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2002 MICHIGAN POTATO RESEARCH REPORT

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INTRODUCTION AND ACKNOWLEDGMENTS

The 2002 Potato Research Report contains reports of the many potato research projects conducted by MSU potato researchers at several locations. The 2002 report is the 34rd report, 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. Thanks also to Don Smucker, Montcalm CED for maintaining the weather records from the MRF computerized weather station. Also, we want to recognize Barb Smith at MPIC for helping with the details of this final draft.

WEATHER

The overall 6-month average temperatures during the 2002 growing season were comparable to the 2001 season, but slightly higher than the 15-year average (Table 1). There were 11 days that the temperature reached 90°F or above and 15 days in April that the temperature was below 32°F. The average maximum temperatures for July, August, and September of 2002 were 4-6 degrees higher than the 15-year average.

Rainfall for April through September was 22.65 inches which is slightly higher than the 15 year average (Table 2). Rainfall recorded during the month of August was the second highest in 15 years. Irrigation at MRF was applied 9 times from June 18th to August 10th averaging 0.61 inches for each application. The total amount of irrigation water applied during this time period was 5.5 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	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1988	52	31	74	46	82	53	88	60	84	61	71	49	75	50
1989	56	32	72	34	81	53	83	59	79	55	71	44	74	46
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**
15 Year Average	55	34	68	44	78	56	81	59	78	58	71	48	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
1988	1.82	0.52	0.56	2.44	3.44	5.36	14.14
1989	2.43	2.68	4.85	0.82	5.52	1.33	17.63
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**
15 Year Average	3.11	3.44	3.66	3.34	4.61	2.97	21.13

GROWING DEGREE DAYS

Table 3 summarizes the cumulative, base 50°F growing degree days (GDD) for May through September, 2002. The total GDD for 2002 were 2,613, 234 GDD higher than 2001, and significantly higher then the 10-year average.

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

	Cumulative Monthly Totals				
Year	May	June	July	August	September
1993	261	698	1348	1950	2153
1994	231	730	1318	1780	2148
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**
10 Year Average	270	781	1398	1967	2299

*1993-2002 data from the weather station at MSU Montcalm Research Farm (Don Smucker, Montcalm County Extension Director).

PREVIOUS CROPS, SOIL TESTS AND FERTILIZERS

The general potato research area was planted to rye in the fall of 2000 and was harvested late in the summer of 2001. The area was fumigated in the fall. The land was disked and the field fitted for potato planting in the spring 2002. Potato early die was not a problem in 2002.

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

	lbs/A			
pH	P_2O_5	K_2O	Ca	Mg
6.2	431	178	571	189

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 ($N\text{-}P_20_5\text{-}K_20$)
Broadcast at plow down	0-0-60	300 lbs/A	0-0-180
At planting	19-17-0	18 gpa	38-34-0
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 0.66 lb/A and Dual at 2.0 pints/A.

Admire was applied at planting at a rate of 13.6 oz/A. Cygon was applied once in late July at 1 pint/A. Fungicides used were Bravo, Previcur, Polyram 80DF and Terrinil over 12 applications. Potato vines were desiccated with Reglone once in mid September at a rate of 1 pint/A.

2002 POTATO BREEDING AND GENETICS RESEARCH REPORT

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INTRODUCTION

At MSU, we conduct a multi-disciplinary program for potato breeding and variety development that integrates traditional and biotechnological approaches. 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 16 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.

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 and 20-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 (42-46°F) and/or 50˚F storage.

III. Germplasm Enhancement

To supplement the genetic base of the varietal breeding program, we have a "diploid" (2x 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, 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 10 years experience in *Agrobacterium*-mediated transformation to introduce genes into important potato cultivars and advanced breeding lines. We presently have genes in vector constructs that confer resistance to PVY, Colorado potato beetle, potato tuber moth, broad-spectrum disease resistance via the glucose oxidase (GO) gene, late blight resistance with the resveratrol synthase (RS) and divinyl ether synthase (DES) genes, and cold/frost resistance (COR15). We also have the *glgC16* gene (ADP-glucose pyrophosphorylase (AGPase) or starch gene) from Monsanto to modify starch and sugar levels in potato tubers. 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 selectable marker (antibiotic resistance) from the transgenic plants.

V. Variety Release

Beginning in 2002, the MSU breeding program has named and released its first three varieties and is in the process of licensing these new varieties to the Michigan Potato Industry Commission. Each year the best lines will be considered for release. In 2003 MSF373-8, with the name Boulder being considered, will be brought forward.

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 2002 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. During the 2002 harvest, about 1200 selections were made from the 35,000 seedlings grown at the Montcalm Research Farm. 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 2003 directly out of 42°F and 50°F storage. 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, 450 and 140 selections were made, respectively. **Table 1** lists some of the potential lines for grower trials in year 2003.

Chip-Processing

Excellent chip-processing selections have been identified in the breeding program, despite switching to a more stringent screening temperature (42 vs. 45°F storage) a few years ago. Over 70% of the single hill selections have a chip-processing parent in their pedigree. Of those selections, about 75% 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, we have a diverse genetic base. We believe that we have at least eight cultivated sources of cold-chipping. We have made various hybrid combinations with these parents from which to pyramid cold-chipping traits and the hybrid populations have been grown out, selected and evaluated. We now have advanced into the crossing block these new MSU selections that have chip quality directly from 42°F storage. Examination of pedigrees shows up to three different cold-chipping germplasm sources have been combined in these selections. Promising chip-processing lines are MSF099-3 (42°F chipper), MSG227-2 (scab resistant 45°F chipper), MSH095-4, MSH094-8, MSH067-3, MSJ147-1, MSJ126-9Y, MSJ167-1, and late blight resistant chipper MSJ461-1.

Tablestock

One of our objectives is also to develop improved cultivars for the tablestock industry. 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. From our 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 2002, while others were tested under replicated conditions at the Montcalm Research Farm. Promising tablestock lines include MSE221-1 as a scab resistant tablestock, while MSE018-1 is a high yielding tablestock with a large oval shape. MSE192-8RUS and MSE202-3RUS are two russet table selections that have excellent type and scab resistance. MSE149-5Y, MSI005-20Y and MSJ033-6Y are yellow-fleshed lines with smooth round appearance and high yield potential. MSF373-8 is a high yielding line with large tubers that also chip out of the field. This line is being considered for release as Boulder. 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 lines.

Disease and Insect Resistance Breeding

Disease screening for scab has been an on-going process this 1988. Results from the 2002 MSU scab nursery indicate that 16 of 160 lines evaluated demonstrated strong resistance (no evidence of infection) to common scab in 2002. In addition, 10 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.

Since the mid-1990's we have directed efforts to identify sources of late blight resistance and use this resistance to breed late blight resistant varieties. At MSU, we have also participated in the national late blight trial and we have conducted our own efforts to use field and greenhouse screening to identify additional sources of resistance that can be used by the breeding community. In the past six years the MSU breeding program has intensely evaluated over 700 crosses between late blight resistant x late blight susceptible parents and have identified parents that transmit strong late blight resistance to the highest percentage of the offspring. As of 2002, based upon six years of inoculated field experiments, we have at least eight sources of foliar resistance to the US8 genotype of *Phytophthora infestans* (Mont.) that have different pedigrees from which their resistance is derived. The resistance in Jacqueline Lee has now held resistance for six years of testing. MSJ461-1, the chip-processing selection, has the same late blight resistance source as Jacqueline Lee. Our other promising late blight resistant lines that have been tested in replicated agronomic trials are MSJ317-1, MSI152-A, MSJ453-4Y, MSJ456-4 and MSL757-1 (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.

Single-hill selections in 2002 also had an exciting number of individuals with pedigrees for potential late blight, Colorado potato beetle or scab resistance or some combination of the three. Of the single hill selections, 40% of progeny have at least one late blight parent, 15% have a Colorado potato beetle resistant parent, and 15% have a scab resistant parent in its pedigree.

