSH095-4	228	263	87	11	86	1	2	1.093	1.5	5	28	0	0	2.5	1.8	
MSI152-A^{LBR}	217	253	86	13	84	2	1	1.075	1.5	0	3	0	0	1.0	4.5	
USDA02-20152	123	242	51	45	51	0	4	1.091	1.5	30	0	0	0	-	2.5	
W1443	167	214	78	17	78	1	5	1.088	1.0	28	8	0	0	1.0	2.5	
MSH031-5	175	203	86	13	86	0	1	1.086	1.5	0	3	0	0	2.7	2.5	
MN99380-1	101	171	59	40	59	0	1	1.078	1.0	0	15	0	0	2.0	1.0	
MN96001-2	135	168	80	18	79	1	2	1.075	2.0	0	10	0	0	1.5	1.0	
V0319-1	104	153	68	32	67	1	0	1.084	1.5	3	0	0	0	-	1.5	
USDA02-20059	75	132	56	41	56	0	3	1.060	2.0	0	15	0	0	-	1.0	
REDS:																
RED PONTIAC	**412**	**440**	**94**	**5**	**85**	**8**	**2**	**1.074**	**2.5**	**13**	**5**	**0**	**0**	**3.0**	**4.0**	**2**
FV12486-2	258	284	91	9	85	5	0	1.070	2.0	0	5	0	0	1.5	1.8	1
CV89023-2R	226	284	80	20	80	0	0	1.077	2.5	0	0	0	0	1.0	1.3	3
VILLETA ROSE (W2275-3R)	144	244	59	41	59	0	0	1.060	2.0	0	0	0	0	-	1.3	
RED NORLAND	**192**	**221**	**87**	**12**	**87**	**0**	**1**	**1.069**	**2.5**	**0**	**3**	**3**	**0**	**1.7**	**1.0**	
MN96013-1	84	117	72	25	69	3	3	1.076	1.5	0	5	0	0	3.0	1.5	

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 6, 2004 (126 DAYS)

										PERCENT (%)						
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[3]						
ENTRY	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]	MERIT[6]
RUSSET / LONG TYPES:																
GEMSTAR (A9014-2RUS)	320	400	80	17	75	5	3	1.093	-	15	3	0	0	0.8	4.3	1
V1102-1	234	283	83	16	76	7	1	1.085	-	0	8	0	0	1.0	1.5	3
RUSSET BURBANK	**147**	**265**	**56**	**40**	**55**	**1**	**5**	**1.084**	**-**	**0**	**3**	**3**	**0**	**0.8**	**3.0**	
ND7882b-7RUS	125	246	51	47	49	1	2	1.080	-	3	5	3	0	-	1.0	
RUSSET NORKOTAH	**126**	**220**	**58**	**41**	**58**	**0**	**1**	**1.082**	**-**	**0**	**5**	**0**	**0**	**1.3**	**1.3**	**2**
AC STAMPEDE RUSSET	94	157	60	39	57	3	2	1.064	-	0	3	0	0	0.5	2.3	
MN99460-21	61	149	41	58	41	0	1	1.082	-	0	0	3	0	2.3	1.3	
MEAN	203	253						1.083								
$LSD_{0.05}$	45	50						0.003								

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: August 24, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[6] MERIT: A Merit rating was given for the best 3 entries within each market class (rank order, 1 = best).

Planted May 3, 2004

ADAPTATION TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 20, 2004 (140 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]					
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]
MSJ036-A	362	386	94	6	86	8	0	1.096	1.0	18	5	0	0	0.8	3.3
A91814-5	324	377	86	9	77	9	5	1.094	1.0	3	5	0	0	2.8	4.3
MSL766-1^{LBR}	317	341	93	5	66	27	2	1.085	1.0	5	0	0	0	2.3	4.0
ATLANTIC	**307**	**326**	**94**	**5**	**82**	**13**	**1**	**1.105**	**1.0**	**53**	**3**	**3**	**3**	**2.4**	**3.5**
NY126(Y)	280	297	94	5	85	9	1	1.095	1.0	8	3	0	0	1.5	3.5
MSK498-1Y	275	305	90	9	89	1	1	1.090	1.0	0	5	0	0	1.5	4.8
W2128-8	268	329	81	16	81	0	3	1.105	1.0	0	10	0	0	0.7	2.8
SNOWDEN	**263**	**292**	**90**	**8**	**87**	**4**	**2**	**1.097**	**1.0**	**3**	**25**	**0**	**0**	**1.9**	**3.5**
MSM051-3	260	279	93	6	88	6	0	1.091	1.0	10	0	0	5	1.0	3.5
MSL007-B	254	287	88	12	85	3	0	1.094	1.0	3	3	0	0	2.0	4.8
W52-26^{LBR}	251	285	88	12	87	1	0	1.083	1.5	0	0	0	0	1.8	2.8
MSK476-1	242	286	85	14	84	1	2	1.109	1.0	3	8	0	0	1.3	5.0
W2133-1	240	276	87	13	84	3	0	1.097	1.5	3	13	0	0	1.5	4.0
MSK061-4	240	275	87	13	87	0	0	1.098	1.0	0	18	0	0	1.3	4.0
MSK128-A^{LBR}	237	267	89	11	89	0	1	1.093	1.5	0	0	0	0	2.8	1.8
MSK049-A	232	311	75	25	73	2	1	1.097	1.0	0	5	0	0	2.3	3.8
MSK136-2^{LBR}	231	280	82	17	82	0	0	1.094	1.5	0	0	0	0	3.0	5.0
MSK009-B	224	246	91	6	82	9	2	1.087	1.0	5	0	0	0	1.5	3.5
PIKE	**223**	**249**	**90**	**9**	**89**	**1**	**1**	**1.099**	**1.0**	**0**	**5**	**0**	**0**	**0.9**	**4.5**
W2154-1	219	277	79	18	78	1	3	1.098	1.0	8	3	0	0	1.7	**1.0**
MSM170-2	213	250	85	14	83	2	1	1.087	1.0	0	0	0	0	4.0	3.3
AF2211-9	206	221	93	5	90	3	2	1.094	1.0	45	10	8	0	2.3	1.3
MSM046-4	197	247	80	19	80	0	1	1.097	1.0	0	15	0	0	1.3	5.0
W2233-2	196	228	86	13	86	0	1	1.086	1.5	8	8	0	0	2.3	1.8

ADAPTATION TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 20, 2004 (140 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]					
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]
MSJ126-9Y	192	213	90	10	86	4	0	1.088	1.0	3	5	0	0	1.3	1.8
NY132	176	208	84	15	84	1	1	1.110	1.0	8	0	0	0	1.5	4.8
W2145-11	171	201	85	14	85	0	1	1.101	1.0	3	0	0	0	1.0	3.8
MSK409-1	155	191	81	14	80	1	5	1.092	1.0	0	5	0	0	1.3	2.0
MEAN	241	276						1.095							
$LSD_{0.05}$	48	47						0.004							

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: August 24, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 3, 2004

Table 5B

ADAPTATION TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
SEPTEMBER 13, 2004 (133 DAYS)

									PERCENT (%)					
	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]					
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	SCAB[3]	MAT[4]
KEUKA GOLD	360	374	96	4	90	6	0	1.087	0	8	0	3	0.8	4.5
MSM224-1[LBR]	347	404	86	11	80	6	3	1.084	0	3	0	0	2.3	5.0
MSL072-C[LBR]	331	359	92	7	86	6	1	1.085	0	3	0	0	2.0	4.5
MSI049-A[MRLBR]	288	318	90	8	82	8	1	1.080	8	0	0	0	2.3	2.5
MSM171-A[LBR]	280	305	92	8	88	4	1	1.073	0	5	0	3	2.5	1.3
MSJ204-3	279	304	92	5	84	8	3	1.083	0	0	0	0	1.7	4.5
STIRLING[LBR]	269	322	83	15	81	2	2	1.081	28	5	0	0	2.3	4.3
MSI005-20Y	242	281	86	13	84	3	1	1.083	0	5	0	0	1.3	2.3
ONAWAY	**242**	**294**	**82**	**9**	**78**	**4**	**9**	**1.071**	**0**	**10**	**0**	**0**	**1.0**	**1.3**
YUKON GOLD	**239**	**246**	**97**	**3**	**87**	**10**	**0**	**1.090**	**10**	**8**	**0**	**0**	**3.0**	**1.3**
MSM137-2[LBR]	237	273	87	11	83	3	2	1.080	8	3	0	0	3.0	1.0
MSM183-1Y[LBR]	225	337	67	25	65	1	9	1.097	0	0	0	0	2.3	5.0
MSK437-A	293	303	97	3	59	38	1	1.082	18	3	0	3	2.0	4.8
MSM037-3	289	318	91	5	79	11	4	1.076	20	8	0	0	1.3	4.8
MSL211-3[LBR]	213	243	88	10	85	3	2	1.080	0	8	0	0	1.3	1.5
MSL228-1	218	245	89	8	88	0	3	1.090	0	10	0	0	1.8	2.3
MSJ033-10Y	214	259	83	13	82	1	4	1.082	0	8	0	0	1.0	3.3
MSK125-3[MRLBR]	212	276	77	15	74	3	8	1.082	8	0	18	0	1.8	4.3
DAKOTA JEWEL	180	212	85	14	85	0	1	1.080	0	0	0	0	0.8	1.0
MODOC	164	218	76	24	75	1	1	1.070	3	5	0	0	2.0	1.8
MEAN	256	295						1.082						
$LSD_{0.05}$	50	49						0.003						

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

[3] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[4] MATURITY RATING: August 24, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 3, 2004

Table 6A

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 13, 2004 (133 DAYS)

										PERCENT (%)					
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[3]					
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]
MSN251-1Y^{LBR}	412	461	89	6	75	14	5	1.094	1.0	35	0	0	0	1.0	5.0
MSN125-2	382	405	94	6	92	3	0	1.091	1.0	0	0	0	0	2.0	5.0
MSM164-2Y	374	417	90	5	66	24	6	1.081	1.5	45	0	45	0	1.3	5.0
MSN144-2	373	398	94	6	73	20	1	1.081	1.0	15	5	0	0	1.3	4.0
ATLANTIC	**365**	**384**	**95**	**3**	**81**	**14**	**2**	**1.102**	**1.0**	**60**	**0**	**0**	**10**	**2.4**	**3.5**
MSN105-1^{LBR}	360	396	91	9	91	0	0	1.094	1.0	0	0	0	0	1.3	4.0
MSM057-D	320	354	90	8	81	10	1	1.091	1.0	0	0	0	0	2.7	4.0
MSL235-AY^{MRLBR}	314	349	90	7	79	11	3	1.081	1.0	25	0	0	0	1.7	5.0
MSN184-2	297	318	93	7	83	10	0	1.085	1.0	0	0	0	0	-	4.5
MSM409-2Y	295	337	87	11	84	4	2	1.089	2.0	20	0	0	0	3.0	4.5
MSM185-1^{MRCPB}	288	334	86	9	82	4	5	1.094	1.0	5	0	0	0	1.0	5.0
MSN065-2	280	323	87	10	83	4	3	1.098	1.0	10	0	0	0	-	2.5
MSM070-1	277	314	88	11	84	4	1	1.086	1.0	0	0	0	0	1.3	3.0
MSM205-A	267	306	87	10	83	4	3	1.086	1.0	0	0	0	0	2.0	3.0
SNOWDEN	**265**	**298**	**89**	**11**	**85**	**4**	**0**	**1.095**	**1.0**	**10**	**20**	**0**	**0**	**1.9**	**3.5**
MSN179-5	264	312	85	10	82	3	6	1.094	1.0	0	0	0	0	1.8	3.5
MSM170-B	263	283	93	7	83	10	0	1.086	1.0	5	0	0	0	1.7	2.5
MSN174-3	261	326	80	20	80	0	0	1.079	1.0	10	0	0	0	1.5	3.0
MSM039-B	260	317	82	17	81	1	1	1.102	1.0	0	0	5	0	1.8	4.0
MSN094-3	258	302	85	14	81	5	1	1.094	1.0	45	0	0	0	1.3	5.0
MSN236-1	240	301	80	17	80	0	3	1.103	1.0	0	0	0	0	1.8	4.0
MSM051-A	231	275	84	14	83	1	2	1.089	1.0	15	0	0	0	3.0	3.5
MSN085-2Y	222	271	82	18	82	0	1	1.107	1.0	5	5	0	0	2.0	3.5
MSN026-4	219	256	86	14	86	0	0	1.097	1.0	0	0	0	0	1.5	3.5
MSL292-A	217	247	88	11	85	3	1	1.093	1.0	10	0	0	0	2.0	2.5
MSL106-AY	216	269	81	16	78	3	4	1.081	1.0	35	0	0	0	2.7	3.0
MSL268-D^{LBR}	215	260	83	17	83	0	1	1.088	1.0	0	0	0	0	2.0	3.5

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 13, 2004 (133 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]					
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]
PIKE	**214**	**234**	**91**	**8**	**90**	**1**	**0**	**1.097**	**1.0**	**0**	**0**	**0**	**0**	**0.9**	**4.5**
MSM188-1[MRCPB]	211	253	84	16	83	1	0	1.099	1.0	10	0	0	0	-	2.5
MSM060-3	205	261	79	20	79	0	1	1.103	1.0	5	10	5	0	1.0	2.5
MSM053-4	194	209	93	7	84	9	0	1.089	1.0	55	0	0	0	2.0	5.0
MSN098-4	183	212	87	11	87	0	3	1.081	1.0	0	0	0	0	1.3	2.5
MSM408-B	160	187	86	13	80	6	2	1.093	1.0	0	0	0	0	-	3.5
MSN209-3[LBR]	155	202	77	11	72	5	12	1.092	1.0	0	0	0	0	2.0	4.5
MEAN	266	305						1.092							
$LSD_{0.05}$	66	68						0.005							

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 20 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: August 24, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 3, 2004

Table 6B

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
SEPTEMBER 13, 2004 (133 DAYS)

										PERCENT (%)					
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[3]					
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]	MAT[5]
MSL179-AY^{LBR}	358	405	88	10	81	7	2	1.088	3.0	0	10	0	0	2.3	4.0
MSN188-1	305	366	83	15	82	1	2	1.087	2.5	10	0	0	0	3.0	4.0
MSN228-5^{LBR}	297	411	72	27	72	0	1	1.088	1.0	0	0	0	0	3.0	4.5
MSL006-AY	292	324	90	9	87	3	1	1.088	1.5	0	15	0	0	4.0	3.0
ARS4008-1	275	333	83	9	79	4	8	1.079	4.0	0	5	0	5	1.8	2.0
MSL045-AY^{LBR}	272	297	92	8	89	3	0	1.077	1.5	0	0	0	0	3.0	2.0
MSL183-AY^{LBR}	269	327	82	17	82	0	1	1.073	1.0	0	0	0	0	2.0	2.5
MSN084-11	250	261	96	4	74	21	0	1.069	1.5	5	0	0	35	3.0	4.0
ONAWAY	**247**	**287**	**86**	**10**	**83**	**3**	**4**	**1.070**	**4.0**	**0**	**0**	**0**	**0**	**1.0**	**1.0**
MSM417-A^{LBR}	245	304	81	18	79	1	1	1.089	1.0	40	0	0	0	2.7	2.5
MSN077-2	240	262	92	8	90	2	0	1.084	1.0	0	0	0	0	3.0	4.0
MSN084-3	213	229	93	6	88	5	1	1.075	1.5	0	0	0	15	2.0	3.0
MSL024-AY^{LBR}	210	297	71	28	71	0	1	1.077	2.0	0	5	0	0	2.3	1.0
MSL175-1	166	171	97	3	80	17	0	1.077	1.5	0	0	0	0	2.0	3.0
NDMS7994-1RUS	140	255	55	44	54	1	1	1.089	2.5	0	0	0	0	0.0	2.0
MSM143-A^{LBR}	138	193	72	28	72	0	0	1.082	1.0	0	0	0	0	1.5	1.5
MSM224-2^{LBR}	138	161	86	14	86	0	0	1.079	2.5	5	0	0	0	3.0	1.0
MSM148-A^{LBR}	132	204	64	35	64	0	0	1.091	1.0	0	0	0	0	1.0	3.5
MEAN	233	283						1.081							
$LSD_{0.05}$	87	79						0.003							

^{LBR} Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot**Percent of 20 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: August 24, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 3, 2004

Table 7

TRANSGENIC TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 7, 2004 (127 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	PERCENT (%) TUBER QUALITY[3]				
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[2]	HH	VD	IBS	BC	SCAB[4]
Spunta-G3	354	418	85	11	79	5	4	1.072	2.0	1	6	4	0	1.8
Spunta-G2	324	380	85	8	79	6	7	1.072	2.0	1	3	1	0	2.0
Atlantic	**313**	**336**	**93**	**5**	**86**	**7**	**2**	**1.107**	**1.0**	**10**	**2**	**3**	**0**	**2.1**
Spunta	**234**	**278**	**84**	**8**	**75**	**9**	**8**	**1.070**	**2.0**	**2**	**7**	**0**	**0**	**2.3**
Atlantic Newleaf	226	262	86	12	83	4	1	1.104	1.0	7	2	1	2	2.0
Lady Rosetta-5.3	114	210	54	46	54	0	0	1.100	1.5	20	1	2	0	nd
Lady Rosetta-5.4	113	219	52	48	52	0	0	1.102	1.5	10	0	0	0	nd
Lady Rosetta-5.1	104	213	49	51	49	0	0	1.094	1.0	13	0	1	0	nd
Lady Rosetta-5.2	104	193	54	40	54	0	6	1.106	1.5	16	0	0	0	nd
Lady Rosetta	**97**	**200**	**49**	**51**	**49**	**0**	**1**	**1.102**	**1.5**	**14**	**0**	**0**	**0**	**1.0**
Lady Rosetta-5.6	67	158	43	56	43	0	1	1.099	1.5	2	0	0	0	nd
MEAN	186	261						1.093						
$LSD_{0.05}$														

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 40 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

nd = no data

Planted May 3, 2004

Table 8A

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

WATER MANAGEMENT TRIAL: STANDARD IRRIGATION TREATMENT
MONTCALM RESEARCH FARM
SEPTEMBER 24, 2004 (130 DAYS)

									PERCENT (%)				
	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[3]				
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	MAT[5]
ATX91137-1RU	366	410	89	9	84	5	1	1.076	0	0	0	0	**4.7**
MSJ080-1	360	387	93	6	86	7	1	1.084	7	3	0	0	4.0
BOULDER	357	393	91	2	56	35	8	1.082	13	0	0	0	5.0
MSE018-1	349	390	90	8	82	8	2	1.092	20	3	0	0	5.0
CO089097-2R	332	373	89	10	87	2	1	1.083	0	13	0	0	3.7
NDTX4271-5R	323	362	89	9	87	2	1	1.073	0	0	0	0	3.0
MSJ147-1	321	345	93	7	92	1	0	1.094	13	0	0	0	4.3
Atlantic	**313**	**346**	**90**	**9**	**89**	**2**	**0**	**1.103**	**3**	**0**	**7**	**0**	**4.7**
Michigan Purple	308	328	94	4	87	7	2	1.077	3	0	0	3	3.0
MSI049-A	295	329	90	10	88	1	0	1.078	0	0	0	0	3.0
NDTX4304-1R	294	326	90	9	89	1	1	1.062	0	7	0	0	2.0
MSG227-2	279	307	91	8	85	5	1	1.088	10	0	0	0	4.0
MSJ461-1	276	368	75	25	75	0	0	1.085	0	3	10	0	5.0
Onaway	**268**	**319**	**84**	**7**	**81**	**3**	**9**	**1.069**	**0**	**20**	**0**	**0**	**2.7**
Snowden	**264**	**302**	**87**	**13**	**84**	**3**	**0**	**1.096**	**13**	**20**	**0**	**0**	**4.0**
BTX1544-2W/Y	254	286	89	11	89	0	0	1.082	3	0	0	0	2.0
MSJ317-1	200	268	74	23	74	0	2	1.086	13	0	0	0	5.0
Russet Norkotah	**199**	**255**	**78**	**16**	**72**	**6**	**6**	**1.077**	**13**	**0**	**0**	**0**	**4.0**
MSH228-6	192	215	90	5	87	3	5	1.086	27	13	0	0	4.0
MSE192-8RUS	105	193	54	43	54	0	2	1.078	0	3	0	0	2.7
MEAN	283	325						1.083					3.8
$LSD_{0.05}$	50	51						0.003					0.9

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot. **Percent of 30 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: Taken August 12, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 17, 2004

WATER MANAGEMENT TRIAL: NON-IRRIGATED TREATMENT
MONTCALM RESEARCH FARM
SEPTEMBER 15, 2004 (132 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						PERCENT (%) TUBER QUALITY[3]				
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	MAT[5]
Michigan Purple	227	265	86	11	85	1	4	1.081	0	0	0	0	1.7
Atlantic	**212**	**243**	**87**	**10**	**86**	**1**	**2**	**1.097**	**3**	**13**	**7**	**7**	**2.0**
MSI049-A	202	255	79	18	79	1	3	1.075	0	0	0	0	1.0
NDTX4304-1R	186	226	82	16	80	2	2	1.064	0	7	0	3	1.0
MSJ080-1	186	208	89	10	87	2	1	1.080	0	3	0	0	2.0
Boulder	181	237	77	8	74	3	16	1.090	23	0	0	0	3.7
BTX1544-2W/Y	176	214	83	16	82	1	2	1.078	0	3	0	3	1.0
Snowden	**173**	**226**	**77**	**22**	**77**	**0**	**1**	**1.090**	**0**	**10**	**0**	**0**	**1.7**
CO89097-2R	173	245	71	25	70	1	4	1.078	0	7	0	0	1.0
Onaway	**170**	**211**	**80**	**12**	**80**	**1**	**7**	**1.074**	**0**	**20**	**0**	**0**	**1.0**
ATX91137-1RU	164	242	68	29	68	0	3	1.077	3	10	0	0	1.0
MSJ147-1	161	210	77	23	77	0	0	1.092	0	7	0	0	2.7
MSE018-1	155	197	79	19	78	1	2	1.090	0	23	0	0	3.0
MSJ461-1	147	221	66	33	66	0	1	1.079	0	3	0	0	2.0
MSH228-6	143	200	71	17	69	2	12	1.089	0	7	0	0	3.0
NDTX4271-5R	141	181	78	19	76	2	3	1.066	0	3	0	0	1.0
MSJ317-1	133	176	76	20	76	0	4	1.081	0	27	0	0	4.7
MSG227-2	128	175	73	25	73	0	2	1.091	0	0	7	3	2.0
Russet Norkotah	**74**	**131**	**56**	**39**	**56**	**0**	**5**	**1.069**	**0**	**7**	**0**	**0**	**1.3**
MSE192-8RUS	35	131	27	73	27	0	0	1.073	0	0	0	0	1.0
MEAN	158	210						1.081					1.9
$LSD_{0.05}$	44	42						0.005					0.5

[1] SIZE: B: <2"; A: 2-3.25"; OV: >3.25"; PO: Pickouts.

[2] CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.

[3] QUALITY: HH: Hollow Heart; BC: Brown Center; VD: Vascular Discoloration; IBS: Internal Brown Spot.**Percent of 30 Oversize and/or A-size tubers cut.**

[4] SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

[5] MATURITY RATING: Taken August 12, 2004; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

Planted May 5, 2004

Table 9

2002-2004 SCAB DISEASE TRIAL SUMMARY
SCAB NURSERY, EAST LANSING, MI

	2004	2004	2004	2003	2003	2003	2002	2002	2002
LINE	RATING	WORST	N	RATING	WORST	N	RATING	WORST	N
Sorted by ascending 2004 Rating;									
A8254-2BRUS	0.0	0	4	0.0	0	3	-	-	-
Goldrush	**0.0**	**0**	**4**	**1.0**	**1**	**2**	**0.3**	**1**	**3**
MSND7994-1	0.0	0	4	-	-	-	-	-	-
Silverton Russet	0.0	0	4	0.3	1	3	-	-	-
AC89536-5RUS	0.3	0	4	0.0	0	3	0.0	0	2
Liberator	0.3	1	4	0.0	0	3	0.0	0	2
Millenium Russet	0.3	1	4	0.7	1	3	0.0	0	3
A8893-1	0.5	1	2	-	-	-	0.0	0	3
Keystone Russet	0.5	1	4	0.5	1	2	0.5	1	2
Stampede Russet	0.5	1	2	0.3	1	3	-	-	-
Keuka Gold	0.7	1	3	-	-	-	-	-	-
Dakota Jewel	0.8	1	4	1.0	1	3	0.7	1	3
GemStar (A9014-2)	0.8	1	4	1.0	1	3	0.3	1	3
MSG227-2	0.8	1	4	0.8	2	6	0.5	1	2
MSJ036-A	0.8	1	4	1.3	2	3	0.5	1	2
MSL025-ARUS	0.8	1	4	0.7	1	3	-	-	-
Russet Burbank	**0.8**	**1**	**4**	**0.5**	**2**	**6**	**-**	**-**	**-**
Pike	**0.9**	**1**	**7**	**1.5**	**2**	**8**	**-**	**-**	**-**
Atlantic 5.4	1.0	2	3	-	-	-	-	-	-
CV89023-2R	1.0	1	1	3.0	4	3	3.0	3	3
FL1922	1.0	1	4	1.3	2	3	-	-	-
Lady Rosetta	1.0	1	5	2.0	5	3	-	-	-
MSE192-8RUS	1.0	3	3	0.3	1	3	0.3	0	3
MSE202-3RUS	1.0	1	3	0.3	1	3	0.0	0	5
MSI152-A	1.0	1	3	3.0	3	3	2.0	3	3
MSJ033-10Y	1.0	1	3	-	-	-	1.0	1	3
MSL045-AY	1.0	1	2	3.0	3	1	-	-	-
MSM051-3	1.0	1	4	1.0	1	1	-	-	-
MSM060-3	1.0	1	4	0.7	1	3	-	-	-
MSM148-A	1.0	1	2	-	-	-	-	-	-
MSM185-1	1.0	1	4	3.3	5	3	-	-	-
MSN251-1Y	1.0	1	1	-	-	-	-	-	-
Onaway	**1.0**	**1**	**5**	**1.4**	**3**	**9**	**1.7**	**3**	**7**
V1102-1	1.0	1	2	-	-	-	-	-	-
Villetta Rose	1.0	2	4	-	-	-	-	-	-
W1443	1.0	1	4	-	-	-	-	-	-
W2145-11	1.0	1	4	-	-	-	-	-	-
MSH228-6	1.3	2	4	0.7	1	3	1.3	2	3
MSI005-20Y	1.3	2	4	1.0	1	3	2.0	2	1

	2004	2004	2004	2003	2003	2003	2002	2002	2002
LINE	RATING	WORST	N	RATING	WORST	N	RATING	WORST	N
Sorted by ascending 2004 Rating;									
MSK061-4	1.3	2	4	2.0	3	3	2.0	1	1
MSK476-1	1.3	2	4	1.0	1	3	1.0	2	2
MSL211-3	1.3	2	4	1.0	1	1	-	-	-
MSM037-3	1.3	2	4	-	-	-	-	-	-
MSM164-2Y	1.3	2	4	1.3	2	3	-	-	-
MSN094-3	1.3	2	4	-	-	-	-	-	-
MSN098-4	1.3	2	4	-	-	-	-	-	-
Russet Norkotah	**1.3**	**2**	**4**	**2.0**	**2**	**3**	**-**	**-**	**-**
MSJ126-9Y	1.3	2	3	1.3	2	3	-	-	-
MSK409-1	1.3	2	3	0.7	1	3	2.0	2	2
MSM046-4	1.3	2	3	0.7	1	3	-	-	-
MSM070-1	1.3	2	3	-	-	-	-	-	-
MSN105-1	1.3	2	3	-	-	-	-	-	-
MSN144-2	1.3	2	3	-	-	-	-	-	-
W2128-8	1.4	2	8	-	-	-	-	-	-
A9305-10	1.5	2	4	1.7	2	3	-	-	-
FL1867	1.5	2	4	1.5	3	4	-	-	-
FV12486-2	1.5	2	2	-	-	-	-	-	-
MN96001-2	1.5	2	4	-	-	-	-	-	-
MSK009-B	1.5	2	4	3.0	3	3	-	-	-
MSK498-1Y	1.5	2	4	2.7	4	3	1.3	2	3
MSM143-A	1.5	2	2	-	-	-	-	-	-
MSM288-2Y	1.5	2	4	2.5	3	2	-	-	-
MSN026-4	1.5	2	4	-	-	-	-	-	-
MSN174-3	1.5	2	4	-	-	-	-	-	-
NorValley	1.5	2	4	1.0	1	1	2.0	2	3
NY126	1.5	2	4	-	-	-	-	-	-
NY132	1.5	2	4	-	-	-	-	-	-
UEC	1.5	2	4	1.3	2	6	1.5	2	4
W2133-1	1.5	2	4	-	-	-	-	-	-
MSL235-AY	1.7	2	3	-	-	-	-	-	-
MSM170-B	1.7	2	3	-	-	-	-	-	-
Red Norland	**1.7**	**2**	**3**	**0.7**	**1**	**3**	**-**	**-**	**-**
A95409-1	1.8	2	4	0.0	0	2	-	-	-
ARS4008-1	1.8	2	4	-	-	-	-	-	-
B0766-3	1.8	2	4	-	-	-	-	-	-
Boulder	1.8	3	4	2.0	3	3	2.5	3	2
MSH094-8	1.8	3	4	2.3	3	3	2.3	3	3
MSJ147-1	1.8	2	4	1.7	3	3	2.0	2	3
MSJ204-3	1.8	2	4	1.0	2	3	2.0	2	2
MSJ461-1	1.8	2	4	2.0	2	3	2.7	3	3
MSK125-3	1.8	2	4	2.2	3	6	-	-	-
MSL228-1	1.8	3	4	1.3	2	3	-	-	-
MSM039-B	1.8	2	4	-	-	-	-	-	-

	2004	2004	2004	2003	2003	2003	2002	2002	2002
LINE	RATING	WORST	N	RATING	WORST	N	RATING	WORST	N
Sorted by ascending 2004 Rating;									
MSN090-2	1.8	2	4	-	-	-	-	-	-
MSN179-5	1.8	2	4	-	-	-	-	-	-
MSN184-2	1.8	2	4	-	-	-	-	-	-
MSN236-1	1.8	2	4	-	-	-	-	-	-
SPG3	1.8	2	4	-	-	-	-	-	-
W1773-7	1.8	2	4	0.7	1	3	2.7	3	3
W2154-1	1.8	2	4	-	-	-	-	-	-
W52-26	1.8	2	4	-	-	-	-	-	-
Snowden	**1.9**	**3**	**8**	**2.4**	**3**	**12**	**2.0**	**2**	**5**
Atlantic Newleaf	2.0	3	4	-	-	-	-	-	-
FL1833	2.0	3	4	1.7	2	3	-	-	-
MN99380-1	2.0	2	3	-	-	-	-	-	-
Modoc	2.0	2	3	-	-	-	-	-	-
MSH112-6	2.0	3	4	2.3	3	3	2.3	3	3
MSK437-A	2.0	3	4	2.0	2	3	-	-	-
MSL007-B	2.0	3	4	0.7	1	3	-	-	-
MSL072-C	2.0	2	2	-	-	-	-	-	-
MSL175-1	2.0	3	3	2.0	2	3	-	-	-
MSL183-AY	2.0	2	2	-	-	-	-	-	-
MSL268-D	2.0	3	3	-	-	-	-	-	-
MSL292-A	2.0	3	3	-	-	-	-	-	-
MSL794-BRUS	2.0	3	4	-	-	-	-	-	-
MSM053-4	2.0	3	4	-	-	-	-	-	-
MSM061-A	2.0	2	1	-	-	-	-	-	-
MSM084-3	2.0	2	1	-	-	-	-	-	-
MSM205-A	2.0	3	4	3.0	4	3	-	-	-
MSN077-2	2.0	2	2	-	-	-	-	-	-
MSN085-2Y	2.0	3	4	-	-	-	-	-	-
MSN125-2	2.0	3	3	-	-	-	-	-	-
MSN209-3	2.0	2	2	-	-	-	-	-	-
MSN267-14Y	2.0	3	3	-	-	-	-	-	-
SPG2	2.0	3	4	-	-	-	-	-	-
Atlantic	**2.1**	**3**	**15**	**2.3**	**4**	**11**	**2.7**	**4**	**11**
MN99460-1	2.3	3	4	-	-	-	-	-	-
MSH095-4	2.3	3	8	1.7	2	3	2.0	3	3
MSI049-A	2.3	3	4	2.3	3	3	2.5	3	2
MSJ080-1	2.3	3	4	2.0	2	3	2.5	3	2
MSK049-A	2.3	3	4	-	-	-	2.3	3	3
MSL766-1	2.3	3	4	2.2	3	6	-	-	-
MSM224-1	2.3	3	4	-	-	-	-	-	-
MSN188-1	2.3	4	4	-	-	-	-	-	-
MSN228-5	2.3	3	4	-	-	-	-	-	-
SP6a3	2.3	3	4	-	-	-	-	-	-
Spunta	2.3	3	4	3.0	5	3	-	-	-

	2004	2004	2004	2003	2003	2003	2002	2002	2002
LINE	RATING	WORST	N	RATING	WORST	N	RATING	WORST	N
Sorted by ascending 2004 Rating;									
Stirling	2.3	3	4	2.7	4	3	-	-	-
W2233-2	2.3	3	4	-	-	-	-	-	-
AF2211-9	2.3	3	3	-	-	-	-	-	-
MSL024-AY	2.3	3	3	-	-	-	-	-	-
MSL179-DY	2.3	3	3	-	-	-	-	-	-
MSM183-1Y	2.3	3	3	-	-	-	-	-	-
Wallowa Russet	2.3	4	3	-	-	-	-	-	-
FL1879	2.5	3	4	-	-	-	-	-	-
MSF099-3	2.5	3	4	2.7	4	3	3.7	4	3
MSJ317-1	2.5	3	4	3.7	4	3	2.5	3	2
MSK136-2	2.5	3	4	2.0	2	3	-	-	-
MSM051-A	2.5	3	4	-	-	-	-	-	-
MSM171-A	2.5	4	4	2.0	2	3	-	-	-
MSH031-5	2.7	3	3	1.7	2	3	2.3	3	3
MSL106-AY	2.7	3	3	-	-	-	-	-	-
MSM057-D	2.7	3	3	-	-	-	-	-	-
MSM417-A	2.7	4	3	4.0	5	2	-	-	-
A91814-5	2.8	3	4	-	-	-	-	-	-
Jacqueline Lee	2.8	3	4	2.5	3	6	2.7	3	3
MSH067-3	2.8	3	4	2.0	3	3	3.0	5	3
MSK128-A	2.8	4	4	-	-	-	-	-	-
MN96013-1	3.0	3	1	-	-	-	-	-	-
MSM137-2	3.0	3	4	-	-	-	-	-	-
MSM224-2	3.0	4	3	-	-	-	-	-	-
MSM409-2Y	3.0	4	4	2.7	3	3	-	-	-
MSN084-11	3.0	3	2	-	-	-	-	-	-
Red Pontiac	**3.0**	**3**	**4**	**3.2**	**4**	**6**	**3.0**	**3**	**3**
Yukon Gold	**3.0**	**4**	**4**	**2.3**	**3**	**3**	**4.0**	**5**	**3**
Michigan Purple	3.3	4	4	2.3	4	6	2.7	3	3
MSL006-AY	4.0	4	1	-	-	-	-	-	-
MSM170-2	4.0	5	4	-	-	-	-	-	-

*SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.

$LSD_{0.05}$ = 1.0

^{LBR} Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2003 at the MSU Muck Soils Research Farm.

Table 10

2004 LATE BLIGHT VARIETY TRIAL
MUCK SOILS RESEARCH FARM

LINE	RAUDPC[1] MEAN	Female	Male	LINE	RAUDPC[1] MEAN
Sorted by ascending RAUDPC value:					
Foliar Resistance Category:				***Foliar Susceptibility Category (select lines)[2] :***	
MSL072-C	0.0	MSE033-1R	Tollocan	Snowden	15.7
MSL268-D	0.0	NY103	Jacqueline Lee	FL1879	16.4
MSM183-1Y	0.0	Torridon	Jacqueline Lee	FL1833	20.6
MSM137-2	0.3	Eramosa	Jacqueline Lee	B0766-3	22.2
MSL766-1	0.3	B0718-3	A91846-5R	Red Pontiac	22.3
Jacqueline Lee	0.4	Tollocan	Chaleur	Pike	22.4
Stirling	0.4	SCRI variety		Atlantic	22.4
MSM148-A	0.5	Jacqueline Lee	MSE028-1	Millenium Russet	22.6
MSL045-AY	0.7	MSB107-1	Jacqueline Lee	UEC	22.8
MSI152-A	0.7	Mainestay	B0718-3	FL1867	23.9
MSJ461-1	0.8	Tollocan	NY88	Keystone Russet	24.6
MSL794-Brus	1.3	A95053-61	A91194-4	NorValley	25.2
MSL603-319	1.3	Jacqueline Lee	MSG227-2	Dakota Jewel	26.1
MSL183-AY	1.6	Boulder	Tollocan	Keuka Gold	26.6
MSM224-1	1.7	MSB106-7	Jacqueline Lee	Silverton Russet	27.1
MSL211-3	2.0	MSG301-9	Jacqueline Lee	Yukon Gold	27.9
MSK128-A	2.3	Jacqueline Lee	MSH094-3	Wallowa	28.1
MSL024-AY	2.3	AWN86514-2	MSF020-23	Goldrush	28.6
MSM143-A	2.4	MSE048-2Y	Jacqueline Lee	Onaway	29.3
MSJ317-1	2.6	B0718-3	Prestile	Russet Burbank	29.3
MSK136-2	2.9	Greta	B0718-3	Red Norland	30.1
MSM171-A	3.0	Stirling	MSE221-1	Modoc	30.1
MSN209-3	3.9	MSJ462-2	MSJ319-1	Villeta Rose	30.6
MSN251-1Y	4.0	Torridon	MSG227-2	Michigan Purple	35.1
MSN228-5	5.3	ND6947B-13	Jacqueline Lee	FL1922	35.6
W52-26	5.8	Cornell University breeding line			
MSN105-1	7.4	MSG141-3	Jacqueline Lee		
MSK049-A	7.6	Brodick	MSH142-2		
MSM409-2Y	8.5	MSJ456-4	MSJ365-6		
MSI049-A	9.4	Brodick	MSC121-7		
$LSD_{0.05}$	10.3				

[1] Ratings indicate the average plot RAUDPC (Relative Area Under the Disease Progress Curve).

[2] 111 potato varieties and advanced breeding lines were tested in all. For brevity purposes, only selected varieties and breeding lines are listed. Varieties and breeding lines with a mean RAUDPC value of 10.3 and less are considered

Phytopthora infestans isolates Pi02-007(US8), Pi99-2(US14), Pi95-2(US6), Pi95-3(US1) were inoculated 30 July 2004.

Planted as a randomized complete block design consisting of 3 replications of 4 hill plots on 23 June 2004.

2004 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE	AVERAGE
ENTRY	0	1	2	3	4	5+	FREE	SPOTS/TUBER
DATE OF HARVEST: LATE HARVEST								
FL1922	25						100	0.0
Boulder	16	5	2	2			64	0.6
Liberator	13	6	4	2			52	0.8
MSH094-8	9	12	2	2			36	0.9
Michigan Purple	11	7	6	1			44	0.9
MSH228-6	9	9	7				36	0.9
MSJ147-1	8	10	6	1			32	1.0
MSJ461-1^{LBR}	8	9	6	2			32	1.1
MSG227-2	7	9	7	2			28	1.2
MSJ080-1	8	8	7	1	1		32	1.2
FL1867	5	13	3	4			20	1.2
B0766-3	6	9	7	3			24	1.3
Jacqueline Lee^{LBR}	8	6	7	4			32	1.3
MSF099-3	5	9	9	2			20	1.3
MSH095-4	4	11	7	2	1		16	1.4
FL1879	6	5	10	4			24	1.5
MSH067-3	3	7	9	6			12	1.7
Snowden	**3**	**6**	**11**	**5**			**12**	**1.7**
UEC	1	8	9	6	1		4	1.9
FL1833	3	6	6	8	2		12	2.0
Atlantic	**1**	**5**	**8**	**7**	**2**	**2**	**4**	**2.4**

* Twenty-five A-size tuber samples were collected at harvest, held at 50 F at least 12 hours, and placed in a six-sided plywood drum and rotated ten times to produce simulated bruising. Samples were abrasive-peeled and scored on November 9, 2004.

The table is presented in ascending order of average number of spots per tuber.

^{LBR} Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials at the MSU Muck Soils Research Farm.