II. Evaluation of Advanced Selections for Extended Storage: MSU Potato Breeding Chip-processing Results From the MPIC Demonstration Commercial Storage (October 2001 - June 2002)

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 three 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 2001, tuber samples from seven lines in the Montcalm Research Farm trials were placed in the bin to be cooled to 46°F. Tubers from another seven lines were placed in the bin that was to be cooled then held at 52°F. The first samples were chip-processed at MSU in October and then, each month until June 2002. Samples were evaluated for chip-processing color and quality.

Table 2 summarizes the chip-processing color of select lines over the 8-month storage season. In the 46°F bin, Snowden was the check variety. In May the Snowden chips went off-color. In contrast only MSG227-2, MSH094-8 and MSH095-4 maintained acceptable chip color until the June 2002 sampling. Of these lines, MSG227-2 and MSH094-8 maintained the lightest chip color throughout the storage season. Chip-processing ability of MSG227-2 and NY112 was also observed during the past two year's storage studies in the Demonstration Storage Facility. MSG227-2 also has scab resistance. If the agronomic performance of MSG227-2 is considered acceptable, it will be considered for commercial release after the 2003 season.

In the 52°F bin Atlantic and Pike were used as check varieties and both varieties chip-processed acceptably until April. Of the six advanced breeding lines evaluated, Liberator and MSJ461-1 chip-processed acceptably throughout the storage season. Liberator offers chip-processing from storage and scab resistance. MSJ461-1 had the most consistent and lightest chip color throughout the storage season. MSJ461-1 also offers strong foliar late blight resistance along with the chip-processing quality; however the solids content is lower than other chip-processing lines.

In addition, MSF099-3 was grown by Sandyland Farms in 2001 and placed in one of the 500 cwt bins. Despite field frost occurring in the harvested tubers, the potatoes chip-processed successfully out of the bin in April 2002 at Utz in Pennsylvania.

III. Germplasm Enhancement

In 2002, about 5% 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 3,000 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 100 selections were made among the diploid material in 2002. 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 be conducting extensive field screening for resistance to Colorado potato beetle in 2003.

Late Blight Breeding and Genetics: Mapping Late Blight Resistance in three Populations

A high priority objective of the breeding program is to identify sources of late blight resistance and use these sources for breeding varieties with late blight resistance. In 1999 we initiated a set of studies (via GREEEN) to identify the genes in potato associated with late blight resistance. If we can identify the genes that contribute to late blight resistance we feel that we could more effectively breed varieties with durable late blight resistance. A diploid potato population was developed with the objectives to map quantitative trait loci (QTL) conferring resistance to *Phytophthora infestans* (Mont.) de Bary and other agronomic traits using simple sequence repeats (SSR) and isozymes and to examine associations between late blight resistance and other agronomic traits. The mapping population was a cross between a late blight resistant selection of *Solanum microdontum* Bitter and a susceptible diploid advanced breeding clone. A second diploid population derives its late blight resistance from *S. berthaultii*. The third population is tetraploid and the resistance comes from Jacqueline Lee. Based upon field trials at the Muck Soils Research Farm, Bath, MI between 1999 and 2002, we have identified major late blight resistance genes in the three populations. Currently, one chromosome region containing the resistance is linked to a genetic marker has been identified in *S. microdontum.* Following the gene mapping analyses this winter, we will find the other two major resistances linking with a genetic The major QTL associated with late blight resistance is suitable for marker-assisted selection to introgress a new source of resistance to *P. infestans* to the cultivated tetraploid germplasm of potato.

The tetraploid cross for mapping (Jacqueline Lee x MSG227-2) offers more than just mapping late blight resistance genes. This cross has traits such as late blight resistance, scab resistance, chip-processing, specific gravity, maturity all segregating at one time. The original cross had over 300 progeny. From those, about 75% had acceptable tuberization characteristics. Following late blight screening at the Muck Soils Research Farm, 41 progeny had foliar late blight resistance. Of those late blight resistant progeny, about 75% had acceptable yield and tuber type for selection. About 30 lines were chip-processed. Of those selections about 10 had acceptable chip-processing color, with 5 having acceptable solids levels in the tubers. About 25 of the selected progeny are being advanced for further evaluation in 2003.

IV. Integration of Genetic Engineering with Potato Breeding

The program has been conducting transformations of potato to introduce a variety of transgenes. Currently we have genetically engineered plants that express the *Bt-cry3A* gene to control the Colorado potato beetle, the glucose oxidase and resveratrol synthase genes for disease resistance, and the AGPase gene for low sugars and high solids.

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* Say (Coleoptera: Chrysomelidae), is the leading insect pest of potato (*Solanum 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 2002 to compare natural (glandular trichomes (NYL235-4) and glycoalkaloid-based (ND5873-15)), engineered (*Bt-cry3A*: NO8.8), and combined (glandular trichomes + *Bt-cry3A* (L28.3) and glycoalkaloids + *Bt-cry3A* (ND8.01) transgenic potato lines) host plant resistance mechanisms of potato for control of Colorado potato beetle. Six different potato lines representing five different host plant resistance mechanisms 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. 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, and the combined resistance lines were effective in controlling feeding by Colorado potato beetle adults and larvae. Effectively no feeding was observed in the glycoalkaloid + *Bt-cry3A* transgenic line. 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. Based on these results, the *Bt-cry3A* gene in combination with glandular trichome or glycoalkaloid-based host plant resistance mechanisms 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. **Figure 1** shows the results of caged trial in 2002.

Bt-cry3A-transgenic line Agronomic Trial

In 2001 and 2002, we had extensive field testing for agronomic performance in replicated trials of our most advanced *Bt-cry3A* transgenic lines. Based upon 2001 agronomic performance and 2002 Bt-cry3A protein concentrations in foliage, 12 of 26 transgenic lines were eliminated. **Table 3** summarizes the results from the Advanced *Bt-cry3A* Breeding Line Preliminary Trial at the Montcalm Research Farm. In general, the *Bt-cry3A* transgenic lines had similar agronomic and tuber characteristics compared to the non-transgenic parental line. These selections represent a diverse portfolio of Bt-cry3A lines that could be commercialized if the intellectual property rights and regulatory requirements could be met. We will maintain these lines in our program. If the acceptance of transgenic food crops becomes deregulated, we will consider these lines for commercialization.

International Project to Develop Potato Tuber Moth Resistant Potatoes (USAID)

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. In the field, the moths lay their eggs on the potato foliage and the hatched larvae mine the foliage and the stems. This feeding damage leads to irregular transparent tunnels in the leaves and weakening of the stem. The larvae attack the tubers through infected stems or directly from eggs, which are oviposited on exposed tubers or where soil cracks allow moths to reach the tubers. Larvae mine the tuber in the field and in storage reducing potato quality and increasing the potential for pathogen infection. Field and storage studies were conducted to evaluate *Bt-cry5* potato lines for resistance to potato tuber moth in Egypt under natural infestations and their agronomic performance in both Egypt and Michigan. From 1997-2001, field experiments were conducted at the International Potato Center (CIP) Research Station, Kafr El-Zyat, Egypt and/or Agricultural Genetic Engineering Institute (AGERI), Giza, Egypt to evaluate resistance to tuber moth. A total of 27 *Bt*-transgenic potato lines from six different Bt constructs were evaluated over a five-year period. Following harvest and evaluation of the agronomic trials, storage evaluation of potato tuber moth damage was done at the CIP Research Station. The 1997 field trial was the first field test of genetically engineered crops in Egypt. Field tests to assess potato tuber moth resistance in Egypt were able to differentiate between the *Bt*-transgenic lines and the non-transgenic lines/cultivars in 1999, 2000 and 2001. The *Bt-cry5*-Spunta lines (Spunta-G2, Spunta-G3, and Spunta-6a3) were the most resistant lines in field with 99-100% of tubers free of damage. In the 2001 storage study, these lines were also over 90% free of tuber moth damage after 3 mo. NYL235-4.13, which combines glandular trichomes with the *Bt-cry5/gus* fusion construct also, had a high percentage of clean tubers in the field studies. In agronomic field trials in Michigan from 1997-2001 the *Bt*-transgenic lines in most instances performed similar to the non-transgenic line in the agronomic trials, however in Egypt (1998-1999) the yields were less than half of those in Michigan. Expression of the *Bt-cry5* gene in the potato tuber and foliage will provide the seed producer and grower a tool in which to reduce potato tuber moth damage to the tuber crop in the field and storage.

Two transgenic 'Spunta' clones, G2 and G3, produced high control levels of mortality in first instars of potato tuber moth in detached-leaf bioassays (80 - 83% mortality), 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'. 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-cry5 gene. We hope to have approval to field test these in Mexico in 2003.

Transformation and Evaluation of Potato Cultivars with the *glgC16* (AGPase) Gene

The processing parameters are strictly defined for potato. For chip processing, a specific gravity of 1.080 is the threshold for processing cultivars. In addition, a low reducing sugar level must occur in the potato tuber at harvest and also during storage prior to processing. Potato breeding of improved cultivars for chip processing has had a low probability of success because of the need to combine numerous economic characteristics into one genotype. In some cases, the genotype may be suitable for chip-processing, but the tuber specific gravity falls below the 1.080 threshold. ADP glucose pyrophosphorylase is an enzyme, which uses the glucose 1-phosphate molecule as a substrate for the biosynthesis of starch. An ADP glucose pyrophosphorylase gene (*glgC-16*) has been isolated from *E. coli* and placed in a plant transformation vector under the control of the patatin promoter. One goal of this study is to examine the value of *glgC-16* to raise the dry matter content for potato tubers.

We have targeted transformation of with the AGPase gene towards lines that have below average solids content. In 2001 and 2002 agronomic field trials were conducted to evaluate agronomic performance, specific gravity, chip-processing, and bruise susceptibility of Onaway, MSE149-5Y and their AGPase transgenic lines. The tuber appearance of the various AGPase lines was similar to non-transgenic Onaway and the MSE149-5Y lines (**Table 4A and 4B**). The results in 2001 and 2002 were, in general, were similar between years. Most of the MSE149-5Y and Onaway AGPase transgenic lines had similar yields, although slightly lower in some lines compared to the non-transgenic parents. In general, the tuber size distribution was quite comparable, although there was a reduction in the number of oversize (>3.25”) tubers. The specific gravity for the Onaway and MSE149-5Y AGPase lines was higher than the non-transgenic parents in almost all cases. We also observed a higher incidence of internal defects, specifically hollow-heart, in these AGPase lines. Unfortunately, the results from the blackspot bruise susceptibility tests indicate that the transgenic lines that had higher specific gravities were also had higher blackspot bruise potential (e.g. ONAGP3, ONAGP1, ONAGP2, EAGP24, EAGP4, EAGP9, and EAGP3). We are now making crosses with these AGPase lines to see the effect of the AGPase gene expression on progeny.

V. Variety Release

The MSU breeding program has now named and released its first varieties and is in the process of licensing the new varieties to the Michigan Potato Industry Commission. Three potato varieties were released in 2001: Jacqueline Lee (MSG274-3), Liberator (MSA091-1), and Michigan Purple. MSU is currently licensing these three varieties to MPIC and working out procedures to market these varieties. MSF373-8 is being considered for release in 2003. The named Boulder is being considered because of the large tuber size and low incidence of internal defects.

Boulder is a round white selection with medium specific gravity that can be used in both the tablestock and chip-processing markets. The tubers will chip process out-of-the-field and from 10°C storage. The tubers of Boulder are large in size with a low incidence of internal defects. Boulder was tested in Michigan State University trials, the North Central Regional Trials, on-farm trials in Michigan and other out-of-state replicated agronomic trials. Under irrigated conditions in Michigan the yield is similar to Atlantic, but specific gravity is less. Boulder has a full-season vine maturity that is similar to Snowden, but the tubers size early.

The seedling generation was grown in 1994, followed by two years of selection and seed multiplication at the Lake City Experiment Station, Lake City, MI. Seed increase was located to the Lake City Experiment Station. Since 1998, Boulder has been tested in replicated agronomic trials at the Montcalm Research Farm, Entrican, MI and in the scab nursery at the Michigan State University Soils Farm, East Lansing, MI. In 2000 it was entered into grower on-farm trials in Michigan and the North Central Regional Trial. In 2001 was placed into commercial seed production.

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

Since 1990 our potato program has offered a fingerprint service to identify and describe potato varieties. This fingerprint method was based upon isozyme proteins in the potato tubers or leaf tissue. This method has been very reliable, but from a practical point of view, the isozyme protein method requires living tissue to express the proteins. Our goal has been develop a fingerprint system that is DNA-based so that the living tissue requirement would be eliminated. We chose an SSR-based system because of the reproducibility of the PCR-based DNA amplification system. Sixteen potato varieties were chosen for the baseline study. Fifteen SSR primer sets were used. DNA was isolated from fresh leaves, fresh tubers, tuber skins, freeze-dried leaf tissue and freeze-dried tuber tissue. Of the 15 SSR sets, 10 sets amplified readable bands on Metaphor agarose gels that could be used to separate potato varieties. In most cases the varieties could be discriminated with as few as 3 SSR primer sets. Moreover, DNA was able to be isolated from all five tissue sources and obtain repeatable band patterns. This ability to isolate DNA from freeze-dried tissue will allow us to fingerprint varieties when fresh tissue is not available for testing. This SSR fingerprint system can be used alone or in combination with the original isozyme fingerprint system.

Table 1. Potential Lines for 2003 On-Farm Grower Trials

Line	Pedigree Female	Male	Comments
Tablestock			
JACQUELINE LEE	Tollocan	Chaleur	Late blight resistant, oval yellow
MICHIGAN PURPLE	W870	Maris Piper	Bright purple skin, white flesh
MSE018-1	Gemchip	W877	Also storage chipper
MSE192-8RUS	A8163-8	Russet Norkotah	Scab resistant russet (Norkotah replacement)
MSE202-3RUS	Frontier Russet	A8469-5	Scab resistant russet
MSE221-1	Superior	MS700-83	Scab resistant (Superior replacement)
MSF373-8	MS702-80	NY88	Chips out of the field, large tubers
MSG050-2	Eramosa	NYL235-4	Flat, round, bright skin
MSH031-5	MSB110-3	MSC108-2	Bright skin
MSI005-20Y	MSA097-1Y	Penta	Yukon appearance
MSI152-A	Mainestay	B0718-3	Late blight resistant, round white
MSJ033-10Y	MSA097-1	Penta	Yellow, Scab resistant
MSJ317-1	B0718-3	Prestile	Late blight resistant, round white
Processing			
MSE018-1	Gemchip	W877	Storage chipper, late
MSF099-3	Snowden	Chaleur	42 °F chipper
MSF373-8	MS702-80	NY88	Chips out of the field, large tubers
MSG227-2	Prestile	MSC127-3	Scab resistant
MSH067-3	MSC127-3	W877	Flat, round
MSH094-8	MSE251-1	W877	45 °F chipper
MSH095-4	MSE266-2	OP	45 °F chipper
MSH112-6	Michigold	Zarevo	42 °F chipper, high solids
MSH228-6	MSC127-3	OP	Scab tolerant
MSH360-1	E55-35	MSF077-8	Scab tolerant
MSI002-3	MSA091-1	MSF134-1	High yield and solids
MSJ080-1	MSC148-A	S440	High yield
MSJ167-1	P84-13-12	MSE250-2	High yield and solids
MSJ453-4Y	Tollocan	MSA091-1	Late blight resistant, yellow
MSJ456-4	Tollocan	Conestoga	Late blight resistant
MSJ461-1	Tollocan	NY88	Late blight resistant

Table 2. 2001-2002 DEMONSTRATION STORAGE CHIP RESULTS
Chip Scores represented using SFA Scale†