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE	AVERAGE
ENTRY	0	1	2	3	4	5+	FREE	SPOTS/TUBER
RUSSET and LONG TYPES TRIAL								
Keystone Russet	24	1					96	0.0
AC Stampede Russet-NCR	24	1					96	0.0
Russet Norkotah-NCR	**23**	**2**					**92**	**0.1**
A8254-2BRUS	22	3					88	0.1
GoldRush	**22**	**2**	**1**				**88**	**0.2**
MSL025-ARUS	20	5					80	0.2
MSE202-3RUS	19	6					76	0.2
Silverton Russet	19	6					76	0.2
A9305-10	21	2	1	1			84	0.3
ND7882b-7rus-NCR	18	5	2				72	0.4
MSE192-8RUS	17	6	2				68	0.4
V1102-1-NCR	18	4	3				72	0.4
Wallowa Russet	17	6	2				68	0.4
A8893-1	13	12					52	0.5
GemStar(A9014-2RUS)-NCR	16	6	3				64	0.5
AC89536-5rus	14	7	4				56	0.6
Russet Burbank-NCR	**11**	**12**	**2**				**44**	**0.6**
MN99460-21-NCR	8	9	5	3			32	1.1
MSL794-BRUS^{LBR}	4	8	8	5			16	1.6
A95409-1	7	3	8	6	1		28	1.6
Millenium Russet	4	5	11	1	4		16	1.8
ADAPTATION TRIAL, CHIP-PROCESSING LINES								
MSK409-1	20	5					80	0.2
MSK009-B	18	7					72	0.3
W52-26^{LBR}	18	3	3	1			72	0.5
MSM046-4	12	8	5				48	0.7
MSK128-A^{LBR}	11	9	4	1			44	0.8
MSK498-1Y	9	12	3	1			36	0.8
MSL766-1^{LBR}	10	10	4		1		40	0.9
W2128-8	15	5	2	1		2	60	0.9
MSJ036-A	9	9	7				36	0.9
MSK061-4	7	13	5				28	0.9
MSK136-2^{LBR}	6	15	4				24	0.9
NY126	11	7	5	2			44	0.9
MSJ126-9Y	8	8	7	2			32	1.1
MSM051-3	6	10	9				24	1.1
Pike	**7**	**11**	**4**	**3**			**28**	**1.1**
W2233-2	9	8	4	2	2		36	1.2

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ENTRY	0	1	2	3	4	5+		
W2154-1	4	13	6	2			16	1.2
AF2211-9	2	11	11	1			8	1.4
MSK476-1	4	8	9	4			16	1.5
MSK049-A	4	8	9	3	1		16	1.6
W2145-11	5	6	6	6	2		20	1.8
W2133-1	3	8	7	4	3		12	1.8
Snowden	**3**	**7**	**6**	**8**	**1**		**12**	**1.9**
NY132	1	7	10	7			4	1.9
MSL007-B	3	5	8	8	1		12	2.0
Atlantic	**3**	**2**	**11**	**5**	**3**	**1**	**12**	**2.2**
ADAPTATION TRIAL, TABLESTOCK LINES								
MSK437-A	22	3					88	0.1
Dakota Jewel	21	3	1				84	0.2
Modoc	20	5					80	0.2
MSM037-3	20	4	1				80	0.2
MSI049-A$^{\mathbf{MRLBR}}$	19	6					76	0.2
MSJ033-10Y	18	7					72	0.3
MSL228-1	17	8					68	0.3
MSM171-A$^{\mathbf{LBR}}$	17	7	1				68	0.4
Yukon Gold	**17**	**7**	**1**				**68**	**0.4**
MSL072-C$^{\mathbf{LBR}}$	17	6	2				68	0.4
Keuka Gold	15	9	1				60	0.4
MSL211-3$^{\mathbf{LBR}}$	13	11	1				52	0.5
MSJ204-3	14	8	3				56	0.6
Onaway	**15**	**7**	**2**	**1**			**60**	**0.6**
MSI005-20Y	13	6	6				52	0.7
MSM137-2$^{\mathbf{LBR}}$	10	10	4	1			40	0.8
MSK125-3$^{\mathbf{MRLBR}}$	9	11	3	2			36	0.9
MSM224-1$^{\mathbf{LBR}}$	13	6	3	2		1	52	0.9
MSM183-1Y$^{\mathbf{LBR}}$	1	5	12	6	1		4	2.0
PRELIMINARY TRIAL, CHIP-PROCESSING LINES								
MSN098-4	24	1					96	0.0
MSN209-3$^{\mathbf{LBR}}$	23	2					92	0.1
MSM051-A	22	3					88	0.1
MSM170-B	20	5					80	0.2
MSN094-3	21	3	1				84	0.2
MSN125-2	20	5					80	0.2
MSN184-2	21	3	1				84	0.2

ENTRY	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
	0	1	2	3	4	5+		
MSL235-AY$^{\text{MRLBR}}$	20	4	1				80	0.2
MSN065-2	20	4	1				80	0.2
MSM188-1$^{\text{MRCPB}}$	19	5	1				76	0.3
MSN174-3	19	5	1				76	0.3
MSM070-1	19	5	1				76	0.3
MSN105-1$^{\text{LBR}}$	17	8					68	0.3
MSN144-2	18	6		1			72	0.4
Pike	**17**	**6**	**2**				**68**	**0.4**
MSM164-2Y	16	7	2				64	0.4
MSM408-B	18	4	2	1			72	0.4
MSM060-3	14	10	1				56	0.5
MSL106-AY	17	3	4	1			68	0.6
MSN026-4	13	10	2				52	0.6
MSM039-B	13	7	4	1			52	0.7
MSN236-1	14	5	5	1			56	0.7
MSM053-4	12	10		3			48	0.8
MSM205-A	10	8	7				40	0.9
MSN179-5	10	10	3	2			40	0.9
MSL268-D$^{\text{LBR}}$	11	8	3	3			44	0.9
MSM185-1$^{\text{MRCPB}}$	9	10	5	1			36	0.9
MSM409-2Y	7	12	5	1			28	1.0
MSM057-D	5	10	8	2			20	1.3
MSN085-2Y	6	7	10	2			24	1.3
MSL292-A	5	10	3	6	1		20	1.5
MSN251-1Y$^{\text{LBR}}$	7	6	5	6	1		28	1.5
Atlantic	**5**	**7**	**5**	**7**		**1**	**20**	**1.7**
Snowden	**4**	**7**	**7**	**5**	**1**	**1**	**16**	**1.8**

PRELIMINARY TRIAL, TABLESTOCK LINES

MSN084-11	24	1					96	0.0
MSL183-AY$^{\text{LBR}}$	23	2					92	0.1
MSN084-3	22	3					88	0.1
MSM143-A$^{\text{LBR}}$	21	4					84	0.2
MSN077-2	21	2	2				84	0.2
MSL175-1	18	6	1				72	0.3
NDMS7994-1RUS	13	12					52	0.5
MSM148-A$^{\text{LBR}}$	14	9	2				56	0.5
MSM417-A$^{\text{LBR}}$	13	8	3	1			52	0.7
ARS4008-1	10	10	5				40	0.8
MSL045-AY$^{\text{LBR}}$	10	11	3	1			40	0.8

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ENTRY	0	1	2	3	4	5+		
MSL006-AY	11	6	6	2			44	1.0
MSN228-5^{LBR}	10	9	2	3	1		40	1.0
MSN188-1	6	11	7	1			24	1.1
MSL024-AY^{LBR}	7	11	4	2	1		28	1.2
Onaway	**4**	**13**	**3**	**4**	**1**		**16**	**1.4**
MSL179-AY^{LBR}	7	7	4	6	1		28	1.5
WATER MANAGEMENT TRIAL								
BTX1544-2W/Y	25						100	0.0
MSI049-A^{MRLBR}	25						100	0.0
ATX91137-1RU	23	2					92	0.1
MSJ317-1^{LBR}	23	2					92	0.1
NDTX4271-5R	23	2					92	0.1
NDTX4304-1R	23	2					92	0.1
Russet Norkotah	**23**	**2**					**92**	**0.1**
MSE192-8RUS	22	3					88	0.1
MSJ080-1	21	3	1				84	0.2
MSJ461-1^{LBR}	22	2			1		88	0.2
MSG227-2	19	4	2				76	0.3
Onaway	**19**	**5**		**1**			**76**	**0.3**
CO089097-2R	18	5	2				72	0.4
Boulder	15	10					60	0.4
MSH228-6	16	8	1				64	0.4
Michigan Purple	15	11					60	0.4
MSJ147-1	12	9	3	1			48	0.7
Snowden	**11**	**8**	**3**	**3**			**44**	**0.9**
Atlantic	**8**	**9**	**6**	**2**			**32**	**1.1**
MSE018-1	5	10	5	5			20	1.4
TRANSGENIC TRIAL								
SPG2	22	3					88	0.1
SPG3	22	3					88	0.1
Spunta	**21**	**4**					**84**	**0.2**
L.ROSE5.2	18	6		1			72	0.4
L.ROSE5.6	15	9	1				60	0.4
L.ROSE5.1	13	7	4	1			52	0.7
Lady Rosetta	**7**	**14**	**3**	**1**			**28**	**0.9**
L.ROSE5.4	6	13	6				24	1.0
L.ROSE5.3	5	10	6	4			20	1.4
Atlantic Newleaf	7	3	8	5	2		28	1.7
Atlantic	**6**	**1**	**7**	**4**	**5**	**2**	**24**	**2.3**

	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ENTRY	0	1	2	3	4	5+		
SNACK FOOD ASSOCIATION: BRUISE SAMPLES								
MSJ461-1$^{\mathbf{LBR}}$	17	5	2	1			68	0.5
A91790-13	16	7	1		1		64	0.5
MSF099-3	13	8	4				52	0.6
Atlantic	**10**	**11**	**3**	**1**			**40**	**0.8**
ND5822C-7	8	15	1	1			32	0.8
W1773-7	9	12	4				36	0.8
Snowden	**10**	**5**	**9**	**1**			**40**	**1.0**
AF2211-9	6	9	8	2			24	1.2
WI201	7	7	7	4			28	1.3
B01240-1	3	8	4	7			12	1.5
NY132	15	1		2	5	2	60	1.5
ND2470-27	4	6	10	2	3		16	1.8
SNACK FOOD ASSOCIATION: CHECK SAMPLES								
MSJ461-1$^{\mathbf{LBR}}$	25						100	0.0
A91790-13	24	1					96	0.0
MSF099-3	24	1					96	0.0
Snowden	**24**	**1**					**96**	**0.0**
W1201	23	2					92	0.1
W1773-3	23	2					92	0.1
B01240-1	22	3					88	0.1
AF2211-9	21	4					84	0.2
ND2470-27	21	4					84	0.2
NY132	21	4					84	0.2
ND5822C-7	19	6					76	0.2
Atlantic	**18**	**6**	**1**				**72**	**0.3**

Management Profile for New Potato Varieties and Lines December 2004

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Summary

Varieties and promising new lines were tested systematically for response to four nitrogen regimes at moderate and high plant population densities. Environmental consequences in terms of residual soil nitrogen and nitrogen fertilizer efficiency were tested as well as yield response and tuber quality effects. Table 1 shows the sources of nitrogen fertility, including fertilizer and poultry manure.

Variety determined yield and tuber quality response, where there were highly significant interactions with nitrogen regime and plant population density. Overall, a higher plant density (8 inch seed spacing within row) provided consistently higher yields for all varieties. The only exceptions were the control variety Snowden and the new release Michigan Purple. For these varieties yield of US No1 tubers was similar for both seed spacing treatments, narrow and wide (Fig. 2 and Fig. 6). For all other varieties, US No1 tubers yields were highest for the higher plant density treated with either the recommended rate of 180 lb N/acre fertilizer, or the same rate applied as 5000 lb/acre poultry manure plus 130 lb N per acre fertilizer (Fig. 3-5).

Consistently lower tuber yields resulted from application of slow-release fertilizer at the 180 lb N/acre rate. This was, however, the most environmentally-friendly treatment associated with the lowest level of residual nitrate-N in the fall soil profile (Table 2). The poultry manure (50 lb N/acre available) + 130 lb N/acre fertilizer treatment was the best economic option. It both optimized yield and reduced nitrogen inefficiency, as indicated by the moderate residual inorganic soil nitrogen observed with the manure treatment (Table 2). The available nitrogen pool in the soil was moderately reduced with the manure and in the slow release nitrogen treatments, compared to the conventional 180 and 270 nitrogen treatments. This is indicated in Fig. 1, which presents the soil nitrate pool as measured by ion exchange probes inserted in the Snowden treatment. Interestingly, the manure + 130 lb N/acre treatment was highly efficient in that it supported maximum yields at moderate petiole N levels, while at the same time building soil organic matter (preliminary data from particulate organic matter nitrogen measurements).

Consistently high yield responses among the chip processing genotypes were observed for the UEC variety (Fig. and the new line MSJ461-1, significantly higher than the standard check Snowden variety. Michigan Purple also showed high yield potential across all management regimes evaluated. Tuber quality was consistently high (Fig. 7), with W1201 the only variety with a trend towards higher internal defects than the other lines.

Table 1. Seed piece spacing compared wide (13 inch) and narrow (8 inch), in factorial combination with nitrogen treatments shown. Mich Purple spacing was wider, 10 and 15 inch.

	Nitrogen Treatment			
Fertilizer or Amendment	**180 lbs. Conventional**	**180 lbs. Manure**	**180 lbs. Slow-release**	**270 lbs Conventional**
		- - - - - *(pounds per acre)* - - - - -		
Potash (0-0-60, pre-plant)	250	250	250	250
Phosphorus (at planting)	35	35	35	35
Meister T10[2] (40% N, pre-plant)			350	
Poultry manure (50 lbs. N/A credit = availability is assumed as 50 lbs)		5000 (3.5%N)		
Urea (46-0-0)				
- at planting – 13 May	91	91	91	91
- at hilling – 28 May	120	65		163
- 23 June	120	65		163
- 18 July	65	65		163
Total N	**182**	**182**	**182**	**268**

Table 2. Residual soil NO3-N and NH4-N at two depths in Snowden plots managed with one of four nitrogen fertilization treatments. Different superscripts indicate significant difference (p≤.05)

Depth	**Nitrogen Treatment**	**NO_3-N (ppm soil)**	**NH_4-N (ppm soil)**
0-8"	180 Conventional	27.35^{a}	3.20
	180 Manure	27.45^{a}	4.30
	180 Slow Release	33.45^{ab}	3.40
	270 Conventional	46.03^{b}	3.33
		p=.0962	*p=.5426*
8-20”	180 Conventional	11.35^{a}	1.33
	180 Manure	13.10^{ab}	1.83
	180 Slow Release	12.23^{a}	1.48
	270 Conventional	18.35^{b}	1.20
		p=.0918	*p=.4848*

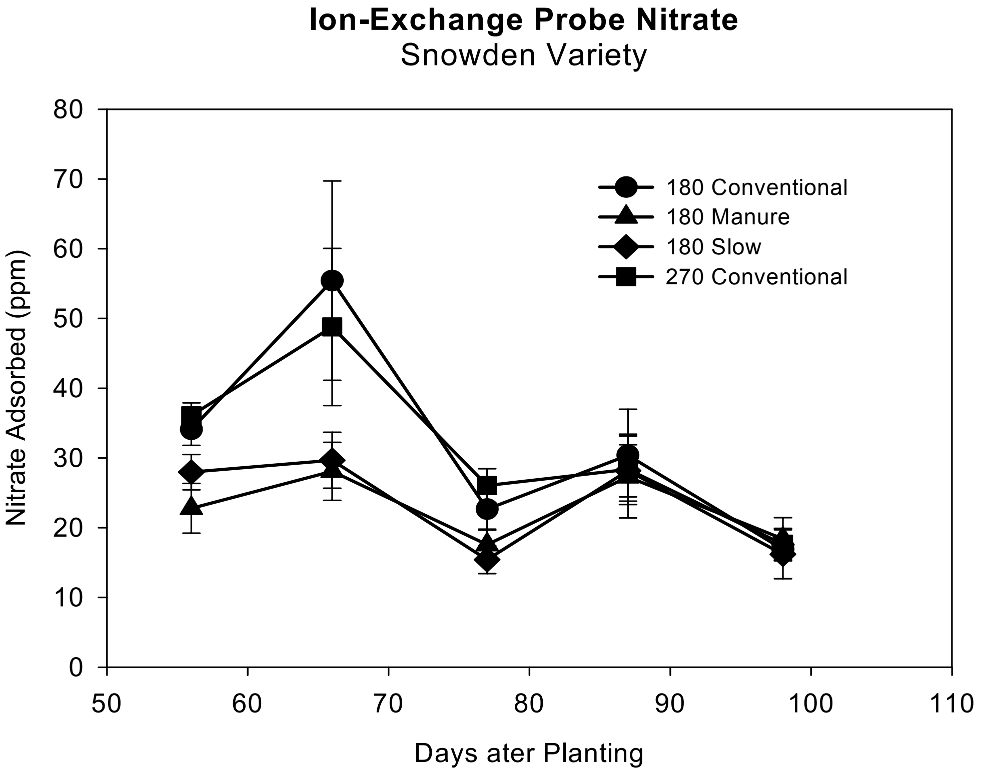

Fig. 1. Ion exchange probe inorganic nitrogen measurement indicate soil nitrogen availability for plant uptake.

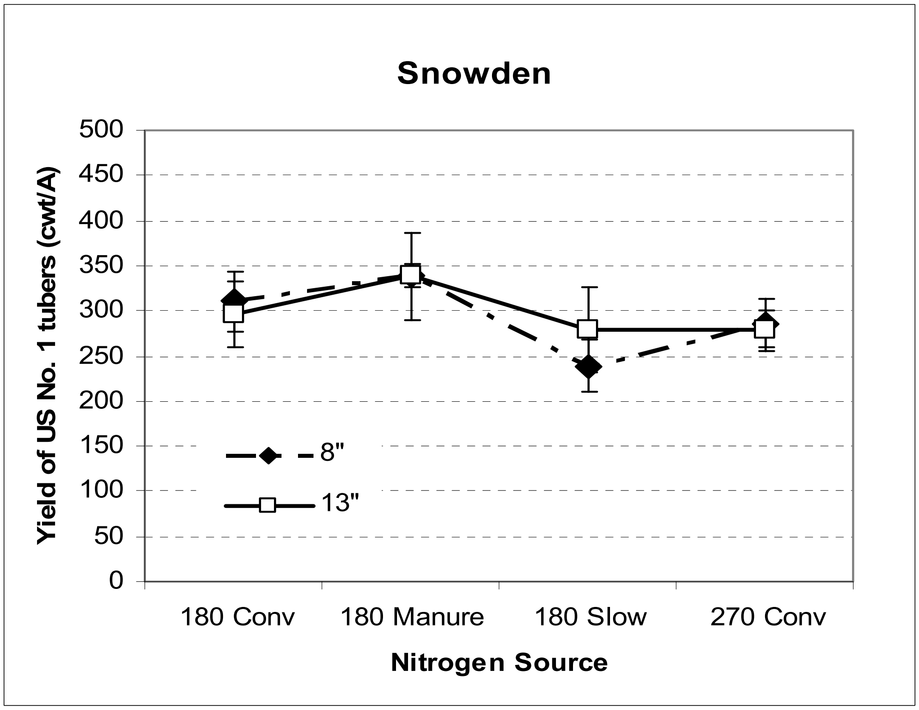

Fig. 2. Snowden 'check' response in 2004 to four nitrogen treatments and two seed spacing treatments, narrow (8" within row) and wide (13" within row).

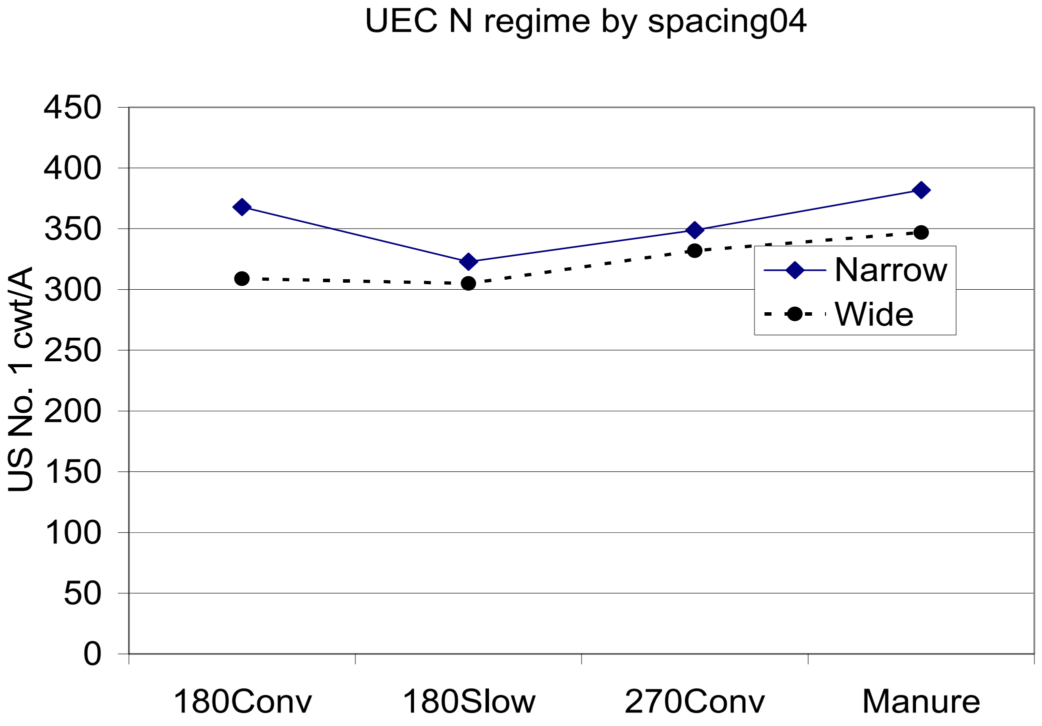

Fig. 3. Yield response of variety UEC in 2004 to four nitrogen treatments and two seed spacing treatments, narrow (8" within row) and wide (13" within row).

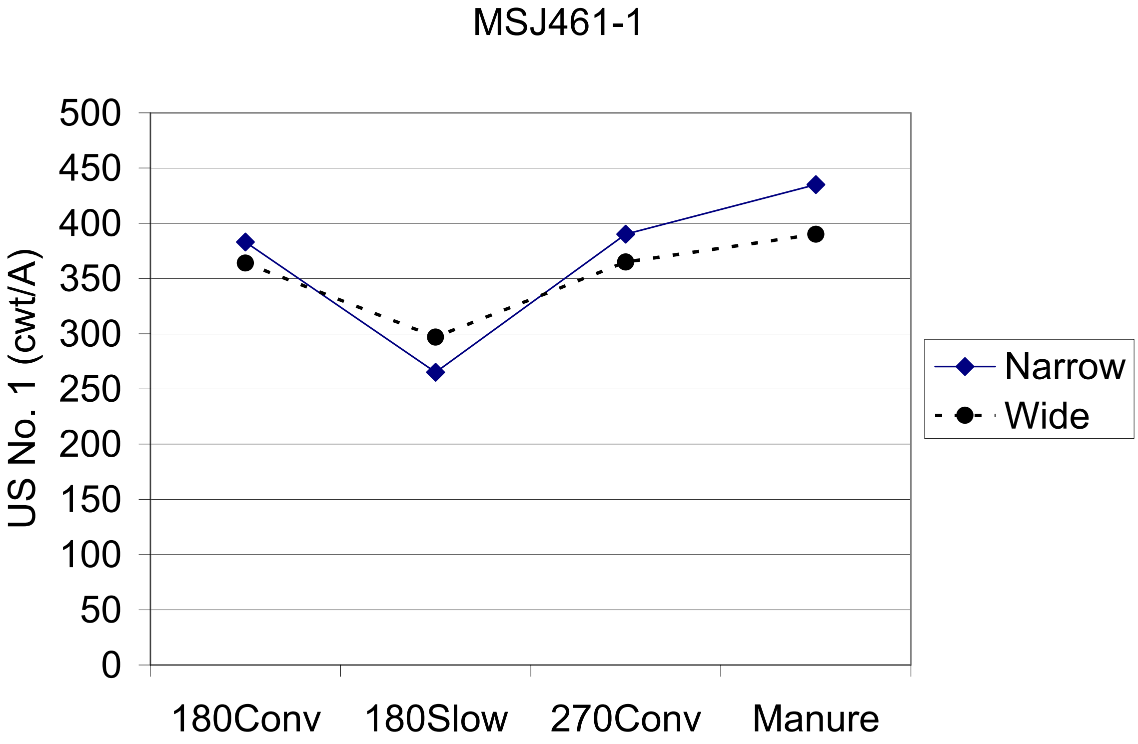

Fig. 4. Yield response of variety MSJ461-1 in 2004 to four nitrogen treatments and two seed spacing treatments, narrow (8" within row) and wide (13" within row).

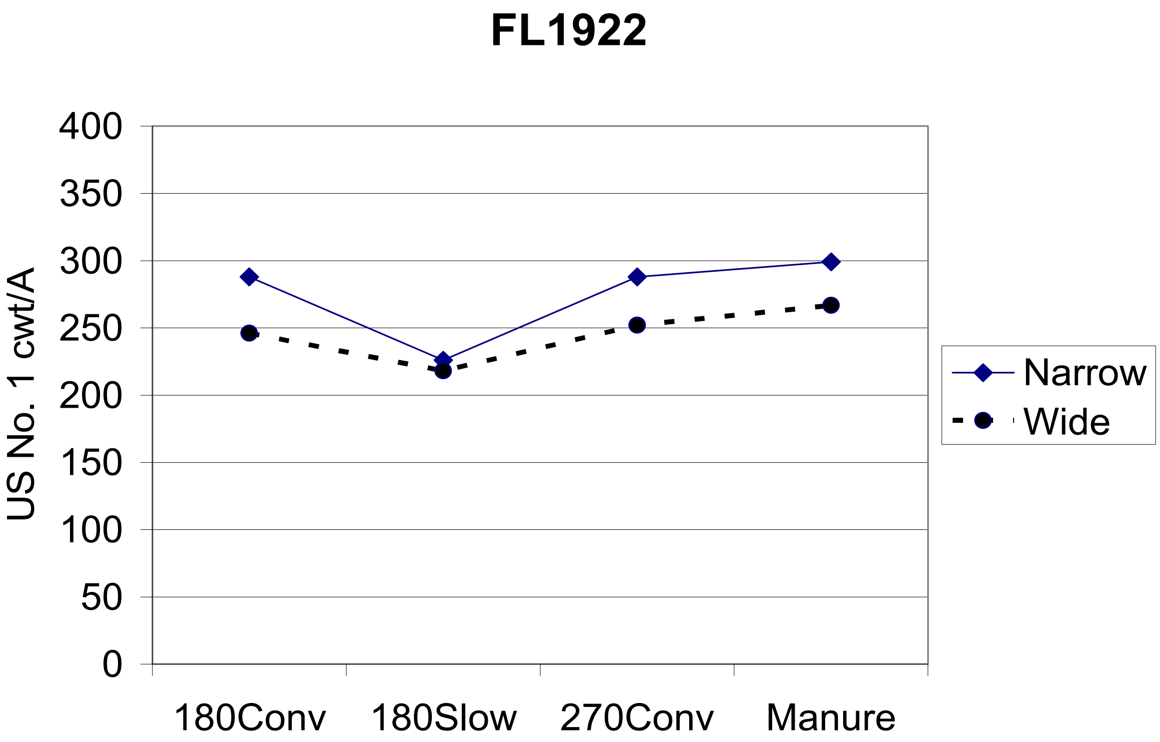

Fig. 5. Yield response of variety FL1922 in 2004 to four nitrogen treatments and two seed spacing treatments, narrow (8" within row) and wide (13" within row).

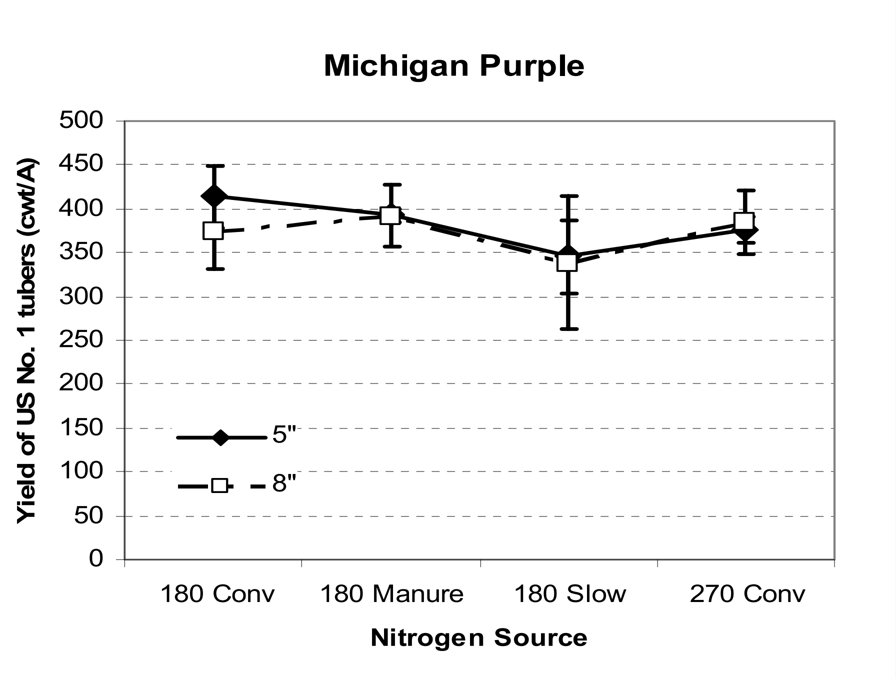

Fig. 6. Yield response of variety Michigan Purple in 2004 to four nitrogen treatments and two seed spacing treatments, narrow (8" within row) and wide (13" within row).

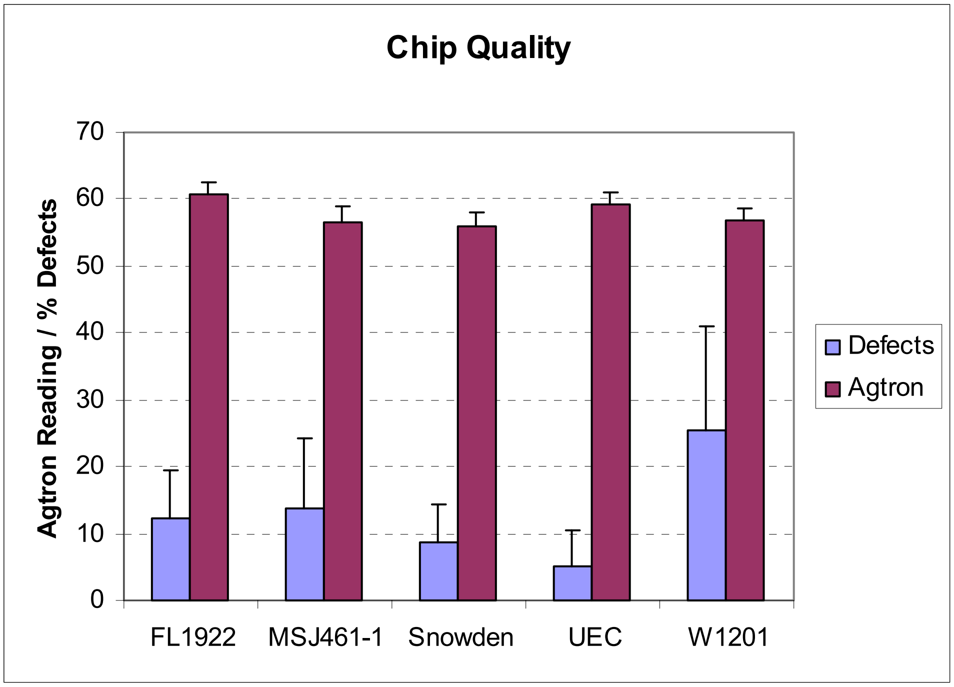

Fig. 7. Chip quality as measured by internal defects and Agtron rating for five chip processing varieties and lines.

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2004 On-Farm Potato Variety Trials

Chris Long, Dr. Dave Douches, Fred Springborn (Montcalm), Dave Glenn (Presque Isle), and Dr. Doo-Hong Min (Upper Peninsula)

Introduction

On-farm potato variety trials were conducted with 11 farms in 2004 at a total of 12 locations. Seven of the locations evaluated processing entries and five evaluated fresh market entries. The processing cooperators were Crooks Farms, Inc. (St. Joseph / Montcalm) counties, L. Walther & Sons, Inc. (St. Joseph), Lennard Ag. Co. (Monroe), 4-L Farms, Inc. (Allegan), and Main Farms (Montcalm). The United States Potato Board/Snack Food Association (USPB / SFA) chip trial was at V & G Farms (Montcalm). Fresh market trial cooperators were Crawford Farms, Inc. (Montcalm), DuRussel's Potato Farms, Inc. (Washtenaw), Wilk Farms (Presque Isle), Horkey Bros. (Monroe) and M.J. Van Damme Farms (Marquette).

Procedure

There were two types of processing trials conducted this year. The first type contained 12 entries which were compared with check varieties Atlantic, Snowden, Pike and FL1879. This trial type was conducted at Main Farms, Lennard Ag. Co., 4-L Farms, and Walthers Farms, Inc. Varieties in these trials were planted in 100' strip plots. Seed spacing was grower dependent, but in general ranged from 9 to 13 inches. The Walther trial was planted in four replicated plots and harvested at two harvest dates of 115 and 158 days after planting. Plot size was 34" wide by 20 hills long. Seed spacing was 9".

The second type of processing trial, referred to as a "Select" trial, contained from five to seven lines which were compared to the variety in the field. In these trials each variety was planted in a 15' row plot. Seed spacing and row width was 10" and 34", respectively.

Within the fresh market trials, there were 24 entries evaluated. There were 10-20 lines planted at each of the following locations; Marquette, Monroe, Montcalm, Presque Isle, and Washtenaw counties. The varieties in each trial ranged from mostly round white varieties to mostly russet varieties. These varieties were planted in 100' strip plots. Again, spacing varied from 7.5 to 12.25 inches depending upon grower production practices and variety.

Results

A. Processing and "Select" Processing Variety Trial Results

A description of the processing varieties, their pedigree and scab rating are listed in Table 1. The overall averages of the three locations of Allegan, Montcalm and Monroe counties are shown in Table 2. The data from Walther Farms, Inc. in St. Joseph County is shown separately in Table 3 (first harvest, 115 days) and Table 4 (second harvest, 158 days). The overall averages of the "Select" processing trial, which are averaged across two locations, are in Table 5.

Processing Variety Highlights

MSG227-2, a scab resistant clone from the Michigan State University (MSU) breeding program, had the third highest yield across all locations (Table 2). This variety had a good yield, acceptable specific gravity and superior scab resistance. Nearly 100 acres of MSG227-2 will be planted commercially in 2005.

W1201 (Megachip) a University of Wisconsin release continues to show promise as a strong yielding, high specific gravity, line. There are plans to plant 60 acres commercially of this variety in Michigan in 2005. The variety bulks early and has low internal defect and possibly could be used for fresh crop. Megachip has shown some susceptibility to black spot bruise, possibly due to its high specific gravity.

FL1922, a scab resistant Frito-Lay, Inc. release, has excellent processing quality but, unlike commercial results, we have been unable to show its yield potential in these trials.

UEC, now "Beacon Chipper", was only in the Walther Farms, St. Joe County data (Table 3 & 4) and Crooks Montcalm County trial (data not shown). This variety continues to perform well agronomically and has proven to store well in storage trials conducted at the Burt Cargill Demonstration Storage facility.

MSJ147-1, another Michigan State clone, was a strong yielding line with good internal quality, excellent chip quality and a slight tolerance to common scab. This variety may be suitable for storage into May and June.

Two varieties that were in the Crooks Farms "Select" trials and are showing some promise for further large scale evaluations are W2128-8 from the University of Wisconsin and MSJ036-A from MSU. W2128-8 has excellent chip quality and yield potential and MSJ036-A has good chip quality, very nice uniform type and excellent common scab resistance.

B. USPB / SFA Chip Trial Results

The Michigan location of the USPB / SFA chip trial was on the V & G Farm in Montcalm county again this year. Table 6 shows the yields, size distribution and specific gravity of the entries when compared with Atlantic and Snowden. Table 7 shows the chip quality evaluations from samples processed and scored by Herr Foods, Inc., Nottingham, PA.

USPB / SFA Chip Trial Highlights

The variety in the 2004 trial that has displayed the greatest potential for commercialization was W1201 (Megachip). Yield potential and specific gravity are excellent. Internal quality of Megachip was also good. The potential for this variety to bulk early in spite of its full season maturity was excellent. The variety can exhibit deep apical eyes at times and given soil conditions, may not be a desirable trait. Megachip has shown severe black spot bruise when cold harvested. This condition may be heightened by the varieties high specific gravity.

C. Fresh Market and Variety Trial Results

A description of the fresh pack varieties, their pedigree and scab rating are listed in Table 8. Table 9 shows the overall average of five locations; Marquette, Monroe, Montcalm, Presque Isle and Washtenaw counties.

Fresh Market Variety Highlights

Three russet lines are worthy of mention from the 2004 variety trial. They are MSA8254-2BRus, Gemstar Russet (A9014-2Rus) and Stampede Russet. MSA8254-2BRus has an unknown pedigree with excellent scab resistance (Table 8). MSA8254-2BRus had a 436 cwt./A US#1 yield with a 1.078 specific gravity. This variety has a nice long type.

Gemstar Russet is a University of Idaho selection with a 412 cwt./A US#1 yield. It’s specific gravity was 1.078. The long type of this variety was very uniform and attractive overall.

Stampede Russet is a Texas A&M selection that has an excellent table stock russet type. The overall yield of this variety appears to be low, but it has exceptional tuber type and internal quality. More testing of this clone needs to be done to manipulate yield, possibly with a change in seed spacing and/or fertilizer levels.

MSJ461-1 is a foliar late blight resistant, round white variety from the MSU breeding program. This variety continues to be a strong yielding variety with an attractive appearance. This variety has a two year US#1 yield average of 444 cwt./A. The specific gravity is generally in the 1.075 to 1.080 range. MSJ461-1 is susceptible to common scab.

ND3196-1R (Dakota Jewel) is a North Dakota State University release with a nice round type and an attractive red skin. Yield of this variety is generally around 300 cwt./A with an attractive marketable appearance. The flesh color of this variety is very white and uniform.

MSJ033-10Y is an MSU clone with an average yield, exceptionally nice yellow flesh. Skin appearance is slightly netted with good internal quality.

Table 1

2004 MSU Processing Potato Variety Trials

Entry	Pedigree	2003 Scab Rating**	Characteristics
Atlantic (B6987-56)	Wauseon X Lenape	3.0	Early maturing, high yield check variety.
FL1879	Snowden X FL1207	2.5	Late maturing, late season storage check variety.
FL1922	-	1.3	Oval to oblong tubers, good chip quality out of late storage.
Monticello (NY102 or K9-29)	Steuben X Kanona	3.0	Mid-season maturity, average yield, high specific gravity, good storability, low internal defects.
Pike (NYE55-35)	Allegany X Atlantic	1.5	Early maturing, early storage check variety.
Snowden (W855)	B5141-6 X Wischip	2.4	Late maturing, late season storage check variety.
AF2211-9	Atlantic X Maine Chip	-	Mid-season maturity, high specific gravity, moderate scab tolerance, good tuber appearance, cold chipping potential, high yield.
B0766-3	B0243-18 X B9792-157 (Coastal Chip)	1.5	Mid-season maturity, high yield, uniform size, scab tolerant, round to oval shape, good chip quality until early March from 50 °F.
MSG227-2	Prestile X MSC127-3	0.5	Average yield potential: flattened round shape, shallow eyes, low internal defects, chip color variable in storage.
MSH067-3	MSC127-3 X W877	2.0	Mid-season maturity, smooth flat oval tubers, some hollow heart may be observed.
MSH095-4	MSE266-2 OP	1.7	Mid-season maturity, bruise susceptibility equal to Snowden.
MSH228-6	MSC127-3 OP	0.7	Mid-season maturity, slightly flattened tubers, shallow eyes, intermediate specific gravity.
MSJ036-A	A7961-1 X Zarevo	1.3	Mid-season maturity, high yield, nice round uniform tuber type.

**Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible.

Entry	Pedigree	2003 Scab Rating**	Characteristics
MSJ080-1	MSC148-A X S440	2.0	Mid-season maturity, yield similar to Atlantic, low internal defects, intermediate specific gravity, smooth tuber type.
MSJ147-1	Norvalley X S440	1.7	Mid-season maturity, good internal quality, very good chip quality.
MSJ461-1	Tollocan X NY88	2.7	Maturity slightly earlier than Snowden, round tubers with bright skin, low defects, strong foliar late blight resistance, chipped well 2003 Demo Storage, intermediate specific gravity.
MSK061-4	MSC148-A X Dakota Pearl	2.0	Medium to late season maturity, high specific gravity, good chip color.
UEC*	Unknown	1.3	Mid-season maturity, high yield, some heat stress and scab tolerance.
W1201	Wischip X FYF 85	1.7	Late maturing, high yield, cold chipper 45 °F, slightly deep eyes.
W1773-7	Steuben X RHL167	1.7	Mid-season maturity, medium to low specific gravity, round, smooth tubers, excellent internal quality, good chip color after 3 months at 48 °F.
W2128-8	W845 X CT80-1	-	Medium late maturity, slight deep eye, good size, high specific gravity, cold chipper, moderate scab tolerance.
W2133-1	Snowden X RHL 167	-	Medium late maturity, scab resistant, good internal quality, good yield, nice tuber type, average specific gravity.
W2154-1	W936 X CT114-10	-	Medium late maturity, good size, medium flat tubers, bruise susceptible, good yield and internal quality.

**Scab rating based on 0-5 scale; 0 = most resistant and 5 = most susceptible.

*Unknown Eastern Chipper (UEC), now “Beacon Chipper”, was previously tested and labeled as the clone B0766-3 in the 2001-2002 Michigan “On-Farm Variety Trials”. B0766-3, a USDA Beltsville potato clone from Dr. Kathleen Haynes’ Breeding Program, Beltsville, Maryland is being considered for release. The official seed source for B0766-3 is the Uihlein Seed Farm, NY. The two clones UEC and B0766-3 have undergone fingerprint analysis at Michigan State University and the pattern of B0766-3 does not match that of UEC. Thus, the UEC clone tested was incorrectly referred to as B0766-3. No known variety or breeding clone matches the UEC fingerprint pattern to date. The origin and pedigree of UEC is currently unknown. UEC seed that is represented in this summary was obtained from Devoe Seed Farm, Limestone, ME. The initial seed stock was obtained from the Maine State Seed Farm which is the Porter Seed Farm. The Michigan State University fingerprint data of UEC shows an identical match between the Devoe Farm seed and the tissue culture plantlets at the Porter Seed Farm from which all the seed labeled as UEC has been derived.

Table 2

2004 Processing Potato Variety Trial
Overall Average - Three Locations
Allegan, Monroe, Montcalm Counties

																3-YR AVG
	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	COMMENTS	CWT/A
MSJ080-1	446	486	92	8	75	17	0	1.074	1.0	1	0	0	0	30	Tr surface scab	-
FL1879	**411**	**434**	**95**	**5**	**76**	**18**	**0**	**1.076**	**1.0**	**1**	**2**	**0**	**0**	**30**	**Sl pitted scab**	**-**
MSG227-2	410	462	89	7	83	6	4	1.084	1.2	1	1	0	0	30	No scab	353
MSJ147-1	405	437	92	7	83	10	1	1.082	1.0	0	1	0	0	30	Surface scab	-
MSJ461-1	392	430	91	8	85	6	1	1.075	1.0	1	1	1	0	30	Sl pitted scab	*365
MSH228-6	392	430	91	6	70	21	3	1.080	1.0	1	3	0	0	30	Sl surface scab	-
Snowden	**386**	**429**	**90**	**10**	**83**	**7**	**0**	**1.083**	**1.0**	**0**	**3**	**0**	**0**	**30**	**Scab**	**334**
W1201	386	424	91	4	67	24	5	1.090	1.0	0	2	1	0	30	Surface scab	362
W1773-7	386	446	86	13	81	5	1	1.089	1.0	1	0	0	0	30	Surface scab	-
B0766-3	346	388	89	10	79	10	1	1.081	1.2	1	1	0	0	30	Surface scab	-
Atlantic	**346**	**376**	**92**	**8**	**73**	**19**	**0**	**1.089**	**1.0**	**2**	**1**	**0**	**0**	**30**	**Pitted scab**	**362**
MSH095-4	330	349	94	4	67	28	1	1.078	1.0	0	2	0	0	30	Sl pitted scab	326
Pike	**275**	**302**	**90**	**8**	**85**	**6**	**1**	**1.086**	**1.0**	**1**	**2**	**0**	**0**	**30**	**Tr surface scab**	**242**
MSH067-3	273	306	89	8	70	19	3	1.082	1.0	3	1	0	1	30	Sl pitted scab, round to flat	-
AF2211-9	273	313	86	13	79	7	1	1.081	1.0	2	0	0	1	30	Pitted scab	-
FL1922	170	218	78	19	77	1	3	1.072	1.0	0	1	0	0	30	Tr surface scab	-
MEAN	325	355	89					1.083								

[1] SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3.25"
OV: > 3.25"
PO: Pickouts

[2] TUBER QUALITY (number of tubers per total cut)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[3] CHIP COLOR SCORE
Snack Food Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

* Two-Year Average

sl = (slight)
tr = (trace)

Table 3

2004 Processing Potato Variety Trial
L. Walther & Sons, Inc. (Three Rivers, MI)

First Harvest[1] August 26, 2004 (115 Days)

	CWT/A		PERCENT OF TOTAL[2]						Total
			US#1		Small	Large			Chip
LINE	US#1	TOTAL	As	Bs	As	As	SP GR	HH[3]	Defects[4]
ND5822C-7	626	655	95	5	95	0	1.085	1.5	17.9
FL1879	**610**	**632**	**97**	**3**	**97**	**0**	**1.087**	**0.3**	**15.3**
MSJ080-1	570	608	94	6	94	0	1.078	1.5	6.5
MSG227-2	519	571	91	9	91	0	1.092	2.5	4.3
W1201	499	513	97	3	97	0	1.093	0.0	2.4
B0766-3	492	514	96	4	96	0	1.088	2.0	29.9
W1773-7	483	521	93	7	93	0	1.098	0.3	0.0
UEC	479	484	99	1	98	1	1.088	2.8	14.6
MSJ461-1	476	534	89	11	89	0	1.084	0.0	0.0
Snowden	**473**	**508**	**93**	**7**	**93**	**0**	**1.087**	**0.5**	**4.9**
Atlantic	**464**	**489**	**95**	**5**	**94**	**1**	**1.090**	**3.0**	**15.4**
MSH228-6	456	481	95	5	95	0	1.088	1.8	0.0
MSJ147-1	414	449	92	8	92	0	1.089	0.0	2.2
MSH067-3	411	445	92	8	92	0	1.090	2.0	0.0
AF2211-9	391	404	97	3	97	0	1.091	4.3	23.8
FL1922	372	387	96	4	96	0	1.083	0.5	4.8
Pike	**350**	**362**	**97**	**3**	**97**	**0**	**1.090**	**0.3**	**0.0**
MSH095-4	344	353	97	3	97	0	1.091	0.5	4.6
AVERAGE	468	495	95	5	95		1.088		

[1] All data presented is based on an average of four replications

[2] Percent of Total (Size)
US#1: 2 - 4 in.
Large As: >4 in.
Small As: 2 - 4 in.
Bs: < 2 in.

[3] Based on a 10 tuber raw sample

[4] Total Chip Defects are comprised of; undesirable color, greening, internal defects and external defects, present in one replication.

Planted May 3, 2004 9" seed spacing Vine Kill: None

Table 4

2004 Processing Potato Variety Trial
L. Walther & Sons, Inc. (Three Rivers, MI)

Second Harvest[1] October 8, 2004 (158 Days)

	CWT/A		PERCENT OF TOTAL[2]						Total
			US#1		Small	Large			Chip
LINE	US#1	TOTAL	As	Bs	As	As	SP GR	HH[3]	Defects[4]
ND5822C-7	789	841	94	6	94	0	1.087	1.8	17.8
B0766-3	656	687	96	4	96	0	1.086	2.8	24.7
W1773-7	641	702	91	9	91	0	1.093	0.8	25.1
W1201	620	666	93	7	93	0	1.088	0.0	31.2
MSJ080-1	615	671	92	8	92	0	1.090	0.0	1.4
MSH228-6	589	615	96	4	96	0	1.086	2.3	12.7
FL1879	**584**	**651**	**90**	**10**	**90**	**0**	**1.086**	**1.3**	**2.4**
MSG227-2	564	671	84	16	84	0	1.086	0.8	11.2
Atlantic	**543**	**589**	**92**	**8**	**92**	**0**	**1.089**	**2.3**	**22.1**
MSJ147-1	538	589	91	9	91	0	1.085	0.3	0.0
Snowden	**523**	**564**	**93**	**7**	**93**	**0**	**1.079**	**0.0**	**10.9**
FL1922	492	533	92	8	92	0	1.081	0.3	0.0
UEC	446	461	97	3	97	0	1.083	1.0	12.7
MSJ461-1	441	538	82	18	82	0	1.082	0.5	13.3
MSH095-4	420	482	87	13	87	0	1.091	0.0	0.0
Pike	**410**	**451**	**91**	**9**	**91**	**0**	**1.090**	**0.3**	**3.9**
MSH067-3	405	420	96	4	96	0	1.090	1.5	0.0
AF2211-9	379	431	88	12	88	0	1.090	2.8	7.4
AVERAGE	536	587	91	9	91		1.087		

[1] All data presented is based on an average of four replications

[2] Percent of Total (Size)
US#1: 2 - 4 in.
Large As: >4 in.
Small As: 2 - 4 in.
Bs: < 2 in.

[3] Based on a 10 tuber raw sample

[4] Total Chip Defects are comprised of; undesirable color, greening, internal defects and external defects, present in one replication.

Planted May 3, 2004 9" seed spacing Vine Kill: September 15, 2004 (135 Days)

Table 5

2004 "Select" Processing Potato Variety Trial
Overall Average - Crooks Farms, Inc., Two Counties
Montcalm & St. Joseph Counties

NUMBER OF LOCATIONS	LINE	CWT/A US#1	TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	COMMENTS
2	W2128-8	560	603	93	5	84	9	2	1.097	0	0	0	0	10	Sl surface scab, flat and oblong
2	MSH228-6	456	487	94	5	86	7	1	1.086	1	0	0	0	10	Tr raised scab, flat and round
2	W1201	422	445	95	4	88	7	1	1.092	0	0	1	0	10	Sl surface scab, sheep nose
2	MSJ036-A	414	468	88	11	87	2	1	1.087	0	1	0	1	10	Tr raised scab, nice size, uniform
2	W2154-1	391	453	87	11	85	1	2	1.092	1	0	0	0	10	Tr pitted scab, not uniform type
	MEAN	449	491	91					1.091						

[1] SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3.25"
OV: > 3.25"
PO: Pickouts

[2] TUBER QUALITY (number of tubers per total cut)
HH: Hollow Heart
BC: Brown Center
VD: Vascular Discoloration
IBS: Internal Brown Spot

sl = (slight)
tr = (trace)

Table 6

USPB / SFA Potato Variety Trial
V & G Farms, Montcalm County, MI

October 4, 2004 (154 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]
ND5822C-7	673	705	95	3	70	25	2	1.085	1.5	14	1	0	12	30	nd
A91790-13	490	543	90	9	85	5	1	1.090	1.0	0	3	1	0	30	nd
W1201	488	504	97	3	80	17	0	1.091	1.0	0	7	0	0	30	nd
B01240-1	487	526	93	3	64	28	5	1.084	1.5	2	3	0	1	30	nd
MSJ461-1	441	484	91	8	84	7	1	1.079	1.0	2	1	2	0	30	1.8
SNOWDEN	**416**	**438**	**95**	**4**	**80**	**15**	**1**	**1.087**	**1.0**	**2**	**11**	**0**	**0**	**30**	**1.9**
ATLANTIC	**415**	**431**	**96**	**3**	**88**	**8**	**0**	**1.093**	**1.0**	**2**	**3**	**0**	**0**	**30**	**2.1**
ND2470-27	408	426	96	3	61	35	1	1.078	1.0	3	12	1	1	30	nd
MSF099-3	391	431	91	3	82	9	6	1.083	1.0	8	1	0	1	30	2.5
W1773-7	384	421	91	9	82	9	0	1.087	2.0	6	0	0	0	30	1.8
NY132	353	361	98	2	75	23	0	1.089	1.0	4	1	0	0	30	1.5
AF2211-9	324	360	90	9	89	1	1	1.085	1.0	0	8	0	0	30	2.3
MEAN	439	469	94					1.086							

[1] SIZE
Bs: < 1 7/8"
As: 1 7/8" - 3.25"
OV: > 3.25"
PO: Pickouts

[2] TUBER QUALITY (number of tubers per total cut)
HH: Hollow Heart
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

[3] CHIP COLOR SCORE
Snack Food Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

[4] SCAB DISEASE RATING
0: No Infection
1: Low Infection <5%
3: Intermediate
5: Highly Susceptible
nd = no data

Planted: April 30, 2004 Seed Spacing : 9" Vine Kill Date: None

Table 7

SFA / USPB Potato Variety Trial
Post Harvest Chip Quality Evaluation[1]

Entry	Agtron Color	SFA[2] Color	Specific Gravity	Percent Chip Defects Internal	External	Total
ND5822C-7	65.4	1.0	1.082	1	5	6
A91790-13	63.8	1.0	1.085	3	3	6
W1201	61.7	1.0	1.089	0	1	1
B01240-1	62.2	1.0	1.080	1	24	25
MSJ461-1	66.1	1.0	1.073	0	1	1
SNOWDEN	**62.6**	**1.0**	**1.082**	**1**	**10**	**11**
ATLANTIC	**61.8**	**1.0**	**1.085**	**2**	**7**	**9**
ND2470-27	63.0	1.0	1.077	0	2	2
MSF099-3	62.0	1.0	1.079	0	0	0
W1773-7	62.1	1.5	1.082	0	5	5
NY132	67.7	1.0	1.088	3	0	3
AF2211-9	68.3	1.0	1.083	0	2	2

[1] Samples collected at harvest October 4 and processed by Herr Foods Inc., Nottingham, PA on October 14, 2004 (11 days).

[2] SFA Color: 1 = lightest, 5 = darkest

Table 8.

2004 MSU Freshpack Potato Variety Trials

Entry	Pedigree	2003 Scab Rating*	Characteristics
Boulder (MSF373-8)	MS702-80 X NY88	2.0	High yield, large tubers, low internal defects, med. deep eyes.
Dakota Jewel (ND3196-1R)	ND2223-8R X ND649-4R	1.0	Early maturity, average yield, smooth round tubers, white flesh, shallow eyes, stores well, some brown center noted, nice red color out of the field.
Dakota Pearl (ND2676-10)	ND1118-1 X ND944-6	1.0	Early maturing, low internal defects, average yield, cold chipping potential at 42 °F.
Eva (NY103)	Steuben X OP	2.8	Mid-season maturity, above average yield, round to oval appearance, resistant to PVX and PVY.
Goldrush (ND1538-1 Rus)	ND450-3 Rus X Lemhi Russet	0.3	Long to oval tubers, heavy russet, check variety.
Katahdin (USDA 42667)	USDA 40568 X USDA 24642	-	Mid-season maturity, high yielding check variety.
Keuka Gold (NY101)	Steuben X Norwis	1.0	Full season maturity, high yield, pale yellow flesh, round to oval shape. Susceptible to internal heat necrosis.
Keystone Russet (AC83064-1)	CalWhite X A7875-5	0.5	Medium-late maturity, high yield, good storability, good internals, resistant to black spot, short dormancy.
Marcy (NY112)	Atlantic X Q155-3	1.8	Full season maturity, high yield, smooth round appearance.
Michigan Purple	W870 X Maris Piper	3.0	Mid-season, attractive purple skin, white flesh, high yield potential, low incidence of internal defects.
Millennium Russet (W1348 Rus)	Atlantic X FL1154 Rus	1.0	Full season, dual purpose, medium to high specific gravity, moderate scab resistance, medium to long dormancy.
Onaway	USDA X96-56 X Katahdin	1.7	Early maturing, high yielding check variety.

*Scab rating based on a 0-5 rating; 0 = most resistant and 5 = most susceptible.

Entry	Pedigree	2003 Scab Rating*	Characteristics
Reba (NY 87)	Monona X Allegany	2.5	High yield, bright tubers, low incidence of internal defects, mid to late season maturity.
Russet Norkotah (ND534-4 Rus)	ND9526-4 Rus X ND9687-5 Rus	2.5	Mid-season maturity, average yield, long to oval tubers, heavy russet, check variety.
Silverton Russet (A083064-6)	A76147-2 X A7875-5	0.0	Oblong to long, medium russet skin, medium yield, masks PVY.
Stampede Russet (TXAV657-27Rus)	BR7091-1 X Lemhi Russet	0.3	Early season maturity, oblong to long, heavy russeting, average yield potential, fresh market.
A9014-2Rus	Gem Russet X A8341-5	1.0	Late season maturity, dual purpose, good dormancy, high specific gravity.
Rio Grande Russet AC89536-5 Rus	Butte X A8469-5	0.0	Mid-season maturity, high yielding, average gravity, dormancy similar to R. Norkotah.
MSA8254-2BRus	Unknown	0.0	Late season maturity, dual purpose, medium specific gravity, good yield.
MSE192-8 Rus	A81163 X Russet Norkotah	1.2	Long russet tubers, low internal defects, bright white flesh, good cooking quality, specific gravity similar to R. Norkotah, PVY expression good.
MSH031-5	MSB110-3 X MSC108-3	2.7	Mid-season maturity, average yield, nice appearance, res. to black spot.
MSI005-20Y	MSA097-1Y X Penta	1.5	Early to mid-season maturity, high yielding, low internal defects, strong yellow flesh color.
MSJ033-10Y	A097-1 X Penta	1.0	Mid-season maturity, strong yellow flesh color, good size profile, nice round type.
MSJ461-1	Tollocan X NY88	2.7	Maturity slightly earlier than Snowden, round, bright skin, low defects, strong foliar late blight resistance, nice flavor, intermediate specific gravity.

*Scab rating based on a 0-5 rating; 0 = most resistant and 5 = most susceptible.

Table 9

2004 Freshpack Potato Variety Trial
Overall Averages - Five Locations
Marquette, Monroe, Montcalm, Presque Isle, Washtenaw Counties

NUMBER OF LOCATIONS	LINE	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL CUT	COMMENTS	3-YR AVG US#1 CWT/A
		US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC			
4	Satina	545	610	89	5	74	15	6	1.070	0	0	2	0	10	Surface scab, knobs, points	-
3	**Onaway**	**529**	**574**	**91**	**3**	**71**	**20**	**6**	**1.071**	**0**	**0**	**0**	**0**	**10**	**Sheep nose, knobs, surface scab**	**381**
5	Keuka Gold	518	540	96	3	71	25	1	1.072	1	0	2	0	10	Uniform type, sl scab, yellow flesh	457*
5	Marcy	505	534	94	5	71	23	1	1.076	1	0	1	0	10	Uniform type, netted skin	478*
3	**Reba**	**467**	**489**	**95**	**5**	**70**	**24**	**1**	**1.073**	**2**	**0**	**0**	**0**	**10**		**397**
5	MSJ461-1	466	526	89	9	73	17	2	1.076	1	0	1	0	10	Scab	444*
3	MSA8254-2BRus	436	528	82	12	63	19	5	1.078	3	0	0	0	10	Long type	-
5	MSI005-20Y	431	474	90	8	75	15	2	1.067	0	0	1	0	10	Nice yellow flesh, knobs, sl scab	378*
4	A9014-2Rus	412	467	87	9	72	15	4	1.078	3	1	0	0	10	Long type, tr scab, heavy russet	-
3	AC89536-5Rus	404	531	74	21	66	8	4	1.080	3	0	0	0	10	Heavy russet skin, long type	309*
3	Michigan Purple	398	438	90	7	64	26	3	1.076	0	0	0	0	10	Scab	355
3	Keystone Russet	397	476	82	16	65	16	2	1.068	2	1	0	0	10	Blocky to oval, light russet skin	385
2	Silverton Russet	386	451	86	12	66	20	2	1.077	0	2	0	0	10		305
5	MSH031-5	386	428	89	10	86	3	1	1.076	0	0	0	0	10	Bright appearance, scab, flat to oval	361
2	**Russet Norkotah**	**377**	**435**	**85**	**15**	**56**	**30**	**1**	**1.072**	**5**	**0**	**0**	**0**	**10**		**274**
3	Millennium Russet	370	511	71	26	68	3	3	1.087	2	0	0	0	10	Heavy russet skin, long type	-
5	MSJ033-10Y	366	421	87	11	74	13	2	1.068	0	0	2	0	10	Growth crack, nice uniform type	-
2	**Eva**	**351**	**384**	**92**	**4**	**69**	**23**	**5**	**1.064**	**0**	**0**	**0**	**0**	**10**		**316***
3	Stampede Russet	323	387	81	18	69	13	1	1.061	0	0	0	0	10	Heavy russet skin, long type	-
3	ND3196-1R	301	342	87	8	70	17	5	1.072	3	0	0	0	10	Very white flesh color, good skin set	274*
2	**Goldrush**	**301**	**409**	**73**	**22**	**60**	**13**	**5**	**1.080**	**0**	**1**	**0**	**0**	**10**		**-**
4	Dakota Pearl	273	338	80	19	78	1	1	1.072	0	0	0	0	10	Nice bright appearance, small size	275
3	MSE192-8Rus	200	305	65	30	60	5	4	1.069	0	1	0	0	10	Heavy russet skin, long type	195
	MEAN	397	461	85					1.073							

[1] SIZE
Bs: < 1 7/8" or < 4 oz.
As: 1 7/8" - 3.25" or 4 - 10 oz.
OV: > 3.25" or > 10 oz.
PO: Pickouts

[2] TUBER QUALITY (number of tubers per total cut)
HH: Hollow Heart
BC: Brown Center
VD: Vascular Discoloration
IBS: Internal Brown Spot

* Two-Year Average

sl = (slight)
tr = (trace)

Funding: MPIC, MSU and Industry

Seed treatments, in-furrow and seed plus foliar treatments for control of potato stem canker and black scurf, 2004.

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Introduction

Stem canker and black scurf of potatoes is caused by the pathogen *Rhizoctonia solani* (AG-3). Rhizoctonia disease is initiated by seedborne or soilborne inoculum. Seedborne inoculum is carried on seed tubers in the form of sclerotia (black scurf) or as mycelium from the previous season. When contaminated seed is planted the fungus grows from the seed surface to the developing sprout and infection of root primordia, stolon primordia and leaf primordia can occur. The sprouts can be killed at this stage and emergence may be prevented or delayed. Mycelia and sclerotia of *R. solani* also survive in soil and on plant debris and can cause disease independently of seedborne inoculum. Soilborne inoculum can infect potato tissue at anytime when plant organs develop in the proximity of inoculum however the plant is most severely impacted when immature sprouts, stolons and roots are infected early in the season. However, as growers in Michigan are constrained by season length and rotation requirements it is necessary to include the application of fungicides effective against *R. solani* in a control program. Trials at MSU and elsewhere have indicated that there are several effective fungicides that can be used to manage *R. solani*, either applied as seed treatments or as in-furrow at-planting applications. These fungicides include fludioxonil-based seed treatments (Maxim products), strobilurin-based products applied in-furrow [azoxystrobin (Quadris, Amistar)], and flutolonil-based fungicides [Moncoat MZ (seed treatment); Moncut (in-furrow)]. Although products are available, new standards are being developed for avoidance of resistance in pathogen populations (not necessarily *R. solani*) to at-risk fungicide classes such as those in group 11 [QoI-fungicides (Quinone outside Inhibitors)] which includes all the strobilurins currently registered for use on potatoes. The broad spectrum of efficacy reported in strobilurins may lead to excessive use in the future as other products such as B2 carcinogens are at risk of further limitations in usage, and therefore a management plan for their use need to be developed which is compatible with potato production in Michigan. Currently there are many fungicidal options available for control of *Rhizoctonia* diseases of potato and the objectives of this project therefore are to identify the efficacy of some fungicides applied as seed treatments or as in-furrow at-planting applications against the Rhizoctonia diseases, stem canker and black scurf of potatoes.

Methods and materials

Potatoes infected with R*hizoctonia solani* (black scurf), 2- 5% tuber surface area infected, were selected for the trials. Potato seed was prepared for planting by cutting and treating with fungicidal seed treatments seven days prior to planting. Seed were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 28 Jun into two-row by 20-ft plots (ca. 10-in. between plants to give a target population of 50 plants at 34-in. row spacing) replicated four times in a randomized complete block design. The two-row beds were separated by a 5-ft unplanted row. Dust formulations were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for 2 min to ensure even spread of the fungicide. Fungicides applied as pre-planting potato seed liquid treatments were applied in water suspension at a rate of 0.02pt/cwt onto the exposed seed tuber surfaces, with the entire seed surface being coated in the Gustafson seed treater. In furrow applications were made over the seed at planting, applied with a single nozzle R&D spray boom delivering 5 gal/A (80 psi) and using one XR11003VS nozzle per row. Fertilizer was drilled into plots before planting, formulated according to results of soil tests. Additional nitrogen (final N 28 lb/A) was applied to the growing crop with irrigation 45 DAP (days after planting). Bravo WS 6SC was applied at 1.5 pt/A on a seven day interval, total of 8 applications, starting after the canopy was about 50% closed. A permanent irrigation system was established prior to the commencement of fungicide sprays and the fields were maintained at soil moisture capacity throughout the season by frequent (minimum 5 day) irrigations. Weeds were controlled by hilling and with Dual 8E at 2 pt/A 10 DAP, Basagran at 2 pt/A 20 and 40 DAP and Poast at 1.5 pt/A 58 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 55 DAP, Thiodan 3 EC at 2.33 pt/A 65 and 87 DAP and Pounce 3.2EC at 8 oz/A 48 DAP. Emergence was rated as the number of plants breaking the soil surface or fully emerged after planting. The rate of emergence was estimated as the area under the plant emergence curve (max=100) from the day of planting until 23 DAP. The rate of canopy development was measured as the RAUCPC, relative area under the canopy development curve, calculated from day of planting to a key reference point taken as 43 DAP (about 100% canopy closure), (max = 100). Severity of stem canker was estimated as the percentage of stems per plant with greater than 10% girdling caused by *R. solani*, measured 43 days after planting (5 plants per sample were destructively harvested and total stem number and number affected was counted). Vines were killed with Reglone 2EC (1 pt/A on 13 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Samples of 50 tubers per plot were harvested 21 days after desiccation (99 DAP). Tubers were washed and assessed for black scurf (*R. solani*) incidence (%) and severity 50 days after harvest on 2 Nov. Severity of black scurf was measured as an index calculated by counting the number of tubers (n = 50) falling in class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 - 15; 4 > 15% surface area of tuber covered with sclerotia. The number in each class is multiplied by the class number and summed. The sum is multiplied by a constant to express as a percentage. Indices of 0 - 25 represent 0 - 5%; 26 - 50 represent 6 - 10%; 51 - 75 represent 11 - 15% and 75 - 100 >15% surface area covered with sclerotia. Maximum and minimum air temperature (^{o}F) were 88.2 and 67.2 (Jun), 87.5 and 67.7 (Jul), 88.1 and 67.7 (Aug) and 85.3 and 66.0 (Sep). Maximum and minimum soil temperature (^{o}F) were 74.5 and 69.8 (Jun), 77.0 and 71.9 (Jul), 78.0 and 71.4 (Aug) and 75.9 and 70.2 (Sep). Maximum and minimum soil moisture (% of field capacity) was 98.5 and 95.8 (Jun, severe flooding); 98.1 and 63.3 (Jul), 85.4 and 71.4 (Aug) and 76.8 and 79.8 (Sep). Precipitation was 4.04" (Jun), 3.68" (Jul), 1.83" (Aug) and 0.93" (Sep).

No seed treatment (ST) or fungicide applied at planting in-furrow (IF) was significantly different from the untreated control or from the Moncoat MZ 0.5 lb (ST) commercial standard treatment in terms of the final plant stand. No seed treatment (ST) or fungicide applied at planting in-furrow (IF) was significantly different from the untreated control or from the Moncoat MZ 0.5 lb (ST) commercial standard treatment in terms of rate of emergence (RAUEPC). No seed treatment (ST) or fungicide applied at planting in-furrow (IF) was significantly different from the untreated control or from the Moncoat MZ 0.5 lb (ST) commercial standard treatment in terms of the rate of canopy formation (RAUCPC) except treatment 4. All treatments significantly reduced the percentage of stolons with greater than 5% girdling due to *R. solani* in comparison with the untreated control but there was no difference among treatments. All treatments significantly reduced the percent incidence of black scurf on tubers in comparison with the untreated control except treatment 1. There was no significant difference among treatments with 16.3 - 48.8%; 37.5 - 75.0%; and 75.0 - 96.3% incidence of tuber black scurf. All treatments significantly reduced the severity of black scurf on tubers in comparison with the untreated control except treatment 1 measured as an index on the 0 - 100 scale. There was no significant difference in the index of severity of black scurf between treatments with indices between 5.0 and 25.3; 20.0 to 42.2 and from 42.2 to 48.4. Treatments with marketable yield between 246 (non-treated control) and 312 cwt/A; and 273 and 340 cwt/A were not significantly different. There were no significant differences among treatments in total yield.

Table 1. Effect of seed treatments and in-furrow at-planting applied treatments on emergence, canopy development and stem and stolon canker and black scurf incidence and severity on potatoes at the Muck Soils Research Farm, 2004.

Treatment and rate/cwt (seed treatment) rate/A (in furrow)[z]			Plant number (%) emerged 23 days after planting		Emergence (RAUEPC)[y]		Canopy development (RAUCPC)[x]	
1	Potato Seed Treater PS 8% 1.0 lb	ST........	97.0	ab[w]	0.27	ab	0.18	ab
2	Moncut 70DF 0.79 oz/1000 ft	IF.........	98.0	ab	0.26	ab	0.18	ab
3	Moncut 70DF 1.18 oz/1000 ft	IF.........	100.0	a	0.26	ab	0.19	a
4	Maxim 4 FS 0.08 fl oz	ST........	100.0	a	0.27	ab	0.13	bcd
5	Maxim 4 FS 0.08 fl oz + Amistar 80WDG 0.12 oz/1000 ft	ST IF.........	99.5	a	0.28	a	0.19	a
6	Moncoat MZ 0.75 lb	ST........	98.0	ab	0.26	ab	0.17	abc
7	Maxim 4 FS 0.08 fl oz + Quadris 2.08SC 0.05 fl oz/1000 ft	ST IF........	100.0	a	0.29	a	0.18	ab
8	Potato Seed Treater PS 8% 1.0 lb + Amistar 80WDG 0.12 oz/1000 ft	ST IF.........	100.0	a	0.25	ab	0.18	ab
9	Potato Seed Treater PS 8% 1.0 lb + Headline 2.09SC 0.05 fl oz/1000 ft	ST IF.........	97.5	ab	0.26	ab	0.18	abc
10	Tops MZ 0.75 lb	ST........	96.0	ab	0.27	a	0.18	ab
11	Amistar 80WDG 0.12 oz/1000 ft	IF.........	98.0	ab	0.27	ab	0.18	ab
12	Headsup 3WDG 0.1 lb	ST........	98.5	ab	0.24	abc	0.16	abcd
13	Headsup 3WDG 0.1 lb + Headsup 3WDG 0.1 lb	ST Foliar...	100.0	a	0.28	a	0.19	a
14	Untreated	NA......	100.0	a	0.26	ab	0.19	a

Treatment and rate/cwt (seed treatment) rate/A (in furrow)[z]			Percent stolons with greater than 10% girdling due to *R. solani*[v]		Incidence of black scurf on tubers (%)[u]		Index of severity of black scurf on tubers (%)[t]		Yield cwt/A Marketable (US1)[s]		Yield cwt/A Total[r]	
1	Potato Seed Treater PS 8% 1.0 lb	ST........	22.3	b[w]	75.0	ab	48.4	a	273.9	ab	283.8	a
2	Moncut 70DF 0.79 oz/1000 ft	IF.........	13.4	b	25.0	c	8.4	c	291.7	ab	304.5	a
3	Moncut 70DF 1.18 oz/1000 ft	IF.........	14.1	b	48.8	bc	20.0	bc	299.7	ab	306.9	a
4	Maxim 4 FS 0.08 fl oz	ST........	16.2	b	30.0	c	11.3	c	286.0	ab	294.3	a
5	Maxim 4 FS 0.08 fl oz + Amistar 80WDG 0.12 oz/1000 ft	ST IF........	13.7	b	37.5	bc	16.9	c	339.6	a	348.4	a
6	Moncoat MZ 0.75 lb	ST........	15.4	b	33.8	c	25.3	bc	301.0	ab	310.2	a
7	Maxim 4 FS 0.08 fl oz + Quadris 2.08SC 0.05 fl oz/1000 ft	ST IF.........	12.1	b	18.8	c	7.8	c	312.2	ab	323.8	a
8	Potato Seed Treater PS 8% 1.0 lb + Amistar 80WDG 0.12 oz/1000 ft	ST IF.........	18.2	b	26.3	c	11.9	c	292.6	ab	337.1	a
9	Potato Seed Treater PS 8% 1.0 lb + Headline 2.09SC 0.05 fl oz/1000 ft	ST IF.......	16.1	b	17.5	c	5.9	c	302.4	ab	313.0	a
10	Tops MZ 0.75 lb	ST........	18.0	b	32.5	c	14.1	c	324.7	a	333.1	a
11	Amistar 80WDG 0.12 oz/1000 ft	IF.........	14.2	b	16.3	c	5.0	c	292.2	ab	302.5	a
12	Headsup 3WDG 0.1 lb	ST.......	14.0	b	42.5	bc	24.7	bc	294.8	ab	303.9	a
13	Headsup 3WDG 0.1 lb + Headsup 3WDG 0.1 lb	ST Foliar..	19.9	b	33.8	c	15.3	c	309.1	ab	316.4	a
14	Untreated	NA......	44.9	a	96.3	a	42.2	ab	245.5	b	278.6	a

[z] Application type, seed treatment (ST), in-furrow at planting (IF), untreated (NA).

[y] RAUEPC (max = 100), relative area under the plant emergence progress curve, day of planting to full emergence 23 days after planting.

[x] RAUCPC (max = 100), relative area under the canopy development curve, day of planting to key reference point, 43 days after planting.

[w] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

[v] Percentage of stems with greater than 10% girdling caused by *R. solani*, average of 5 plants taken 43 days after planting.

[u] Percent incidence of tubers with sclerotia of *R. solani* from sample of 50 tubers per replicate.

[t] Severity of black scurf (index calculated by counting tuber number (n = 50) falling in class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 - 15%; 4 >16%surface area. Indices of 0 - 25 cover the range 0 - 5%; 26 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15% and 75 - 100 >15% surface area of tuber with sclerotia.

[s] Marketable yield, tubers greater than 2.5" in any plane (US1 grade).

[r] Total yield, combined total of US1 grade and tubers less than 2.5" in any plane.

Funding: MPIC / Industry

Potato Seed Piece and Variety Response to Variable Rates of Gibberellic Acid 2003-2004

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Introduction

The Michigan potato industry is currently growing chip processing varieties that have a small set of generally large (over 3.25") round potatoes. This can cause a problem for seed production. The resulting seed pieces of these varieties are generally oversize and the eye distribution is poor in the cut seed, thus resulting in poor quality seed and the need for higher plant populations. Commercial producers suffer equally from the small set of oversize tubers which results in reduced yield, the need for excess amounts of seed and increased internal tuber defects. The potato industry needs a way to increase tuber set and effectively decrease the size profile of these varieties.

In 2003 and 2004 an experiment was conducted on two Frito-Lay, Inc. varieties, FL1879 and FL1833; in 2004 a Michigan State University (MSU) developed clone, Michigan Purple was added. Our goal was to investigate the possibility of increasing tuber set by hormonally influencing the tuber eyes' ability to produce an increased number of stems. It has been documented that stem number directly influences tuber set (Toosey 1958). Wilkins (1958) indicates that gibberellic acid (GA) is implicated in increasing the number of stems emerging from each tuber eye. Gibberellic acid, although believed to increase the number of stems, ultimately influences tuber size and yield (Smeltzer and MacKay 1963). The objectives of this study are to: (1) establish the effectiveness of GA in inducing greater stem numbers arising from a given potato seed piece and (2) establish whether the increase in stem numbers per plant will increase tuber set and decrease tuber size of three commercially available varieties.

Procedure

In 2003 and 2004 two varieties, FL1879 and FL1833, were evaluated for their response to three levels of GA. In 2003, seed was obtained and cut into approximately two ounce seed pieces on May 17, 2003. The cut seed was immediately treated with 0, 4, 8, or 12 ppm Pro Gibb 4%, a trademark product of VALENT U.S.A. Corporation. Each treatment required 55 lbs of seed to plant the 3 replication randomized block design. For every 55 lbs of seed, 135 ml of distilled water was used as a carrier for the GA. The control had 135 ml of distilled water applied. The 4 ppm treatment had 0.447 ml of 4% ProGibb added to the water. The 8 ppm treatment had 0.893 ml of ProGibb added and the 12 ppm treatment had 1.34 ml of ProGibb added to the 135 ml of distilled water before it was poured onto the seed. The 55 lbs of cut seed was placed into a light industrial cement mixer and the treatment solution was added. Once the seed pieces appeared uniformly wet an arbitrary amount of bark flour was added to absorb any free water. The seed was placed into plastic ventilated trays and allowed to dry. The plot was planted two days after the seed treatment was applied at the Michigan State University, Montcalm Research Farm, Entrican, Michigan on May 19, 2003. On June 26, 2003 stand counts and the stem numbers per plant were also recorded. Harvest was conducted on September 29, 2003 and total tuber yield, US#1 yield, and total tuber number for four size categories were recorded (< 1 7/8", Pick-outs, >3 1/4" and 1 7/8" to 3 1/4"), specific gravity, and hollow heart were recorded for each replication.

The procedures were very similar for the 2004 season with exception to the application rates for GA. The change in application rates will be explained in the discussion section of this article. In 2004, the application rates were 0, 1, 2 and 4 mg of active ingredient per 100 lbs. (mg a.i./cwt) of cut potato seed. Seed treatments were applied on May 7, 2004 and planting was conducted on May 17, 2004. Stand and stem counts were taken June 24, 2004. The 2004 plot was harvested on October 1, 2004. Due to poor plant stand the FL1833, 4 mg a.i. treatment was lost and no data is presented.

Results

In 2003 the 8 and 12 ppm treatments for both FL1879 and FL1833 significantly increased stem number (Table 1). Figure 1 depicts the effect of the GA treatments on the cut seed pieces of FL1833. As the concentration of GA increased in the FL1833 variety the US#1 yield decreased. The number of tubers under 1 7/8" increased and the number of oversize tubers decreased (>3 1/4"). The number of "A" size tubers, as well as, the total tuber count per treatment increased as GA level increased (Table 1).

For the FL1879 variety, these same trends were observed up to the 8 ppm level. The 12 ppm treatment for the FL1879 variety responded more like its corresponding 4 ppm treatment (Table 1). The line along with GA treatment caused an increase of "B" size tubers.

In 2004, both FL1833 and FL1879 exhibited a statistically significant increase in "B" size tubers as GA level increased (Table 1). The variety Michigan Purple displayed a 3 fold increase in the number of "B" size tubers as the GA level was increased from 0 mg a.i. to 4 mg a.i.. Figures 2 and 3 depict the effect of the GA treatments on the cut seed pieces of FL1879 and Michigan Purple, respectively.

Discussion

The weather at planting in 2003 was far more conducive to a successful growing season than in 2004. Rainfall in early May 2004 caused a number of delays in planting at the Montcalm Research Farm. Cut seed was treated two day prior to planting in 2003 and in 2004 there was a ten day period between seed treatment and planting. The 2004 treated seed was moved into and out of a 50 ºF cooler at least three times, which may have negatively affected seed quality prior to planting.

In 2003 the seed treatment rates were measured in ppm as was thought to be the industry standard for GA application. But as the industry was surveyed their GA treatment practices were found to be different, which resulted in an inconsistent seed piece response among growers. Growers were not using the same amount of water to apply a treatment to a given amount of cut seed. For example, one grower was applying 400 ml (3.2 mg a.i.) of an 8 ppm solution to one cwt. of cut seed and another grower was applying 88 ml (0.7 mg a.i.) of the same 8 ppm solution to the same amount of cut seed. As is evident here, the amount of active ingredient applied to the cut seed is influenced by the volume of the treatment solution. This appears to be a problem in identifying consistent results between growers who are treating seed with GA. In 2004 each treatment of GA was measured in mg of active ingredient per 100 pounds of cut seed (mg a.i./ cwt) which was applied by producing a 8 ppm solution and varying the volume of this solution that was applied per cwt. of cut seed. For example, to obtain 1 mg of a.i. per cwt, 125 ml of an 8 ppm GA solution was applied per 100 pounds of cut seed. For 2 mg of GA, 250 ml of the 8 ppm solution would be applied and for 4 mg, 500 ml would be applied. This appears to be a better standard when referring to amount of GA applied to cut seed. In 2005 we are hoping to repeat the study and show the results of this approach to GA application. The spring 2004 weather made it hard to draw many conclusions from this data set.

Strictly looking at the results from the 2003 data, it is apparent that the GA treatments do decrease US#1 yield and oversize tuber production. An 8 ppm GA application (approximately 260 ml of solution per cwt cut seed) was the optimal treatment to increase the number of stems per hill, increase the number of "A" and "B" size tubers, while not effecting the specific gravity or number of "pick-out" tubers.

Due to the poor growing conditions and seed quality going into the 2004 season, the data that resulted was not very conclusive. This study will be repeated using the mg a.i. treatment system in 2005 with the varieties FL1833, FL1879 and FL1922.

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Table 1.

Gibberellic Acid Plot Averages for 2003 and 2004 Field Data

2003

					Tuber Count					Internal***	
Line	GA* Level	US# 1 Yield in CWT/A	Total Yield in CWT/A	Specific Gravity	<1 7/8"	P.O.	> 3 1/4"	1 7/8" - 3 1/4"	Total Tuber Number	Tuber Defects HH	Average # Stems/Hill
FL1833	0	324	345	1.088	13	5	21	82	121	13	1.7
FL1833	4	283	308	1.086	23	6	8	114	152	3	1.8
FL1833	8	270	291	1.087	27	3	6	130	165	0	2.3
FL1833	12	268	295	1.089	33	5	5	128	171	13	2.3
FL1879	0	382	393	1.082	12	1	17	127	158	23	3.5
FL1879	4	343	367	1.081	32	2	7	163	204	3	4.4
FL1879	8	311	345	1.081	45	4	2	165	216	7	4.6
FL1879	12	332	353	1.083	26	2	5	169	202	13	4.6
Line**		0.001	0.012	0.001	0.014	0.003	0.148	<0.001	<0.001	0.332	<0.001
level**		0.015	0.082	0.58	<0.001	0.729	<0.001	<0.001	<0.001	0.05	0.004
Line x level**		0.918	0.998	0.956	0.001	0.072	0.599	0.789	0.551	0.782	0.412

2004

FL1833	0	308	316	1.091	13	0	12	104	128	15	1.7
FL1833	1	244	260	1.092	22	2	6	118	149	20	1.6
FL1833	2	274	301	1.094	36	1	3	127	167	3	1.7
FL1879	0	230	239	1.087	10	2	2	93	106	15	2.5
FL1879	1	335	357	1.088	31	0	1	159	192	17	2.9
FL1879	2	220	251	1.088	34	3	0	118	154	0	3.3
FL1879	4	225	258	1.088	46	1	1	136	183	5	4.4
MI Purple	0	293	317	1.078	13	6	8	114	141	0	2.5
MI Purple	1	229	259	1.076	25	8	4	98	133	0	2.5
MI Purple	2	249	274	1.075	21	3	6	101	131	10	2.2
MI Purple	4	276	321	1.077	39	7	2	135	183	0	2.55
Line**		0.812	0.684	0.001	0.242	0.002	0.025	0.426	0.554	0.396	0.002
level**		0.799	0.912	0.989	0.015	0.69	0.107	0.537	0.303	0.645	0.723
Line x level**		0.36	0.345	0.434	0.648	0.168	0.367	0.519	0.472	0.788	0.058

* GA level in 2003 was recorded in ppm and in 2004 was recorded as mg of active ingredient per hundred pounds of cut seed.
** P = 0.05
*** 30 tubers per treatment were evaluated for hollow heart (HH).

Figure 1. Cut seed of FL1833, 28 days after treatment with GA (2003).

0 ppm   4 ppm   8 ppm   12 ppm

Figure 2. Cut seed of FL1879, 28 days after treatment with GA (2004).

0 mg a.i   1 mg a.i.   2 mg a.i.   4 mg a.i

Figure 3. Cut seed of Michigan Purple, 28 days after treatment with GA (2004).

0 mg a.i.   1 mg a.i.   2 mg a.i.   4 mg a.i.

Funding MPIC and MSU

Managing Rhizoctonia Diseases of Potato with Optimized Fungicide Applications and Varietal Susceptibility; Results from the Field Experiments.

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Introduction

The pathogen *Rhizoctonia solani* (AG-3) causes stem canker and black scurf of potatoes. Rhizoctonia diseases are initiated by seedborne or soilborne inoculum. Seedborne inoculum is carried on seed tubers in the form of sclerotia (black scurf) or as mycelium from the previous season. When contaminated seed is planted the fungus grows from the seed surface to the developing sprout and infection of root primordia, stolon primordia and leaf primordia can occur. The sprouts can be killed at this stage and emergence may be prevented or delayed. Mycelia and sclerotia of *R. solani* also survive in soil and on plant debris and can cause disease independently of seedborne inoculum. Soilborne inoculum can infect potato tissue at anytime when plant organs develop in the proximity of inoculum, however the plant is most severely impacted when immature sprouts, stolons and roots are infected early in the season. During early potato development in April in MI soil temperature is well within the optimal range (average about 10^{o}C) for infection by *R. solani*.