POTATO LINE	2001 DOH* CWT/A US#1	2001 DOH* CWT/A TOTAL	2001 DOH* SP GR	2001 SCAB†† RATING	11/7/2001	12/5/2001	1/1/2002	2/13/2002	3/13/2002	4/10/2002	5/8/2002	6/3/2002
					Sample Dates: Bin Temperature (^{o}F)							
BIN#4 [46 °F]					57 °F	56 °F	47 °F	48 °F	47 °F	50 °F	56 °F	62 °F
MSG227-2	403	449	1.073	0.3	1.5	1.0	1.5	1.0	1.0	1.5	2.0	1.5
MSH094-8	370	420	1.073	1.3	1.0	1.0	2.0	1.5	1.0	1.5	1.5	2.0
MSH095-4	444	496	1.080	0.7	1.0	1.0	1.5	1.5	1.5	1.5	2.0	2.5
MSH098-2	344	381	1.074	1.0	1.5	1.0	1.5	1.5	1.5	1.5	2.5	2.0
DAKOTA PEARL	320	407	1.069	0.7	1.5	1.0	1.5	2.5	1.5	2.0	2.5	2.5
SNOWDEN	**396**	**458**	**1.076**	**-**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.5**	**2.5**	**2.5**
W1386	345	436	1.073	1.5	1.5	1.5	1.5	2.5	2.0	2.0	1.5	2.5
BIN#5 [52 °F]					57 °F	56 °F	52 °F	52 °F	54 °F	54 °F	55 °F	62 °F
LIBERATOR	395	460	1.075	0.3	1.5	1.0	2.0	2.0	1.5	1.0	1.5	1.5
ATLANTIC	**448**	**491**	**1.081**	**1.8**	**1.5**	**1.5**	**1.5**	**2.5**	**1.5**	**1.5**	**2.0**	**2.5**
MSG015-C	304	384	1.067	1.0	2.0	2.0	2.0	2.0	2.0	3.0	3.5	4.5
MSH067-3	370	420	1.078	2.0	1.0	1.0	1.5	1.5	1.5	1.5	3.5	3.5
MSJ461-1	300	451	1.067	1.0	1.5	1.0	1.5	1.5	1.5	1.0	1.5	1.5
NY120	451	488	1.074	0.3	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.5
PIKE	**355**	**388**	**1.080**	**-**	**1.0**	**1.0**	**1.5**	**1.5**	**1.0**	**1.5**	**1.5**	**2.0**
$LSD_{0.05}$	63	57	0.003									

†CHIP SCORE: Snack Food Association Scale (Out of the field); Ratings: 1-5; 1: Excellent, 5: Poor.
††SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
*Agronomic data from Date of Harvest, Round-White Late Harvest (DOH) Trial; Montcalm Research Farm, September 21, 2001.
Chip scores were from two-slice samples from five tubers of each line collected at each sample date.

Table 3. MSU ADVANCED *Bt-cry3A* SELECTIONS PRELIMINARY TRIAL
Montcalm Research Farm, 2001-2002.

	2001				2002			
	CWT/A		%		CWT/A		%	
LINE	US#1	TOTAL	US#1	SP GR	US#1	TOTAL	US#1	SP GR
MSE018-1	**524**	**634**	**83**	**1.080**	**377**	**398**	**95**	**1.074**
E08.10	491	547	90	1.081	374	400	93	1.078
MSG274-3	**287**	**591**	**49**	**1.075**	**336**	**432**	**78**	**1.071**
G38.03	231	530	44	1.073	343	458	75	1.073
ND5873-15	**274**	**311**	**88**	**1.077**	**167**	**227**	**74**	**1.070**
ND8.01	306	335	91	1.079	141	178	79	1.067
ND8.04	303	347	87	1.080	178	220	81	1.070
Norwis	**379**	**402**	**94**	**1.059**	**154**	**165**	**93**	**1.054**
NO8.03	381	428	89	1.060	177	193	92	1.055
NO8.08	328	354	93	1.063	184	191	96	1.055
NO8.28	372	415	90	1.062	186	194	96	1.056
NY123	**424**	**508**	**83**	**1.080**	**370**	**400**	**93**	**1.074**
NY8.10	328	424	77	1.074	313	334	93	1.069
NYL235-4	**436**	**533**	**82**	**ND***	**312**	**397**	**79**	**1.067**
L28.2	294	385	77	ND	288	328	88	1.067
L28.3	316	432	73	ND	301	345	87	1.069
L28.5	308	455	68	ND	292	348	84	1.069
Spunta	**292**	**334**	**87**	**ND**	**313**	**358**	**87**	**1.055**
SP8.3	332	423	79	ND	276	315	88	1.056
Yukon Gold	**315**	**350**	**90**	**ND**	**255**	**282**	**90**	**1.064**
YG8.8	251	305	82	ND	175	186	94	1.059
YG8.12	265	307	86	ND	151	167	90	1.062
ATLNewLeaf	468	501	93	1.084	321	349	92	1.078
RBNewLeaf	51	258	20	1.075	112	155	72	1.059

Lines are grouped by transgenic parental clone family. Parental clone is bolded.
*ND: No Data.

Table 4A. 2001 and 2002 AGPase AGRONOMIC TRIAL, Moncalm Research Farm.

	2001			2002			2001	2002	2001	2002	2002
	CWT/A		%	CWT/A		%					CHIP
LINE	US#1	TOTAL	US#1	US#1	TOTAL	US#1	SP GR	SP GR	HH[1]	HH	SCORE[2]
					ONAWAY						
ONAWAY	**423**	**496**	**85**	**324**	**366**	**89**	**1.059**	**1.057**	**0**	**0**	**3.5**
ONAGP2	349	414	84	226	269	84	1.069	1.067	3	7	3.0
ONAGP3	311	373	84	148	183	81	1.071	1.065	1	4	3.5
ONAGP1	301	360	84	283	319	89	1.068	1.067	2	3	4.0
MEAN	346	411		233	272		1.067	1.063			
$LSD_{0.05}$	33	51		57	56		0.002	0.003			
					MSE149-5Y						
MSE149-5Y	**457**	**509**	**90**	**314**	**337**	**93**	**1.063**	**1.059**	**0**	**4**	**2.5**
EAGP20	431	502	86	281	328	86	1.062	1.062	1	3	4.0
EAGP15	419	481	87	291	335	87	1.063	1.062	0	8	1.5
EAGP4	376	425	89	236	263	90	1.069	1.068	13	22	2.0
EAGP8	360	452	80	308	355	87	1.064	1.062	0	5	2.0
EAGP9	331	369	90	191	215	89	1.070	1.069	29	34	1.5
EAGP24	295	347	85	168	199	84	1.070	1.069	4	16	1.5
MEAN	381	441		256	290		1.066	1.064			
$LSD_{0.05}$	59	53		46	45		0.003	0.003			

Potato lines sorted in decreasing 2001 yield within each parental clone. Parental clone is bolded.
[1]HH: Hollow Heart. Number of tubers out of 40 cut.
[2]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/13/02); Ratings: 1-5; 1: Excellent, 5: Po
2001: Planted May 1, 2001; Harvested September 27, 2001 (150 DAYS)
2002: Planted May 1, 2002; Harvested September 11, 2002 (133 DAYS)

Table 4B. 2001 and 2002 AGPase SIMULATED BLACKSPOT BRUISE SUSCEPTIBILITY TEST

	2001								2002							
	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS PER TUBER	NUMBER OF SPOTS PER TUBER						PERCENT (%) BRUISE FREE	AVERAGE SPOTS PER TUBER
LINE	0	1	2	3	4	5+			0	1	2	3	4	5+		
								ONAWAY								
ONAWAY	**17**	**7**	**1**				**68**	**0.36**	**12**	**9**	**4**				**48**	**0.680**
ONAGP2 *	5	8	5	3	3	1	20	1.76	4	5	9	1		6	16	2.240
ONAGP1 *	5	2	9	5	2	2	20	2.12	4	7	4	4	3	3	16	2.160
ONAGP3 *	2	1	4	2	1	15	8	3.76	5	4	3	5	1	7	20	2.560
								MSE149-5Y								
EAGP15	16	8	1				64	0.40	20	3	2				80	0.280
EAGP8	15	9	1				60	0.44	12	8	3	1	1		48	0.840
E149-5Y	**16**	**6**	**2**		**1**		**64**	**0.56**	**24**	**1**					**96**	**0.040**
EAGP20	11	8	4	2			44	0.88	21	1	3				84	0.280
EAGP9 *	4	4	6	3	1	7	16	2.56	2	2	6	8	1	6	8	2.880
EAGP4 *	2	2	6	3	2	10	8	3.24			1	9	4	11	0	4.000
EAGP24 *	4	1	3	3	4	10	16	3.28	5	1	8	5	3	3	20	2.360

Simulated bruise samples were prepared as follows: twenty-five A-size tuber samples were collected at harvest, held at 50 F at least 12 hours, placed in a six-sided plywood drum, and rotated ten times to produce simulated bruising. Samples were abrasive-peeled and scored on October 29, 2001 and October 24, 2002. The table is presented in 2001 ascending order of average number of spots per tuber. Parental clone is bolded.