High temperature tends to minimize the impact of *R. solani* even when inoculum is abundant. Some potato varieties appear to be more sensitive than others to but there are none which exhibit high levels of resistance, however information on currently grown varieties is not available. Current recommendations for control of this disease are focused on reducing both seedborne and soilborne inoculum. It is known that minimizing the time between planting and emergence can minimize sprout infection. Crop rotation in warm climates to about three years can also reduce inoculum in the soil. As growers in MI are constrained by season length and rotation requirements it is necessary to include the application of fungicides effective against *R. solani* in a control program. Trials at MSU and elsewhere have indicated that there are several effective fungicides that can be used to manage *R. solani*, either applied as seed treatments or as in-furrow at-planting applications. These fungicides include fludioxonil-based seed treatments (Maxim products), strobilurin-based products applied in-furrow [azoxystrobin (Quadris, Amistar); pyraclostrobin (Headline), trifloxystrobin (Gem)], and flutolonil-based fungicides [Moncoat MZ (seed treatment); Moncut (in-furrow)]. Although products are available, new standards are being developed for avoidance of resistance in pathogen populations (not necessarily *R. solani*) to at-risk fungicide classes such as those in group 11 [QoI-fungicides (Quinone outside Inhibitors)] which includes all the strobilurines currently registered for use on potatoes. The broad spectrum of efficacy reported in strobilurines may lead to excessive use in the future as other products such as B2 carcinogens are at risk of further limitations in usage, and therefore a management plan for their use need to be developed which is compatible with potato production in MI. Currently there are many fungicide options available for control of Rhizoctonia diseases of potato however, to achieve optimal performance and preserve efficacy, a systematic approach of usage needs to be established. This approach also should address the climatic variability on the epidemiology of *R. solani* in potatoes to establish the threshold at which the application of fungicide intervention would have no effect.

The objectives of this project therefore are to A) to identify the efficacy of some fungicides (identified below) applied at different timings during early crop development in combination with and without seed treatments on a chipping cultivar and a table stock cultivar grown in two potentially different soil temperature regimes; and B) evaluate the effect of soil temperature on currently grown varieties at the Plant Pathology Research Farm on a sand/mineral site.

Materials and Methods

A) The seed treatment and fungicide application timing experiment for the control of symptoms of *Rhizoctonia solani* was tested at two locations and on three varieties. The potato cultivar ‘Superior’ was planted in a grower’s field near Elmira, MI, while the cultivars ‘FL 1879’ and ‘Russet Norkotah’ were planted at the Michigan State University Muck Soils Research farm near Bath, MI. All three cultivars were tested for the control of Rhizoctonia disease symptoms under identical chemical regimes. Within each regime three chemicals, Amistar (a.i. azoxystrobin), Moncut (a.i. flutolonil), Headline (a.i. pyraclostrobin), were examined for efficacy at three application times, at-planting in-furrow, at emergence, and 14 days after emergence. Also, the efficacy of the addition of a seed treatment, Maxim (a.i., fludioxonil), in combination with the fungicides was examined at each application timing (Table 1).

Table 1: Experimental layout for seed treatment and timing of application of fungicides in-furrow at-planting, emergence and post-emergence

Seed treatment	In-furrow	Emergence	14 day post-emergence	Seed treatment	In-furrow	Emergence	14 day post-emergence
Yes	Amistar			No	Amistar		
Yes		Amistar		No		Amistar	
Yes			Amistar	No			Amistar
Yes	Moncut			No	Moncut		
Yes		Moncut		No		Moncut	
Yes			Moncut	No			Moncut
Yes	Headline			No	Headline		
Yes		Headline		No		Headline	
Yes			Headline	No			Headline
Yes				No			

‘Superior’ seed was cut and treated with the seed treatment one day prior to planting. Seed pieces were planted near Elmira, MI in sandy loam soil on 2 June, into four- row by 20 ft plots (approximately 13-in. between plants give a target population of 72 at 34-in. row spacing) replicated four times in a randomized complete block design. Cut ‘FL1879’ seed and whole ‘Russet Norkotah’ seed was also treated with the seed treatment one day prior to planting. Seed pieces were planted in Houghton muck soil at the Michigan State University Muck Soils Research Farm, Bath, MI on 23 June, into four- row by 20 ft plots (approximately 13-in. between plants give a target population of 72 at 34-in. row spacing) replicated four times in a randomized complete block design. The seed treatment was applied, in a water suspension of at a rate of 0.8 fl. oz/cwt in 0.8 fl. oz/cwt of water for a total final solution of 0.16 fl. oz/cwt, onto the entire seed surface. In-furrow applications were made over the seed at-planting, applied with a single nozzle R&D spray boom delivering 5 gal/A (80 psi) and using one XR11003VS nozzle per row.

At the Elmira site, pesticides were applied by the grower cooperator. Weeds were controlled with 1 lb/A of Lorox and 0.5 lb/A Sencor at hilling, and Eptam was applied at a rate of 3.5 pt/A (broadcast rate) 6 times throughout the growing season. Insects were controlled with Platinum applied at a rate of 0.25 pt/A at-planting, and Asana was used once at 8 oz/A. Seven applications of Bravo WS 6SC, three applications of Bravo WS 6SC with Endura 6WDG, and one application of Bravo WS 6SC with Copper Oxychloride were used as protectants against other fungal pathogens on a seven day spray schedule. Bravo WS 6SC was used at a rate of 1.5pt/A, Endura 6WDG was used at a rate of 0.16 lb/A, and Copper Oxychloride was used at a rate of 1 lb/A.

Fertilizer was drilled into plots before planting, formulated according to results of soil tests at the Bath, MI location. Bravo WS 6SC was applied at 1.5 pt/A on a ten day interval, total of six applications, starting two weeks after the last application of experiment treatments. A permanent irrigation system was established prior to the commencement of fungicide sprays and the fields were maintained at soil moisture capacity throughout the season by frequent (minimum 5-day) irrigations. Weeds were controlled with Dual 8E at 2 pt/A 15 DAP (days after planting), Basagran at 2 pt/A 25 and 45 DAP and Poast at 1.5 pt/A 63 DAP. Insects were controlled with Admire 2F at 1.25 pt/A at-planting, Sevin 80S at 1.25 lb/A 36 and 60 DAP, Thiodan 3 EC at 2.33 pt/A 70 DAP and Pounce 3.2EC at 8 oz/A 53 DAP.

Emergence was rated as the number of plants breaking the soil surface or fully emerged after planting. The rate of emergence was estimated as the area under the plant emergence curve (max=100) from the day of planting until 29 DAP for ‘Superior and 20 DAP for ‘FL1879’ and ‘Russet Norkotah’.

Tuber, stem, and stolon numbers, and percentages of stems and stolons with greater than 5% girdling caused by *Rhizoctonia solani* were measured via a destructive mid-season harvest (4 plants per 'Superior' replication, and 2 plants per replication for 'FL1879' and 'Russet Norkotah') at 50 DAP for all three varieties. Vines were killed with Reglone 2EC (1 pt/A on 1, and 23 Sep at Elmira and Bath, respectively). Plots (20-ft row) were harvested on 13 Oct and individual treatments were weighed and graded. Samples of 20 tubers per plot were washed and assessed for black scurf (*R.. solani*) incidence (%) and severity 13 days after harvest on 26 Oct. Severity of black scurf was measured as an index calculated by counting the number of tubers (n = 20) falling in class 0 = 0%; 1 = 1 - 5%; 2 = 6 -10%; 3 = 11 – 15%; 4 = > 15% surface area of tuber covered with sclerotia. The number in each class is multiplied by the class number and summed. The sum is multiplied by a constant to express as a percentage. Indices of 0 - 25 represent 0 - 5%; 26 - 50 represent 6 - 10%; 51 - 75 represent 11 - 15% and 75 - 100 >15% surface area covered with sclerotia.

B) The variety experiment was located at the Plant Pathology farm in East Lansing, MI and tested nine potato cultivars (Atlantic, FL1833, FL1867, FL1879, Jacqueline Lee, Michigan Purple, Pike, Russet Norkotah, and Snowden). The nine varieties were planted at three times, which were done once the soil temperature at 4-in. reached a daily average of 8, 14 and 20^{o}C. The soil temperatures were monitored at each planting time with a Cole-Parmer 12 channel scanning thermometer. Each planting took place once the threshold (8, 14, 20^{o}C) was surpassed as a one day average. Timing 1 was planted 19 April, timing 2 on 17 May, and timing 3 on 28 June. Tubers were hand planted into pre-hilled sandy soil in four rows by 10 ft. treatments in a randomized complete block design. Plants were spaced approximately 12-in. apart, with each row having nine plants (36 plants total per replication). Vines were killed with Reglone 2EC (1 pt/A on 17 Sep). All tubers from four plants were harvested from all timings on 4 Oct. Tubers were washed and assessed for black scurf (*R. solani*) incidence (%) and severity 24 days after harvest on 28 Oct, as described above.

Results and Conclusions

The effect of seed treatment, fungicide application, and timing of the applications in-furrow at-planting, emergence or post-emergence on potato growth and development and yield (See Table 2 A- C)

Fungicide treatments on 'Superior' with no seed treatment

- The rate of emergence (RAUEPC) for applications of Headline at emergence (8) and 14 days post-emergence (9) were significantly higher than either the application of Amistar at 14 days post-emergence (3) or Headline applied at-planting (7), but there was not a significant difference between any treatment and the untreated control (10). Treatments with RAUEPC values between 0.39 - 0.44 and 0.41 - 0.45 were not significantly different.
- The number of tubers was significantly higher for treatments of Moncut at all three application times (4, 5, 6), and Headline applied at emergence (8) compared to the untreated control (10). There were no other significant differences among treatments with the exception between treatment of Amistar at-planting (1) and Moncut at emergence (5). Treatments with the number of tubers between 12.0 - 16.9, 14.1 - 19.0 and 16.9 - 20.5 were not significantly different.
- The number of stems for Moncut applied at emergence (5) and 14 days post-emergence (6) was significantly higher than the untreated control (10), but there was no difference among treatments. Treatments with the number of stems between 2.3 - 3.3 and 2.9 - 3.8 were not significantly different.
- The stolon number was significantly higher for Amistar applied at emergence (2) and Moncut applied at emergence (5) or 14 days post-emergence (6) compared to the untreated control (10), but there was not a significant difference among them. Also, applications of Moncut at emergence (5) and 14 days post-emergence (6) were significantly higher than applications of Amistar 14 days post-emergence (3), and at-planting applications of Moncut (4) and Headline (7). Treatments with the number of stolons between 10.9 - 14.1, 11.6 - 14.6, 12.4 - 16.0 and 13.4 - 16.9 were not significantly different.
- Marketable yield of Amistar applied at emergence (2) was significantly lower than either in-furrow at-planting applications of Amistar (1) or Headline (7), and Moncut applied 14 days post-emergence (6). However, no treatment was significantly different from the untreated control (10). Treatments

with a marketable yield between 381.3 – 424.4 and 390.0 – 441.6 cwt/A were not significantly different.

Fungicide treatments on 'Superior' with seed treatment

- Headline applied at emergence (8), 14 days post-emergence (9) and Amistar applied 14 days post-emergence (3) had significantly higher rates of emergence (RAUEPC) compared to Moncut applied in-furrow at-planting (4), but there was not a significant difference between any treatment and the untreated control (10). Treatments with a RAUEPC value between 0.41 - 0.46, 0.42 - 0.47 and 0.44 - 0.49 were not significantly different.
- The number of tubers was significantly higher for Headline applied at emergence (8) and 14 days post-emergence (9) compared to Moncut applied 14 days post-emergence (6) but no treatment significantly differed from the untreated control (10). Treatments with the number of tubers between 19.4 - 23.9, and 19.6 - 24.8 were not significantly different.
- Headline applied at emergence (8) had a significantly higher number of stems than the application of Amistar at emergence (2), but no treatment differed significantly from the untreated control (10). Treatments with the number of stems between 3.4 – 4.4 and 3.8 – 4.8 were not significantly different.
- The number of stolons was significantly higher for Headline applied at emergence (8) and 14 days post-emergence (9) compared to the untreated control (10). In addition, the number of stolons was significantly higher for Headline applied at emergence (8) compared to Amistar at emergence (2) and Moncut applied 14 days post-emergence. Treatments with the number of stolons between 16.1 – 20.8, 16.9 – 21.9, and 18.4 – 23.3 were not significantly different.
- Marketable yield was not significantly different among treatments (316.5 – 372.9 cwt/A).

Fungicide treatments on 'FL1879' with no seed treatment

- There was no significant difference among treatments for the rate of emergence (RAUEPC). Treatments with RAUEPC values between 0.11 - 0.14 were not significantly different.
- The number of tubers among treatments was not significantly different (23.5 – 43.6).
- Moncut applied in-furrow at-planting (4) had a significantly higher number of stems compared to either the untreated control (10) or Amistar applied at emergence (2). Treatments with the number of stems between 3.3 – 5.4 and 3.8 – 6.3 were not significantly different.
- Moncut applied in-furrow at-planting (4) had a significantly higher number of stolons compared to the untreated control (10). Treatments with the number of stolons between 34.1 – 49.8 and 40.0 – 59.9 were not significantly different.
- Amistar applied at emergence (2) had a significantly higher marketable yield than Moncut applied 14 days post-emergence (6), but no treatment was significantly different yield from the untreated control (10). Treatments with a marketable yield between 297.1 – 429.0 and 323.6 – 506.6 were not significantly different.

Fungicide treatments on 'FL1879' with seed treatment

- The untreated control (10) had a significantly lower rate of emergence (RAUEPC) than Amistar applied in-furrow at-planting (1), Moncut applied either in-furrow at-planting (4) or 14 days post-emergence (6) and Headline applied at emergence (8). Treatments with a RAUEPC value between 0.12 - 0.16, 0.13 – 0.17 and 0.14 and 0.18 were not significantly different.
- The number of tubers among treatments was not significantly different (31.5 – 45.8).
- Both Amistar applied in-furrow at-planting (1) and at emergence (2) had significantly higher numbers of stems compared to either Amistar or Headline applied 14 days post-emergence (3, 9). However, no treatment was significantly different from the untreated control (10). Treatments with the number of stems between 4.5 – 7.3 and 5.0 – 7.8 were not significantly different.
- The number of stolons among treatments was not significantly different (38.8 – 64.0).
- Moncut applied at emergence (5) had a significantly higher marketable yield than Amistar applied in-furrow at-planting (1), but no treatment was significantly different yield from the untreated control (10). Treatments with a marketable yield between 321.1 – 409.5 and 334.9 – 421.4 were not significantly different.

Fungicide treatments on 'Russet Norkotah' with no seed treatment

- Headline applied in-furrow at-planting (7) had a significantly higher rate of emergence (RAUEPC) than all other treatments except Headline applied at emergence (8). Treatments with a RAUEPC value between 0.19 - 0.21 and 0.21 and 0.22 were not significantly different.
- The number of tubers among treatments was not significantly different (24.8 – 33.9).
- The number of stems among treatments was not significantly different (3.8 – 5.1).
- Only Headline applied at emergence (8) had a significantly lower number of stolons compared to the untreated control (10). Treatments with the number of stolons between 10.0 – 15.5 and 10.3 – 16.3 were not significantly different.
- Amistar applied 14 days post-emergence (3) and Moncut applied in-furrow at-planting (4) both had significantly higher marketable yields than Headline applied at emergence (8), but there was no treatment was significantly different from the untreated control (10). Treatments with a marketable yield between 155.6 – 250.8 and 219.6 – 261.5 were not significantly different.

<u>Fungicide treatments on ‘Russet Norkotah’ with seed treatment</u>

- Amistar applied at emergence (2) and 14 days post-emergence (3) and Moncut at emergence (5) had significantly higher rates of emergence (RAUEPC) compared to Moncut applied 14 days after emergence (6). In addition, both Amistar applied 14 days post-emergence (3) and Moncut applied at emergence (5) had a significantly higher rate of emergence (RAUEPC) than Headline applied in-furrow at-planting (7). However, there was no treatment that had a significant difference from the untreated control (10). Treatments with a RAUEPC value between 0.185 - 0.204, 0.188 - 0.208, and 0.195 – 0.212 were not significantly different.
- The number of tubers among treatments was not significantly different (26.3 – 36.3).
- The number of stems among treatments was not significantly different (4.3 – 6.0).
- The number of stolons among treatments was not significantly different (10.1 – 17.1).
- Marketable yield was not significantly different among treatments (177.9 – 250.4 cwt/A).

The effect of seed treatment, fungicide application, and timing of the applications in-furrow at-planting, emergence or post-emergence on disease symptoms caused by *Rhizoctonia solani* growth and development (See Table 3 A – C)

<u>Fungicide treatments on ‘Superior’ with no seed treatment</u>

- Headline applied in-furrow at-planting (7) and 14 days post-emergence (9) had significantly lower percentages of diseased stems compared to Moncut applied in-furrow at-planting (4), but no treatment was significantly different from the untreated control (10). Treatments with the percentage of diseased stems between 13.5 – 37.5 and 16.7 – 41.7 were not significantly different.
- Moncut applied in-furrow at-planting (4) had a significantly higher percentage of diseased stolons than Moncut applied 14 days post-emergence (6) or Headline applied either in-furrow at-planting (7) or at emergence (8), but no treatment was significantly different from the untreated control (10). Treatments with the percentage of diseased stolons between 1.0 – 15.7 and 4.0 -23.2 were not significantly different.
- Headline applied at emergence (8) had a significantly higher incidence of Rhizoctonia sclerotia on mature tubers compared to Amistar applied 14 days post-emergence (3) and both Moncut and Headline applied in-furrow at-planting (4, 7). There was no significant difference between any treatment and the untreated control (10). Treatments with an incidence value between 0.0 – 23.8 and 7.5 – 35.0 were not significantly different.
- Headline applied at emergence (8) had a significantly higher severity of Rhizoctonia sclerotia on mature tubers compared to Amistar applied 14 days post-emergence (3) and both Moncut and Headline applied in-furrow at-planting (4, 7). There was no significant difference between any treatment and the untreated control (10). Treatments with a severity value between 0.0 – 12.8 and 3.4 – 17.2 were not significantly different.

<u>Fungicide treatments on ‘Superior’ with seed treatment</u>

- The percentage of diseased stems was not significantly different among treatments (6.4 – 16.9).

- Moncut applied 14 days post-emergence (6) had a significantly higher percentage of diseased stolons compared to the untreated control (10), all application timings of Amistar (1, 2, and 3), and both Moncut and Headline applied in-furrow at-planting (4, 7). Treatments with a percentage of diseased stems between 1.5 – 4.5 and 3.8 – 8.5 were not significantly different.
- The incidence of Rhizoctonia sclerotia on mature tubers was not significantly different among treatments (0.0 – 8.8).
- The severity of Rhizoctonia sclerotia on mature tubers was not significantly different among treatments (0.0 – 5.6).

<u>Fungicide treatments on ‘FL1879’ with no seed treatment</u>

- Headline applied in-furrow at-planting (7) had a significantly lower percentage of diseased stems than Headline applied at emergence (8) and Moncut applied in-furrow at-planting (4), but no treatment was significantly different from the untreated control (10). Treatments with a percentage of diseased stems between 14.8 – 42.9, 19.8 – 46.7 and 25.6 – 53.3 were not significantly different.
- Amistar applied in-furrow at-planting (1) had a significantly lower percentage of diseased stolons compared to Amistar applied at emergence (2) and both Headline applied at emergence (8) and 14 days post-emergence (9), but no treatment was significantly different from the untreated control (10). Treatments with a percentage of diseased stolons between 38.8 – 70.0, 43.8 – 75.0 and 53.8 – 81.3 were not significantly different.
- Headline applied at emergence (8) had a significantly higher incidence of Rhizoctonia sclerotia on mature potatoes compared to Amistar applied in-furrow at-planting (1) and Moncut applied 14 days post-emergence (6), but no treatment that was significantly different from the untreated control (10). Treatments with an incidence value between 38.8 – 70.0, 43.8 – 75.0, and 53.8 – 81.3 were not significantly different.
- Headline applied at emergence (8) had a significantly higher severity of Rhizoctonia sclerotia on mature potatoes compared to Amistar applied in-furrow at-planting (1) and Moncut applied 14 days post-emergence (6), but no treatment was significantly different from the untreated control (10). Treatments with a severity value between 18.4 – 39.4, and 24.7 – 44.7 were not significantly different.

<u>Fungicide treatments on ‘FL1879’ with seed treatment</u>

- Headline applied in-furrow at-planting (7) had a significantly higher percentage of diseased stems compared to Amistar applied at emergence (2) and Headline applied 14 days post-emergence (9), but no treatment was significantly different from the untreated control (10). Treatments with a percentage of diseased stems between 11.9 – 43.1 and 23.2 – 54.1 were not significantly different.
- Amistar applied at emergence (2) had a significantly lower percentage of diseased stolons compared to the untreated control (10). Treatments with a percentage of diseased stolons between 10.2 - 33.4 and 23.1 – 40.6 were not significantly different.
- The incidence of Rhizoctonia sclerotia on mature tubers was not significantly different among treatments (47.5 – 77.5).
- The severity of Rhizoctonia sclerotia on mature tubers was not significantly different among treatments (21.9 – 41.9).

<u>Fungicide treatments on ‘Russet Norkotah’ with no seed treatment</u>

- Headline applied at emergence (8) had a significantly lower percentage of diseased stems compared to either Headline applied in-furrow at-planting (7) or the untreated control (10). Treatments with a percentage of diseased stems between 42.1 – 72.9 and 58.1 – 82.3 were not significantly different.
- The percentage of diseased stolons was not significantly different among treatments (28.6 – 54.9).
- Amistar applied at emergence (2) had significantly lower incidence of Rhizoctonia sclerotia on mature tubers compared to Headline applied in-furrow at-planting (7), and either Amistar or Moncut applied 14 days post-emergence (3, 6). However, no treatment was significantly different from the untreated control (10). Treatments with an incidence value between 30.0 – 56.3 and 42.5 – 63.8 were not significant.

- Amistar applied at emergence (2) had significantly lower severity of Rhizoctonia sclerotia on mature tubers compared to the untreated control (10), Moncut either applied in-furrow at-planting (4) or 14 days post-emergence (6), Headline applied in-furrow at-planting (7) and Amistar applied 14 days post-emergence (3). Treatments with a severity value between 10.0 – 23.8 and 17.8 – 31.6 were not significant.

Fungicide treatments on 'Russet Norkotah' with seed treatment

- Amistar applied at emergence (2) and Headline applied in-furrow at-planting (7) had significantly lower percentages of diseased stems compared to Moncut applied in-furrow at-planting (4), but no treatment was significantly different from the untreated control (10). Treatments with a percentage of diseased stems between 45.2 – 75.7 and 51.9 – 80.8 were not significantly different.
- Headline applied in-furrow at-planting (7) had significantly lower percentages of diseased stolons compared to Amistar applied 14 days post-emergence (3), Moncut applied in-furrow at-planting (4), and Headline applied at emergence (8), but no treatment was significantly different from the untreated control (10). Treatments with a percentage of diseased stolons between 9.9 – 33.9 and 16.6 – 41.8 were not significantly different.
- The incidence of Rhizoctonia sclerotia on mature tubers was not significantly different among treatments (37.5 – 56.3).
- The severity of Rhizoctonia sclerotia on mature tubers was not significantly different among treatments (15.6 – 26.6).

The effect of seed treatment on potato growth and development and yield (See Table 4) and on disease symptoms caused by *Rhizoctonia solani* growth and development (See Table 5)

'Superior'

- Treatments with the seed treatment Maxim 4FS had significant increases in the rate of emergence (RAUEPC), tuber, stem and stolon number, but had a significant decrease in marketable yield when compared to treatments without the seed treatment.
- Treatments with the seed treatment had a significantly lower percentage of stems and stolons with greater than 5% girdling, compared with treatments without the seed treatment. In addition, treatments with the seed treatment also significantly reduced both the incidence and severity of sclerotia formed by *Rhizoctonia solani* on mature tubers, when compared to treatments without the seed treatment.

'FL1879'

- Treatments with the seed treatment Maxim 4FS had significant increases in the rate of emergence (RAUEPC), and the number of tubers, when compared to treatments without the seed treatment. However, there were not significant differences for the number of tubers, numbers of stolons or marketable yield.
- The treatments with the seed treatment significantly reduced the percentage of stems with greater than 5% girdling, when compared to treatments without the seed treatment. There was no significant difference between treatments with and without the seed treatment for the percentage of stolons with greater than 5% girdling, or the incidence and severity of sclerotia formed by *Rhizoctonia solani* on mature tubers.

'Russet Norkotah'

- Treatments with the seed treatment Maxim 4FS had a significant increase on the number of tubers, compared with treatments without the seed treatment. There were not significant differences between treatments with and without the seed treatment for the rate of emergence (RAUEPC), the number of tubers, numbers of stolons or marketable yield.
- Treatments with the seed treatment significantly reduced the percent of solons with greater than 5% girdling, compared to treatments without the seed treatment. There was no significant difference between treatments with and without the seed treatment for the percentage of stems with greater than 5% girdling, or the incidence and severity of sclerotia formed by *Rhizoctonia solani* on mature tubers.

The effect of seed treatment and the timing of application of fungicides in-furrow at-planting (IF), emergence (Em), or 14 days post-emergence (PE) on potato growth and development and yield (see Table 6), and on disease symptoms caused by *Rhizoctonia solani* (see Table 7)

‘Superior’ with no seed treatment

- There was no significant difference among application times for the rate of emergence (RAUEPC). Application times with RAUEPC values between 0.40 – 0.43 were not significantly different. Also, there was no significant difference among application times for the number of tubers (15.6 – 18.7) and the number of stems (3.1 – 3.3). Treatments that were applied at emergence (Em) had significantly higher number of stolons compared to treatments applied in-furrow at-planting (IF). Application times with the number of stolons between 12.3 – 13.8 and 13.8 – 14.9 were not significantly different. Treatments applied in-furrow at-planting (IF) had significantly higher marketable yield when compared to treatments applied at emergence (Em). Application times with a marketable yield between 391.0 – 417.8 and 417.8 – 432.1 were not significantly different.
- There was no significant difference among application times for the percentage of diseased stems (18.1 – 27.5), percentage of diseased stolons (7.2 – 13.3), or the severity of *R. solani* on mature tubers (1.7 – 10.4). Treatments applied in-furrow at-planting (IF) had a significantly lower incidence of *R. solani* on mature tubers compared to treatments applied at emergence (Em).

‘Superior’ with seed treatment

- The rate of emergence (RAUEPC) for treatments applied in-furrow at-planting (IF, 0.42) was significantly lower than treatments applied either at emergence (Em, 0.46) or 14 days post-emergence (PE, 0.45). Application times were not significantly different for the number of tubers (21.8 – 23.0), stems (4.0 – 4.2), stolons (19.5 – 19.6) or marketable yield (335.2 – 358.4 cwt/A).
- There was no significant difference among application times for the percentage of diseased stems (8.8 – 13.7), incidence of *R. solani* on mature tubers (2.5 – 2.9), or the severity of *R. solani* on mature tubers (0.8 – 1.9). Treatments applied in-furrow at-planting (IF) had a significantly lower percentage of diseased stolons compared to treatments applied 14 days post-emergence (PE). Application times with a percentage of diseased stolons between 2.7 – 3.7 and 3.7 – 5.5 were not significantly different.

‘FL1879’ with no seed treatment

- Application times were not significantly different for the rate of emergence (RAUEPC) (0.12 – 0.13), the number of tubers (35.0 – 37.5), stems (4.3 – 5.3), stolons (42.4 – 49.9), and marketable yield (369.4 – 392.5 cwt/A).
- There was no significant difference among application times for either the percentage of diseased stems (37.4 – 53.3) or the percentage of diseased stolons (29.6 – 34.4). Treatments applied in-furrow at-planting (IF) had both a significantly lower incidence and severity of sclerotia formed by *Rhizoctonia solani* compared to treatments applied at emergence (Em). Application times with an incidence value between 51.7 – 59.2 and 59.2 – 74.6, or severity values between 24.3 – 30.5 and 30.5 – 40.7 were not significantly different.

‘FL1879’ with seed treatment

- Application times were not significantly different for the rate of emergence (RAUEPC) (0.15 – 0.16), the number of tubers (36.2 – 42.5), stems (5.4 – 6.5), stolons (46.9 – 60.5), and marketable yield (359.1 – 366.1 cwt/A).
- Application times were not significantly different for the percentage of diseased stems (21.5 – 41.0), percentage of diseased stolons (21.1 – 27.5), incidence of sclerotia formed by *Rhizoctonia solani* (56.3 – 65.4) and severity of sclerotia (27.1 – 35.3).

‘Russet Norkotah’ with no seed treatment

- Application times were not significantly different for the rate of emergence (RAUEPC) (0.19 – 0.20), the number of tubers (27.7 – 29.7), stems (3.8 – 4.6), stolons (11.4 – 12.8), and marketable yield (208.0 – 249.7 cwt/A).
- Application times were not significantly different for the percentage of diseased stems (57.2 – 75.0), percentage of diseased stolons (35.3 – 39.2), and incidence of sclerotia formed by *Rhizoctonia solani* (42.9 – 57.1). Treatments applied at emergence (Em) had a significantly lower severity of sclerotia

formed by *Rhizoctonia solani* on mature tubers compared to treatments applied 14 days post-emergence (PE). Application times with a severity value between 17.7 – 23.6 and 23.6 – 26.7 were not significantly different.

‘Russet Norkotah’ with seed treatment

- Application times were not significantly different for the rate of emergence (RAUEPC) (0.19 – 0.20), the number of tubers (30.9 – 32.5), stems (4.6 – 5.3), stolons (13.4 – 14.4), and marketable yield (192.9 – 228.7 cwt/A).
- Application times were not significantly different for the percentage of diseased stems (60.5 – 64.2), percentage of diseased stolons (25.6 – 32.3), incidence of sclerotia formed by *Rhizoctonia solani* (44.2 – 50.0) and severity of sclerotia (19.2 – 22.0).

The effect of planting time for nine varieties of potato, based upon soil temperature (8, 14, or 20^{o}C), on incidence and severity of sclerotia formed by *Rhizoctonia solani* on mature tubers; East Lansing, MI; 2004 (See Table 8)

Timing 1 (8^o C)

- There was no difference among cultivars for the incidence of sclerotia formed by *R. solani* on mature tubers (61.65 – 100).
- ‘FL1833’ had a significantly higher value of severity of sclerotia formed by *R. solani* on mature tubers compared to cultivars ‘Pike’, ‘FL1879,’ and ‘Snowden. Cultivars with a severity value between 10.92 - 22.08 and 14.61 – 29.48 were not significantly different.

Timing 2 (14^o C)

- ‘Jacqueline Lee’ had a significantly higher incidence of sclerotia formed by *R. solani* on mature tubers compared to all cultivars except ‘Snowden’, ‘FL1833’, and ‘FL1879’. Cultivars with an incidence value between 4.23 – 39.28 and 13.27 – 62.83 were not significantly different.
- ‘Jacqueline Lee’ had a significantly higher severity of sclerotia formed by *R. solani* on mature tubers compared to all cultivars except ‘Snowden’, ‘FL1833’, and ‘FL1879’. Cultivars with a severity value between 0.42 – 7.19 and 4.35 – 11.54 were not significantly different.

Timing 3 (20^o C)

- Both cultivars ‘MI Purple’ and ‘FL1879’ had a significantly lower incidence of sclerotia formed by *R. solani* on mature tubers compared to ‘Jacqueline Lee’, ‘Atlantic’, and ‘Snowden’. Cultivars with an incidence value between 0.0 – 15.18, 5.68 – 29.00, 15.18 – 37.02 were not significantly different.
- Both cultivars ‘MI Purple’ and ‘FL1879’ had significantly lower incidence of sclerotia formed by *R. solani* on mature tubers compared to ‘Jacqueline Lee’, and ‘Snowden’. Cultivars with an incidence value between 0.0 – 2.14, 0.36 – 6.75, 0.57 – 7.16 and 2.14 – 8.35 were not significantly different.

The effect of planting time based upon soil temperature (8, 14, or 20^{o}C) on incidence and severity of sclerotia formed by *Rhizoctonia solani* on mature tubers; East Lansing, MI; 2004 (See Table 9)

- Planting time 1 (8^{o}C) had a significantly higher incidence of sclerotia formed by *R. solani* on mature tubers compared to planting times 2 (14^{o}C) and 3 (20^{o}C).
- Planting time 1 (8^{o}C) had a significantly higher severity of sclerotia formed by *R. solani* on mature tubers compared to planting times 2 (14^{o}C) and 3 (20^{o}C).

Table 2a-c: The effect of seed treatment, fungicide application, and the timing of application; in-furrow at-planting (IF), emergence (Em), or 14 days post-emergence (PE) on potato growth and development and yield. Experiments located at A) Elmira, MI, ‘Superior’; B) Bath, MI, ‘FL1879’; C) Bath, MI, ‘Russet Norkotah’; 2004.

Treatment number	Seed Treatment	Treatment Application (amount per 1000 ft)	Application timing [z]	Rate of Emergence (RAUEPC) [y]		Tuber number [x]		Stem number [x]		Stolon number [x]		Marketable Yield cwt/A [w]	
A 1	None	Amistar 80WDG 0.25 oz	IF	0.41	ab [u]	14.1	bc	2.9	ab	13.4	abcd	441.6	a
2			Em	0.41	ab	16.9	abc	3.1	ab	14.6	abc	381.3	b
3			PE	0.39	b	14.5	bc	2.9	ab	12.1	cd	424.4	ab
4		Moncut 70DF 1.18 oz	IF	0.41	ab	19.0	ab	3.3	ab	11.6	cd	416.1	ab
5			Em	0.43	ab	20.5	a	3.8	a	16.0	ab	392.6	ab
6			PE	0.44	ab	17.1	ab	3.6	a	16.9	a	439.1	a
7		Headline 0.21 fl oz	IF	0.39	b	14.3	bc	3.0	ab	11.8	cd	438.6	a
8			Em	0.45	a	18.8	ab	3.1	ab	14.1	abcd	399.1	ab
9			PE	0.44	a	15.3	bc	2.9	ab	12.4	bcd	390.0	ab
10		Non-treated		0.44	ab	12.0	c	2.3	b	10.9	d	409.6	ab
1	Maxim 4FS [v]	Amistar 0.25 oz	IF	0.44	bc	22.6	ab	4.4	ab	19.7	abc	335.6	a
2			Em	0.44	abc	20.6	ab	3.4	b	16.9	bc	316.5	a
3			PE	0.47	ab	22.9	ab	4.0	ab	19.3	abc	358.9	a
4		Moncut 70 DF 1.18 oz	IF	0.41	c	23.9	ab	4.0	ab	18.4	abc	349.5	a
5			Em	0.46	abc	19.9	ab	3.8	ab	18.4	abc	338.0	a
6			PE	0.43	bc	19.4	b	4.1	ab	17.4	bc	344.6	a
7		Headline 0.21 fl oz	IF	0.42	bc	22.4	ab	3.9	ab	20.8	abc	360.0	a
8			Em	0.49	a	24.8	a	4.8	a	23.3	a	351.1	a
9			PE	0.46	ab	24.8	a	4.4	ab	21.9	ab	371.8	a
10		Non-treated		0.45	abc	19.6	ab	4.1	ab	16.1	c	372.9	a

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[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] RAUEPC: Relative area under the emergence progress curve (max = 100), calculated from the day of planting to 38 days after planting

[x] Numbers of tubers, stems, and stolons are the average of 4 plants (per replicate) taken 50 days after planting

[w] Marketable yield: all tubers greater than 2.5” in any plane (US1 grade), 84 days after planting for

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Funding MPIC and MSU

Treatment number	Seed Treatment	Treatment Application (amount per 1000 ft)	Application timing [z]	Rate of Emergence (RAUEPC) [y]		Tuber number [x]		Stem number [x]		Stolon number [x]		Marketable Yield cwt/A [w]	
B 1	None	Amistar 80WDG 0.25 oz	IF	0.11	a	28.8	a	4.4	ab	41.9	ab	413.1	ab
2			Em	0.11	a	32.0	a	3.3	b	42.6	ab	506.6	a
3			PE	0.14	a	35.8	a	3.8	ab	40.0	ab	429.0	ab
4		Moncut 70DF 1.18 oz	IF	0.14	a	40.1	a	6.3	a	59.0	a	350.1	ab
5			Em	0.13	a	42.4	a	5.1	ab	49.8	ab	330.9	ab
6			PE	0.13	a	30.9	a	4.6	ab	40.1	ab	297.1	b
7		Headline 0.21 fl oz	IF	0.13	a	43.6	a	5.3	ab	48.9	ab	352.8	ab
8			Em	0.12	a	33.4	a	5.4	ab	40.1	ab	340.0	ab
9			PE	0.12	a	38.4	a	4.4	ab	47.1	ab	382.1	ab
10		Non-treated		0.12	a	28.5	a	3.3	b	34.1	b	323.6	ab
1	Maxim 4FS [v]	Amistar 0.25 oz	IF	0.17	ab	40.5	a	7.8	a	64.0	a	321.1	b
2			Em	0.15	abc	40.1	a	7.5	a	52.8	a	339.0	ab
3			PE	0.13	bc	41.8	a	4.5	b	50.1	a	334.9	ab
4		Moncut 70 DF 1.18 oz	IF	0.17	ab	41.1	a	5.8	ab	56.3	a	393.3	ab
5			Em	0.16	abc	31.5	a	5.0	ab	38.8	a	421.4	a
6			PE	0.17	ab	40.3	a	7.3	ab	59.3	a	409.5	ab
7		Headline 0.21 fl oz	IF	0.15	abc	45.8	a	6.1	ab	61.4	a	363.0	ab
8			Em	0.18	a	37.0	a	5.0	ab	49.1	a	337.9	ab
9			PE	0.14	abc	43.8	a	4.5	b	46.8	a	349.9	ab
10		Non-treated		0.12	c	41.3	a	5.6	ab	42.5	a	395.3	ab

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] RAUEPC: Relative area under the emergence progress curve (max = 100), calculated from the day of planting to 20 days after planting

[x] Numbers of tubers, stems, and stolons are the average of 2 plants taken 50 days after planting

[w] Marketable yield: all tubers greater than 2.5” in any plane (US1 grade), 90 days after planting

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Treatment number	Seed Treatment	Treatment Application (amount per 1000 ft)	Application timing [z]	Rate of Emergence (RAUEPC) [y]		Tuber number [x]		Stem number [x]		Stolon number [x]		Marketable Yield cwt/A [w]	
C 1	None	Amistar 80WDG 0.25 oz	IF	0.19	b	30.0	a	3.8	a	12.1	ab	250.8	ab
2			Em	0.19	b	33.3	a	4.0	a	15.5	ab	242.1	ab
3			PE	0.19	b	30.5	a	5.1	a	13.3	ab	261.5	a
4		Moncut 70DF 1.18 oz	IF	0.19	b	30.5	a	3.8	a	11.0	ab	255.8	a
5			Em	0.19	b	24.8	a	4.4	a	10.3	ab	226.4	ab
6			PE	0.19	b	30.8	a	4.8	a	14.9	ab	240.5	ab
7		Headline 0.21 fl oz	IF	0.22	a	28.5	a	3.8	a	11.0	ab	219.6	ab
8			Em	0.21	ab	25.1	a	4.4	a	10.0	b	155.6	b
9			PE	0.19	b	27.0	a	4.0	a	10.4	ab	247.1	ab
10		Non-treated		0.19	b	33.9	a	4.5	a	16.3	a	232.1	ab
1	Maxim 4FS [v]	Amistar 0.25 oz	IF	0.20	abc	30.8	a	6.0	a	13.5	a	191.6	a
2			Em	0.21	ab	36.1	a	4.6	a	17.1	a	228.1	a
3			PE	0.21	a	35.3	a	6.0	a	15.1	a	194.3	a
4		Moncut 70 DF 1.18 oz	IF	0.20	abc	36.3	a	4.5	a	16.1	a	209.3	a
5			Em	0.21	a	28.6	a	4.8	a	10.1	a	237.8	a
6			PE	0.18	c	34.1	a	5.4	a	16.9	a	250.4	a
7		Headline 0.21 fl oz	IF	0.19	bc	29.0	a	4.4	a	13.5	a	177.9	a
8			Em	0.19	abc	28.0	a	4.5	a	13.0	a	220.3	a
9			PE	0.20	abc	28.3	a	4.4	a	10.9	a	224.6	a
10		Non-treated		0.20	abc	26.3	a	4.3	a	16.4	a	191.9	a

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] RAUEPC: Relative area under the emergence progress curve (max = 100), calculated from the day of planting to 20 days after planting

[x] Numbers of tubers, stems, and stolons are the average of 2 plants taken 50 days after planting

[w] Marketable yield: all tubers greater than 2.5” in any plane (US1 grade), 90 days after planting

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Table 3a-c: The effect of seed treatment, fungicide application, and the timing of application; in-furrow at-planting (IF), emergence (Em), or 14 days post-emergence (PE) on disease symptoms caused by *Rhizoctonia solani* growth and development. Experiments located at A) Elmira, MI, ‘Superior’; B) Bath, MI, ‘FL1879’; C) Bath, MI, ‘Russet Norkotah’; 2004.

Treatment number	Seed Treatment	Treatment Application (amount per 1000 ft)	Application timing [z]	Percentage of diseased stems [y]		Percentage of diseased stolons [y]		Rhizoctonia incidence on mature tubers [x]		Rhizoctonia severity on mature tubers [w]	
A 1	None	Amistar 80WDG 0.25 oz	IF	24.5	ab [u]	9.1	ab	10.0	ab	5.0	ab
2			Em	24.7	ab	13.3	ab	7.5	ab	3.4	ab
3			PE	24.0	ab	12.6	ab	0.0	b	0.0	b
4		Moncut 70DF 1.18 oz	IF	41.7	a	23.2	a	0.0	b	0.0	b
5			Em	37.5	ab	12.2	ab	23.8	ab	10.6	ab
6			PE	16.7	ab	1.0	b	15.0	ab	6.3	ab
7		Headline 0.21 fl oz	IF	14.1	b	7.7	b	0.0	b	0.0	b
8			Em	20.2	ab	4.0	b	35.0	a	17.2	a
9			PE	13.5	b	8.0	ab	23.8	ab	12.8	ab
10		Non-treated		26.6	ab	15.7	ab	20.0	ab	10.0	ab
1	Maxim 4FS [v]	Amistar 0.25 oz	IF	16.9	a	3.3	b	0.0	a	0.0	a
2			Em	15.8	a	2.7	b	0.0	a	0.0	a
3			PE	13.0	a	3.6	b	3.8	a	1.6	a
4		Moncut 70 DF 1.18 oz	IF	12.2	a	2.1	b	7.5	a	3.4	a
5			Em	11.3	a	3.8	ab	0.0	a	0.0	a
6			PE	8.3	a	8.5	a	2.5	a	0.6	a
7		Headline 0.21 fl oz	IF	8.2	a	1.8	b	0.0	a	0.0	a
8			Em	7.8	a	4.5	ab	8.8	a	5.6	a
9			PE	6.9	a	4.5	ab	1.3	a	0.3	a
10		Non-treated		6.4	a	1.5	b	7.5	a	2.8	a

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] Percent of stems and stolons with greater than 5% girdling caused by *Rhizoctonia solani* are from an average of 4 plants per replicate

[x] Percent incidence of tubers with sclerotia of R. solani from a sample of 20 tubers per replicate taken 84 days after planting

[w] Severity of black scurf (index calculated by counting the tuber number (n = 20 per replicate) falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia (Taken 84 days after planting).

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Treatment number	Seed Treatment	Treatment Application (amount per 1000 ft)	Application timing [z]	Percentage of diseased stem number [y]		Percentage of diseased stolon number [y]		Rhizoctonia incidence on mature tubers [x]		Rhizoctonia severity on mature tubers [w]	
B 1	None	Amistar 80WDG 0.25 oz	IF	40.3	ab [u]	41.8	abc	38.8	c	18.4	b
2			Em	38.5	ab	26.2	abc	72.5	ab	38.4	ab
3			PE	51.9	ab	25.6	abc	58.8	abc	29.4	ab
4		Moncut 70DF 1.18 oz	IF	53.7	a	46.7	ab	62.5	abc	29.7	ab
5			Em	55.3	a	19.8	bc	70.0	abc	39.1	ab
6			PE	43.6	ab	32.4	abc	43.8	bc	22.8	b
7		Headline 0.21 fl oz	IF	18.2	b	14.8	c	53.8	abc	24.7	ab
8			Em	31.4	ab	53.3	a	81.3	a	44.7	a
9			PE	64.4	a	30.8	abc	75.0	ab	39.4	ab
10		Non-treated		50.4	ab	42.9	abc	67.5	abc	35.9	ab
1	Maxim 4FS [v]	Amistar 0.25 oz	IF	28.6	ab	23.1	ab	47.5	a	21.9	a
2			Em	14.5	b	10.2	b	77.5	a	41.9	a
3			PE	32.9	ab	25.0	ab	57.5	a	31.3	a
4		Moncut 70 DF 1.18 oz	IF	40.3	ab	28.8	ab	60.0	a	28.8	a
5			Em	23.2	ab	27.8	ab	55.0	a	29.1	a
6			PE	43.1	ab	33.4	ab	61.3	a	32.2	a
7		Headline 0.21 fl oz	IF	54.1	a	24.3	ab	65.0	a	30.6	a
8			Em	26.9	ab	25.3	ab	63.8	a	35.0	a
9			PE	11.9	b	24.0	ab	50.0	a	25.3	a
10		Non-treated		38.2	ab	40.6	a	53.8	a	24.4	a

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE).

[y] Percent of stems and stolons with greater than 5% girdling caused by *Rhizoctonia solani* are from an average of two plants per replicate.

[x] Percent incidence of tubers with sclerotia of *Rhizoctonia solani* from a sample of 20 tubers per replicate 90 days after planting

[w] Severity of black scurf (index calculated by counting the tuber number (n = 20 per replicate) falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia (Taken 90 days after planting).

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Treatment number	Seed Treatment	Treatment Application (amount per 1000 ft)	Application timing[z]	Percentage of diseased stem number[y]		Percentage of diseased stolon number[y]		Rhizoctonia incidence on mature tubers[x]		Rhizoctonia severity on mature tubers[w]	
C 1	None	Amistar 80WDG 0.25 oz	IF	72.5	ab[u]	53.6	a	42.5	ab	17.8	ab
2			Em	71.4	ab	36.6	a	30.0	b	10.0	b
3			PE	72.9	ab	28.6	a	57.5	a	28.8	a
4		Moncut 70DF 1.18 oz	IF	70.8	ab	31.5	a	48.8	ab	25.0	a
5			Em	58.1	ab	31.2	a	45.0	ab	19.4	ab
6			PE	72.0	ab	54.9	a	62.5	a	31.6	a
7		Headline 0.21 fl oz	IF	81.7	a	30.5	a	63.8	a	28.1	a
8			Em	42.1	b	38.0	a	53.8	ab	23.8	ab
9			PE	67.5	ab	33.9	a	51.3	ab	19.7	ab
10		Non-treated		82.3	a	38.7	a	56.3	ab	28.1	a
1	Maxim 4FS[v]	Amistar 0.25 oz	IF	57.4	ab	31.1	ab	43.8	a	18.8	a
2			Em	45.2	b	22.2	ab	45.0	a	20.6	a
3			PE	64.5	ab	37.3	a	55.0	a	25.6	a
4		Moncut 70 DF 1.18 oz	IF	80.8	a	41.8	a	56.3	a	25.3	a
5			Em	71.6	ab	33.9	ab	53.8	a	26.6	a
6			PE	53.4	ab	16.6	ab	40.0	a	15.6	a
7		Headline 0.21 fl oz	IF	45.4	b	9.9	b	50.0	a	21.9	a
8			Em	75.7	ab	40.8	a	48.8	a	18.4	a
9			PE	63.5	ab	22.8	ab	37.5	a	16.3	a
10		Non-treated		51.9	ab	29.7	ab	37.5	a	16.3	a

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] Percent of stems and stolons with greater than 5% girdling caused by R. solani are from an average of two plants per replicate

[x] Percent incidence of tubers with sclerotia of R. solani from a sample of 20 tubers per replicate taken 90 days after planting

[w] Severity of black scurf (index calculated by counting the tuber number (n = 20 per replicate) falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3= 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia (Taken 90 days after planting).

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Table 4: Effect of seed treatment on potato growth and development and yield; Experiments located at A) Elmira, MI, ‘Superior’; B) Bath, MI, ‘FL1879’; C) Bath, MI, ‘Russet Norkotah’; 2004

Variety and Location		Seed Treatment	Rate of Emergence (RAUEPC) [z]		Tuber number [y]		Stem number [y]		Stolon number [y]		Marketable Yield cwt/A [x]	
A	Superior	None	0.42	b [v]	16.2	b	3.1	b	13.4	b	413.3	a
		Maxim 4FS [w]	0.45	a	22.1	a	4.1	a	19.2	a	349.9	b
B	FL 1879	None	0.13	b	35.4	a	4.6	b	44.4	a	420.9	a
		Maxim 4FS	0.15	a	40.3	a	5.9	a	52.1	a	441.2	a
C	Russet Norkotah	None	0.20	a	29.4	a	4.2	b	12.5	a	306.2	a
		Maxim 4FS	0.20	a	31.3	a	4.9	a	14.3	a	313.4	a

[z] RAUEPC: Relative area under the emergence progress curve (max = 100), calculated from the day of planting to 38 days after planting for “Superior,” calculated from the day of planting to 20 days after planting for “FL 1879” and “Russet Norkotah”.

[y] Numbers of tubers, stems, and stolons are the average of 4 plants (per replicate) taken 50 days after planting for “Superior” and the average of 2 plants taken 50 days after planting for “FL 1879” and “Russet Norkotah”.

[x] Marketable yield: all tubers greater than 2.5” in any plane (US1 grade), 84 days after planting for “Superior” and 90 days after planting for “FL 1879” and “Russet Norkotah”.

[w] Maxim 4FS at seed treatment at 0.08 fl oz/cwt.

[v] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison).

Table 5: Effect of seed treatment on disease symptoms caused by *Rhizoctonia solani* growth and development; Experiments located at A) Elmira, MI, 'Superior'; B) Bath, MI, 'FL1879'; C) Bath, MI, 'Russet Norkotah'; 2004

Variety and Location		Seed Treatment	Percent stems with greater than 5% girdling due to R. solani [z]		Percent stolons with greater than 5% girdling due to R. solani [z]		Incidence of black scurf on tubers (%) [y]		Index of severity of black scurf on tubers [x]	
A	Superior	None	24.3	a [v]	10.7	a	13.5	a	6.5	a
		Maxim 4FS [w]	10.7	b	3.6	b	3.1	b	1.4	b
B	FL 1879	None	44.8	a	33.4	a	62.4	a	32.3	a
		Maxim 4FS	31.4	b	26.2	a	59.1	a	30.0	a
C	Russet Norkotah	None	69.1	a	37.8	a	51.1	a	23.2	a
		Maxim 4FS	60.9	a	28.6	b	46.8	a	20.5	a

[z] Percent of stems and stolons with greater than 5% girdling caused by R. solani are from an average of 4 plants per replicate for 'Superior' and an average of 2 plants per replicate for 'FL1879' and 'Russet Norkotah'

[y] Percent incidence of tubers with sclerotia of R. solani from a sample of 20 tubers per replicate taken 84 days after planting for "Superior" and 90 days after planting for "FL 1879" and "Russet Norkotah"

[x] Severity of black scurf (index calculated by counting the tuber number (n = 20 per replicate) falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia (Taken 84 days after planting for "Superior" and 90 days after planting for "FL 1879" and "Russet Norkotah").

[w] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[v] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Table 6: The effect of seed treatment and the timing of application of fungicides in-furrow at-planting (IF), emergence (Em), or 14 days post-emergence (PE) on potato growth and development and yield. Experiments located at A) Elmira, MI, 'Superior'; B) Bath, MI, 'FL1879'; C) Bath, MI, 'Russet Norkotah'; 2004.

Variety and Location		Seed Treatment	Application timing [z]	Rate of Emergence (RAUEPC) [y]		Tuber number [x]		Stem number [x]		Stolon number [x]		Total MaketableYield cwt/A [w]	
A	Superior	None	IF	0.40	a [u]	15.8	a	3.1	a	12.3	b	432.1	a
			Em	0.43	a	18.7	a	3.3	a	14.9	a	391.0	b
			PE	0.42	a	15.6	a	3.1	a	13.8	ab	417.8	ab
		Maxim 4FS [v]	IF	0.42	b	23.0	a	4.1	a	19.6	a	348.4	a
			Em	0.46	a	21.8	a	4.0	a	19.5	a	335.2	a
			PE	0.45	a	22.4	a	4.2	a	19.5	a	358.4	a
B	FL1879	None	IF	0.13	a	37.5	a	5.3	a	49.9	a	372.0	a
			Em	0.12	a	35.9	a	4.6	a	44.2	a	392.5	a
			PE	0.13	a	35.0	a	4.3	a	42.4	a	369.4	a
		Maxim 4FS [v]	IF	0.16	a	42.5	a	6.5	a	60.5	a	359.1	a
			Em	0.16	a	36.2	a	5.8	a	46.9	a	366.1	a
			PE	0.15	ab	41.9	a	5.4	a	52.0	a	364.8	a
C	Russet Norkotah	None	IF	0.20	a	29.7	a	3.8	a	11.4	a	242.0	a
			Em	0.20	a	27.7	a	4.3	a	11.9	a	208.0	a
			PE	0.19	a	29.4	a	4.6	a	12.8	a	249.7	a
		Maxim 4FS [v]	IF	0.19	a	32.0	a	5.0	a	14.4	a	192.9	a
			Em	0.20	a	30.9	a	4.6	a	13.4	a	228.7	a
			PE	0.20	a	32.5	a	5.3	a	14.3	a	223.1	a

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] RAUEPC: Relative area under the emergence progress curve (max = 100), calculated from the day of planting to 20 days after planting

[x] Numbers of tubers, stems, and stolons are the average of 2 plants taken 50 days after planting

[w] Marketable yield: all tubers greater than 2.5" in any plane (US1 grade), 90 days after planting

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Table 7: The effect of seed treatment and the timing of application of fungicides in-furrow at-planting (IF), emergence (Em), or 14 days post-emergence (PE) on disease symptoms caused by *Rhizoctonia solani* growth and development. Experiments located at A) Elmira, MI, ‘Superior’; B) Bath, MI, ‘FL1879’; C) Bath, MI, ‘Russet Norkotah’; 2004.

Variety and Location		Seed Treatment	Application timing [z]	Percentage of diseased stem number [y]		Percentage of diseased stolon number [y]		Rhizoctonia incidence on mature tubers [x]		Rhizoctonia severity on mature tubers [w]	
A	Superior	None	IF	26.7	a	13.3	a	3.3	b	1.7	a
			Em	27.5	a	9.8	a	22.1	a	10.4	a
			PE	18.1	a	7.2	a	12.9	ab	6.4	a
		Maxim 4FS [v]	IF	8.8	a	2.4	b	2.5	a	1.1	a
			Em	7.5	a	3.7	ab	2.9	a	1.9	a
			PE	13.7	a	5.5	a	2.5	a	0.8	a
B	FL1879	None	IF	37.4	a	34.4	a	51.7	b	24.3	b
			Em	41.8	a	33.1	a	74.6	a	40.7	a
			PE	53.3	a	29.6	a	59.2	ab	30.5	ab
		Maxim 4FS [v]	IF	41.0	a	25.4	a	57.5	a	27.1	a
			Em	21.5	a	21.1	a	65.4	a	35.3	a
			PE	29.3	a	27.5	a	56.3	a	29.6	a
C	Russet Norkotah	None	IF	75.0	a	38.5	a	51.7	a	23.6	ab
			Em	57.2	a	35.3	a	42.9	a	17.7	b
			PE	70.8	a	39.2	a	57.1	a	26.7	a
		Maxim 4FS [v]	IF	61.2	a	27.6	a	50.0	a	22.0	a
			Em	64.2	a	32.3	a	49.2	a	21.9	a
			PE	60.5	a	25.6	a	44.2	a	19.2	a

[z] Application timings: In-furrow at-planting (IF); at emergence (Em); 14 days post-emergence (PE)

[y] Percent of stems and stolons with greater than 5% girdling caused by R. solani are from an average of 4 plants per replicate for ‘Superior’ and an average of 2 plants per replicate for ‘FL1879’ and ‘Russet Norkotah’

[x] Percent incidence of tubers with sclerotia of R. solani from a sample of 20 tubers per replicate taken 84 days after planting for “Superior” and 90 days after planting for “FL 1879” and “Russet Norkotah”

[w] Severity of black scurf (index calculated by counting the tuber number (n = 20 per replicate) falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia (Taken 84 days after planting for “Superior” and 90 days after planting for “FL 1879” and “Russet Norkotah”).

[v] Maxim 4FS at Seed treatment at 0.08 fl oz/cwt

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison)

Table 8: Effect of variety and planting time on incidence and severity of sclerotia on potato tubers of different varieties caused by *Rhizoctonia solani*, East Lansing, MI.

	Timing 1 [z]				Timing 2 [y]				Timing 3 [x]			
Variety	Incidence [w]		Severity [v]		Incidence [w]		Severity [v]		Incidence [w]		Severity [v]	
Atlantic	89.4	a [u]	18.8	ab	15.6	b	3.0	b	29.0	ab	6.8	abc
FL 1833	100.0	a	29.5	a	38.6	ab	6.9	ab	10.0	bc	1.6	bcd
FL 1867	91.2	a	22.1	ab	17.7	b	2.2	b	7.6	bc	1.3	bcd
FL 1879	69.8	a	16.1	b	39.3	ab	7.2	ab	2.4	c	0.4	cd
Jacqueline-Lee	61.6	a	10.9	b	13.3	b	1.6	b	15.2	ab	2	ab
Michigan Purple	95.8	a	19.4	ab	62.8	a	3.0	a	0.0	c	7.2	d
Pike	82.8	a	14.6	b	15.7	b	3.1	b	9.0	bc	1.5	bcd
Russet Norkotah	90.8	a	17.7	ab	4.2	b	0.4	b	5.7	bc	0.6	bcd
Snowden	80.3	a	17.1	b	26.7	ab	4.3	ab	37.0	a	8.3	a

[z] Timing 1: planting done once soil temperatures at 4 inch depth reached 8°C.

[y] Timing 2: planting done once soil temperatures at 4 inch depth reached 14°C.

[x] Timing 3: planting done once soil temperatures at 4 inch depth reached 20°C.

[w] Percent incidence of tubers with sclerotia of R. solani from a sample of 4 plants per replicate taken 25 October

[v] Severity of black scurf (index calculated by counting the tuber number falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia.

[u] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison).

Table 9: Effect of planting time on incidence and severity of sclerotia on potato tubers of different varieties caused by *Rhizoctonia solani*, East Lansing, MI

Time of planting [z]	Incidence of tuber black scurf [y]		Severity of tuber black scurf [x]	
1	85.6	a [w]	43.6	a
2	25.4	b	14.3	b
3	14.4	b	10.0	b

[z] Timing 1, 2 and 3, planted when soil temperatures at 4 inch depth reached 8, 14 and 20°C, respectively.

[y] Percent incidence of tubers with sclerotia of *R. solani* from a sample of 4 plants per replicate taken 25 October

[x] Severity of black scurf (index calculated by counting the tuber number falling into class 0 = 0%; 1 = 1 - 5%; 2 = 6 - 10%; 3 = 11 - 15%; 4 = >16% surface area. Indices of 0 to 25 cover the range 0 - 5%; 25 - 50 cover the range 6 - 10%; 51 - 75 cover the range 11 - 15%; 75 - 100 cover the range >15% surface area of the tuber with sclerotia.

[w] Values followed by the same letter are not significantly different at a = 0.05 (Student's Pairwise Comparison).

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Host Plant Resistance and Reduced Rates and Frequencies of Fungicide Application to Control Potato Late Blight (Co-operative trial Quad State Group 2004).

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INTRODUCTION

Late blight of potato caused by *Phytophthora infestans* (Mont de Bary), is a major threat to the production of high quality potatoes. Unchecked, *P. infestans* can rapidly defoliate plants in the field and can infect potato tubers when spores are washed into the soil. Potato late blight control strategies changed following the migration of mefenoxam/metalaxyl-resistant populations of *P. infestans* from Mexico to North America and necessitate cultural control methods and crop protection strategies that rely primarily on protectant foliar fungicide applications. There are several potential methods for reducing fungicide inputs in potato crop management. These include the use of fungicides with less active ingredient, reduced application rates, longer application intervals and a combination of any of these strategies. There are currently few late blight resistant potato cultivars that meet commercial standards in the United States. Typical fungicide application programs use a 5-7 day spray interval depending on environmental conditions and grower preference. The frequent fungicide spray intervals and rates currently used by growers to control late blight are expensive and more economical control measures are needed.

Therefore, the objective of this research was to determine if acceptable control of foliar late blight can be achieved by using increased fungicide spray intervals and reduced application rates of residual contact fungicides on potato germplasm with a range of susceptibility to late blight developed at each of the four potato breeding programs in Michigan, Minnesota, North Dakota and Wisconsin.

MATERIALS AND METHODS

Potato Germplasm

Previous experiments from the co-operating breeding programs have identified potato cultivars and advanced breeding lines (ABL) with different responses to foliar late blight. In the present study, any cultivar/ABL with foliar late blight severity measured as the Relative Area Under the Disease Progress Curve [RAUDPC] value that was not significantly higher than that of Torridon was classified as late blight resistant (R). Any cultivar/ABL with a RAUDPC value significantly higher than that of Snowden or with a RAUDPC value that was not statistically different from that of Atlantic was classified as late blight susceptible (S). Cultivars/ABL were classified as moderately resistant (M) if the RAUDPC value was significantly higher than that of Torridon but significantly lower than that of Snowden. The cultivars/ABL included in the trials from 2004 are listed in Table 1.

Residual Contact Fungicides

Omega 5SC (Syngenta) was used for this experiment. Fungicides were applied with an ATV rear-mounted spray boom (R&D Sprayers, Opelousas, LA) 20 gal H_2O/A (80 psi pressure) with three XR11003VS nozzles per row positioned 12" apart and 18" above the canopy. In the fungicide application interval and reduced dose rates trial, Omega 5SC was applied at 5, 10 and 15 day intervals at 0, 50 and 100% MRAR to the ABL and cultivars described in Table 1. The first fungicide application occurred at 24 days after planting (DAP) (21 Jul 2004) when potato plants were approximately 6" tall. Fungicides were applied until non-treated plots of susceptible controls reached about 100% diseased foliar area (4 Sep). The 5, 7, 10 and 15-day interval treatments received nine, seven, five and three applications in 2004, respectively.

Experimental Design and Agronomic Practices

All experiments were conducted at the Michigan State University Muck Soils Research Station, Bath, MI (90% organic muck soil). Soils were plowed to 20 cm depth during October following harvest of preceding crops. Soils were prepared for planting with a mechanical cultivator in early May and fertilizer applied during final bed preparation on the day of planting. Cultivars/ABL were planted on June 28, 2004 in two-row by 50 ft plots (34" row spacing). Fertilizers were applied in accordance with results from soil testing carried out in the spring of each year and about 200 cwt N/A (total N) was applied in two equal doses at planting and hilling. Additional micronutrients were applied according to petiole sampling recommendations and in all years. Approximately 0.2, 0.3 and 0.2 cwt/A boron, manganese and magnesium, respectively were applied as chelated formulations. Cut and whole seed pieces (2.5 -5.0 oz) of selected cultivars and ABL were used in all experiments.

The experimental design for the fungicide application interval and reduced dose rate trials was a randomized complete block design with four replications. If a fungicide treatment on a cultivar/ABL resulted in an RAUDPC that was not significantly higher than non-treated Jacqueline Lee, then it was classified as effective late blight control (E). Any fungicide treatment and cultivar/ABL combination in which the RAUDPC was significantly higher than, or was not significantly different from that of non-treated Snowden was classified as a non-effective (NE) treatment. Furthermore, if a fungicide treatment on a cultivar/ABL resulted in an RAUDPC significantly higher than that of non-treated Torridon but significantly less than that of non-treated Snowden, the treatment was classified as providing intermediate late blight control (I).

When relative humidity (RH) dipped below 80% (measured with RH sensors mounted within the canopy, described below), a mist irrigation system (described below) was turned on to maintain RH at >95% within the plant canopy. Plots were irrigated as necessary to maintain canopy and soil moisture conditions conducive for development of foliar late blight with turbine rotary garden sprinklers (Gilmour Group, Somerset, PA, U.S.A.) at 112 gal H_2O A/hr and managed under standard potato agronomic practices. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 28 Jun), Basagran (2 pt/A on 28 Jun and 25 Jul) and Poast (1.5 pt/A on 25 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 28 Jun), Sevin 80S (1.25 lb/A on 11 and 25 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 25 Jul).

Pathogen Preparation and Inoculation.

Zoospore suspensions were made from *P. infestans* cultures of several isolates from different genetic backgrounds, including [US8, US14 and US17 genotypes, with a mixture of sensitivity to mefenoxam/metalaxyl, but A2 mating types (13)], the predominant genotypes present in the major potato growing regions of North America (12), grown on rye agar plates for 14 days in the dark at 15°C. Sporangia were harvested from the rye agar plates by rinsing the mycelial/sporangial mat in cold (4°C) sterile, distilled water and scraping the mycelial/sporangial mat from the agar surface with a rubber policeman. The mycelial/sporangial suspension was stirred with a magnetic stirrer for 1 hour. The suspension was strained through four layers of cheesecloth and the concentration of sporangia was adjusted to about 1 x 10^2 sporangia/fl oz using a hemacytometer. Sporangial cultures were incubated for 2-3 hours at 40°F to stimulate zoospore release. All plots were inoculated simultaneously through an overhead sprinkler irrigation system, on July 30, 2004; by injecting the zoospore suspension of *P. infestans* into the irrigation water feed pipeline under 20 psi CO_2 pressure and applied at a rate of about at 10^4 spores/fl oz on 30 Jul over the whole trial area. The amount and rate of inoculum applied was estimated from prior calibration of the irrigation system (described above) and was intended to expose all potato foliage to inoculum of *P. infestans*.

Disease Evaluation and Data Analysis

As soon as late blight symptoms were detected (about 7 days after inoculation, DAI), each plant within each plot was visually rated at 3 to 5 day intervals for percent leaf and stem (foliar) area with late blight lesions. The mean percent blighted foliar area per treatment was calculated. Evaluations continued until untreated plots of susceptible cultivars reached 100% foliar area diseased (45 DAI in 2004). Days after inoculation were used as a key reference point for calculation of Relative Area Under the Disease Progress Curve [RAUDPC].

Microclimate Measurement

Climatic variables were measured with a Campbell Weather Station equipped with air temperature and humidity sensors located within the potato canopy on site. Microclimate within the potato canopy was monitored beginning when 50% of the potato plants had emerged and ending when canopies of healthy plants reached 100% senescence. The Wallin Late Blight Prediction Model was developed in the Eastern United States under conditions similar to those in Michigan and was adapted to local conditions (1). Late blight disease severity values (DSV) were estimated from the Wallin Late Blight Prediction Model and accumulated from inoculation to final evaluation to estimate the conduciveness of the environment for late blight development.

RESULTS

Microclimate conditions

Late blight developed rapidly during August; non-treated susceptible controls reached about 100% diseased foliar area 48 DAI. Maximum and minimum air temperature (°F) were 88.2 and 67.2 (Jun), 87.5 and 67.7 (Jul), 88.1 and 67.7 (Aug) and 85.3 and 66.0 (Sep). Maximum and minimum soil temperature (°F) were 74.5 and 69.8 (Jun), 77.0 and 71.9 (Jul), 78.0 and 71.4 (Aug) and 75.9 and 70.2 (Sep). Maximum and minimum soil moisture (% of field capacity) was 98.5 and 95.8 (Jun, severe flooding); 98.1 and 63.3 (Jul), 85.4 and 71.4

(Aug) and 76.8 and 79.8 (Sep). Precipitation was 4.04” (Jun), 3.68" (Jul), 1.83" (Aug) and 0.93" (Sep). The total number of late blight disease severity values (DSV) over the inoculation period was 116 and 44 (using 80% and 90% ambient %RH as bases for DSV accumulation), respectively (Figure 1). Plots were irrigated to supplement precipitation to about 0.1”/A/4 day period with overhead sprinkle irrigation. This indicated that environmental conditions were conducive to late blight development (DSV > 18).

The lower and upper thresholds used to determine the efficacy of the fungicide and variety combination programs were RAUDPC = 1.4 and 25.3 (7-day 100%MRAR and non-treated, Snowden), respectively. Therefore, fungicide treatment and variety combinations with an RAUDPC NSD from Snowden, 100% MRAR, 7-day application interval, $\mathrm{RAUDPC}_{\mathrm{SF7}}$) were defined as effective (E); combinations NSD from the non-treated Snowden control (RAUDPC = 25.3) were defined as non-effective (NE); and combinations with RAUDPC values significantly different from both standards were defined as partially effective (PE); (Table 1).

Application of Omega 5SC at 50% and full rate of application at a 5 or 7-day interval resulted in effective control of late blight in all varieties. The mean RAUDPC for non-treated MSJ461-1 and Torridon ranged from 0.0 to 0.3, which were classified as resistant. Fungicide treatments did not significantly effect late blight development in either MSJ461-1 or Torridon.

All cvs. /ABL were effectively protected by application of the fungicide at 50 and 100% MRAR on 5 or 7 -day intervals. The cvs./ ABL MN15620R/-yel and Villetta Rose were PE on a 10-day interval at both rates of fungicide application. Late blight was partially effectively controlled by both rates of application at a 15-day interval in Atlantic and at 50% MRAR in Freedom Russet. Late blight was not effectively controlled in Dakota Jewel (50% MRAR) at either rate of fungicide application in MN15620R/-yel on a 15-day application interval.

DISCUSSION

The results of this study were consistent with previous studies and indicate that a combination of cultivar/ABL resistance and managed application of protective fungicides will reduce foliar late blight to acceptable levels in most situations. When conditions were conducive to late blight development (as in 2004), reduced amounts of fluazinam were either fully or partially effective at most application rates tested on all cultivars/ABL compared to the non-treated controls. However. in some cultivars/ABL, 50% of the MRAR of fungicide was sufficient to achieve acceptable control, whereas other cultivars/ABL required 100% MRAR to control late blight. On late blight susceptible cultivars, applications of fluazinam at either 10 or 15-day intervals were usually partially effective for controlling late blight at the doses tested. However, in the resistant cultivars Torridon and MSJ461-1 the fungicides did not reduce the RAUDPC in comparison with untreated plots of these cultivars and fungicides are not required for late blight control in these entries.

The opportunity to manage late blight by applying reduced rates of fungicides at increased spray intervals to cultivars less susceptible to late blight was demonstrated in this study. In addition, the efficacy of reduced rates and increased application intervals of fungicides against other potato pathogens such as early blight has not been established and may prove to be a major constraint in the adoption of managed fungicide applications. As new cultivars with enhanced late blight resistance are developed and released it will be important to provide growers with recommendations for the most effective and economical chemical control of late blight in these new cultivars. In the future, the type of information gathered in this study will be used to develop models, based on cultivar resistance and response to fungicide application, to advise and guide growers as to which fungicide, rate and frequency of application is required to provide protection against late blight. Climatic conditions within the canopy will also impact choice of fungicide and rate and frequency of application. Therefore, new cultivars will need to be carefully screened in the manner described in this study, over several seasons in order to develop accurate models for fungicide application.

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Table 1. Efficacy of fluazinam applied at reduced rates and frequencies on potato cultivars and Advanced breeding lines from North Central US potato breeding programs, MSU 2004.

Cultivar/ABL[1]	Rate of fluazinam[2]	Application frequency (days)														
		0			5			7			10			15		
		RAUDPC[3]														
Atlantic	0	24.6	ab[4]	S[5]												
	50				0.3	n	E[6]	0.5	mn	E	3.1	j-n	E	13.2	d-k	PE
	100				0.6	mn	E	0.2	mn	E	1.0	l-n	E	10.0	c-g	PE
Dakota Jewel	0	25.0	ab	S												
	50				1.8	k-n	E	2.3	k-n	E	7.1	g-n	E	21.6	a-c	NE
	100				0.6	mn	E	1.4	k-n	E	9.3	f-n	E	5.1	d-l	E
Freedom Russet	0	16.2	b-e	I												
	50				0.7	l-n	E	1.9	k-n	E	4.2	h-n	E	12.1	d-i	PE
	100				0.3	n	E	0.3	n	E	3.2	j-n	E	6.5	f-n	E
MSJ461-1	0	0.0	n	R												
	50				0.0	n	E	0.0	n	E	0.0	n	E	0.0	n	E
	100				0.0	n	E	0.0	n	E	0.0	n	E	0.0	n	E
MN15620R/-yel	0	23.6	ab	S												
	50				3.5	i-n	E	6.3	f-n	E	14.1	c-f	PE	17.0	a-e	NE
	100				0.6	mn	E	1.6	k-n	E	14.0	c-f	PE	17.4	a-d	NE
ND5822C-7	0	23.4	ab	S				.						.		
	50				0.3	n	E	0.6	l-n	E	2.4	k-n	E	3.9	l-n	E
	100				0.1	n	E	0.1	n	E	0.2	n	E	1.2	h-n	E
Snowden	0	25.3	a	S												
	50				0.9	l-n	E	1.4	k-n	E	4.0	k-n	E	8.4	e-n	E
	100				0.4	mn	E	0.7	l-n	E	2.0	h-n	E	5.7	f-n	E
Torridon	0	0.6	mn	R												
	50				0.1	n	E	0.1	n	E	0.1	n	E	0.1	n	E
	100				0.0	n	E	0.0	n	E	0.1	n	E	0.1	n	E
Villetta Rose	0	23.2	ab	S												
	50				0.2	n	E	0.7	l-n	E	9.1	d-h	PE	12.3	d-m	PE
	100				0.4	mn	E	0.3	n	E	7.2	d-j	PE	11.6	f-n	PE

[1] Varieties and advanced breeding lines from the Quad State potato breeding programs.

[2] Application rate of fluazinam as percent of manufacturer's recommended rate (full rate = 0.6 pt/A)

[3] Relative area under the disease progress curve from inoculation to 100% late blight in susceptible control (Snowden); max = 100.

[4] Means followed by the same letter were not significantly different at p = 0.05; comparison between all combinations of fungicide application rate and frequency of application in all cultivars/ABL.

[5] Susceptibility of non-treated control to late blight; R = Resistant, not significantly different from Torridon (non-treated); S = Susceptible, not significantly different from Snowden (non-treated); I = Intermediate, significantly different from both Torridon and Snowden (non-treated).

[6] Effectiveness of fungicide treatment in comparison to Snowden treated with a full application rate of fluazinam at a 5-day interval or with non-treated Snowden control; E = RAUDPC NSD from treated Snowden control; PE significantly different from treated Snowden control and non-treated control; NE = NSD from Snowden non-treated control at p = 0.05.

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Evaluation of Tuber Late Blight Response of potato cultivars and advanced breeding lines and their potential to reduce seed-borne epidemics of late blight.

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Introduction

Late blight of potato, caused by *Phytophthora infestans*, is a major worldwide threat to the production of high quality potatoes. Late blight is readily transmitted by seed-borne inoculum (Kirk et al. 1999) and consequently, immature stems and leaves may be exposed to late blight from infected seed pieces. Recent work has indicated that the new immigrant clones, especially US-8 genotype, are more aggressive in tubers and sprouts. The new genotypes of late blight are 10 times more likely to produce infected sprouts than their predecessor, US-1 (Stevenson, 1993). Potato breeding efforts at MSU have resulted in varieties that are largely resistant to foliar late blight (Kirk et al 2001a) but not significantly less susceptible than other varieties in terms of tuber blight resistance (Kirk et al. 2001b). The transmission dynamics of late blight inoculum from seed to sprout and ultimately to the stem are still largely unknown and have been tested with only a limited number of varieties of potato and isolates of *P. infestans*. In this study, advanced breeding lines (MSU and other germplasm sources) will be evaluated for resistance to tuber blight. Subsequently, tubers will be under seed storage conditions and after storage prepared for planting by increasing temperature in the storage. Transmission of late blight from seed to foliage will be evaluated and potential risk measured. Potentially, the release of varieties with resistance to foliar and tuber blight will be of great economic benefit to the industry and to the environment and reduces the risk of threats to food security.

Objectives

1. Evaluate late blight response of potato tubers of advanced breeding lines from the MSU and other potato breeding programs to the US-8 genotype of *P. infestans.*
2. Evaluate the potential for late blight to be transmitted from seed to foliage in potato cultivars and advanced breeding lines to a variety of *P. infestans* genotypes.
3. Evaluate late blight response of potato tubers from different cultivars and advanced breeding lines using five different genotypes of the late blight pathogen (*P. infestans)*.

Materials and methods

Tubers for the experiments were obtained from the potato breeding program at MSU and breeding programs in Wisconsin, Minnesota and North Dakota. Potato tubers were stored at 38^{o}F (3^{o}C) in the dark at 90% relative humidity until used. Tubers for all the experiments were within the size grade range 50 - 150 mm diameter (any plane). Visual examination of a random sample of tubers from each entry (n = 2) for disease symptoms indicated that the tubers were free from late blight. The sample was further tested with the ELISA immuno-diagnostic Alert Multi-well kit (Alert Multiwell Kit - *Phytophthora sp.* Neogen Corporation, Lansing, MI, USA). *P. infestans* was not detected in any of the tubers. Three experiments were carried out in this study and were repeated in 2003 and 2004. In experiment (1), potato tubers from cultivars and advanced breeding lines were evaluated for tuber blight susceptibility against the US-8 genotype of *P. infestans*. In this experiment, tubers were inoculated followed by storage at 50°F (10°C) for 30 days and blight severity was evaluated by an image analysis technique. In experiment (2), sixteen potato cultivars and ABL were inoculated with five different genotypes of *P. infestans* (US-1, US-6, US-8, US-11 and US-14) into a freshly cut tuber surface, incubated for 5 days at 50F (10°C), then planted at the Muck Soils Research Farm, Laingsburg, MI and plant emergence and foliar late blight was evaluated. In experiment (3), tubers from potato cultivars and ABL used in experiment 2 were inoculated as in experiment 2 and were incubated for 30 days at 50°F (10°C). Tubers were then cut and evaluated for blight severity using image analysis technique.

***P. infestans* culturing and inoculations:**

Cultures of *P. infestans* were propagated on rye agar petri plates for 14 days in the dark at 17°C. Prior to inoculation, all tubers were washed in distilled H_2O to remove soil. The tubers were then surface sterilized by soaking in 2% sodium hypochlorite (Clorox 5.25%) solution for 30 min. Tubers were dried in a controlled environment with continuous airflow at 15°C in dry air (30% relative humidity) for four hours prior to inoculation.

Tuber tissue inoculation

Experiment 1 Evaluation of potato cv/ABL tuber susceptibility to US-8 genotype

Sporangia were harvested from the petri dishes by rinsing the mycelium/sporangia mat in cold (4°C) sterile, distilled H_2O and scraping the agar surface with a rubber policeman. The mycelium/sporangia suspension was stirred with a magnetic stirrer for 1 hour. The suspension was strained through four layers of cheesecloth and sporangia concentration was adjusted to about 1 x 10^6 total sporangia ml^{-1} (discharged and non-discharged) with the aid of a haemacytometer. The sporangial suspensions were stored for 2 h at 4°C to encourage zoospore release from the sporangia. The washed, surface-sterilized tubers were inoculated by a sub-peridermal injection of a sporangia suspension of 2 x 10^5 ml^{-1} with a hypodermic syringe and needle at the apical end of the tuber about 1 cm from the dominant sprout to a maximum depth of 1 cm. In total fifty five cultivars and ABL were tested in 2003 and forty nine in 2004 (Table 1). Ten tubers from each cultivar/ABL were inoculated as above and were incubated in a temperature-controlled environment chamber, 1.8 m^3 volume (Environmental Growth Chambers, Chagrin Falls Ohio, USA) at 50°F (10°C). Three replicates per cv/ ABL were inoculated. In total 30 tubers were tested for each cultivar or ABL. Relative humidity was maintained at 90% within the chamber. The non-inoculated control tubers (n=10 x 3 rep.) were inoculated with cold (4°C) sterile distilled H_2O and incubated under the same conditions as above.

Experiment 2 Blight Transmission in seed tubers

As in experiment 1, but a smaller number of cultivars/ ABL were inoculated with five different genotypes of *Phytophthora infestans*, US1, US6, US8, US11 and US14. Sixteen cultivar/ABL were inoculated with *P. infestans* genotypes (Table 2). The seed tuber was cut into two pieces with a sterile knife. The exposed cut surface was placed face down on a 14 day old, homogenized mixture of mycelium and sporangia of *P. infestans* in rye agar for 30 s. The homogenate was prepared from 20 plate cultures (9 cm diameter x 15 mm depth petri plates). Each plate produced between 10^5 - 10^6 spores ml^{-1} from 50 ml of wash water. An estimate of the amount of mycelium from each plate was not attempted. Following inoculation tubers were incubated for 5 days at 50^{o}F (10^{o}C). Tubers (n=8 per cv./ABL) were then planted at the MSU Muck Soils research Farm and irrigated with adequate moisture to allow emergence. Plant stand, rate of emergence and foliar late blight especially on stems, and immature foliage were evaluated.

Experiment 3 Evaluation of blight severity in storage at 10C

Potato cultivars and advanced breeding lines used for the transmission experiment (experiment 2) were evaluated for tuber blight in storage. Tubers were inoculated in the same manner as in experiment 2 and were then stored in the dark in net bags within ventilated plastic boxes (8 tubers/box). Disease development rates within tubers in relation to storage temperature were known from previous experiments and a single sampling date was selected about 30 days after inoculation (DAI). Sample size was n = 8 tubers plus 8 control tubers per variety/genotype combination.

Tuber blight severity measurements with digital image analysis

A digital image analysis technique was used to assess tuber tissue infection. Briefly, the scanned surface was the cut face of a sample tuber. A sharp knife was used to ensure a smooth cut face. Fresh-cut tuber sections were placed cut surface down on a glass plate, 40 x 30 cm and 2 mm thick. The glass plate was used to prevent surface contamination of the scanner glass and permitted multiple samples to be prepared and moved to the scanner for image production. The plate was transferred to a flatbed scanner (Epson perfection 4870) controlled by PC. Scanner control software (Adobe Photoshop version 7.0) generated an image of the cut tuber surfaces against a black background. The image was formed from light reflected from the cut tuber surfaces. The brightness value of the image controlled the light intensity of every pixel in the image. The contrast value controlled the differences between light and dark regions of the image. While the scanner control software was able to automatically adjust the brightness and contrast of the image by comparing the relative size of the pale tuber surfaces against the black background. A photograph-quality image was taken and stored for analysis (e.g. Fig. 1). A typical image in Tagged Image Format (*.tif) occupies 1 megabyte. Typical ARI values for a range of infected and uninfected cut tuber surfaces were shown on Figure 1. The image files created with the scanner software were loaded into the image analysis software (Sigma Scan Pro ver. 5.0, Jandel Scientific, San Rafael, CA). The black background has 0 light intensity units (LIU), while pure white has 255 LIU. Disease-free and blemish-free tuber tissue is pale. Diseased or blemished tuber tissue is darkened. The image of the cut tuber surface was selected for analysis, and isolated from the adjacent regions of the image. The image was carefully cropped for irregularly shaped tubers to remove the image of the adjacent tuber skin, and the image of the cut surface was unedited. The area was selected with the Afill@ tool, which encompassed all pixels within a given area brighter than the cut-off threshold. The area selection cut-off threshold was set to 10 LIU, effectively allowing the software to exclude all parts of the image darker than 10 LIU, e.g. the black background. The average reflective intensity (ARI) of all the pixels within the image gave a measurement of infection severity of the tuber tissue of each sample. The ARI was measured in sections from the apical, middle and basal regions of the tuber, approximately 25% (apical), 50% (middle) and 75% (basal) of the length of the tuber (respectively) as measured from the apical end. The amount of late blight infected tissue per tuber was expressed as a single value (Mean ARI) calculated as the average ARI of the apical, middle and basal sections evaluated 30 DAI. Tuber rot severity was expressed relative to the ARI of the non-inoculated treatments for each cv./ABL. Relative average reflective intensity of a treatment was calculated as follows: % RARI = [1- Mean ARI $_{\text{treatment}}$ / Mean ARI $_{\text{control]}}$ *100; % RARI has a minimum value of zero (no visible symptoms) and maximum value of 100 (Tuber surface is completely blackened). Data were analyzed by analysis of variance ANOVA using SAS program.