*These transgenic lines had higher solids than their non-transgenic parental line.

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2002 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. 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, Fusarium dry rot, and blackspot bruising are determined.

PROCEDURE

Twelve field experiments were conducted at the Montcalm Research Farm in Entrican, MI. They were planted as randomized complete block designs with 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. This year the fields were fumigated in the fall prior to the field season.

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 Long White and Russet, North Central Regional, Yellow Flesh, Adaptation (tablestock and chip-processors), Preliminary (tablestock and chip-processors) and Frito Lay 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 42°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 15 entries that were evaluated at two harvest dates. Atlantic, Snowden and Pike were used as checks. The plot yields were below average in the early harvest (97 days), and most lines increased between 60-200 cwt/a in yield for the second harvest date (144 days). The results are summarized in **Tables 1 and 2**. Tuber specific gravity readings were significantly below average for 2002. For example, Atlantic and Snowden had specific gravity readings of 1.079 and 1.075, respectively, in the late harvest. In the early harvest trial, MSI002-3 had the highest yield, while Atlantic, MSH095-4, B0766-3, MSF373-8 and W1201 were similar in yield behind MSI002-3. At the later harvest, many of the same lines were among the top yielding lines along with MSE018-1. These top yielding lines were also classified as blackspot bruise susceptible in the simulated bruise test. MSF099-3, W1201 and B0766-3 were also the top yielding lines in the on-farm processing trials. MSJ461-1 is a promising chip-processing line with strong foliar resistance to late blight. MSF373-8 continues to be a high yielding line with a significantly higher percentage of large tubers (62% oversize), and it chip-processes well out of the field. A Canadian group is interested in licensing MSF373-8 as a tablestock line. The scab level in the agronomic trial was high and scab ratings were collected in addition to the scab nursery. Liberator, Pike and MSG227-2 continue to be the lines with the highest scab resistance along with chip-processing ability. Chip-processing quality was high among all the entries in the out-of-the-field samples. Snowden, W1201, B0766-3, Liberator and MSF099-3 are in the 500 cwt bins of the Commercial Demonstration Storage. Incidence of internal defects was generally low, but Atlantic had a higher frequency of hollow heart in both early and late harvests.

Variety Characteristics

<u>LIBERATOR</u> - a MSU selection for chip-processing with strong scab resistance. Yield and specific gravity over the past five 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 2002 Commercial Demonstration Storage.

<u>MSF099-3</u> – a MSU chip-processing selection. It has high specific gravity, smooth attractive tubers, and excellent chip quality and will chip-process from 45°F cold storage. In 2000 it was one of the best chip-processors in the 42°F MPIC demonstration storage. It yielded well on the on-farm trials, but the large tubers tended to elongate. It is also scab susceptible. MSF099-3 has been put in the 2001 and 2002 Commercial Demonstration Storage 500 cwt. bins.

<u>MSG227-2</u> – 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. This line will be considered for release in 2003.

<u>MSH094-8</u> - a new chip-processing selection with cold-chipping potential from 42ºF storage.

This line also has a low incidence of internal defects and mid-season maturity. It will in on-farm trials in 2002.

MSH095-4 - a mid-season maturing line with excellent chip quality and bruise susceptibility equal to Snowden. It was comparable to Atlantic for yield and solids at the Montcalm Research Farm. It was in the on-farm trials for 2001-2002.

MSF373-8 - a high yielding selection with acceptable specific gravity for chip-processing. It will chip out-of-the-field and from 50°F storage. Produces large tubers with a low incidence of internal defects. Scab tolerance is intermediate.

MSE018-1 - a very high yield potential, high specific gravity selection with moderate tolerance to scab. It has a late maturity, large vine and some reduced susceptibility to late blight. Tuber appearance is bright and smooth with a round-oval shape. It has chip-processed well in May and June from the Commercial Demonstration Storage the past two years.

MSJ461-1 – an exciting, new 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 average yield, but an intermediate specific gravity.

MSI002-3 – a new MSU selection with high yield and high solids potential. It was in a few on-farm trials in 2002. It is a progeny of Liberator, but it does not have a high level of scab resistance.

B0766-3 – a selection from USDA-Beltsville. It has high yield potential and scab tolerance along with excellent chip-processing quality. It is in one of the 500 cwt 2002 Commercial Demonstration Storage bins.

W1201 – a selection from Wisconsin that has high solids, chip-processing quality and high yield potential. The large tubers tend to sheep nose. It is in one of the 500 cwt 2002 Commercial Demonstration Storage bins.

B. Round White Varieties: Tablestock (Tables 3 and 4)

There were 9 entries that were evaluated at two harvest dates. Onaway was used as a check. The plot yields were average in the early harvest (97 days), and a moderate yield increase was observed for the second harvest date (132 days). Tuber specific gravity readings were below average. The results are summarized in **Tables 3 and 4**. In the early harvest trial, Onaway, Michigan Purple, MSE221-1 and MSH031-5 were the top yielding lines. There was very little incidence of internal defects in the early harvest. In the later harvest, Onaway, MSH031-5, MSI152-A, and Michigan Purple were the top yielding lines. Overall, incidence of internal defects was low in comparison to previous years. MSE221-1 and Onaway were the only lines to classify as scab tolerant. MSE221-1 and Jacqueline Lee had above average bruising in the simulated bruise tests. Another strong performing line is Michigan Purple, which was released in 2001, that has a bright purple skin and excellent internal quality. Jacqueline Lee, a smooth, bright-skinned, yellow-flesh variety with strong resistance to foliar late blight and maturity equal to Snowden, was also released in 2001. MSI152-A is a high yielding, round white line with foliar resistance to late blight, however, the maturity is full season.

Variety Characteristics

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. The strength of this selection is its strong foliar resistance to the US8 genotype of late blight. Vine maturity is similar to Snowden.

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. We regard this as a variety that can compete in the red market.

MSH031-5 – a MSU tablestock/chip selection with high yield potential, attractive round shape and bright skin. It has also performed well in North Carolina. It is scab susceptible.

MSE221-1 - a MSU tablestock selection. It has high yield potential as seen in the MSU and on-farm trials. General appearance is good, but it has a netted appearance similar to Superior. It has strong resistance to scab. It is being considered for release in 2002.

MSG004-3 - a MSU tablestock selection. It has average yield potential and produces bright attractive tubers with good internal quality.

C. Long Whites and Russet Varieties (Table 5)

The long white and russet trial had 14 lines evaluated in 2002. GoldRush, Russet Burbank and Russet Norkotah were the standard varieties in the trial and the results are summarized in **Table 5**. Scab resistance was prevalent among the lines tested. Internal quality was high except for A8893-1RUS and CO92077-2RUS. Specific gravity measurements were well below average with Russet Burbank having a 1.063 reading. The three standards were very low yielding in the trial. The yield of the overall trial was below average for 2002, however, Keystone Russet was the highest yielding line by over 170 cwt/A. All lines were chip-processed out of the field with NDC5372-1RUS and TC1675-1RUS having excellent color.

Variety Characteristics

MSB106-7 - a MSU tablestock selection. It has high yield potential as seen in the on-farm trials, but performed poorly at MSU. Tubers are oblong-long with a light netting. Internal quality is excellent and it has a very white flesh.

MSE192-8RUS - a MSU tablestock selection. The tubers have an attractive russeting and shape. The vine is small which may make this line uncompetitive in small plot trials. The tuber type suggests that it be considered a replacement for Russet Norkotah. The tubers have a white flesh that does not darken after cooking. It has performed well in taste tests.

MSE202-3RUS – a MSU dual-purpose russet selection. It has a late maturity and high yield potential. Its specific gravity is equivalent to Russet Burbank and the tubers are long with a lighter, but attractive russet skin. Scab resistance is also high. Frito Lay is testing MSE202-3RUS as a directional chipper.

D. North Central Regional Trial (Table 6)

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-four breeding lines and seven varieties were tested in Michigan. The results are presented in **Table 6**. The range of yield was wide and specific gravities of the lines were very low in 2002. The MSU lines MSE018-1, MSE221-1, MSE202-3RUS and MSF313-3 were all included in the North Central Trial for the first time in 2002. ND2470-27 was the highest performing line and chip-processed out of the field. ND5822C-7 was also high yielding, but was susceptible to hollow heart. This line also has some Colorado potato beetle resistance. NY112 is a promising line that is being released by Cornell University, but has shown susceptibility to blackspot bruise. The top-rated red-skinned line was ND5084-3R when you consider yield, shape, red color and internal defects. MSE221-1, a scab resistant MSU tablestock selection, was also a promising selection in the trial. The top-rated russet line was W1836-3Rus, but in general, the russet varieties and lines performed below average.

E. Yellow Flesh Trial (Table7)

Eleven varieties and advanced selections were tested in 2002. Yukon Gold and Saginaw Gold were used as checks. The results are summarized in **Table 7**. The trial was harvested after 145 days, and yields were below average and varied considerably. The best yielding lines in 2002 were MSJ033-10Y, MSI005-20Y, MSJ453-4Y, and MSE149-5Y. These results were similar to 2001. Internal defects and late vine maturity make MSJ453-4Y, a late blight resistant selection, undesirable at the commercial level. MSI005-20Y was a strong overall performing line with high yield, excellent internal quality, and medium-early maturity. Torridon and MSJ459-2Y also have foliar late blight resistance, but are scab susceptible, late maturing and suffer from internal defects. Some entries were evaluated for chip-processing quality out-of-the-field and MSE149-5Y, Saginaw Gold and MSJ453-4Y had acceptable chip color. The high incidence of internal brown spot in Torridon was observed in both 2001 and 2002.

F. Adaptation Trial (Tables 8A and 8B)

The Adaptation trial was divided into chip-processing and tablestock trials. Two cultivars (Snowden and Atlantic) and 26 advanced breeding lines are reported in the chip-processing trial. The trial was harvested after 146 days and the results are summarized in **Table 8A**. The high yielding lines identified in 2002 were W2062-1, B1240-1, MSJ167-1 and A91790-13, but these lines were also the later-maturing selections. In addition, these lines were classified as blackspot bruise susceptible in the simulated bruise test. As in all the 2002 trials, the specific gravity readings were below average, but W2062-1, MSJ167-1, MSH112-6 and W1980-4 had readings higher than

Atlantic. Other lines of interest were observed. MSH067-3 is a chip-processing selection with cold-chipping potential. It has mid-season maturity and intermediate scab tolerance. The tubers are flattened and round. MSJ456-4 and MSJ319-1 have strong foliar late blight resistance. Based upon two years of study, MSH228-6, MSJ126-9Y and MSH356-A showed some scab tolerance.

In the tablestock trial Onaway and Superior were the check varieties and 17 advanced breeding lines and new varieties were evaluated. The trial was harvested after 139 days and the results are summarized in **Table 8B**. Eight red-skinned entries were compared. Mazama was the top yielding line, but the red skin color was not strong. Durango Red and NDTX4271-5R had the best combination of shape and red skin color. Among the red lines, internal defects were low except for the vascular discoloration in Mazama and CO89097-2RED. ATX85404-8W was the highest yielding line, but has some hollow heart susceptibility. MSJ317-1 is a round white selection with a bright skin that has strong foliar resistance to late blight, but the vine maturity is very late. MSJ319-7 and MSJ307-2 also have late blight resistance, but the tuber type is not as desirable. Scab tolerance was limited to Superior, Onaway, Cal Red and Mazama. Interestingly, no entries were classified as blackspot bruise susceptible.

H. Preliminary Trial (Tables 9A and 9B)

The Preliminary trial is the first replicated trial for evaluating new advanced selections from the MSU potato breeding program. Twenty-nine advanced selections and three check varieties were tested and reported in two separate Preliminary trials. The division of the trials was based upon chip-processing or tablestock utilization. The chip-processing trial is summarized in **Table 9A.** The top yielding line was MSJ316-A and was also classified as scab resistant. Another promising line is MSK061-4 which has a high percentage of uniformed A-sized tubers. Other scab tolerant lines identified in this trial are MSK498-1Y, MSK476-1, NY120, MSH015-2, and MSG301-9. Internal defects were generally low in the trial with Atlantic showing the greatest susceptibility to hollow heart. Blackspot bruise susceptibility was also low in this trial.

Table 9B summarizes the results from the Preliminary tablestock trial. Harvest was completed after 134 days. No late blight resistant lines were among the chip processors, but 5 entries in the tablestock trial had strong foliar resistance to late blight. Of those, MSL757-1 shows the most promise. It has above average yield potential, an attractive blocky oval shape and above average solids. MSK125-3 is from has a late blight pedigree, but is not highly resistant. However, it has high yield and attractive smooth tubers. Silverton Russet was an attractive, scab resistant russet variety that had nice russet type among the A-sized tubers. Other scab resistant lines are MSK217-3P, MSJ036-A, MSK247-9Y and MSK004-AY.

I. Frito Lay Trial (Table 10)

A separate trial was conducted with the three major Frito Lay varieties because of the late arrival of the seed. It was planted about two weeks later than our other agronomic trials. For comparison Snowden, Atlantic and Liberator were included in the trial. Chip-processing out of the field was acceptable for all varieties. For US#1 yield, no differences existed among the varieties. FL1867 and Liberator had the highest total yields, while Atlantic and Liberator had the highest specific gravity readings. Atlantic and FL1833 were most susceptible to hollow heart in the oversize tubers.

Liberator and FL1833 had little scab incidence compared to the other varieties. Blackspot bruise was low in this trial.

J. Potato Scab Evaluation (Table 11)

Each year a replicated field trial at the MSU Soils Farm is conducted to assess resistance to common and pitted scab. For the second year, 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 11** categorizes many of the varieties and advanced selections tested in 2002 at the MSU Soils Farm Scab Nursery. 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 2002 the scab disease incidence at the nursery was typical compared to other years, and the data were separated into three categories (Resistant = 0.0-1.2; Moderately Resistant = 1.3 – 1.70; 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 11**). 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 lines are Liberator, MSG227-2, MSE192-8RUS, MSE202-3RUS, MSE221-1, MSG301-9, MSH228-6, MSJ126-9Y, MSH015-2, MSJ316-A and MSJ036-A. Scab results from the disease nursery are also found in the Trial Summaries (**Tables 2, 4-10**).

K. Late Blight Trial (Table 12)

In 2002, a late blight trial was conducted at the Muck Soils Research Farm. Over 160 entries were evaluated in replicated plots. The field was planted on 7 June and inoculated 26 July with isolates 94-3, 95-7, 98-2, and 00-1, 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 and lines from the National Late Bight Variety Trial. The results are summarized in **Table 12**. Lines with the least infection from multi-year testing have been LBR8, LBR9, A90586-11, Jacqueline Lee, MSJ461-1, B0767-2, B0692-4, B0718-3, AWN86514-2 and Torridon (a Scottish variety). Jacqueline Lee has demonstrated strong late blight resistance over the past six years. In addition, many new MSU selections were in this top tier. Included in this group are MSJ453-4Y, MSJ456-4, MSJ456-2 and MSJ457-2 which all are progeny of Tollocan; MSJ307-2, MSJ319-1, MSJ317-2, MSI152-A and MSJ319-7 which are progeny of B0718-3. We also have progeny of Jacqueline Lee with strong late blight resistance: MSK106-A, MSK106-B, MSK101-2 and MSK128-2. These resistant progeny indicate that we can continue to breed for resistance using Jacqueline Lee as a parent. Some of the promising new selections for resistance are MSL766-1, MSL757-1, MSL211-3, MSK027-C, MSK034-1 and MSK136-2. We find these late blight resistant lines valuable because many of them also have marketable maturity. Many 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.