Data Analysis

The presence of *P. infestans* in sample tubers was confirmed by ELISA (described above) and by isolating pure cultures of *P. infestans* from the infected tuber tissue and successful re-inoculation of potato tubers and leaves. Treatment effects were determined by ANOVA, and grouped as most susceptible within the parameters of the varieties sampled. Cultivars and ABL were considered resistant to tuber blight if their RARI values were not significantly different from the least susceptible cultivar or ABL among the cv./ABL evaluated. Cultivars and ABL were considered susceptible if their RARI values were not significantly different from the most susceptible cv/ABL. Cultivars and ABL that were significantly different from both the most susceptible and least susceptible cv/ABL were considered moderately susceptible. All comparisons were made relative the cv/ABL included in each experiment. For experiment 1, the mean RARI of individual tubers was compared to that of non-inoculated controls of the same variety/ABL. For experiment 2, the number of emerged plants was measured over a 60 day period after planting and the final plant stand and relative area under the emergence progress curve was calculated. For experiment 3, comparisons were made among different genotypes within individual cvs. /ABL.

Results

Experiment 1

In both 2003 and 2004 trials, cultivars and ABL tested demonstrated variable levels of susceptibility to tuber late blight. In 2003 the relative average reflective intensity values of tubers had a minimum value of 4.3 (ABL WTS 1212-6) and maximum of 35.8 for the cultivar Russet Norkotah. Significant differences in tuber susceptibility were observed among different cv./ABL and were accordingly categorized into three classes (susceptible, moderately susceptible and resistant). Cultivars and ABL that were not significantly different form the most susceptible cultivar/ABL (Russet Norkotah in 2003) were classified as susceptible. This included 10 cv./ABL that had RARI values of 26.9-35.8. Cultivars and ABL that were not significantly different from the least susceptible cv/ABL (ABL WTS 1212-6) were classified as resistant (16 cv/ABL) (Table 1), these cvs/ABL had a RARI values of 4.3 to 12.4. Other cvs./ABL that were significantly different from both the most susceptible and least susceptible cv/ABL were classified as moderately susceptible (28 cv/ABL) (Table 1).

Similarly In 2004 trial the cvs./ABL had a wide range of susceptibilities to tuber blight and were classified in the same manner as in 2003 trial. The advanced breeding line MSK027C had the lowest RARI value of 6.5, while the ABL Fl1922 had the highest RARI value of 34.7. Cultivars and ABL were categorized according to their significant differences of RARI values from the most susceptible and least susceptible cv/ABL. Accordingly the resistant cv/ABL are those with RARI values between 6.5 and 14.9 which included 3 cv/ABL. The susceptible cvs/ABL were those that were not significantly different from the most susceptible advanced breeding line FL 1922. The range of RARI for this category was 27.1-34.7. Other cvs./ABL were classified as moderately susceptible and had a rang of RARI of 14.9 to 26.1 (Table 1).

Experiment 2

The analyses of variance indicated that overall the US-8 genotype was the most virulent and aggressive of those tested reflected by poor emergence and plant stand across most cvs/ABL in both 2003 and 2004 trails, followed by the US14 genotype (Table 2 & 3). The US1 and US6 genotypes were rarely virulent and were the least aggressive causing only moderate reductions in emergence across cvs/ABL (Table 2 & 3). The rate of emergence and number of plants emerged was significantly different from the non-inoculated control for most cv/ABL inoculated with US8 and US14. Cultivars and ABL inoculated with other genotypes (US11, US6 and US1) were in most cases not significantly different from the non-inoculated controls (Tables 2, 3, 4). There is a wide range in tuber susceptibility to US8 which is clearly a virulent and aggressive genotype of *P. infestans*. As U8 is the predominant genotype of *P. infestans* in North America it would be prudent to continue to screen and develop novel sources of resistance including germplasm from other sources. However, as US8 suddenly appeared and quickly impacted potato production significantly during the 1990s, it would also be prudent to screen promising cultivars/ABL for their reaction to other genotypes of *P. infestans.* Despite that most cultivars and ABL inoculated with the US-8 genotype had poor emergence and high rate of tissue rotting and deterioration, there were some cases in some cultivars and ABL were emergence occurred (e.g. Fl1867, Torridon and Snowden). These emerged plants, although small percentage had a potential to start an epidemic in the field. However, foliar symptoms of late blight were not detected in 2003 or 2004 trails.

Experiment 3

The rate of tuber tissue rotting and discoloration after inoculation with different genotypes was evaluated 30 days post inoculation. Cultivars and ABL demonstrated variable responses to different genotypes of *P. infestans.* Consistent with results from the transmission experiment (experiment 2) the US-8 genotype caused the highest level of tuber rotting as observed from the values of RARI of scanned tuber sections in both 2003 and 2004 trials (Tables 5 & 6). However values of RARI where higher in 2003 compared to 2004. In 2003 trial values of RARI ranged from 0 to 42.72 while in 2004 the RARI values were between 0 and 28.33 (Tables 5,6). The US-6 and US-1 genotypes caused the lowest level of tuber rotting in all cultivars and ABL tested. In 2003 trial, among the cv./ABL tested, the cultivar Pike demonstrated the highest level of tuber rotting across all *P. Infestans* genotype with mean RARI value of 36.15, followed by the cv./ABL I157-A, J317-1, Jacqueline Lee, J319-A, J461-A, Torridon, J319-7, Fl 1879, J453-4Y, Atlantic and J456_Y respectively (Table 5). In 2004, trial the cv. Atlantic demonstrated the highest level of tuber resistance against *P. infestans* across all genotypes tested with mean RARI value of 0.71. The highest level of tuber susceptibility occurred in the ABL MN 98642 with mean RARI value of 9.42 across all genotypes tested.

Table 1. Susceptibility of tubers of potato cultivars/ABL to the US8 genotype of *Phytophthora infestans*.

	Tuber late blight susceptibility index						
Cultivar/ABL 2003	RARI			Cultivar/ABL 2004	RARI		
Russet Norkotah	35.80	ac	S	FL1922	34.70	a	S
Snowden	32.90	a-b	S	MSL175_B	32.20	a-b	S
MSJ462-AB	31.30	a-c	S	MSH067_3	32.00	a-b	S
MSJ343-1	31.20	a-c	S	MSM182_1	31.30	a-c	S
MSJ456-2Y	28.90	a-d	S	MSL179_AY	29.40	a-d	S
MSJ319-7	28.80	a-d	S	MSH360_1	28.00	a-e	S
MSJ319-1	28.20	a-e	S	MSL211_3	27.10	a-f	S
MSJ317-1	28.10	a-e	S	Ach7340_2W	26.10	b-g	S
MSK101-2	27.80	a-e	S	MSM183_1	25.60	b-h	S
MSJ453-4Y	27.10	a-f	S	Jacqueline Lee	25.50	b-h	S
Atlantic	26.90	a-g	S	MSM414-3Y	25.40	b-h	MS
MSJ334-2Y	26.70	b-g	MS	FL1879	24.00	c-i	MS
MSJ461-1	26.30	b-g	MS	MSL737_A	24.00	c-i	MS
MSJ453-4YA	25.70	b-h	MS	MSG227_2	23.80	c-i	MS
MSK136-2A	24.90	b-h	MS	MSM171_A	23.60	c-i	MS
MSJ462-A	24.80	b-h	MS	Liberator	23.60	c-i	MS
MSJ438-2	24.40	b-i	MS	MSM224-1	23.50	c-i	MS
MSI157-A	23.60	c-j	MS	A95053_61	23.20	d-j	MS
CIPLBR 46	22.00	d-k	MS	MSK128_A	22.80	d-j	MS
MSJ307-2	21.90	d-k	MS	MSL210_A	21.90	d-k	MS
CIPLBR 50	21.80	d-k	MS	MSF 373_8	21.80	d-k	MS
MSK136-2	21.80	d-k	MS	MSJ080_1	21.70	d-k	MS
AWN86514-2	21.30	d-l	MS	Snowden	21.40	e-l	MS
MSK 458-2	21.30	d-l	MS	MSM140_B	21.10	e-l	MS
ho26-3rus	21.30	d-l	MS	MSH094_8	20.40	e-l	MS
WTS 1210-4	21.30	d-l	MS	MSM418-5	20.20	e-l	MS
CIPLBR 24	20.40	d-m	MS	A96895-58 lb	20.20	f-l	MS
MSKO34-1	20.20	d-m	MS	MSF099	20.10	f-l	MS
Jacqueline Lee. Lee	20.00	d-m	MS	MSH095_4	19.40	f-l	MS
MSJ464-5	19.60	e-m	MS	MSH112_6	19.00	g-l	MS
MSJ457-2	19.40	e-m	MS	MSJ147-1	18.80	g-l	MS
MSJ456-4Y	18.30	f-n	MS	MSK124_A	18.70	g-l	MS
Torridon	17.90	g-o	MS	Onaway	18.70	g-l	MS
MSK128-1	16.60	h-p	MS	MSj461_1	18.70	g-l	MS
BO718-3	15.60	i-q	MS	A97039_51	18.60	g-l	MS
CIPLBR 33	15.50	i-q	MS	MSj1671	18.20	h-l	MS
CIPLBR 07	15.10	j-r	MS	MSL159_AY	17.60	i-l	MS
CIPLBR 01	14.20	k-r	MS	FL1867	17.40	i-m	MS
CIPLBR 12	14.00	k-r	MS	Dakota Pearl	17.20	i-m	MS
WTS 1217-7	12.40	l-s	R	MSM417-A	16.80	i-m	MS
CIPLBR 02	11.80	m-s	R	MSM205_A	16.80	i-m	MS
CIPLBR 39	11.70	m-s	R	MSL045_AY	16.60	i-m	MS
CIPLBR 20	9.90	n-s	R	Pike	16.30	i-m	MS
A90586-11	9.90	n-s	R	FL1833	15.60	j-m	MS
LBR 9	9.60	n-s	R	MSM409-2Y	14.90	k-m	R

CIPLBR 18	9.00	o-s	R	Atlantic	13.90	l-n	R
CIPLBR 19	8.60	p-s	R	BO766_3	13.80	l-n	R
WTS 1217-3	8.40	p-s	R	MSH228_6	9.80	m-n	R
CIPLBR 08	8.20	p-s	R	MSK027C	6.50	n	R
CIPLBR 05	8.20	p-s	R				
CIPLBR 4	7.50	p-s	R				
BO767-2	7.20	q-s	R				
CIPLBR 38	6.10	rs	R				
LBR 8	4.40	s	R				
WTS 1212-6	4.30	s	R				

[a] Normalized susceptibility score expressed % RARI=[1- Mean ARI $_{\text{treatment}}$ / Mean ARI $_{\text{control}}$] *100;

% RARI has a minimum value of zero (no visible symptoms) and maximum value of 100 (Tuber surface is completely blackened). Mean average reflective intensity of n = 30 tubers cut three times at apical, middle and basal region of inoculated potato tubers in light intensity units where LIU 0 = black and 255 = white

[b] Advanced breeding line.

[c] Mean ARI within cultivar/ABL followed by the same letter are not significantly different at P = 0.05 (Tukey multiple comparison test).

Table 2 . Survival after planting of potato cultivars and Advanced Breeding Lines inoculated with different genotypes of *Phytophthora infestans* in 2003.

	Mean RAUEPC[a]											
	Genotype of *Phytophthora infestans* [b]											
Cultivar/ ABL[c]	Non-inoculated control		US1		US6		US8		US11		US14	
Atlantic	72.1	a[d]	68.3	a	76.7	a	3.3	c	64.2	a	25.4	b
J-Lee	52.9	a	7.5	b	49.6	a	1.3	b	20.4	b	2.5	b
Pike	47.5	a	0.0	b	39.6	a	0.0	b	3.3	b	0.0	b
Torridon	63.3	a	68.8	a	70.4	a	1.7	b	40.0	ab	2.1	b
FL1879	69.2	a	37.1	bc	70.4	a	0.0	d	67.1	ab	13.3	cd
I157-A	51.7	a	8.8	c	44.2	ab	0.0	c	18.3	bc	0.0	cd
J317-1	48.8	a	12.5	ab	41.3	a	17.5	ab	22.1	ab	0.0	b
J319-7	66.7	a	60.8	ab	39.2	ab	21.7	ab	67.1	a	3.3	b
J319-A	54.2	a	48.8	a	30.0	ab	0.0	b	19.2	ab	0.0	b
J453-4Y	68.8	a	44.2	ab	64.6	a	2.1	c	62.9	a	19.2	bc
J456-Y	57.1	a	30.4	ab	58.3	a	0.0	b	34.2	ab	30.8	ab
J461-1	59.2	a	7.5	b	50.4	a	0.0	b	42.1	a	9.6	b

[a] RAUEPC, relative area under the percent plant emergence progress curve calculated from 0 - 60 days after planting [full final emergence (max = 100)].

[b] Genotype classification according to Goodwin et al. 1995.

[c] Advanced breeding line.

[d] Values followed by the same letter are not significantly different at P = 0.05 for comparisons of mean RAUEPC among different genotypes of *P. infestans* within each cultivar/ABL (Tukey Multiple Comparison).

Table 3: Survival after planting of potato cultivars and Advanced Breeding Lines inoculated with different genotypes of *Phytophthora infestans* in 2004.

	Mean RAUEPC[a]											
	Phytophthora infestans genotypes[b]											
Cv/ABL[c]	**Control**		**US1**		**US11**		**US14**		**US6**		**US8**	
Atlantic	86.63	a-b[d]	75.29	a-e	82.10	a-c	74.31	a-f	82.31	a-c	0.00	o
FL1833	65.92	a-h	84.24	a-c	43.78	d-m	49.55	b-m	77.99	a-d	0.29	o
FL1867	66.10	a-h	67.53	a-g	54.21	a-l	20.23	k-o	80.51	a-d	2.97	n-o
FL1879	82.20	a-c	88.90	a	62.69	a-i	57.44	a-k	83.45	a-c	0.00	o
II-152-A	74.95	a-e	65.76	a-h	65.15	a-i	38.90	e-n	77.01	a-d	3.73	n-o
Jacqueline Lee	78.73	a-d	76.99	a-d	77.65	a-d	72.38	a-g	76.64	a-d	3.89	n-o
MN15620	56.33	a-k	59.72	a-j	65.92	a-h	53.44	a-m	57.97	a-j	2.65	n-o
MN98642	48.36	c-m	62.21	a-i	56.73	a-k	29.24	h-o	47.11	c-m	0.00	o
MSJ317-1	68.09	a-g	70.44	a-g	37.26	f-o	28.10	i-o	64.62	a-i	0.29	o
MSJ461-1	80.16	a-d	81.06	a-d	76.14	a-e	78.87	a-d	77.44	a-d	0.00	o
ND2443	78.07	a-d	75.45	a-e	64.62	a-i	73.57	a-g	71.66	a-g	1.40	n-o
ND5822C-7	71.21	a-g	73.01	a-g	64.12	a-i	66.13	a-h	74.92	a-e	1.27	o
Pike	68.06	a-g	59.06	a-j	16.53	m-o	0.00	o	71.93	a-g	0.00	o
Snowden	83.05	a-c	82.47	a-c	50.66	b-m	36.68	g-o	22.78	j-o	2.12	n-o
Torridon	81.25	a-d	75.37	a-e	86.39	a-b	80.46	a-d	84.59	a-c	16.71	l-o
Megachip	73.86	a-g	79.95	a-d	56.94	a-k	18.22	l-o	76.99	a-d	0.29	o

[a] RAUEPC, relative area under the percent plant emergence progress curve calculated from 0 - 25 days after planting [full final emergence (max = 100)].

[b] Genotype classification according to Goodwin et al. 1995.

[c] Advanced breeding line.

[d] Values followed by the same letter are not significantly different at P = 0.05 for comparisons of mean RAUEPC among different genotypes of *P. infestans* within each cultivar/ABL (Tukey Multiple Comparison).

Table 4: Percent plant sand after planting of potato cultivars and Advanced Breeding Lines inoculated with different genotypes of *Phytophthora infestans* in 2004.

Percentage Plant Stand %[a]												
Phytophthora infestans genotypes [b]												
Cv/ABL[c]	**Control**		**US1**		**US11**		**US14**		**US6**		**US8**	
Atlantic	100.00	a [d]	87.50	a-d	96.88	a-b	87.50	a-d	96.88	a-b	0.00	k
FL1833	81.25	a-e	96.88	a-b	53.13	b-i	56.25	a-i	90.63	a-c	0.00	k
FL1867	78.13	a-e	81.25	a-e	62.50	a-i	21.88	h-k	93.75	a-b	3.13	j-k
FL1879	96.88	a-b	100.00	a	75.00	a-f	71.88	a-g	96.88	a-b	0.00	k
I152-A	87.50	a-d	81.25	a-e	68.75	a-g	46.88	c-j	90.63	a-c	6.25	j-k
Jack lee	96.88	a-b	87.50	a-d	87.50	a-d	84.38	a-d	87.50	a-d	3.13	j-k
MN15620	84.38	a-d	78.13	a-e	75.00	a-f	65.63	a-h	78.13	a-e	0.00	k
MN98642	62.50	a-i	84.38	a-d	68.75	a-g	37.50	e-k	62.50	a-i	0.00	k
MS317-1	93.75	a-b	90.63	a-c	43.75	d-k	31.25	f-k	87.50	a-d	0.00	k
MSJ461	100.00	a	100.00	a	90.63	a-c	93.75	a-b	87.50	a-d	0.00	k
ND2443	93.75	a-b	87.50	a-d	75.00	a-f	87.50	a-d	81.25	a-e	3.13	j-k
ND5822C-7	87.50	a-d	78.13	a-e	71.88	a-g	71.88	a-g	84.38	a-d	0.00	k
Pike	75.00	a-f	71.88	a-g	18.75	i-k	0.00	k	87.50	a-d	0.00	k
Snowden	93.75	a-b	93.75	a-b	56.25	a-i	43.75	d-k	28.13	g-k	0.00	k
Torridon	90.63	a-c	87.50	a-d	93.75	a-b	93.75	a-b	96.88	ab	21.88	h-k
W1201	87.50	a-d	93.75	a-b	65.63	a-h	21.88	h-k	90.63	abc	0.00	k

[a] Percentage plant stand calculated from 0 – 60 days after planting [full final plant stand (max = 100)].

[b] Genotype classification according to Goodwin et al. 1995.

[c] Advanced breeding line.

[d] Values followed by the same letter are not significantly different at P = 0.05 for comparisons of mean percent plant stand among different genotypes of *P. infestans* within each cultivar/ABL (Tukey Multiple Comparison).

Table 5. Susceptibility of tubers of potato cultivars and advanced breeding lines to different genotypes of *Phytophthora infestans* in 2003; susceptibility is expressed in terms of relative average reflective intensity (RARI%).

	Phytophthora infestans genotypes									
CV/ABL [a]	**US-1**		**US-6**		**US-8**		**US-11**		**US-14**	
					RARI [b]					
Atlantic	0.00	a [c]	0.00	a	42.45	c	0.00	a	12.74	b
J-Lee	41.59	c	12.62	b	40.65	c	12.62	b	41.59	c
Pike	42.25	c	12.21	b	42.72	c	41.31	c	42.25	c
Torridon	0.00	a	0.00	a	41.98	c	13.21	b	41.04	c
FL1879	13.21	b	0.00	a	41.04	d	0.00	a	28.30	c
I157-A	42.45	d	12.26	b	41.04	d	28.30	c	41.51	d
J317-1	29.25	c	12.74	b	41.51	d	28.77	c	41.51	d
J319-7	0.00	a	11.74	b	42.25	c	0.00	a	41.31	c
J319-A	13.15	b	12.68	b	41.78	d	28.64	c	42.25	d
J453-4Y	12.15	b	0.00	a	29.91	c	0.93	a	29.44	c
J456-Y	14.08	c	0.47	a	11.27	b	11.74	b	12.68	b-c
J461-1	41.31	d	0.47	a	27.23	c	13.62	b	42.25	d

[a] Cultivar /Advanced breeding line.

[b] Normalized susceptibility score expressed % RARI=[1- Mean ARI $_{\text{treatment}}$ / Mean ARI $_{\text{control}}$] *100; % RARI has a minimum value of zero (no visible symptoms) and maximum value of 100 (Tuber surface is completely blackened). Mean average reflective intensity of n = 30 tubers cut three times at apical, middle and basal region of inoculated potato tubers in light intensity units where LIU 0 = black and 255 = white

[c] Mean RARI within cultivar/ABL followed by the same letter are not significantly different at P = 0.05 (Tukey multiple comparison test).

Table 6. Susceptibility of tubers of potato cultivars and advanced breeding lines to different genotypes of *Phytophthora infestans*; susceptibility is expressed in terms of relative average reflective intensity (RARI%).

	Phytophthora infestans genotypes									
	Pi 95_3 (US-1)		**Pi 96_1 (US-11)**		**Pi 96_2 (US-6)**		**Pi 98_1 (US-14)**		**Pi02007 (US-8)**	
CV/ABL [a]	RARI [b]									
Atlantic	0.00	s [c]	0.37	r-s	0.56	r-s	0.19	r-s	2.48	m-s
I-152 A	5.92	h-s	7.44	g-o	10.79	e-i	5.82	h-s	4.27	j-s
J461-1	1.29	o-s	3.35	k-s	2.50	m-s	2.66	l-s	28.33	a
Jacqueline Lee	4.71	i-s	4.46	j-s	0.77	q-s	1.71	n-s	9.08	e-k
MN 98642	8.02	e-m	7.78	f-n	1.15	p-s	8.73	e-l	21.42	b
Mn15620	7.74	f-n	6.93	g-q	1.05	p-s	8.70	e-l	11.10	e-i
MS317-1	3.86	j-s	0.16	r-s	3.90	j-s	2.78	l-s	9.60	e-j
ND 2443	3.27	k-s	0.67	r-s	0.17	r-s	0.93	q-s	17.30	b-d
ND5822C7	2.38	m-s	0.60	r-s	1.38	o-s	0.98	p-s	12.55	d-g
Pike	6.24	h-r	4.48	j-s	0.55	r-s	14.08	c-e	12.77	d-g
Snowden	3.90	j-s	7.09	g-p	5.84	h-s	5.69	h-s	19.01	b-c
Torridon	1.96	m-s	6.08	h-s	1.07	p-s	0.36	r-s	13.73	c-f
Megachip	2.64	l-s	4.70	j-s	1.23	p-s	4.90	i-s	11.77	d-h

[a] Cultivar /Advanced breeding line.

[b] Normalized susceptibility score expressed % RARI = [1- Mean ARI $_{\text{treatment}}$ / Mean ARI $_{\text{control]}}$ *100;
% RARI has a minimum value of zero (no visible symptoms) and maximum value of 100 (Tuber surface is completely blackened). Mean average reflective intensity of n = 8 tubers cut three times at apical, middle and basal region of inoculated potato tubers in light intensity units where LIU 0 = black and 255 = white

[c] Mean RARI within cultivar/ABL followed by the same letter are not significantly different at P = 0.05 (Tukey multiple comparison test).

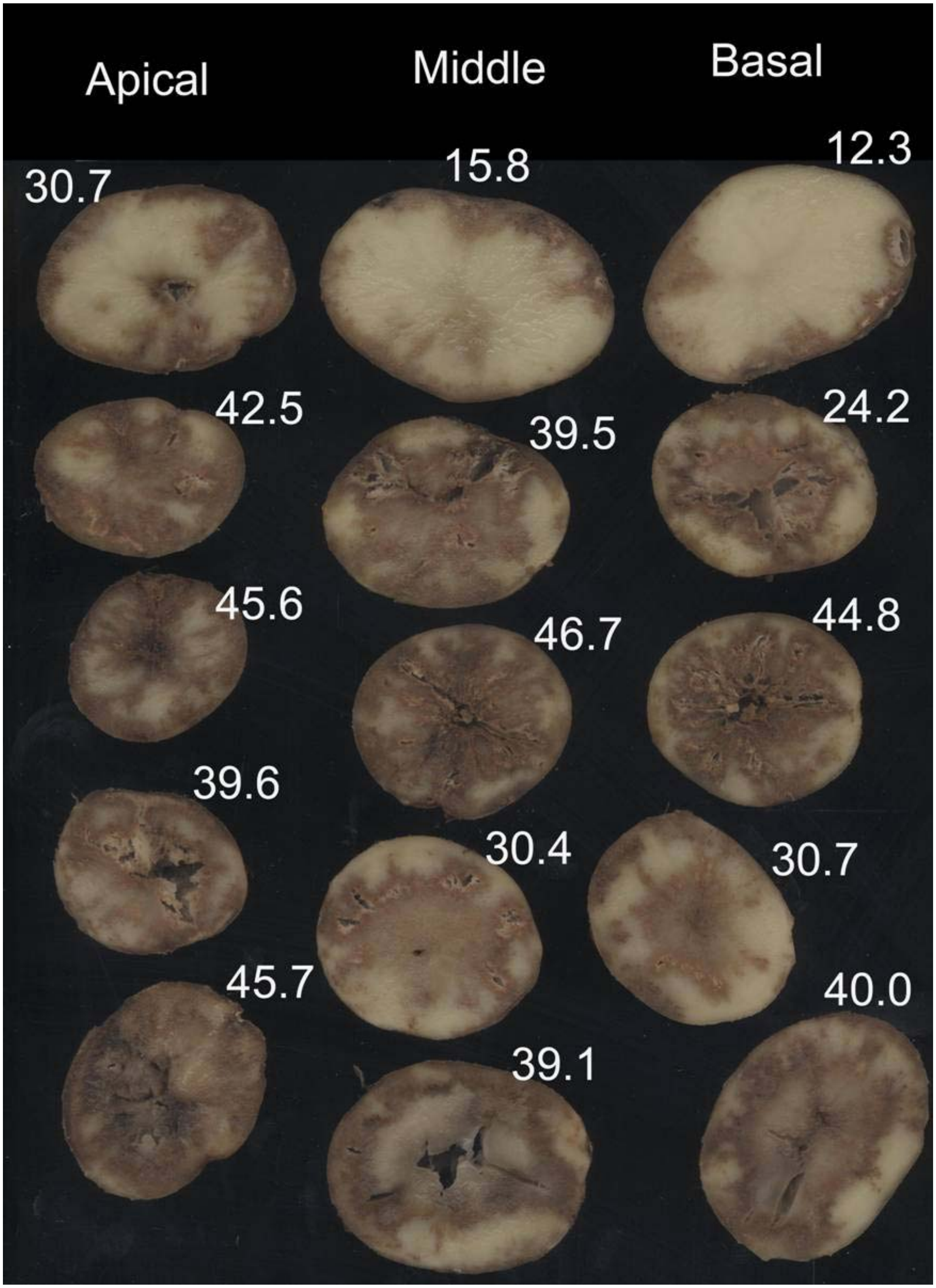

Figure 1. Scanned images of blighted tubers with RARI values. Higher values indicate more darkening due to greater susceptibility to *Phytophthora infestans*.

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Evaluation of fungicide programs for potato late blight control, 2004.

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Introduction

Potato late blight caused by *Phytophthora infestans* (Mont. de Bary) is the most important foliar and tuber disease of potato, both in the field and in storage. Late blight causes rapid defoliation of plants in the field and can infect potato tubers when spores are washed into the soil. Potato late blight management strategies have changed considerably following the migration of metalaxyl resistant isolates of *P. infestans* from Mexico to North America and necessitate utilization of cultural control measures and modification of the previous chemical control practices. The new strategies rely on reducing fungicide inputs, and this can be achieved by introducing new fungicides or integrating new fungicides with specific activity against late blight and lower amount of active ingredient.

The lack of availability of varieties with host resistance necessitates cultural control methods and crop protection strategies that rely primarily on protectant foliar fungicide applications. Fully-protectant foliar fungicide programs usually begin before the predicted onset of potato late blight, consist of fungicide applications that continue throughout the growing season at regular intervals, and may be initiated by weather-based potato late blight prediction models. Full protectant programs potentially require unnecessary input in seasons that are non-conducive to potato late blight development, and may have the most environmental impact; however they have the least failure risk. Risk of failure may occur for several reasons; presence of late blight contaminated seed; highly conducive environmental conditions that enhance sporulation and infection; fungicide misapplication or application at sub-effective rates, therefore, many growers initiate fungicide application programs early in the season and continue until vines are fully desiccated at frequency of 5 to 7 day intervals with the maximum labeled rates of protectant fungicides to ensure late blight free produce.

The Muck Soils Research Farm, Bath, Michigan is the designated location for potato late blight research at Michigan State University. This location has been an ideal testing site for foliar reaction to *P. infestans* because: 1) of its isolation from potato production regions, 2) a humid microclimate that is conducive to the development and spread of late blight disease, and 3) consistent *P. infestans* infection levels over years. New fungicide products require evaluation and the objective of this program is to test the efficacy of fungicides under extremely conducive conditions in the presence of aggressive strains of the pathogen *P. infestans.*

Method and materials

Potatoes [cut seed, treated with Maxim MZ 0.5D (0.5 lb/cwt)] were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 28 Jun into two-row by 25-ft plots (34-in row spacing), separated by a five-foot unplanted row and replicated four times in a randomized complete block design. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All rows were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* [US8 biotype (insensitive to mefenoxam, A2 mating type)] at 10^4 spores/fl oz on 30 Jul. All fungicides in this trial were applied on a 7-day interval from 21 Jul to 8 Sep (8 applications) with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. The pivot trial was chemigated on a 7-day interval from 21 Jul to 27 Aug (7 applications) with a Valley Irrigation overhead single span pivot delivering 5,000 gal water/A per application (see Table 4). Weeds were controlled by hilling and with Dual 8E (2 pt/A on 28 Jun), Basagran (2 pt/A on 28 Jun and 25 Jul) and Poast (1.5 pt/A on 25 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 28 Jun), Sevin 80S (1.25 lb/A on 11 and 25 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 25 Jul). Plots were rated visually for percentage foliar area affected by late blight on 30 Jul; 11, 17, 24 Aug and 2 and 13 Sep [5 days after final application (DAFA), 45 days after inoculation (DAI)] when there was 100% foliar infection in the untreated plots. The relative area under the disease progress curve was calculated for each treatment from date of inoculation, 30 Jul to 13 Sep, a period of 45 days. Vines were killed with Reglone 2EC (1 pt/A on 13 Sep). Plots (2 x 25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Maximum and minimum air temperature (^{o}F) were 88.2 and 67.2 (Jun), 87.5 and 67.7 (Jul), 88.1 and 67.7 (Aug) and 85.3 and 66.0 (Sep). Maximum and minimum soil temperature (^{o}F) were 74.5 and 69.8 (Jun), 77.0 and 71.9 (Jul), 78.0 and 71.4 (Aug) and 75.9 and 70.2 (Sep). Maximum and minimum soil moisture (% of field capacity) was 98.5 and 95.8 (Jun, severe flooding); 98.1 and 63.3 (Jul), 85.4 and 71.4 (Aug) and 76.8 and 79.8 (Sep). Precipitation was 4.04” (Jun), 3.68" (Jul), 1.83" (Aug) and 0.93" (Sep). The total number of late blight disease severity values (DSV) over the inoculation period was 116 and 44 (using 80% and 90% ambient %RH as bases for DSV accumulation), respectively (Figure 1). Plots were irrigated to supplement precipitation to about 0.5"/A/4 day period with overhead sprinkle irrigation.

Results

Block 1

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 13 Sep. Taking 34 DAI as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control except programs 16 and 17. Programs with 0.4 to 2.1% foliar late were not significantly different. Taking 45 DAI as a key reference point, there was complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control except programs 16 and 17. Programs with 1.8 - 11.8% foliar late blight; and those with 11.8 - 25.0% foliar late blight were not significantly different. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 45 DAI) compared to the untreated control except programs 16 and 17. Application programs with RAUDPC values between 0.35 and 4.62 were not significantly different. All treatments had significantly greater marketable yield in comparison to the non-treated control except programs 16 and 17. Programs with marketable yield from 304 - 409 cwt/A, from 269 - 373 cwt/A, and from 186 - 291 cwt/A were not significantly different. All treatments had significantly greater total yield in comparison to the non-treated control except programs 16 and 17. Treatments with total yield between 351 and 467 cwt/A; 315 and 428 cwt/A; between 242 and 359 cwt/A; and between 227 and 339 cwt/A were not significantly different. Phytotoxicity was not noted in any of the treatments.

Table 1. Efficacy of fungicides applied by ground equipment against foliar late blight (Block 1); MSU 2004.

		Foliar late blight (%)		RAUDPC^x	Yield (cwt/A)	
	Treatment and rate/acre	34 DAI^z	45 DAI 5 DAFA^y	Max (100) 0 - 45 DAI	US1	Total
1	Dithane RS 75DF 1.5 lb (A,B,C,D,E,F,G,H^w)	6.3 b^v	25.0 b	4.62 b	345 ab	401 ab
2	Gavel 75DF 2.0lb (A,B,C,D,E,F,G,H)	0.7 b	1.8 c	0.47 b	373 ab	428 ab
3	Echo ZN 2.13 pt (A,B,C,D,E,F,G,H)	0.5 b	2.8 c	0.50 b	322 ab	383 ab
4	Echo 825 1.38 pt (A,B,C,D,E,F,G,H,I)	0.5 b	2.5 c	0.46 b	306 ab	371 ab
5	Echo ZN 2.13 pt + Amistar 80WDG 0.13 lb (A,C); Echo ZN 2.13 pt (B,D,E,F,G,H)	0.6 b	3.3 c	0.56 b	304 ab	382 ab
6	Bravo WS 6SC 1.5 pt (A,B,C,E,F); Omega 5SC 0.5 pt (D,G); Ranman 40SC 0.17 pt + Silwet 6SC 0.1 pt (H)	0.5 b	3.5 c	0.58 b	291 bc	353 abc
7	Bravo WS 6SC 1.5 pt (A,B,C,D,F,H); Ranman 40SC 0.17 pt + Silwet 6SC 0.1 pt (E,G)	0.7 b	2.8 c	0.54 b	298 b	359 abc
8	Bravo WS 6SC 1.5 pt (A,B,C,G); Omega 5SC 0.5 pt (D,H); Ranman 40SC 0.17 pt + Silwet 6SC 0.1 pt (E,G)	0.5 b	2.0 c	0.39 b	333 ab	396 ab
9	Bravo WS 6SC 1.5 pt (A,B); Ranman 40SC 0.17 pt + Silwet 6SC 0.1 pt (C,E,G); Omega 5SC 0.5 pt (D,F,H)	0.8 b	3.0 c	0.59 b	281 bc	338 bcd
10	Bravo WS 6SC 1.5 pt + Amistar 80WDG 0.13 lb (A,C); Bravo WS 6SC 1.5 pt (B,D,E,F,G,H)	0.4 b	1.8 c	0.35 b	298 b	374 ab
11	Equus 6SC 1.5 pt + Amistar 80WDG 0.13 lb (A,C); Equus 6SC 1.5 pt (B,D,E,F,G,H)	0.4 b	3.3 c	0.51 b	304 ab	352 abc
12	Equus ZN 2.13 pt + Amistar 80WDG 0.13 lb (A,C); Equus ZN 2.13 pt (B,D,E,F,G,H)	0.8 b	4.5 c	0.82 b	291 bc	353 abc
13	Untreated	56.3 a	92.5 a	24.6 a	104 e	171 e

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.

[y] Days after final application of fungicide.

[x] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.

[w] Application dates: A= 21 Jul; B= 28 Jul; C= 4 Aug; D= 11 Aug; E= 18 Aug; F= 25 Aug; G= 1 Sep; H= 8 Sep.

[v] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Block 2

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 13 Sep. Taking 34 DAI as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Programs with 0.4 to 8.0% foliar late were not significantly different. Taking 45 DAI as a key reference point, there was complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control. Programs with 1.5 - 8.8% foliar late blight; 2.5- 12.8% foliar late blight; 5.3- 15.0% foliar late blight; 7.8- 17.3% foliar late blight; 12.8 - 22.5% foliar late blight; 17.3 - 27.5% foliar late blight; and 22.5 - 28.8% foliar late blight were not significantly different. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 45 DAI) compared to the untreated control. Application programs with RAUDPC values between 0.30 and 4.07; and 0.95 and 5.43 were not significantly different. Most treatments had significantly greater marketable yield in comparison to the non-treated control except programs with less than 293 cwt/A. Programs with marketable yield from 259 - 374 cwt/A were not significantly different. All treatments had significantly greater total yield in comparison to the non-treated control except programs with less than 361 cwt/A. Treatments with total yield between 296 and 421 cwt/A were not significantly different. Phytotoxicity was not noted in any of the treatments.

Table 2. Efficacy of fungicides applied by ground equipment against foliar late blight (Block 2); MSU 2004.

	Foliar late blight (%)		RAUDPC^x	Yield (cwt/A)	
Treatment and rate/acre	34 DAI^z	45 DAI 5 DAFA^y	Max = 100 0 - 45 DAI	US1	Total
1 Reason 500SC 0.26 pt + Dithane RS 75DG 1.0 lb + Bond 500SC 0.5 pt (A,C,E,G^w) Dithane RS 75DG 2.0 lb (B,D,F,H)...	2.8 b^v	27.5 bc	4.04 bc	259 ab	313 ab
2 Reason 500SC 0.26 pt + Echo 720SC 1.0 pt + Bond 500SC 0.5 pt (A,C,E,G) Dithane RS 75DG 2.0 lb (B,D,F,H)...	2.4 b	15.0 def	2.44 bc	310 a	359 ab
3 Bravo ZN 6SC 2.13 pt (A,C,E,G,H); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (B,D).......................	0.8 b	3.0 gh	0.59 c	266 ab	305 ab
4 Bravo ZN 6SC 2.13 pt (A,C,E,G,H); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (B,D)........................	0.6 b	5.3 fgh	0.83 c	343 a	397 a
5 Bravo ZN 6SC 2.13 pt (A,C,E,G,H); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (B); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (D)..........................	0.6 b	2.8 gh	0.51 c	322 a	368 a
6 Bravo ZN 6SC 2.13 pt (A,C,E,G,H); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (B); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (D)............................	0.5 b	1.8 h	0.37 c	351 a	394 a
7 Bravo ZN 6SC 2.13 pt (A,C,G,H); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (B,E); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (D)............................	0.4 b	2.5 gh	0.40 c	316 a	360 ab
8 Bravo ZN 6SC 2.13 pt (A,C,G,H); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (B,E); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (D)..........................	0.4 b	1.5 h	0.30 c	350 a	401 a
9 Bravo ZN 6SC 2.13 pt (A,C,F,G,H); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (B,D); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (E)............................	0.7 b	2.5 gh	0.50 c	374 a	421 a
10 Bravo ZN 6SC 2.13 pt (A,C,F,G,H); Headline 2SC 0.38 pt + Bravo WS 6SC 1.0 pt (B,D); Endura 6WDG 0.16 lb + Bravo WS 6SC 1.0 pt (E)...........................	0.5 b	3.3 gh	0.54 c	334 a	374 a
11 Bravo Ultrex 82.5 WDG 1.08 lb (A,B,C,D,E,F,G,H).........................	0.8 b	3.5 gh	0.65 c	261 ab	296 ab
12 Bravo Ultrex 82.5 WDG 0.74 lb (A,B,C,D,E,F,G,H).........................	4.5 b	17.3 cde	3.16 bc	307 a	361 ab
13 Dithane RS 75WDG 2.0 lb (A,B,C,D,E,F,G,H)................................	3.0 b	27.5 bc	4.07 bc	321 a	368 a
14 Amistar 80WDG 0.13 lb + Bravo WS 6SC 1.5 pt (A,C); Bravo WS 6SC 1.5 pt (B,D,E,G); Sonata (QRD 286) 4.0 pt + Biotune (QRD 602) 0.5 pt (F, H)............	8.0 b	28.8 b	5.43 b	293 ab	348 ab
15 Amistar 80WDG 0.13 lb + Bravo WS 6SC 1.5 pt (A,C); Bravo WS 6SC 1.5 pt (B,D,E,G); Sonata (QRD 286) 4.0 pt + Kocide 2000 6DF 2.0 lb + Biotune (QRD 602) 0.5 pt (F,H)...	2.1 b	8.8 efgh	1.63 bc	312 a	368 a
16 Penncozeb 75DF 2.0 lb (A,B,C,D,E,F,G,H).......................................	2.0 b	27.0 bc	3.79 bc	317 a	370 a
17 Untreated...	71.3 a	100 a	31.5 a	170 b	234 b

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.

[y] Days after final application of fungicide.

[x] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.

[w] Application dates: A= 21 Jul; B= 28 Jul; C= 4 Aug; D= 11 Aug; E= 18 Aug; F= 25 Aug; G= 1 Sep; H= 8 Sep.

[v] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Block 3 (Ground and Chemigation comparison of Tanos applciation)

In both the pivot and ground application trials, ate blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 13 Sep. In the ground application trial, taking 34 DAI as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Programs with less than 0.9 to 4.5% foliar late were not significantly different. Taking 45 DAI as a key reference point, there was complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control. Programs with 2.5 - 7.0% foliar late blight; and those with 27.5% (program 5) and those with 40.0 - 50.0% foliar late blight were not significantly different. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 45 DAI) compared to the untreated control. Application programs with RAUDPC values between 0.53 to 1.09; those with RAUDPC values 1.09 to 3.92; those with RAUDPC values 3.92 to 6.52; and those with RAUDPC values 6.32 to 7.26 were not significantly different. All treatments had significantly greater marketable yield in comparison to the non-treated control but there was no difference among treatments. All treatments had significantly greater total yield in comparison to the non-treated control but there was difference among treatments with total yield between 264 and 312 cwt/A and between 272 and 319 cwt/A. In the pivot trial, taking 25 DAI as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Taking 34 DAI as a key reference point, there was close to complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control. Programs with 1.3 to 2.7% foliar late blight; and those with 2.7 to 6.5% foliar late blight were not significantly different. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 45 DAI) compared to the untreated control. There were no significant differences in RAUDPC among application programs. All treatments had significantly greater marketable and total yield in comparison to the non-treated control but there was no difference among treatments. Phytotoxicity was not noted in any of the treatments.

Table 3. Efficacy and comparison of fungicides applied by ground and chemigation equipment against foliar late blight (Block 3); MSU 2004.