L. Blackspot Susceptibility (Table 13)

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 13**. 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 2002 the bruise levels were lower than other years. This may be attributed to the lower solids observed in the tubers. The most bruise resistant lines this year were MSF099-3, MSG227-2, MSH031-5, MSF313-3, MSE202-3RUS, MSE192-8RUS, MSJ033-6Y, MSI005-20Y, AC87340-2W, A90490-1, MSH228-6, Cherry Red, MSI049-A, Durango Red, NDTX4271-5R, MSK061-4, MSK125-3 and most of the russet lines. The most susceptible lines were MSH095-4, MSE018-1, Torridon, W2062-1, NDTX4930-5W and NY120.

M. Post-harvest Disease Evaluation: Fusarium Dry Rot

As part of the post harvest evaluation, resistance to *Fusarium sambucinum* (Fusarium dry rot) was assessed by inoculating 3 whole tubers post-harvest from selected lines and varieties in the 2002 MRF variety trials. The tubers were held at 20°C (room temperature) for approximately three weeks post inoculation with *Fusarium* mycelial plugs and then scored for dry rot infection depth and width. A total of 104 breeding lines and varieties were tested. Overall the mean infection depth of the lesion ranged from 0.6-15.9 mm with an $LSD_{0.05}$ = 6.2 mm. The 2002 infection level was about 50% of the 2001 infection level. In the previous two years we classified Superior, GoldRush, NorValley, Liberator and Michigan Purple in the tolerant group. In 2001, MSH067-3 also had a low infection level. The 2002 results concur. **Table 14** lists many additional lines in the 2002 are classified as having low infection level. Also consistent with the 2001 data, the varieties classified as susceptible in the 2002 evaluation were Atlantic and Pike. At this time, complete resistance to Fusarium dry rot has not been found in the cultivated germplasm, but genetic variation for tolerance to dry rot does exist.

N. Seed Availability of MSU New Varieties and Advanced Selections

The MSU Potato Breeding program has entered a new stage of development as we have released the first three potato varieties and have numerous lines with commercial potential. These lines are in tissue culture and have greenhouse tuber production and in many cases there is field generation seed available. **Table 15** summarizes the current seed available of the new MSU varieties and advanced selections.

Table 1

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

ROUND WHITE CHIP POTATOES: EARLY HARVEST
MONTCALM RESEARCH FARM
AUGUST 6, 2002 (97 DAYS)

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	CHIP SCORE[3]	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	3-YR AVG US#1 CWT/A
MSI002-3	311	347	89	10	86	4	0	1.078	1.0	5	0	0	0	40	-
ATLANTIC	**264**	**295**	**90**	**8**	**85**	**5**	**3**	**1.079**	**1.5**	**12**	**0**	**0**	**0**	**40**	**342**
MSH095-4	257	281	91	6	80	11	3	1.076	1.0	1	0	0	0	40	300*
B0766-3	251	267	94	6	91	3	0	1.073	1.0	3	0	0	0	40	-
MSF373-8	241	249	97	1	66	32	2	1.068	1.5	0	0	0	0	40	344
W1201	238	261	91	7	88	3	1	1.076	1.0	3	0	0	0	40	-
LIBERATOR	216	243	89	10	86	3	2	1.076	1.0	1	0	0	0	40	276
MSE018-1	215	246	87	12	81	6	0	1.074	1.0	4	0	0	0	40	309
MSF099-3	211	246	85	13	83	2	1	1.077	1.0	1	0	0	0	40	254
MSJ461-1 [LBR]	196	252	78	22	77	0	0	1.065	1.5	0	0	0	0	40	200*
SNOWDEN	**195**	**234**	**83**	**16**	**83**	**1**	**1**	**1.075**	**1.0**	**1**	**0**	**0**	**0**	**40**	**252**
MSH094-8	193	216	89	11	88	1	0	1.074	1.0	1	0	0	0	40	291
MSG227-2	176	222	79	19	79	0	2	1.070	1.5	3	0	0	0	40	282
PIKE	**169**	**207**	**81**	**19**	**81**	**0**	**0**	**1.073**	**1.0**	**0**	**0**	**0**	**0**	**40**	**232**
MSI083-5	159	190	84	15	83	1	1	1.069	1.0	0	0	0	0	40	-
MEAN	219	250						1.074							
$LSD_{0.05}$	32	33						0.002							

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.

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

Planted May 1, 2002

Table 2

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ROUND WHITE CHIP POTATOES: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 23, 2002 (144 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	NURSERY	TRIAL			3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	SCAB[4]	MAT[5]	BRUISE[6]	CWT/A
MSE018-1	438	470	93	5	74	19	1	1.079	1.5	8	2	0	0	40	3.6	1.6	3.9	SUSC.	438
MSF373-8	392	401	98	1	36	62	1	1.072	1.5	4	0	0	0	40	2.5	1.1	3.0	SUSC.	457
B0766-3	390	407	96	4	77	19	0	1.072	1.0	4	3	0	0	40	1.5	0.1	2.8	SUSC.	-
MSI002-3	376	420	90	10	84	5	0	1.077	1.5	2	0	1	0	40	4.0	1.9	1.9		-
W1201	364	391	93	5	84	9	2	1.081	1.5	0	5	0	0	40	1.3	0.5	3.3	SUSC.	-
ATLANTIC	**328**	**352**	**93**	**5**	**81**	**12**	**1**	**1.078**	**1.5**	**11**	**1**	**2**	**0**	**40**	**2.7**	**0.9**	**2.5**	**SUSC.**	**398**
MSH095-4	326	351	93	5	77	16	2	1.076	1.0	1	2	0	2	40	2.0	0.4	2.5	SUSC.	385*
MSF099-3	323	348	93	6	83	10	1	1.076	1.5	2	0	0	0	40	3.7	1.1	2.4		329
MSH094-8	299	324	92	7	88	4	1	1.075	1.5	0	0	0	0	40	2.3	0.9	2.3		366
MSJ461-1 [LBR]	279	330	84	15	84	0	0	1.069	1.0	0	0	0	0	40	2.7	2.0	3.0		289*
LIBERATOR	276	309	89	7	80	9	4	1.074	1.5	1	0	0	1	40	0.0	0.0	2.5		358
PIKE	**262**	**302**	**87**	**13**	**86**	**1**	**0**	**1.077**	**1.0**	**0**	**0**	**0**	**0**	**40**	**1.1**	**0.6**	**2.5**		**317**
SNOWDEN	**262**	**304**	**86**	**13**	**81**	**5**	**0**	**1.073**	**1.0**	**3**	**4**	**0**	**2**	**40**	**2.0**	**1.1**	**2.5**		**343**
MSG227-2	256	326	78	12	74	4	10	1.072	1.0	0	1	0	0	40	0.5	0.0	2.9		366
MSI083-5	255	288	89	10	85	3	1	1.072	2.0	0	0	0	0	40	3.3	2.8	2.8		-
MEAN	322	355						1.075											
$LSD_{0.05}$	53	50						0.002											

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.

[3]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/25/02); Ratings: 1-5; 1: Excellent, 5: Poor.

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

[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.