Ground application

Treatment and rate/acre	Foliar late blight (%)		RAUDPC[x] Max = 100 0 - 45 DAI	Yield (cwt/A)	
	34 DAI[z]	45 DAI 5 DAFA[y]		US1	Total
1 Tanos 50WDG 0.25 lb + Manzate 75DF 1.5 lb (A,C,E,G)[w] Manzate 75DF 2.0 lb (B,D,F,H)	4.3 a[x]	42.5 b	6.32 bc	261 a	307 ab
2 Tanos 50WDG 0.39 lb + Manzate 75DF 1.5 lb (A,C,E,G) Manzate 75DF 2.0 lb (B,D,F,H)	3.3 a	40.0 b	5.74 bc	269 a	312 ab
3 Tanos 50WDG 0.5 lb + Manzate 75DF 1.5 lb (A,C,E,G) Manzate 75DF 2.0 lb (B,D,F,H)	3.3 a	46.3 b	6.52 bc	224 a	274 ab
4 Tanos 50WDG 0.5 lb + Manzate 75DF 1.5 lb (A,C,E,G) Bravo WS 6SC 1.5 pt (B,D,F,H)	0.9 a	2.5 d	0.53 e	252 a	298 ab
5 Tanos 50WDG 0.39 lb + Super Tin 80WP 0.16 lb (A,C,E,G) Manzate 75DF 2.0 lb + Super Tin 80WP 0.16 lb (B,D,F,H)	2.1 a	27.5 c	3.92 cd	269 a	319 a
6 Manzate 75DF 2.0 lb (B,D,F,H)	4.5 a	50.0 b	7.26 b	226 a	264 b
7 Amistar 80WDG 0.13 lb (A,C,E,G) Bravo WS 6SC 1.5 lb (B,D,F,H)	0.9 a	7.0 d	1.09 de	230 a	272 ab
8 Untreated	82.5 b	100.0 a	33.37 a	87 b	136 c

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.

[y] Days after final application of fungicide.

[x] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.

[w] Application dates: A= 21 Jul; B= 28 Jul; C= 4 Aug; D= 11 Aug; E= 18 Aug; F= 25 Aug; G= 1 Sep; H= 8 Sep.

[v] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Pivot application

Treatment and rate/acre	Foliar late blight (%)		RAUDPC[y] Max = 100 0 - 34 DAI	Yield (cwt/A)	
	25 DAI[z]	34 DAI		US1	Total
1 Tanos 50WDG 0.5 lb + Manzate 75DF 1.5 lb (A,C,E,G)[x] Manzate 75DF 2.0 lb (B,D,F)	2.1 b[w]	6.5 b	1.36 b	256 a	390 a
2 Tanos 50WDG 0.5 lb + Manzate 75DF 1.5 lb (A,C,E,G) Bravo WS 6SC 1.5 pt (B,D,F)	0.9 b	2.7 bc	0.57 b	247 a	399 a
3 Amistar 80WDG 0.13 lb (A,C,E,G) Bravo WS 6SC 1.5 lb (B,D,F)	0.6 b	1.3 c	0.30 b	267 a	408 a
4 Untreated	46.5 a	94.4 a	23.68 a	139 b	303 b

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.

[y] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.

[x] Application dates: A= 15 Jul; B= 22 Jul; C= 19 Jul; D= 5 Aug; E= 12 Aug; F= 19 Aug; G= 27 Aug.

[w] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Block 4

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 13 Sep. Taking 34 DAI as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Programs with 0.7 to 1.6% foliar late were not significantly different. Taking 45 DAI as a key reference point, there was complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control. Programs with 1.0 - 4.5% foliar late blight were not significantly different. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 45 DAI) compared to the untreated control. Application programs with RAUDPC values between 0.34

and 0.89 were not significantly different. All treatments had significantly greater marketable and total yield in comparison to the non-treated control. Programs with marketable yield from 223 - 274 cwt/A; and from 242 - 307 cwt/A were not significantly different. Treatments with total yield between 297 and 327 cwt/A were not significantly different. Phytotoxicity was not noted in any of the treatments.

Table 4. Efficacy of fungicides applied by ground equipment against foliar late blight (Block 4); MSU 2004.

	Foliar late blight (%)		RAUDPC[x]	Yield (cwt/A)	
	34 DAI[z]	45 DAI 5 DAFA[y]	Max = 100 0 - 45 DAI	US1	Total
Treatment and rate/acre					
1 Bravo WS 6SC 1.5 pt (A-H[w])	1.4 b[v]	3.0 b	0.8 b	245 bc	297 b
2 Bravo WS 6SC 0.75 pt (A-H)	1.1 b	4.5 b	0.9 b	223 b	293 b
3 Acrobat 50 WP 0.4 lb + Dithane RS 75WDG 2.0 lb (A-H)	0.8 b	2.1 b	0.6 b	307 c	364 b
4 BAS 550 SC 0.38 pt + Dithane RS 75WDG 2.0 lb (A-H)	1.6 b	2.9 b	0.9 b	268 bc	310 b
5 BAS 550 SC 0.38 pt + Parafnic Oil 75SC 0.5 pt (A-H)	1.0 b	3.0 b	0.7 b	242 bc	301 b
6 BAS 550 SC 0.38 pt + Parafnic Oil 75SC 0.5 pt + Dithane RS 75WDG 2.0 lb (A-H)	0.7 b	1.0 b	0.3 b	274 bc	327 b
7 Untreated	47.5 a	100.0 a	25.9a	75 a	148 a

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.

[y] Days after final application of fungicide.

[x] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.

[w] Application dates: A= 21 Jul; B= 28 Jul; C= 4 Aug; D= 11 Aug; E= 18 Aug; F= 25 Aug; G= 1 Sep; H= 8 Sep.

[v] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Block 5

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 13 Sep. Taking 34 DAI as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Programs with 0.58 to 2.80 % foliar late were not significantly different. Taking 45 DAI as a key reference point, there was complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control. Programs with 1.75 – 5.5 % foliar late blight were not significantly different. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 45 DAI) compared to the untreated control. Application programs with RAUDPC values between 0.40 and 5.3 were not significantly different. All treatments had significantly greater marketable yield in comparison to the non-treated control except program 3. Programs with marketable yield from 193 - 276 cwt/A were not significantly different. All treatments had significantly greater total yield in comparison to the non-treated control except program 3. Treatments with total yield between 239 and 332 cwt/A were not significantly different. Although treatments 1 and 2 had zero incidence of tubers with symptoms or signs of late blight there was no significant difference among any treatments or the non-treated control. Phytotoxicity was not noted in any of the treatments.

Table 5. Efficacy of fungicides applied by ground equipment against foliar late blight (Block 5); MSU 2004.

		Foliar late blight (%)				RAUDPC[x] Max = 100		Yield (cwt/A)				Tuber LB[w]
	Treatment and rate of application/A	34 DAI[z]		45 DAI 5DAFA[y]		0 - 45 DAI		US1		Total		
1	Calguard 1.0 pt + Rezist 2.0 pt + Sugar Mover 1.0 pt + Bravo WS 6SC 1.5 pt (A,B[v]) Calguard 1.0 pt + Rezist 2.0 pt + Sugar Mover 1.0 pt + Previcur 1.2 pt (C,D,E,F)	0.85	b[u]	1.75	c	0.4	b	256	a	315	a	0.0
2	Calguard 1.0 pt + Sugar Mover 1.0 pt + Bravo WS 6SC 1.5 pt (A,B) Calguard 1.0 pt + Sugar Mover 1.0 pt + Previcur 1.2 pt (C,D,E,F)	2.80	b	5.5	c	1.4	b	233	a	284	a	0.0
3	Calguard 1.0 pt + Rezist 2.0 pt + Sugar Mover 1.0 pt (A,B,C,D,E,F)	2.75	b	37.5	b	5.3	b	193	ab	239	ab	4.4
4	Bravo WS 6SC 1.5 pt (A,B,C,D,E,F)	0.58	b	2.5	c	0.4	b	276	a	332	a	9.0
5	Untreated...	65.0	a	100	a	28.0	a	84	b	145	b	7.6
	LSD (p = 0.05)[t]											18.53

[z] Days after inoculation with *Phytophthora infestans*, US8, A2.

[y] Days after final application of fungicide.

[x] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight.

[w] Incidence of tubers with symptoms or signs of potato late blight 82 days after harvest.

[v] Application dates: A= 4 Aug; B= 11 Aug; C= 18 Aug; D= 25 Aug; E= 1 Sep; F= 8 Sep.

[u] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

[t] Least significant difference at p = 0.05 if no significant difference amongst mean values for any measurement.

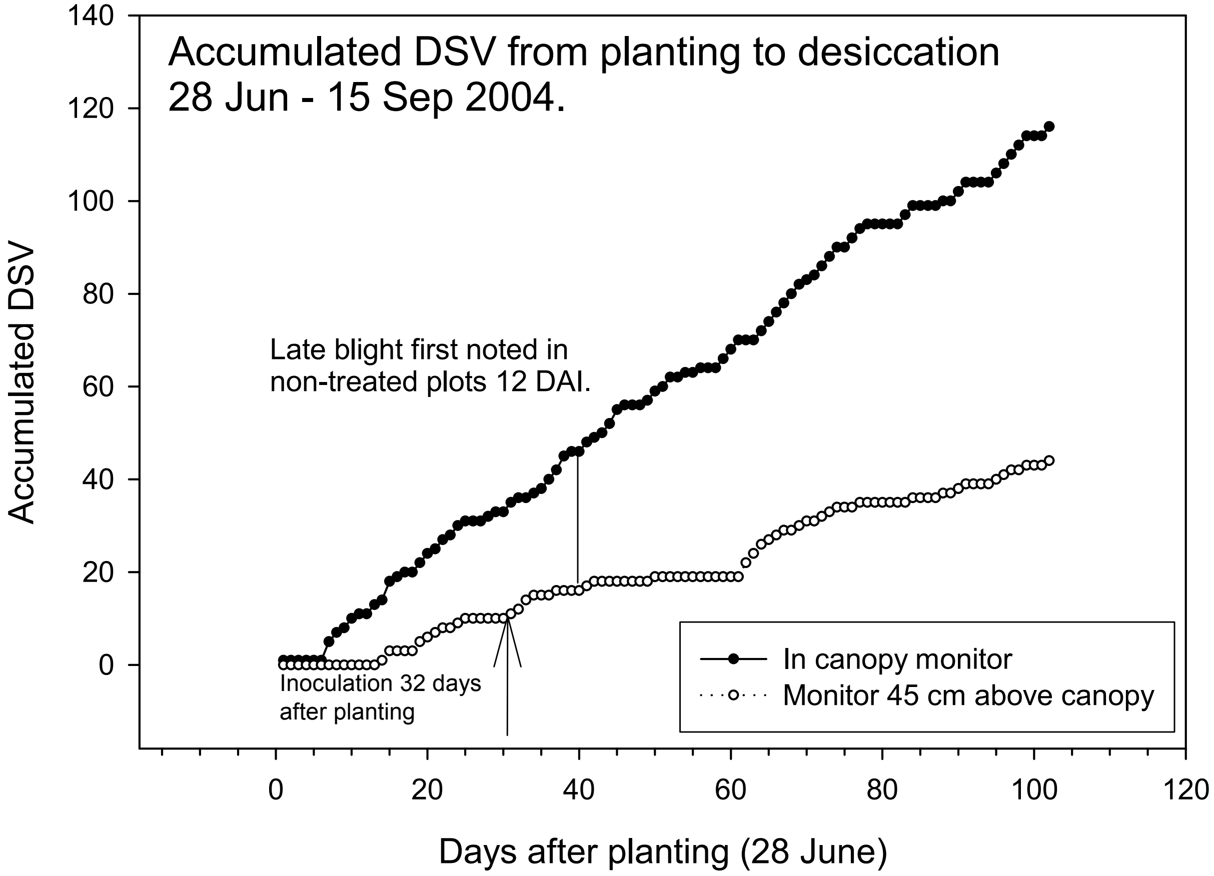

Figure 1. Accumualted late blight disease sevetiy values from planting to desiccation.

Michigan Potato Industry Commission
2004 Nematology Annual Report

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The 2004 Michigan State University Potato Nematode Research Program consisted of the following three projects:

1. Evaluation of potato lines and varieties for tolerance or resistance to the Potato Early-Die Disease Complex (Federal Project funded).

2. Impact of alternative tillage practices on tuber yield and root-lesion nematodes associated with potato production (MPIC funded).

3. Identification of the impacts of an alternate short-tem potato/vegetable cropping system trial and a soil quality restoration trial on soil quality as measured by nematode community structure analysis (MPIC funded).

A history of the Potato Early-Die Disease Complex Research in Michigan is included as an introduction to the 2004 Annual Report. The section entitled, *Evaluation of Potato Varieties and Breeding Lines for Tolerance to Early-Die*, was published in the February 2005 issue of the *Michigan Potato News Line*.

History of the Potato Early-Die Disease Complex Research in Michigan

When I arrived at Michigan State University in August of 1973, Michigan potato growers were just beginning to recognize the significance of potato early-die. A few farms were experimenting with soil fumigants such as D-D, Telone and Vorlex for control of this disease complex. The objective of this article is to: 1) review what has happened in MI during the last three decades in relation to potato early-die, 2) briefly describe my views about future research needs and 3) outline the current management recommendations.

Nature and Extent of the Problem.- The potato early-die disease complex is caused by an interaction between the root-lesion nematode (*Pratylenchus penetrans*) and a fungus known as *Verticillium dahliae*. It is usually most severe in coarse textured soils (sands and sandy loams). A 1975 survey funded by MIPC indicated that the root-lesion nematode was present in 63.6% of MI potato fields. In a similar survey in 1982, this nematode was recovered from 93.8% of the acreage sampled. In 2004, the potato early-die disease complex remains as a serious challenge to about 50% of MI potato acreage. MI tuber yields in the presence of potato early-die can be as low as 150 cwt/acre, whereas they can exceed 500 cwt/acre in the absence of this problem. The problem is most severe in sites that are degraded or of low soil quality. The overall concept of soil quality is discussed in this article.

In the late 1980s and early 1990s, our nematology laboratory began a comprehensive research program to learn more about the nature of the underground growth and development of the potato plant. Much to my surprise, the situation was more complex than expected. The below ground part of the potato plant consists of eight different parts (seed piece, basal roots, below ground stems, nodal roots, stolons, stolon roots, tubers and tuber roots). All of these parts have different functions and develop at different times. We learned that when root-lesion nematodes are present, basal root growth is inhibited within the first three weeks after planting, leading to low tuber yields at harvest. It was then discovered that root-lesion nematodes can directly invade stolon tissue, stolon roots and tuber roots, leading to further reductions in potato yield potential and tuber quality.

Thresholds-Predictive Models.- Research designed to determine root-lesion nematode and *Verticillium* population densities required for a potato early-die problem and management was funded by MPIC in the late 1970s. This work resulted in the potato early-die action thresholds currently used by MSU Diagnostic Services, www.cips.msu.edu/diagnostsics. It is strongly encouraged that all MI potato land that is not making its yield goals or is known to have a high risk to potato early-die be periodically sampled for both the root-lesion nematode and *V. dahliae*.

Nematicide Use and Research.- Research on fumigant and non-fumigant nematicides was conducted at MSU from 1974 through 1999. This work consisted of evaluation of fumigant nematicides such as Telone, Telone II, Vorlex, Vidden-D, Soil-Brom, Nemagon and Fumazone; non-fumigant nematicides such as Temik, Mocap, Vydate, Mocap and Furadan; and chemigants such as Vapam and Busan 1020. Many experimental compounds were also evaluated. In recent years, the MSU Bird Nematology Laboratory has also evaluated a large number of bionematicides.

Shortly after MI potato growers began to use D-D, Telone or Vorlex for nematode control, the non-fumigant nematicide-insecticide, Temik 15G was registered for use in potato production. I previously had five years of experience with this product as a cotton nematologist at the University of Georgia. Temik was used on about 50% of the MI potato acreage the first year it was available and 75% the second year. The third year, Temik usage was reduced to about 50% of the acreage, where it remained as long as this product was available in MI for use in potato production. Temik was easy to apply, did an excellent job of controlling root-lesion nematodes, was less expensive than most other nematicides and also provided control of some economically important potato insect pests.

Chemigation became popular in MI potato production in the mid-1980s. Initially, chemigants such as Vapam or Busan 1020 were applied through center-pivot irrigation systems, resulting in outstanding root-lesion nematode control and extremely high tuber yields. Later, systems were developed for application through travelers and ground-driven equipment. Chemigation remains an important component of MI potato production in 2004.

When Temik, an organocarbamate, was banned for use in Michigan, most potato growers using this product switched to Mocap, an organophosphate. Although Mocap is an excellent product for root-lesion nematode control, it does not move very well in soil water like Temik. Mocap must be thoroughly incorporated into the soil. The MI potato production system did not have a very good way to incorporate this product and results were often less satisfactory than that previously experienced through the use of Temik or a chemigant. In recent years there has been a significant increase in the use of Vydate, an organocarbamate, for root-lesion nematode control in MI potato production.

The MPIC pesticide use survey is excellent and provides information that is currently not available for most other MI commodities. I strongly encourage the industry to continue this initiative.

Resistant Varieties.- Research on the severity of potato early-die associated with various potato varieties was conducted with relatively little success between 1975 and 1997. In 1998, the Bird-Nematology Laboratory at MSU began to evaluate selected varieties and lines associated with Dr. Douches potato breeding program. The results of this USDA-funded initiative is described in detail in the 2003 Michigan Potato Research Report. A number of lines with potato early-die tolerance have been identified, and one line has exhibited possible resistance. If I have one regret in relation to my potato-early die research program, it would be that the resistant variety program was not started much earlier. The availability of numerous excellent soybean cyst nematode resistant soybean varieties has had a major positive impact on the MI soybean industry. During the past year I have started a new sugar beet cyst nematode resistant variety program that looks promising.

Biological Control.- There are two types of biological control in relation to nematodes that relate to potato production. The first uses living organisms to control plant-parasitic nematodes, such as the root-lesion nematode. Many potential biological control agents have been evaluated during the past decade for management of potato dearly-die in MI. Most of the candidates have worked well under laboratory conditions. None of them, however, have been successful in our trials under field conditions.

The second aspect relates to an important group of nematodes known as entomopathogenic nematodes. These are used as biological control agents for insects, such as the Colorado potato beetle. A number of entomopathogenic nematode products are commercially available and some provide excellent insect control in specific situations. It is my opinion that this area has excellent potential for future insect control in MI potato production.

Crop Rotation – Farming Systems.- In 1990, MPIC began to fund a long-term (10 year) crop rotation study designed to manage potato early-die. One of the first things learned was that late 1st-year alfalfa and 2nd-year alfalfa were very different than alfalfa grown in pots under greenhouse conditions. With very few exceptions, the highest tuber yields and least amount of potato early-die were associated with potato crops following two years of alfalfa. Another revelation was that when corn and wheat were removed from the system, risk to crop loss caused by northern root-knot nematodes increases. By 1995, it became readily apparent that the potato early-die problem could not be resolved through simple crop rotation and that many aspects of the production system had to be taken into consideration. The project was redesigned into a farming systems trial which lead to a realization of the importance of overall soil quality in relation to the incidence of potato early-die.

In 1979, MPIC began to fund a seven-year integrated project that was designed to investigate interactions between soil nutrition, potato early-die management and other potato production challenges. The 1979–1985 Michigan Potato Research Reports are full of data related to this project. Unfortunately, the project was about 10 to 15 years ahead of its time and both the researchers and the potato growers were unable to appreciate the potential significance of the work and plan adequately for the next steps.

In the late 1990s, research with the techniques and equipment associated with precision agriculture were evaluated in relation to their use in potato early-die management. Commercial potato fields were mapped in relation to the physical and chemical properties of the soil and also for root-lesion nematode population densities and associated tuber yields. It was shown that the technology of precision agriculture was excellent for identification of sites and parts of fields with a high risk of potato early-die. The procedures of precision agriculture clearly demonstrated that under commercial field conditions, risk to early-die and low tuber yields were highly correlated with coarse textured soils, high population densities of root-lesion nematodes and various other soil factors associated with degraded or poor quality soil.

Currently, there are two major farming system trials at the Montcalm Potato Research Station. One is designed to determine the impact of different tillage systems on potato early-die. This is a six-year trial. After the first six years, it appears that risk to potato early-die and root-lesion nematodes is less with a chisel-till system than with the conventional mold-board plot system. The second trial involves a two-year rotation with snap beans and sweet corn in addition to various cover crops and organic amendments.

Soil Quality.- Today, it is well known that most nematodes in MI are not plant parasites like the root-lesion nematode. The vast majority of nematodes in MI feed on bacteria and fungi. It is through this process that they mineralize nutrients such as nitrogen, and make it readily available for plant growth and development. In many sites the highest population densities of these beneficial nematodes are in the litter layer or o-horizon and not below the soil surface. Population densities of bacterial and fungal feeding nematodes are frequently low in poor quality or degraded soils having a high risk to potato early-die. This frequently results in: 1) an increase in population densities of plant parasitic nematodes like the root-lesion nematode, 2) damage to basal roots, nodal roots, stolons, stolon roots and tuber roots, 3) disruption of soil nutrient cycling and reduced availability for use by the potato plant and 4) early plant death with low tuber yields.

A high quality soil is one that resists degradation and responds to management. It contains a high diversity of different types of bacteria, fungi and fauna. This results in the soil structure and enrichment properties necessary for optimal plant growth. Recent studies has shown that specific chemicals previously used in potato production for control of infectious diseases caused by fungi and insect pests can have direct and indirect negative impacts on some types of bacterial and fungal feeding nematodes. In addition to disrupting soil nutrient cycles, this allows nematodes that are less sensitive to these chemicals to increase their population densities. The root-lesion nematode is one that has been identified as being among those that are tolerant to these chemicals! Does this mean that potato early-die is actually an unexpected result of some of our farming practices? Recent investigations have also demonstrated that both inorganic fertilizers and herbicides can impact soil ecosystems in ways that alter nutrient cycling and may reduce overall soil quality.

During the past 50 years, research on the role of soil fauna in relation to nutrient cycling has been very limited. It is now being recognized that soil fauna are an essential component of a high quality soil. By definition, a high quality soil is one that does not have a potato early-die problem. One long-term research project at Montcalm is designed to demonstrate the importance of high quality soil in relation to eliminating risk to potato early-die. This project was started at the end of the 2003 growing season. It is designed as a soil renovation initiative. Various crop rotations, soil tillage procedures and soil amendments are being used. The objective is to enhance the soil's Structure Index and Enrichment Index through a long-term increase in the quality and quantity of soil organic matter. Detailed description of the Structure Index and Enrichment Index concepts in relation to potato production and reduction in potato early-die risk will be the topic of future articles and presentations. These terms were introduced to the Michigan potato industry at the 2004 Montcalm Potato Research Farm Field Day.

Future Research Needs.- When I look back over the last 30 years, I believe that it was a mistake to separate Michigan potato research into its university disciplines. As all growers are very well aware, everything in a potato production system (late blight, Colorado potato beetle, early-die, plant genetics, plant nutrition, seed piece storage-quality, water use, soil quality, etc) impacts all other parts of the system. The original MPIC Integrated Project is an example of the type of research necessary for long-term success of the industry. This, however, must be supplemented with projects designed to provide short-term answers to immediate issues while work is progressing on how the system should really work (a work in progress that will never and should never be completed). My goal is to continue to provide the MI potato industry with chemical, biological, cultural and genetic potato early-die controls. I strongly believe, however, that the potato early-die problem can be eliminated through enhancement of soil quality. I plan to make this a major component of my MSU research activities and look forward to interacting with the MI potato industry on this topic.

Early-Die Management Recommendations.- It is essential that every potato grower have an understanding of the early-die risk associated with each field. The best way to do this is through keeping high quality long-term records of potato yields, tuber quality and crop rotations for each site. If yield goals are not being obtained, soil and root tissue should be submitted to MSU Diagnostic Services for analysis for root-lesion nematodes, *Verticillim dahliae* and early-die risk. The MSU early-die threshold chart can be used to determine future risk to early-die. It must be remembered that once seed pieces have been planted in a site with high risk to early-die, it is almost impossible to control the problem. Prevention, therefore is the only appropriate strategy. This should include rotations designed to reduce population densities of root-lesion nematodes and *V. dahliae*, use of varieties that have a history of yielding reasonably well in early-die sites, and maintenance of optimal soil nutrition and moisture.

When population densities of root-lesion nematodes or *V. dahliae* exceed their individual or joint action thresholds, it may be necessary to apply a nematicide. If appropriate, chemigation with metham or fumigation with Telone II should be done the fall before potato planting. The nematicidal rate of metham is all that is necessary for early-die control. Application rates and methods are described on page 91 of MSU Extension Bulletin E-312, entitled 2004 Insect, Disease and Nematode Control for Commercial Vegetables. If desirable, Vydate should be applied at planting as described in MSU Ext Bulletin E-312. Use of this material as a foliar spray for Colorado potato beetle control will also reduce risk to early-die, providing a pre-plant or at-plant nematicide has also been used. If Mocap is used, every possible attempt should be made to incorporate this product. MSU research data show that the best way to use this product is on a pre-plant incorporated basis. Mid-season root densities of lesion nematodes can provide as excellent indication of the success of nematode control, early-die risk and potential tuber yield.

The key to elimination of risk to early-die is currently believed to be soil organic matter. Both the quality and quantity of soil organic matter are thought to be important. Michigan potato growers should ask themselves the following four questions about each of their potato fields.

- What was the soil organic matter content 150 years ago?
- What was the soil organic matter content 10 years ago?
- What is the current soil organic matter content?
- What do you want the soil organic matter content to be 10 years from now?

If the soil organic matter in a field has declined or is less than optimal for highly structured ecosystems that have the enrichment capabilities required for profitable potato production, the quality and quantity of the soil organic matter needs to be enhanced. During the past five years I have been surprised at how little soil organic matter exists in some coarse textured soils in MI and how much organic matter exists at other coarse textured sites. Anything that can be done to improve the long-term organic matter content of MI potato soils should reduce risk to early-die.

In my soil classification system, soils with an early-die problem are degraded soils. Some of these respond to management and some do not. In either case, a soil renovation project is probably warranted to improve soil quality. During the past 10 years, science has begun to recognize that nematode community structure can be used as an indicator of the quality of soil, water and air. MSU Diagnostic Services offers a nematode community structure assessment. This procedure is being used as part of the soil renovation project at the Montcalm Potato Research Farm

Evaluation of Potato Varieties and Breeding Lines for Tolerance to Early-Die

Since 1998, selected potato varieties and lines have been evaluated annually at the Montcalm Potato Research Farm for tolerance to the Early-Die Disease Complex. This work has been supported by the USDA Potato Grant and done in cooperation with the MSU Potato Breeding Program under the direction of Dr. Dave Douches. Twenty-two lines and varieties were evaluated in 2004. Five exhibited tolerance (Table 1), based on their relative high yields, lack of response to soil fumigation and support of normal root population densities of the root-lesion nematode, *Pratylenchus penetrans* (Table 2). The varieties-lines exhibiting PED tolerance included Boulder (formerly F373-3), WI 1201 (to be named Megachip), FL 1879 and UEC (Unknown Eastern Chipper). Boulder was described by Douches *et al.* in 2003 (Am. Potato Res. 80:345-352). Seventeen additional lines-varieties, including three PED susceptible standards, were susceptible to PED in 2004. There were no significant differences among the mid-season nematode population densities for any of the 22 varieties-lines. Mid-season root population densities associated with plants grown under non-fumigated conditions were higher than expected. A metham fumigation rate of 37.5 gpa was used in 2004; whereas, 75 gpa was used for the 1998-2003 evaluations.

In summary, this research has demonstrated that one potato variety, Boulder (MS 702 x NY 88) and one line, MSE 228-1 (Russet Nugget x Spartan Pearl) are tolerant to PED and suitable for in PED risk sites (Table 3). Thirteen additional lines-varieties have exhibited tolerance, but require one to three additional years of evaluation before they can be classified as tolerant to PED. Ten varieties and three lines have been classified as susceptible to PED and should not be planted on PED risk sites without the use of soil fumigation, chemigation, non-fumigant nematicides or alternative PED managaement practices. Twenty-one lines have exhibited susceptibility, but require one to three additional years of evaluation before they can be classified as susceptible to PED. An additional nine lines have exhibited variable response to soil fumigation, indicating inconclusive results in relation to PED susceptibility-tolerance. One highly scab susceptible line, MSF 349-1RY (Rose Gold x WI 877) exhibited four years of resistance to PED without having any specific known source of resistance. This was followed by tolerant and susceptible responses in 2003 and 2004, respectively. It is thought that the highly unique resistant reaction was antibiotic mediated through the extensive Actinomycete pressure associated with this line.

Impact of Tillage on Potato Tuber Yield and Root-Lesion Nematodes

The research consists of two tillage systems (chisel plow and mold board plow) used in a three-year rotation with potato, wheat and corn. Clover is frost-seeded into the wheat. It is a six-year trial with two cycles of the three-year rotation. At the end of the first four years of the research project designed to determine the impact of tillage (chisel plow vs mold board plow) on potato tuber yield and population dynamics of the root-lesion nematode (*Pratylenchus penetrans*), total tuber yields associated with the chisel plow system were 21% greater than those associated with the mold board plow system (Table 4). A-size tuber yields associated with the chisel plow system were 25% greater than those associated with the mold board plow system (Table 5). This response appeared to stabilize during the third year of the research project. Distinct patterns of root-lesion nematode population dynamics are becoming evident (Tables 5 & 6). At the beginning of the growing season, most the root-lesion nematodes associated with the wheat and cover are in root tissue (see 2003 MPIC Annual Report). In general, soil root-lesion nematode population densities at this time a lower than those associated with the plots previously in potato or corn (Table 6). Mid-season population densities of root-lesion nematodes are higher in corn and wheat/clover, compared to potato (Table 7).

Soil Quality of Short Term Potato/Vegetable Rotation Systems

The short-term potato/vegetable rotation trial was established by Dr. Snapp in 2001. It consists of nine cropping systems, in a two-year rotation, with both potato and snap bean produced annually for each of seven of the system. Each system is also done with and without a manure input. During the past 50 years, very little research has been done on the role of soil biology in relation to soil nutrient mineralization. This very important chapter of the soil science text book has yet to be written. The 2004 MPIC report on the nematode part of the cropping systems project will focus on the nature of the impacts of nematodes and other soil fauna on making nutrients available for potato production. Nematodes and other soil fauna are responsible for mineralization of about 38% of the biologically-mediated soil nutrient mineralization. Bacterial-feeding nematodes can be responsible for about 67% of the nutrients mineralized by soil fauna. Recently, nematologists have developed a comprehensive model for prediction of soil quality based on structural and enrichment indices. This system has been modified for use in Michigan and will serve as the basis for the soil quality assessment associated with this cropping systems research project.

Soil Quality Restoration Trial

In 2003, a soil quality restoration research site was established at the Montcalm Potato Research Farm. This is a cooperative projective with George Bird, Sieglinde Snapp, Willie Kirk and Mark Otto serving as co-principal investigators. The trial consists of four soil management systems: 1) Control (wheat/rye/potato, fumigated), 2) Wheat & Mustard (wheat/mustard & rye/potato), 3) Ultra-Biofumigant (mustard & rye/sudax/ mustard & rye/potato and 4) Ultra-Legume (vetch & rye/soybean green manure/vetch & rye/potato. Bacterial feeding nematodes were significant higher in the ultra –biofumigant treatment at the end of the 2004 growing season, compared to the control (Table 8). Population densities of fungivores, omnivores and carnivores were low, indicating a degraded soil quality in all of the systems. It appeared that control of plant-parasitic nematodes was obtained with both the soil fumigation treatment and the ultra-biofumigant treatment. The mycorrhizae situation in regards to potato production is still unclear and the low population densities of oligocheates is an additional indication of a degraded soil with both poor structural and enrichment properties.

Table 1. Tuber yields associated with the 2004 potato variety-line Montcalm Potato Research Farm field trial for evaluation of tolerance to Potato Early-Die (PED).

PED tolerant lines-varieties	Fumigated	Non-fumigated	Yield Adv	P
1. WI 1201 (Megachip)	339 cwt/a	359 cwt/a	-5.6	0.476
2. FL 1879	313 cwt/a	353 cwt/a	-11.3	0.330
3. H095-4	222 cwt/a	327 cwt/a	-32.1	0.226
4. Boulder (F373-3)	317 cwt/a	316 cwt/a	0.32	0.445
5. UEC	218 cwt/a	247 cwt/a	-11.7	0.377
PED susceptible lines-varieties				
1. FL 1833	314 cwt/a	298 cwt/a	5.4	0.373
2. FL 1867	239 cwt/a	220 cwt/a	8.6	0.220
3. FL 1922	236 cwt/a	220 cwt/a	7.3	0.453
4. H067-3	266 cwt/a	283 cwt/a	6.0	0.330
5. Spunta	320 cwt/a	302 cwt/a	6.0	0.300
6. G227-2	321 cwt/a	290 cwt/a	10.7	0.111
7. Marcy (NY112)	391 cwt/a	351 cwt/a	11.4	0.27
8. MI Purple	329 cwt/a	286 cwt/a	15.0	0.170
9. I005-20Y	356 cwt/a	300 cwt/a	18.7	0.133
10. E192-8Rus	229 cwt/a	193 cwt/a	18.7	0.112
11. E-018-1	323 cwt/a	269 cwt/a	20.1	0.041
12. F349-1RY	313 cwt/c	254 cwt/a	23.2	0.109
13. J461-1	424 cwt/a	341 cwt/a	24.3	0.045
14. H094-8	347 cwt/a	248 cwt/a	39.9	0.021
PED susceptible standards				
1. Snowden	329 cwt/a	271 cwt/a	21.4	0.107
2. Atlantic	319 cwt/a	248 cwt/a	28.6	0.040
3. Russet Norkodah	313 cwt/a	216 cwt/a	44.9	0.042

Table 2. Mid-season root population density of root-lesion nematodes (*Pratylenchus penetrans*) associated with 22 potato varieties-lines evaluated in 2004 for tolerance to Potato Early-Die (PED).

PED tolerant Varieties-lines	Root-lesion nematodes per 100 cm^3 soil Non-fumigated	Fumigated
1. WI 1201 (Megachip)	219	6
2. FL 1879	51	24
4. H095-4	163	10
5. Boulder (F373-3)	191	20
6. UEC	166	7
PED susceptible lines-varieties		
1. FL 1833	183	45
2. FL 1867	243	5
3. FL 1922	139	2
4. H067-3	188	13
5. Spunta	81	5
6. G227-2	80	25
7. Marcy (NY112)	164	15
8. MI Purple	210	25
9. I005-20Y	280	24
10. E192-8Rus	309	11
11. E-018-1	169	3
12. F349-1RY	271	13
13. J461-1	119	10
14. H094-8	390	9
PED susceptible standards		
1. Snowden	136	3
2. Atlantic	193	11
3. Russet Norkodah	250	4

Table 3. Summary of 1998-2004 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research conducted at the Montcalm Potato Research Farm.

Potato Early-Die Tolerant Variety-Line

High yield in presence of potato early-die conditions with normal root-lesion nematode reproduction during four or more growing seasons.

Boulder, MSF 373-3 (98, 00, 03, 04)
MSE 228-1, Russet Nuggett x Spartan Pearl (98, 99, 00, 01)

Probable Tolerance Variety-Lines

One to three years of additional PED evaluation are required.

WI 1201 (02, 04)
MSH 095-4 (03)
MSJ 316-A (03)
NY 120 (01, 02)
MSH 333-3 (01
MSE 028-1 (00)
MSF 060-6 (00)
MSE 018-1 (99, 00, 03)
MSJ 461-1 (03)
Bannock Russett (02)
MSH 094-8 (01, 02)
WI 1431 (01)
MSE 273-8 (00)

Susceptible Varieties and Lines

Low yields in presence of potato early-die conditions, normal or high root-lesion nematode reproduction, and good response to soil fumigation.

Atlantic (97, 99, 00, 01, 02, 03, 04)
Russet Norkotah (02, 03, 04)
Jacqueline Lee, MSG 274-3 (99, 00, 01, 02)
Onaway (01, 02, 03)
Superior (01, 02, 03)
MSE 202-3 Rus (00, 01, 02, 03)
MSE 149-5Y (98, 99, 00,01)
Snowden (97, 99, 00, 01, 02, 03, 04)
Goldrush (02, 03)
Liberator, MSA091 (01, 02)
Russet Burbank (03)
Pike (02)
MSF 099-3 (99, 00, 01, 02)

Table 3 (continued)

Probable Susceptibility

One to three years of additional PED evaluation are required.

MSH 067-3 (03, 04)
MSE 192-8Rus (03, 04)
WI 1836-3Rus (03)
MSK 061-4 (03)
MSJ 167-1 (03)
MSG 015-C (010
MSP 81-11-5 (00)
MSH094-8 (03, 04)
MSE 221-1 (00, 01, 03)
NDTX 4271-SR (03)
MSJ 317-1 (03)
MSB 076G-3 (01)
MSG 124-85 (00)
WI 1368 (01)
MSG 227-2 (03, 04)
BO 766-3 (03)
MS I005-20Y (03)
MSF 099-3 (03)
MSB 106-7 (00)
MSH 026-3 Rus (01)
WI 1386 (01)

Inconclusive

Variable response to soil fumigation, additional information required.

MI Purple (00 tolerant, 01 susceptible, 02 tolerant, 03 susceptible, 04 susceptible)
NY112, Marcy (01 tolerant, 02 tolerant, 04 susceptible)
MSG 227-2 (00 susceptible, 01 tolerant, 02 tolerant)
MSG 004-3 (00 susceptible, 01 tolerant)
MSH 031-5 (00 tolerant, 01 susceptible)
MSB 107-1 (98 inconclusive, 99 susceptible, 00 tolerant)
MSF 313-3 (98 susceptible, 00 tolerant)
MSG 050-2 (99 possible resistance, 00 susceptible)
MSE 048-2Y (98 possible tolerant., 99 susceptible, 00 susceptible)

Highly Unique Response

MSF349-1RY (98, 00, 01, 02 resistant; 03 tolerant; 04 susceptible)

Rose Gold x WI 877, highly susceptible to scab. The resistant reaction most likely was antibiotic mediated through extensive Actinomycetes pressure in 98, 00, 01 and 02, but not in 04.

Table 4. 2001-2004 influence of alternative tillage systems on potato tuber yield (cwt/acre).

Tillage	2001	2002	2003	2004	Mean
Chisel Plow	247	487	180	280	299
Mold Board Plow	196	382	134	232	236
T Test P Value	0.33	0.64	0.00	0.09	0.01

Table 5. 2001-2004 influence of alternative tillage systems on A-size potato tuber yield (cwt/acre).

Tillage	2001	2002	2003	2004	Mean
Chisel Plow	220	452	159	256	272
Mold Board Plow	165	340	103	202	203
T Test P Value	0.31	0.23	0.00	0.09	0.01

Table 6. Early-season soil population densities of root-lesion nematodes (*Pratylenchus penetrans*)associated with alternative potato production till systems.

System	2001	2002	2003	2004
Chisel plow				
Corn	102 c	160 c	76 b	110 bc
Potato	131 bc	62 b	107 bc	97 bc
Wheat	95 bc	6 a	6 a	33 ab
Mold board plow				
Corn	42 a	78 b	124 b	111 c
Potato	43 a	124 bc	76 b	86 abc
Wheat	67 ab	8 a	7 a	24 a

Table 7. Mid-season (1.0 g root tissue) population densities of root-lesion nematodes (*Pratylenchus penetrans*)associated with alternative potato production till systems.

System	2001	2002	2003	2004
Chisel plow				
Corn	520 b	304 bc	145 a	323 ab
Potato	169 a	46 a	125 a	134 a
Wheat	278 ab	132 ab	524 b	424 b
Mold board plow				
Corn	316 b	382 c	525 b	453 b
Potato	130 a	54 a	216 a	154 a
Wheat	270 ab	87 a	450 b	423 b

Table 8. 2004 end-of-season nematode population densities associated with the Montcalm Potato Research Farm soil restoration trial.

Nematode Guild (P)	Soil restoration treatment			
	Control	Wheat/Mustard	Ultra-Biofumigant	Ultra-Legume
Bacterivores (0.001)	44 a	229 ab	579 b	265 ab
Fungivores (0.252)	9	13	25	31
Herbivores (0.088)	2	30	14	81
Omnivores (0.300)	4	18	15	14
Carnivores (1.000)	0	0	0	0
Mycorrhizae (0.113	25	50	23	41
Oligocheates (0.159)	3	1	5	8

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Potato Insect Biology and Management

Report to the Michigan Potato Industry Commission
January 12, 2005

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Outline.

I. Resistance of Colorado potato beetle populations to imidacloprid and thiamethoxam was evaluated for field populations from Michigan, as well as other locations in the Midwest and locations in the northeastern and western U.S.

II. Field insecticide evaluations of registered and experimental insecticides.

III. Effectiveness of Fulfill® treated potato plants for preventing transmission of PVY by aphids.

I. Resistance of Colorado potato beetle populations to imidacloprid and thiamethoxam.

Imidacloprid (Admire®, Provado®) has been the primary insecticide for Colorado potato beetle control since its registration in 1995. Such long term and widespread use of one compound greatly increases the chances for resistance development. In 2002, thiamethoxam (Platinum®, Actara®), also a neonicotinoid, became available for commercial use. The similarities between these two compounds warrant careful scrutiny for resistance and cross-resistance development.

Our objectives were to continue gathering data on baseline susceptibility to imidacloprid and thiamethoxam in Colorado potato beetle populations collected from commercial potato fields in Michigan and other regions of the United States. A second objective was to determine if susceptibility to thiamethoxam was correlated with susceptibility to imidacloprid. To accomplish these objectives, 21 Colorado potato beetle populations (six Michigan populations, 11 populations collected in other states, and four laboratory populations) were bioassayed with imidacloprid and/or thiamethoxam.

Methods

During 2004, six Colorado potato beetle populations were collected from three different Michigan counties (Isabella, Mecosta, and Montcalm). Syngenta representatives and other cooperators also provided one population each from Delaware, Idaho, Massachusetts, New York, and Washington, two populations from Minnesota, and four populations from Wisconsin. Four strains maintained in the laboratory were also tested (Table I.1).

Colorado potato beetle adults were either kept at room temperature (25±1° C) and fed foliage daily or, for longer term storage, kept in controlled environment chambers (11±1° C) and fed weekly. Beetles were treated with 1 μl of acetone/insecticide solution of known concentration applied to the ventral surface of the abdomen using a 50 μl Hamilton® microsyringe. Following treatment, beetles were placed in 100 mm diameter petri dishes lined with Whatman® No. 1 filter paper and provided with fresh potato foliage. They were kept at 25±1° C and the foliage and filter paper were checked daily and changed as needed.

A preliminary screen was conducted on each population to determine relative susceptibility to imidacloprid and thiamethoxam by testing 10 beetles each with four concentrations of insecticide/acetone solution. Based on the results of these screens, a range of five concentrations was selected for each population to be assayed and each bioassay was replicated up to three times. In each replicate, 9-15 beetles were treated with each concentration (three to five beetles per dish and three dishes per concentration).

Beetle response was assessed 7 days post treatment. A beetle was classified as dead if its abdomen was shrunken, it did not move when its legs or tarsi were pinched, and its elytra were darkened. A beetle was classified as walking and healthy if it was able to grasp a pencil and walk forward normally. A beetle was classified as poisoned if its legs were extended and shaking, it was unable to right itself or grasp a pencil, and it was unable to walk forward normally at least one body length. Dead and poisoned beetle numbers were pooled for analysis. Data were analyzed using standard log-probit analysis (SAS® System v8.01).

Results

Imidacloprid. The LD_{50} values for imidacloprid, 7 days post treatment, ranged from 0.027 μg/beetle (Newell) to 0.828 μg/beetle (Mecosta) for Michigan populations and from 0.031 μg/beetle (Eltopia, WA) to 7.675 μg/beetle (Little Creek, DE) for out-of-state populations (Table I.2, Figure I.1). For the first time in the Midwest, significant levels of resistance to imidacloprid were discovered. Beetles from the Mecosta (0.828 μg/beetle) and Sackett (0.572 μg/beetle) samples were 23-fold and 16-fold resistant to imidacolprid, respectively, compared to the susceptible New Jersey strain (LD_{50} = 0.036 μg/beetle). The two samples were from fields on the same farm, ca. 1 km apart, and are believed to be from the same population. The Sackett beetles were overwintering adults from 2003 and the Mecosta beetles were newly emerged summer adults. Populations from

Massachusetts and Delaware both showed high levels of resistance, providing results very similar to those from the same sites in previous years. The values for LD_{50} Minnesota, Washington, Wisconsin, and the rest of Michigan were at or near susceptible levels, consistent with results obtained for Colorado potato beetles from the same areas in previous years. Due to high mortality prior to testing, the Idaho population was not bioassayed, but the preliminary screens indicated that it was also a highly susceptible population.

Thiamethoxam. LD_{50} values for thiamethoxam, 7 days post treatment, ranged from 0.018 µg/beetle (Isabella) to 0.339 µg/beetle (Sackett) for Michigan populations and from 0.033 µg/beetle (Hancock, WI) to 0.635 µg/beetle (Little Creek, DE) for out-of-state populations (Table I.3, Figure I.2). The Little Creek, DE (19-fold resistant) and Northampton, MA (11-fold resistant) populations both showed elevated levels of resistance to thiamethoxam when compared to the susceptible New Jersey strain (LD_{50} = 0.033 µg/beetle). Likewise, the Sackett (10 fold) and Mecosta (5 fold) populations showed higher levels of tolerance than we have previously detected in Michigan. All other field populations were consistent with results from previous seasons. As with imidacloprid, the Idaho population was not bioassayed, but the preliminary screens indicated it was a highly susceptible population.

Susceptibility to imidacloprid (as measured by LD_{50}) in field-collected Colorado potato beetle populations was highly correlated with susceptibility to thiamethoxam (Figure I.3). This result was also found in 1998, 1999, 2000, 2002, and 2003. This clearly shows that selection with imidacloprid over the past 10 years has also selected for resistance to thiamethoxam, although at a much lower level than imidacloprid resistance.

Laboratory strain LD_{50} values ranged from 0.036 µg/beetle (New Jersey) to 8.995 µg/beetle (Hadley) for imidacloprid and from 0.033 µg/beetle (New Jersey) to 1.222 µg/beetle (Hadley) for thiamethoxam. The Hadley strain was collected from a commercial field in Massachusetts in 2003 and was the first field population to show elevated resistance to thiamethoxam (LD_{50} = 0.867 µg/beetle). Survivors from bioassays in 2003 were used to start a laboratory strain, and emergent adults from each generation have been selected with thiamethoxam doses targeting 60-90% mortality. After five generations, there has been an increase in the thiamethoxam LD_{50} value, but the difference was not significant due to overlapping confidence intervals. Despite frequent selection pressure, this strain still exhibits high variability in its response to thiamethoxam, suggesting that complex genetic factors may be involved.

Adults from a susceptible strain that originated from an organic potato farm in Michigan's Upper Peninsula were selected with thiamethoxam to start the S-Sel strain. Each generation, adults were selected with thiamethoxam doses targeting 60-90% mortality. The strain was maintained for nine generations, with bioassays conducted every third generation. The thiamethoxam LD_{50} increased from 0.044 µg/beetle (95% fiducial limit = 0.038-0.050) to 0.814 µg/beetle (95% fiducial limit = 0.695-0.982) by the ninth generation. Despite no exposure, the imidacloprid LD_{50} also increased from 0.031 µg/beetle (95% fiducial limit = 0.026-0.039) to 1.151 µg/beetle (95% fiducial limit =

0.930-1.643) by the ninth generation. These numbers are roughly a 25-fold increase in resistance to thiamethoxam and a 32-fold increase in resistance to imidacloprid, when compared to the New Jersey susceptible strain.

In contrast, the Fiesta strain showed an entirely different pattern in response to selection with thiamethoxam. The Fiesta strain was started by selecting adults from a resistant strain collected at Long Island, NY. The strain was also maintained for nine generations and bioassayed every third generation. The thiamethoxam LD_{50} showed an initial increase by the third generation (from 0.241 µg/beetle to 0.455 µg/beetle), but then decreased by the ninth generation (0.290 µg/beetle). It is unclear why this population showed no significant increase in the level of resistance to thiamethoxam.

Summary

- Resistance to imidacloprid continues to increase in the eastern U.S.
- Resistance to imidacloprid appeared for the first tiem in a field population in the Midwest in 2004
- Resistance to thiamethoxam, first detected in 2003, has appeared in two more locations in 2004 (DE and MA)
- Laboratory selection shows that thiamethoxam resistance can increase rapidly with selection but results are variable
- Under lab selection with thiamethoxam, resistance to imidacloprid remains stable or increases

Table I.1. Colorado potato beetle populations bioassayed for susceptibility to imidacloprid and thiamethoxam in 2004.

Michigan populations
Anderson Adults were collected by Mark Otto from a commercial potato field in Montcalm Co. on 19 July 2004.
Isabella Adults were collected by Mark Otto from a commercial potato field in Isabella Co. on 9 August 2004.
Mecosta Adults were collected by Mark Otto from a commercial potato field in Mecosta Co. on 26 July 2004.
Montcalm Farm Adults were collected from the Michigan State University Montcalm Potato Research Farm in Montcalm Co. on 22 July 2004.
Newell Adults were collected by Mark Otto from a commercial potato field near Trufant, Montcalm Co. on 27 and 31 July 2004.
Sackett Adults were collected by Mark Otto from a commercial potato field in Mecosta Co. on 1 June 2004.
Out-of-state populations
Clear Lake, Minnesota Adults were collected by Brett Miller, Syngenta Crop Protection, Inc., from untreated edges of a commercial potato field near Clear Lake, MN on 19 August 2004.
Coloma, Wisconsin Adults were collected by Steve Dierks, University of Wisconsin-Madison, from the Jacobs West field, Coloma Farms Inc. on 10 August 2004.
Eltopia, Washington Adults were collected by Chris Clemens, Syngenta Crop Protection Inc., from untreated potatoes at a research farm in Eltopia, WA on 13 August 2004.
Gyndon, Minnesota Adults were collected by Don Carey, North Dakota State University, from untreated potatoes near Gyndon, MN on 4 August 2004.
Hancock, Wisconsin Adults were provided by Jeff Wyman, University of Wisconsin-Madison, from the Hancock Agricultural Research Station, Waushara Co. on 29 July 2004.
Hudson, New York Adults were collected by Kurt Jones, Syngenta Crop Protection, Inc., from untreated potatoes at the Syngenta Eastern Region Technical Center, Hudson, NY on 2 June 2004.
Little Creek, Delaware Adults were collected by Joanne Whalen, Extension IPM Specialist at University of Delaware, from a commercial potato field near Little Creek, DE on 23 June 2004.
Northampton, Massachusetts Adults were collected by Sandra Shinn, Syngenta Crop Protection Inc., in Northampton, MA on 12 July 2003.
Oakley, Idaho Adults were collected by Marty Schraer, Syngenta Crop Protection Inc., from untreated potatoes near Oakley, ID on 28 June 2004.
Plover, Wisconsin Adults were provided by Jeff Wyman, University of Wisconsin-Madison, from a commercial potato field in Ellis, WI on 16 August 2004.
Prairie, Wisconsin Adults were collected by Ronnie Wolosek, University of Wisconsin-Madison, from a commercial potato field in Plover, WI on 9 August 2004.
Laboratory strains
Fiesta Originally collected from Jamesport, Long Island, NY in August 1999 and maintained in the laboratory without selection. Starting in 2002, adults and subsequent offspring were selected with thiamethoxam doses targeting 60-80% mortality.
Hadley Collected from Hadley, MA in July 2003. Adults from each generation have been selected with thiamethoxam doses targeting 60-80% mortality.
New Jersey Adults obtained from the Phillip Alampi Beneficial Insects Rearing Laboratory, New Jersey Department of Agriculture.
NY-Sel Collected from Long Island, NY in 1997 and adults were selected with imidacloprid doses targeting 60-80% mortality to maintain resistance.
S-Sel Collected from an organic farm near Calumet, MI in 1999. Adults from each generation were selected with thiamethoxam doses targeting 60-80% mortality.

Table I.2. LD_{50} values (µg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with imidacloprid at 7 days after treatment.

	LD_{50}	95% fiducial limits
Michigan populations		
Anderson	0.088	0.077-0.099
Isabella	0.058	0.039-0.073
Mecosta	0.828	0.363-1.114
Montcalm Farm	0.047	0.034-0.059
Newell	0.027	0.003-0.050
Sackett	0.572	0.374-0.740
out-of-state populations		
Clear Lake, MN	0.106	0.081-0.158
Coloma, WI	0.108	0.091-0.128
Eltopia, WA	0.031	0.020-0.042
Gyndon, MN	0.044	0.032-0.055
Hancock, WI	0.066	0.016-0.100
Hudson, NY	0.076	0.057-0.133
Little Creek, DE	7.675	4.500-523.878
Northampton, MA	2.327	1.825-3.331
Plover, WI	0.120	0.019-0.226
Prairie, WI	0.072	0.059-0.084
laboratory strains		
Fiesta	1.164	0.326-1.765
Hadley	8.995	*
New Jersey	0.036	0.032-0.041
NY-Sel	7.207	5.473-11.700
S-Sel	1.151	0.930-1.643

Table I.3. LD_{50} values (μg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with thiamethoxam at 7 days after treatment.		
	LD_{50}	95% fiducial limits
Michigan populations		
Anderson	0.057	0.047-0.064
Isabella	0.018	*
Mecosta	0.171	0.144-0.199
Montcalm Farm	0.056	0.036-0.080
Newell	0.036	0.013-0.049
Sackett	0.339	0.272-0.393
out-of-state populations		
Clear Lake, MN	0.045	0.037-0.053
Coloma, WI	0.056	0.037-0.070
Gyndon, MN	0.046	0.041-0.052
Hancock, WI	0.033	0.000-0.070
Hudson, NY	0.047	0.024-0.064
Little Creek, DE	0.635	0.543-0.724
Northampton, MA	0.355	0.282-0.483
Plover, WI	0.072	0.001-0.126
Prairie, WI	0.042	0.022-0.055
laboratory strains		
Fiesta	0.290	0.245-0.333
Hadley	1.222	0.606-8.708
New Jersey	0.033	0.029-0.037
NY-Sel	0.687	0.536-1.055
S-Sel	0.814	0.695-0.982

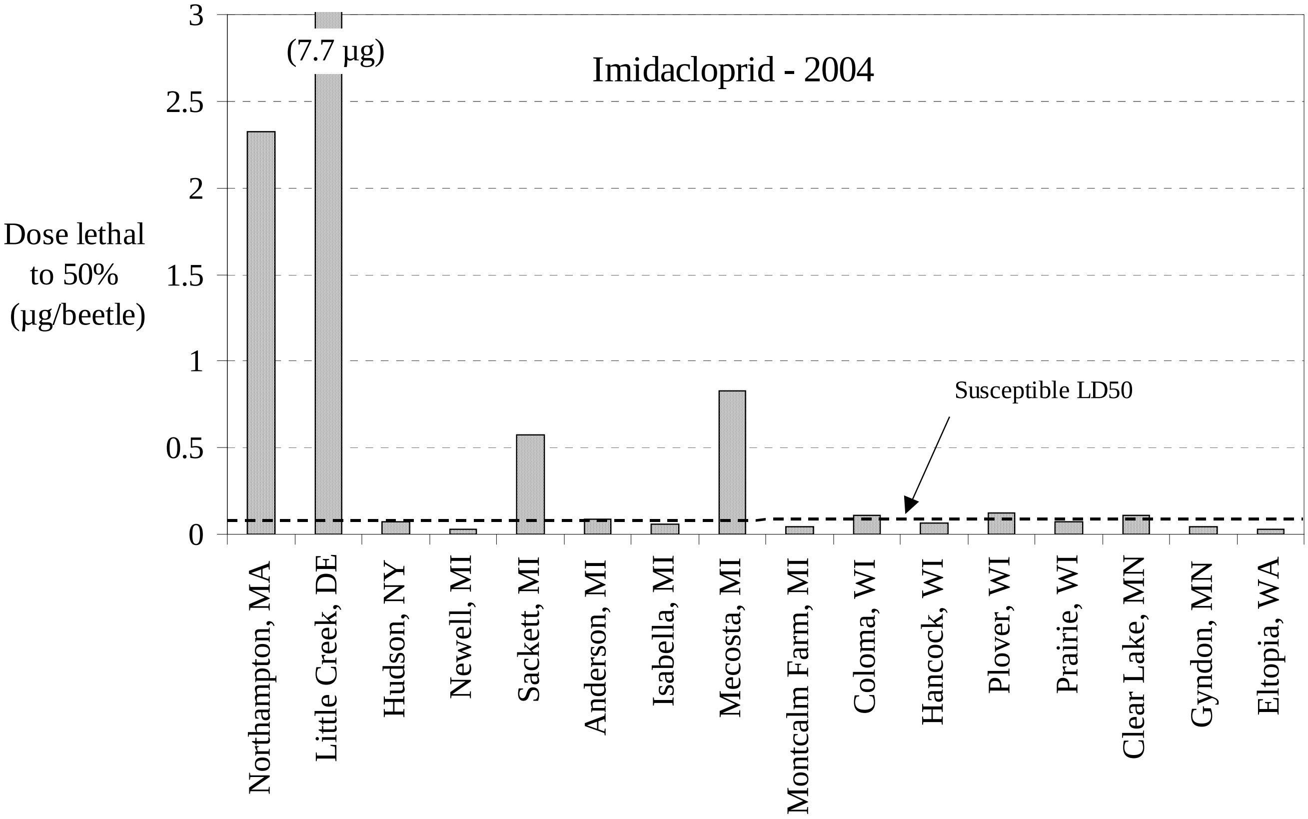

Figure I.1. Doses lethal to 50% of Colorado potato beetle populations to imidacloprid.

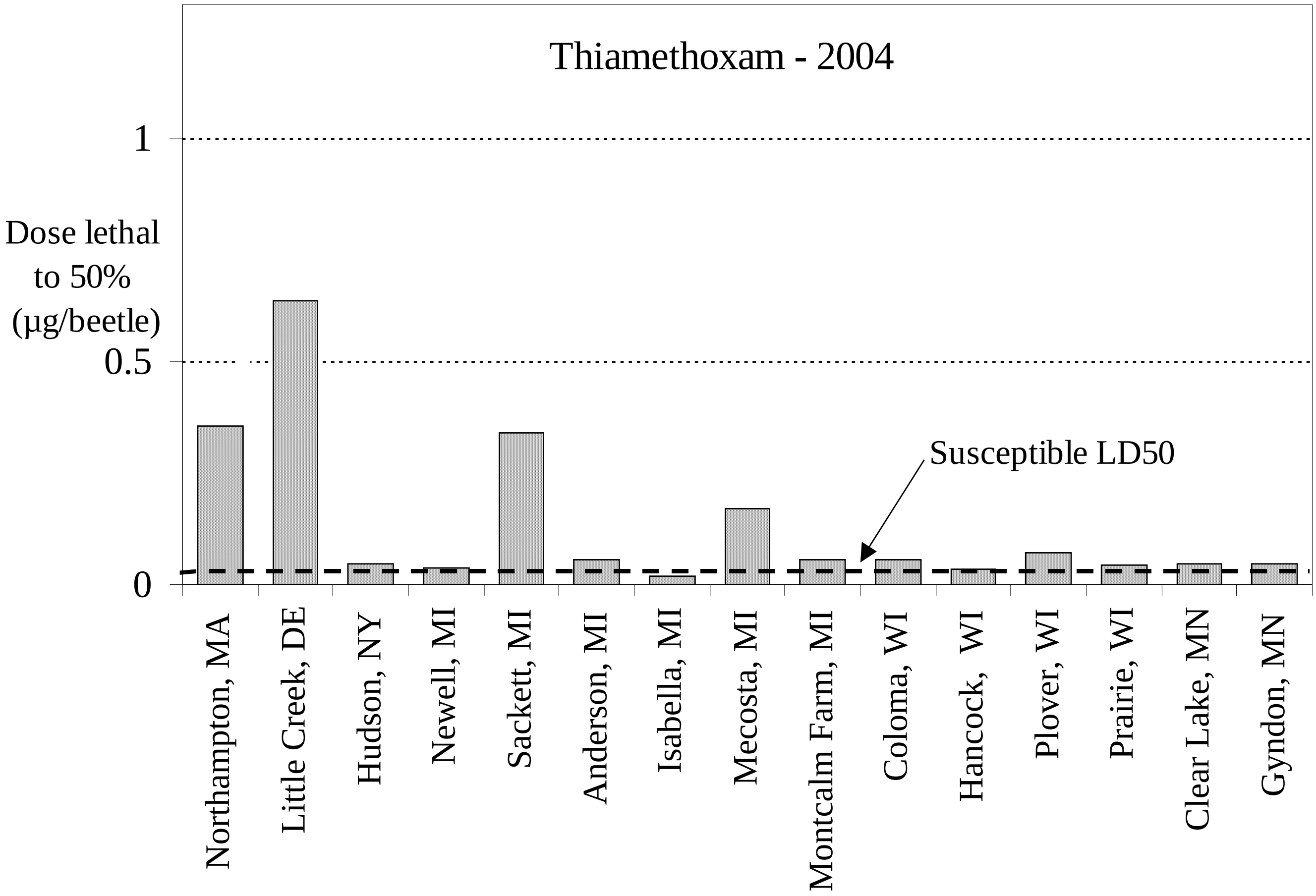

Figure I.2. Doses lethal to 50% of Colorado potato beetle populations to thiamethoxam

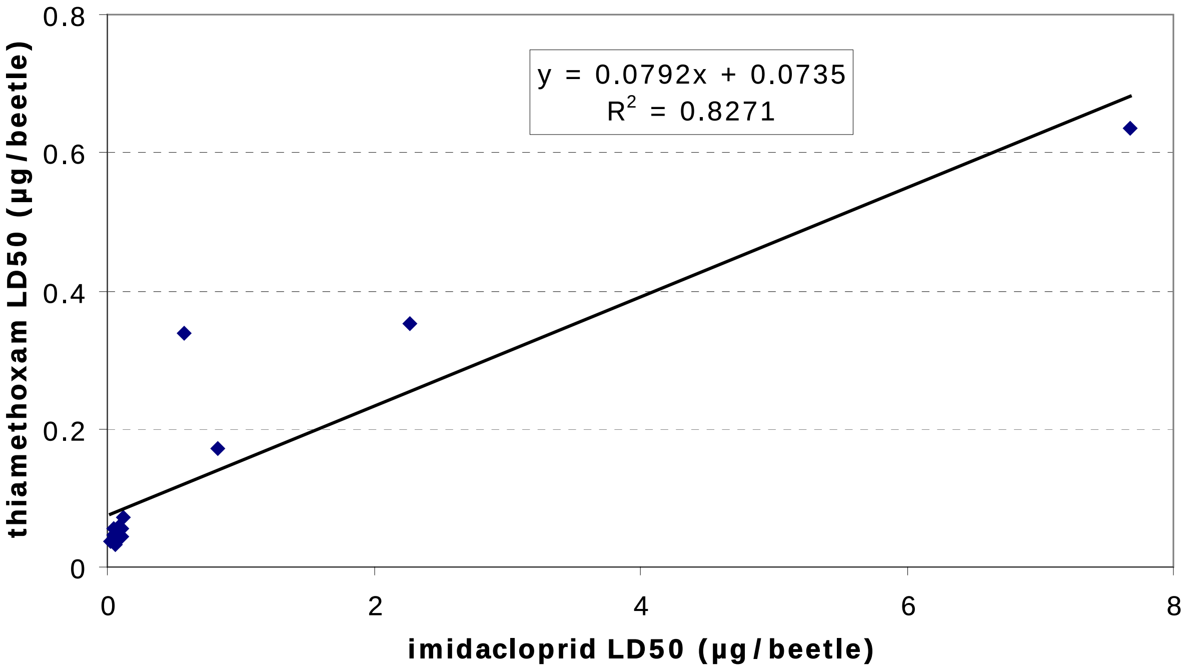

Figure I.3. Correlation between susceptibility to imidacloprid and thiamethoxam for all field populations tested in 2003 (n=14).

II. Field insecticide evaluations of registered and experimental insecticides.

The Colorado potato beetle (CPB) is one of the most widespread and destructive insect pests to potato crops in the northeastern United States and Canada. Their ability to develop resistance to insecticides makes it very important to continue testing new chemistries and the efficacy of existing compounds.

Methods

Fourteen insecticide treatments (Table II.1) were compared to two untreated controls at the Michigan State University Montcalm Research Farm, Entrican, MI for control of CPB. 'Atlantic' potatoes were planted 12 in. apart, with 34 in. row spacing on 6 May 2004. Treatments were replicated four times in a RCB design. Plots were 40 ft long and three rows wide.

Admire, Belay, Platinum, and one rate of V10112 (seven treatments total) were applied as in-furrow sprays at planting, using a single-nozzle hand-held boom (30 gpa, 30 psi). Foliar treatments were first applied at greater than 50% egg hatch on 14 Jun. Subsequent first-generation sprays for most treatments were applied on 22 Jun, 29 Jun, and 6 Jul (depending on treatment, Table 1).

Post-spray counts of CPB adults and larvae (small and large) on five randomly selected plants for the middle row of each plot were made 2 d after each foliar application. Defoliation ratings were taken on 6 Jul and 22 Jul by assessing five randomly chosen plants from the middle row of each plot. On 1 Sep, the middle row of each plot was harvested mechanically and the tubers were separated by size and weighed. Data were analyzed using two-way ANOVA (treatment and block) and significant differences were determined with Fisher's Protected LSD test ($p=0.05$).

There were significant differences between treated and untreated plots in the seasonal means of egg masses, small larvae, large larvae, and adults (Table II.1). Numbers of small larvae include larvae that were still on the egg masses and had not begun to feed on foliage, resulting in high variability in these numbers. All treatments resulted in significantly fewer large larvae and adults than in the untreated plots. There were also significant differences among treatments in overall yield and defoliation ratings (Table II.2).

Table II.1. Seasonal mean number of Colorado potato beetle egg masses, small larvae, large larvae, and adults per plant.

			Seasonal mean of 1^{st}-generation CPB			
Treatment/formulation	Rate	Application dates	Egg Masses	Small Larvae	Large Larvae	Adults
Admire 2F	13 fl oz/acre	at planting	0.5 cde	3.0 bc	1.5 b	0.5 bc
Admire 2F	16 fl oz/acre	at planting	0.5 de	3.3 c	1.9 b	0.5 bc
Belay 16	12 oz/acre	at planting	0.0a	0.3a	0.0a	0.2ab
Belay 16	18 oz/acre	at planting	0.0ab	0.0a	0.0a	0.2ab
Clutch	1.5 oz/acre	14 Jun, 22 Jun	0.5 de	2.7 cd	0.2a	0.2ab
Clutch	2.0 oz/acre	14 Jun, 6 Jul	0.4 cde	3.6 cdef	0.2a	0.2ab
Leverage 2.7SE	3.75 fl oz/acre	14 Jun, 29 Jun, 6 Jul	0.4 cde	3.2 cdef	0.2a	0.2ab
Platinum FS	6.5 oz/acre	at planting	0.2abcd	0.6ab	0.2a	0.3ab
Platinum FS	8.0 oz/acre	at planting	0.3abcde	0.4ab	0.2a	0.5 bc
Provado	3.75 oz/acre	14 Jun, 29 Jun	0.3 cde	3.3 cd	0.4a	0.2ab
Spintor 2 SC	4.5 oz/acre	22 Jun, 29 Jun, 6 Jul	0.4 cde	8.6 fg	0.5a	0.3ab
V10112 20 SG	60 g AI/acre	14 Jun, 29 Jun	0.4 cde	3.1 cdef	0.2a	0.2ab
V10112 20 SG	80 g AI/acre	14 Jun, 6 Jul	0.4 cde	3.5 cdef	0.5a	0.1a
V10112 20 SG	120 g AI/acre	at planting	0.3 cde	3.0 cde	3.0 c	0.4abc
untreated check 1			0.6 e	11.1 g	13.0 d	1.8 d
untreated check 2			0.2abc	6.9 efg	9.2 d	1.0 c
P value			0.0112	0.0001	0.0001	0.0001

Means within a column followed by different letters are significantly different ($P<0.05$, Fisher's Protected LSD). Data transformed for analysis with log (x+1), means presented in non-transformed units.

Table II.2. Mean yield (weight/40 row ft) harvested and defoliation ratings taken on two sampling dates.

			Yield (lb/40 row ft)			Defoliation rating[b]	
Treatment/formulation	Rate	Application dates	Size A[a]	Size B[a]	Total	6 Jul	20 Jul
Admire 2F	13 fl oz/acre	at planting	63.6 d	3.8	67.4 e	1.0a	1.6ab
Admire 2F	16 fl oz/acre	at planting	57.8 bcd	3.0	60.8 bcde	1.1a	1.4a
Belay 16	12 oz/acre	at planting	63.8 d	3.6	67.4 e	1.0a	1.0a
Belay 16	18 oz/acre	at planting	62.0 cd	3.5	65.5 de	1.0a	1.0a
Clutch	1.5 oz/acre	14 Jun, 22 Jun	58.3 bcd	3.4	61.7 bcde	1.0a	1.2a
Clutch	2.0 oz/acre	14 Jun, 6 Jul	46.2ab	3.8	50.0abc	1.2a	1.0a
Leverage 2.7SE	3.75 fl oz/acre	14 Jun, 29 Jun, 6 Jul	57.9 bcd	4.1	62.0 bcde	1.0a	1.2a
Platinum FS	6.5 oz/acre	at planting	58.2 bcd	4.2	62.4 bcde	1.0a	1.2a
Platinum FS	8.0 oz/acre	at planting	62.2 cd	2.9	65.1 cde	1.0a	1.0a
Provado	3.75 oz/acre	14 Jun, 29 Jun	46.4ab	3.0	49.4ab	1.0a	1.2a
Spintor 2SC	4.5 oz/acre	22 Jun, 29 Jun, 6 Jul	55.0 bcd	3.9	58.9 bcde	1.0a	1.2a
V10112 20 SG	60 g AI/acre	14 Jun, 29 Jun	58.4 bcd	3.5	61.9 bcde	1.0a	1.2a
V10112 20 SG	80 g AI/acre	14 Jun, 6 Jul	60.1 bcd	3.1	63.2 bcde	1.2a	1.1a
V10112 20 SG	120 g AI/acre	at planting	49.2 bcd	4.2	53.5 bcde	1.2a	1.4a
untreated check 1			33.4a	2.8	36.1a	2.4 c	3.2 c
untreated check 2			48.1abc	2.9	50.9abcd	1.8 b	2.2 b
P value			0.0207	0.3313	0.0121	0.0001	0.0001

Means within a column followed by different letters are significantly different (P<0.05, Fisher's Protected LSD).

[a] Size A = tubers greater than 2 inches. Size B = tubers that are 2 inches or less.

[b] Defoliation rating: 1, no defoliation; 2, 1-25% defoliation; 3, 26-50% defoliation; 4, 51-75% defoliation; 5, 76-100% defoliation.

III. Effectiveness of Fulfill® treated potato plants for preventing transmission of PVY by aphids.

Methods

A foliar field rate (2.75 oz/A) application of Fulfill® was applied to 16 virus-free 4-week old 'Atlantic' potato plants grown in plastic pots. A population of potato aphids was established on 'Atlantic' potato plants that were rub inoculated with PVY infected tubers. Aphids were maintained on these plants for one week prior to the start of the test. Five PVY infectious potato aphids were placed on individual Fulfill® treated plants 1, 3, and 6 days after spray application. Additionally, five PVY infectious aphids were placed on individual virus-free untreated plants on the same dates as above to serve as a positive control. Each treatment was replicated four times. Aphid survival was determined 6 days after the aphids were placed on the plants.

Results

No living aphids were found on any of the Fulfill® treated plants regardless of when the aphids were placed on the plants. The number of aphids on the untreated plants increased to >20, 7 days after initial placement.

The potato plants that were rub inoculated with PVY infected tubers and meant to serve as the infection source were not infected by this technique. No PVY symptoms were observed in any of the plants. We plan to repeat the experiment starting January 17, 2005 as we now have PVY infected plants.

Potato Vine Desiccation Study

Christy Sprague and Gary Powell, Department of Crop and Soil Sciences

Snowden potatoes were planted at the Montcalm research station to evaluate chemical desiccation of potato foliage. Herbicides were applied on August 12 to actively growing potatoes (approximately 20% flowering), and again eleven days later on August 23 to 'yellowing' potatoes past flowering.

Two treatments of 'Rely' (glufosinate) were applied as a single application, at both timings, at a rate of 3 pints of product per acre. 'Regone' (diquat) was applied as a split application at 1 pint per acre at both application timings. 'Aim' (carfentrazone) 2EC was applied as a split application at 1.6 fluid ounce followed by 2.0 fluid ounce, and another treatment of 2.0 fluid ounces at the second application timing only.

Potato stem desiccation, potato leaf desiccation, and common lambsquarters control were visually evaluated at 7 and 19 days after herbicide application. Potatoes were harvested 33 days after application and evaluated for tuber yield and quality.

Rely applied at the 1st application timing resulted in greater stem desiccation than Rely applied at the 2nd application. Reglone and Aim applied in split applications resulted in potato leaf and stem desiccation similar to a single application of Rely in the 1st application. A single application of Aim applied at the 2nd timing resulted in less desiccation of potato stems and leaves than when applied at the 1st application.

Potato yield was significantly higher in the untreated control than any of the desiccation treatments. When Aim was applied as a split application there was a trend towards higher potato yield as compared to the other desiccation treatments, although this was not significant. No significant difference in potato quality or specific gravity were observed between any of the treatments in this study.

Potato Vine Kill

Trial ID: POT-01 Study Dir.: Sprague, Powell
Conducted: Montcalm Investigator: MSU Crop and Soil Science Weed Control

Date Planted:	May-17-04	**Row Spacing:**	34 IN
Variety:	Snowden	**No. of Reps:**	4
Population:		**% OM:**	2.1
Soil Type:	Sandy Loam	**pH:**	5.3
Plot Size:	10 **X** 30 **FT**	**Design:**	RANDOMIZED COMPLETE BLOCK

Tillage: Spring Moldboard Plow. Previous Crop: Corn

Crop and Weed Description

Weed	**Code**	**Common Name**	**Scientific Name**
1.	CHEAL	Common lambsquarters	Chenopodium album L.
Crop	**Code**	**Common Name**	
1.	SOLTU	POTATO	

Application Description

	A	**B**
Application Timing:	POST	L. POST
Date Treated:	Aug-12-04	Aug-23-04
Time Treated:	1:45 PM	11:00 AM
% Cloud Cover:	75	90
Air Temp., Unit:	64 F	78 F
% Relative Humidity:	65	63
Wind Speed/Unit/Dir:	0 mph -	3 mph n
Soil Temp., Unit:	63 F	71 F
Soil/Leaf Surface M:	5 5	5 5
Soil Moist (1=w 5=d):	2	4

Crop Stage at Each Application

	A	**B**
Crop Name:	SOLTU	SOLTU
Height (In.):	15-20	15-20
Stage (L):	20%flower	yellowing

Weed Stage at Each Application

	A	**B**
Weed 1 Name:	CHEAL	CHEAL
Height (In.):	40-50	40-50
Stage (L):	many	many

Weed Density (plants/sq. ft.)

	1
Date:	Aug-12-04
Weed Name:	CHEAL
Density:	2-10 ft

Application Equipment

Appl	**Sprayer Type**	**Speed MPH**	**Nozzle Type**	**Nozzle Size**	**Nozzle Height**	**Nozzle Spacing**	**Boom Width**	**GPA**	**Carrier**	**PSI**
A	Cub	3.8	AirMix	11003	38"	20"	120"	19	Water	27
B	Cub	3.8	AirMix	11003	38"	20"	120"	19	Water	27

Potato Vine Kill

Trial ID: POT-01 Study Dir.: Sprague, Powell
Conducted: Montcalm Investigator: MSU Crop and Soil Science Weed Control

Weed Code											CHEAL			CHEAL	
Crop Code								SOLTU	SOLTU	SOLTU		SOLTU	SOLTU		SOLTU
Rating Data Type								leaf %	stem %	overall %	control	leaf %	stem %	control	Skin Set
Rating Unit								desicat	desicat	desicati	percent	desicat	desicat	percent	0-10
Rating Date								Aug-19-04	Aug-19-04	Aug-19-04	Aug-19-04	Aug-31-04	Aug-31-04	Aug-31-04	Sep-14-04
Trt-Eval Interval								7 DA-A	7 DA-A	7 DA-A	7 DA-A	19 DA-A	19 DA-A	19 DA-A	33 DA-A
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	Appl Code								
1	Rely	1	L	3	PT/A	post	A	88	38	64	63	95	91	85	0
2	Rely	1	L	3	PT/A	L. post	B					95	78	56	0
3	Reglone	2	L	1	PT/A	post	A	85	56	73	78	97	98	86	0
3	Activator 90 NIS		L	0.25	% V/V	post	A								
3	Reglone	2	L	1	PT/A	L. post	B								
3	Activator 90 NIS		L	0.25	% V/V	L. post	B								
4	Untreated Control							0	0	0	0	38	24	0	0
5	Aim	2	EC	0.025	LB A/A	post	A	43	25	36	68	98	92	89	0
5	MSO		L	1	% V/V	post	A								
5	Aim	2	EC	0.032	LB A/A	L. post	B								
5	MSO		L	1	% V/V	L. post	B								
6	Aim	2	EC	0.032	LB A/A	post	A	55	33	45	74	84	79	89	0
6	MSO		L	1	% V/V	post	A								
LSD (P=.05)								13.6	14.4	15.3	9.0	14.8	11.9	13.7	0.0
Standard Deviation								8.8	9.4	9.9	5.8	9.8	7.9	9.1	0.0
CV								16.3	31.0	22.87	10.39	11.65	10.3	13.45	0.0

Potato Vine Kill

Trial ID: POT-01 Study Dir.: Sprague, Powell
Conducted: Montcalm Investigator: MSU Crop and Soil Science Weed Control

Weed Code														
Crop Code								SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU	SOLTU
Rating Data Type								Stem End	HollowHeart	Specific	CWT/A	CWT/A	CWT/A	CWT/A
Rating Unit								0-10	0-10	Gravity	USA #1	B's	Knob's	Total
Rating Date								Sep-14-04	Sep-14-04	Sep-14-04	Sep-14-04	Sep-14-04	Sep-14-04	Sep-14-04
Trt-Eval Interval								33 DA-A	33 DA-A	33 DA-A	33 DA-A	33 DA-A	33 DA-A	33 DA-A
Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Grow Stg	Appl Code							
1	Rely	1	L	3	PT/A	post	A	0	1.0	0.927	139	19	1.1	160
2	Rely	1	L	3	PT/A	L. post	B	0	0.8	0.923	153	16	0.0	170
3	Reglone	2	L	1	PT/A	post	A	0	0.3	0.925	143	16	0.3	159
3	Activator 90 NIS		L	0.25	% V/V	post	A							
3	Reglone	2	L	1	PT/A	L. post	B							
3	Activator 90 NIS		L	0.25	% V/V	L. post	B							
4	Untreated Control							0	0.5	0.924	243	16	0.5	260
5	Aim	2	EC	0.025	LB A/A	post	A	0	0.0	0.923	172	26	0.0	198
5	MSO		L	1	% V/V	post	A							
5	Aim	2	EC	0.032	LB A/A	L. post	B							
5	MSO		L	1	% V/V	L. post	B							
6	Aim	2	EC	0.032	LB A/A	post	A	0	0.0	0.922	146	15	0.0	161
6	MSO		L	1	% V/V	post	A							
LSD (P=.05)								0.0	1.17	0.0025	44.2	7.9	1.52	48.9
Standard Deviation								0.0	0.77	0.0017	29.3	5.2	1.01	32.4
CV								0.0	185.9	0.18	17.64	28.84	315.3	17.57

Funding: MPIC

Summary Report for the 2003-2004
Dr. B. F. (Burt) Cargill Potato Demonstration Storage

Brian Sackett, Chris Long, Dick Crawford, Todd Forbush (Techmark, Inc.), Steve Crooks, Dennis Iott, Keith Tinsey, Tim Young, Jason Walther, Troy Sackett, Randy Styma and Ben Kudwa

Introduction

This is a summary report of the 2003-2004 Dr. B.F. (Burt) Cargill Potato Demonstration Storage Annual Report Volume 3. This report is designed to provide a short summary of the 2003-2004 storage committee activities. To obtain a copy of the full 2003-2004 Demonstration Storage Report please contact the Michigan Potato Industry Commission office (517-669-8377) or Chris Long at Michigan State University (517-355-0271 ext.#193). The full report will be provided to you free of charge.

Summary and Highlights

The 2003 growing season was notably dry. The Montcalm County region had over 7.5 inches of rainfall which was under the 15 year average for this location. There were a limited number of days that the day time high temperature reached 90 °F or above. These conditions resulted in slightly lower specific gravity numbers for our region and some increases in internal defects such as stem end discoloration and internal necrosis. The storage season was dry and this helped to reduce the number of pathological issues that are more common in wetter seasons.

The goal of the MPIC Storage and Handling Committee for the 2003-2004 storage season was to develop storage profiles on three promising advanced seedlings. Liberator (MSA091-1) is from the potato breeding program at Michigan State University. UEC*, now “Beacon Chipper”, is a clone that has an unknown origin and pedigree but is of great interest in Michigan, and is likely to be jointly released by the states of Michigan and Maine. Megachip (W1201) originated from the breeding program at the University of Wisconsin, Madison, overseen by Dr. Jiming Jiang. The committee’s main objective was to determine what the optimal storage temperature was for each variety, while maintaining acceptable storage quality. Also of interest was the level of pressure bruise damage that may be incurred by each variety at a given storage temperature. A brief description of each varieties storage performance is provided.

The goal for the variety Liberator was to evaluate its longevity at a given storage temperature. The potatoes in bulk bins 2 and 3 were planted and harvested at the same time. The committee chose to hold bin 2 at 52 ºF and positioned this bulk bin for an April-May shipping period. Bin 3 was designated for a shorter term storage profile and was held at 55 ºF. The Megachip variety, based on its maturity, was slated for a long term storage profile and plans were made to store it at 50 ºF. It was planned to be processed during a March to May shipping window. The committee chose to evaluate UEC on the basis of its planting date and how the planting date would impact the physiological age and storability of this variety. The early planted UEC's were held at 51 ºF and slated for January/February sale. The UEC's in bin 6 were planted later and positioned for sale in March or April. The holding temperature for this bin was designated to be 48 ºF.

The results for the bulk bins were as follows:

The Liberators (MSA091-1) in bulk bin 2 and 3 struggled with internal sugar defects all season. All attempts to remove sugar by increasing internal respiration appeared not to have a great impact. The bins were not processed due to our inability to clean-up internal sugars.

Megachip (W1201) was shipped for processing, but due to internal sugars and a high level of black spot bruise, possibly resulting from high specific gravity and cold harvest conditions, the load was rejected.

Beacon Chipper (UEC) in bins 5 and 6 were shipped successfully on February 26, 2004 and April 1, 2004 with 5% and 1% defects noted at the processing plant, respectively.

Promising varieties in the box bin trial were MSG227-2 and MSJ461-1. These varieties will be considered for larger scale evaluations in the 2004-2005 storage season.

BEACON CHIPPER

Unknown Eastern Chipper, (UEC)

*Unknown Eastern Chipper (UEC), now "Beacon Chipper", was previously tested and labeled as the clone B0766-3. B0766-3, a USDA Beltsville potato clone from Dr. Kathleen Haynes' Breeding Program, Beltsville, Maryland is being considered for release. The official seed source for B0766-3 is the Uihlein Seed Farm, NY. The two clones UEC and B0766-3 have undergone fingerprint analysis at Michigan State University and the pattern of B0766-3 does not match that of UEC. Thus, the UEC clone tested was incorrectly referred to as B0766-3. No known variety or breeding clone matches the UEC fingerprint pattern to date. The origin and pedigree of UEC is unknown. **UEC seed that was tested and reported in the 2001-2002, 2002-2003 and 2003-2004 Cargill Potato Demonstration Storage Annual Report Volumes 1, 2 and 3 was obtained from Devoe Seed Farm, Limestone, ME.** The initial seed stock was obtained from the Maine State Seed Farm which is the Porter Seed Farm. The Michigan State University fingerprint data of UEC shows an identical match between the Devoe Farm seed and the tissue culture plantlets at the Porter Seed Farm from which all the seed labeled as UEC has been derived.