Planted May 2, 2002

Table 3

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ROUND WHITE TABLESTOCK POTATOES: EARLY HARVEST
MONTCALM RESEARCH FARM
AUGUST 6, 2002 (97 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	CWT/A
MSE221-1	360	381	94	3	82	13	3	1.063	0	0	0	0	40	397
MSH031-5	286	324	88	12	88	0	0	1.074	0	0	0	0	40	346
MICHIGAN PURPLE	283	311	91	5	83	8	4	1.063	1	1	0	0	40	341*
ONAWAY	**256**	**291**	**88**	**9**	**79**	**9**	**3**	**1.059**	**0**	**0**	**0**	**0**	**40**	**388**
MSE080-4	247	260	95	5	89	6	0	1.067	0	0	0	0	40	-
MSF313-3	183	239	76	23	76	1	1	1.070	0	0	0	0	40	226
MSG004-3	181	192	95	4	90	4	1	1.057	1	0	0	0	40	238
JACQUELINE LEE LBR	179	307	58	39	58	0	3	1.069	0	0	0	0	40	187
MSI152-A LBR	135	170	80	19	80	0	2	1.058	1	0	0	0	40	-
MEAN	234	275						1.064						
$LSD_{0.05}$	41	48						0.003						

* Two-Year Average

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.
Planted May 1, 2002

Table 4

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ROUND WHITE TABLESTOCK POTATOES: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 11, 2002 (132 DAYS)

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	NURSERY SCAB[3]	TRIAL SCAB[3]	MAT[4]	BRUISE[5]	3-YR AVG US#1 CWT/A
MSE221-1	397	418	95	3	84	11	2	1.063	3	1	0	0	40	1.3	1.0	1.3	SUSC.	412
MICHIGAN PURPLE	341	355	96	3	81	16	1	1.066	2	0	0	0	40	2.7	2.5	1.6		331*
MSH031-5	334	365	91	9	91	1	0	1.074	0	0	0	0	40	2.3	2.8	2.0		363
MSI152-A [LBR]	309	345	90	9	84	6	2	1.061	4	0	0	0	40	2.0	2.0	3.1		-
ONAWAY	**294**	**321**	**92**	**6**	**83**	**9**	**2**	**1.060**	**0**	**6**	**0**	**0**	**40**	**1.7**	**1.3**	**1.3**		**412**
MSF313-3	249	293	85	14	84	1	1	1.070	0	0	0	0	40	2.3	2.8	3.0		282
MSE080-4	239	256	93	6	85	8	0	1.067	0	0	0	0	40	1.7	2.0	1.5		-
MSG004-3	225	241	93	5	83	11	2	1.058	0	0	0	0	40	1.5	1.8	2.5		275
JACQUELINE LEE [LBR]	220	360	61	38	61	0	1	1.075	0	0	0	0	40	2.7	2.0	2.6	SUSC.	276
MEAN	290	328						1.066										
$LSD_{0.05}$	47	48						0.002										

* Two-Year Average

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.
[3]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[4]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)
[5]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.
Planted May 2, 2002

Table 5

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

LONG WHITE and RUSSET TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 9, 2002 (132 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL				3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]	BRUISE[6]	CWT/A
KEYSTONE RUSSET	488	549	89	9	56	33	2	1.057	2.0	0	6	0	0	40	0.5	3.5		-
A8893-1RUS	310	404	77	19	63	14	4	1.067	2.0	15	6	0	0	40	0.0	2.6		356
AC92009-4R	287	345	83	10	63	20	7	1.077	2.0	1	1	0	0	40	0.0	3.3		-
MSE202-3RUS	265	344	77	17	67	10	6	1.071	2.5	4	0	0	0	40	0.0	3.4		371
AC89536-5RUS	256	362	71	28	65	6	1	1.076	2.0	5	1	1	0	40	0.0	3.3		265*
NDC5372-1RUS	231	353	65	33	64	2	2	1.077	1.0	4	0	0	0	40	1.0	3.9	SUSC.	-
CO92077-2RUS	224	291	77	21	66	11	2	1.058	2.0	0	0	5	4	40	1.5	3.0		-
MSB106-7	217	308	70	19	61	10	11	1.055	-	0	2	0	0	40	1.0	1.3		294
CO85026-4	214	271	79	15	62	17	6	1.074	1.5	1	0	0	0	40	0.7	3.5		224*
MSE192-8RUS	212	326	65	33	59	6	2	1.064	2.0	0	4	0	0	40	0.3	1.6		252
GOLDRUSH	**201**	**299**	**67**	**27**	**61**	**6**	**6**	**1.056**	**2.5**	**0**	**1**	**0**	**0**	**40**	**0.3**	**1.8**		**228***
RUSSET BURBANK	**181**	**291**	**62**	**27**	**54**	**8**	**10**	**1.063**	**2.0**	**2**	**1**	**1**	**0**	**40**	**1.0**	**1.9**		**242**
TC1675-1RUS	172	297	58	40	55	3	2	1.075	1.0	1	3	0	0	40	0.7	3.1	SUSC.	-
RUSSET NORKOTAH	**106**	**231**	**46**	**54**	**43**	**3**	**1**	**1.058**	**2.0**	**1**	**3**	**0**	**0**	**40**	**1.2**	**1.3**		**214**
MEAN	240	334						1.066										
$LSD_{0.05}$	52	55						0.005										

* Two-Year Average

[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.
[3]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/13/02); Ratings: 1-5; 1: Excellent, 5: Poor.
[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).
[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.
Planted May 1, 2002

Table 6

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 9, 2002 (131 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL				
ENTRY	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]	BRUISE[6]	MERIT[7]
ND2470-27	524	567	92	7	87	5	1	1.068	1.0	0	1	0	0	40	3.0	2.8		1W
ND5822C-7	509	548	93	7	85	7	1	1.080	1.5	17	0	0	0	40	2.7	3.1	SUSC.	
NY112	463	479	97	3	88	8	0	1.070	1.0	0	2	0	0	40	1.3	2.6	SUSC.	2W
ND5084-3R	406	427	95	3	67	28	1	1.055	2.5	0	0	0	0	40	2.0	3.1		1RD
MSE018-1	400	428	94	5	73	20	1	1.076	1.5	2	2	0	0	40	3.6	3.6	SUSC.	4W
MSE221-1	398	414	96	3	84	12	1	1.061	1.5	3	2	0	0	40	1.3	1.3		3W
W1386	381	403	94	5	84	10	1	1.074	1.0	4	0	0	0	40	2.3	2.3	SUSC.	
MN18710Rus	376	407	92	7	67	25	1	1.068	2.5	0	0	0	0	40	0.0	3.4		
D.R. NORLAND	**373**	**410**	**91**	**9**	**91**	**0**	**0**	**1.052**	**2.0**	**0**	**0**	**0**	**0**	**40**	**2.7**	**1.3**		**2RD**
ATLANTIC	**365**	**393**	**93**	**7**	**91**	**2**	**1**	**1.077**	**1.5**	**3**	**0**	**0**	**2**	**40**	**1.3**	**1.9**		
W1201	347	369	94	5	84	10	1	1.081	1.0	1	4	0	0	40	2.8	3.3		
W1431	340	364	93	5	81	12	1	1.078	1.0	24	0	0	0	40	1.5	2.9	SUSC.	
B0766-3	339	360	94	6	90	5	0	1.072	1.0	1	0	0	0	40	2.0	2.8		5W
SNOWDEN	**320**	**394**	**81**	**19**	**81**	**0**	**0**	**1.074**	**1.0**	**0**	**2**	**0**	**0**	**40**	**2.0**	**2.1**	**SUSC.**	
MN19525R	318	353	90	9	80	10	0	1.061	3.0	0	1	0	0	40	1.0	2.4		4RD
W1836-3Rus	314	394	80	16	73	7	4	1.071	2.0	6	0	0	0	40	0.0	2.9		1RUS
CV89023-2R	291	350	83	16	83	0	1	1.063	2.5	0	0	0	0	40	2.0	1.0		3RD
MSE202-3Rus	287	363	79	16	74	5	4	1.071	2.5	12	0	0	2	40	0.0	2.5		2RUS
NORVALLEY	**279**	**324**	**86**	**11**	**85**	**1**	**3**	**1.067**	**1.0**	**0**	**1**	**0**	**0**	**40**	**2.0**	**1.9**	**SUSC.**	
RED PONTIAC	**263**	**314**	**84**	**7**	**74**	**10**	**9**	**1.055**	**3.0**	**4**	**1**	**0**	**0**	**40**	**3.0**	**3.6**		
A9014-2Rus	263	308	85	13	52	33	1	1.072	1.0	15	0	0	0	40	0.3	3.6		3RUS
MSF313-3	247	299	83	17	82	0	0	1.070	1.5	0	0	0	0	40	2.3	2.9		
MN18747Rus	235	266	88	11	84	5	1	1.056	1.0	0	1	0	0	40	-	1.1		
A90586-11Rus[LBR]	224	320	70	27	69	2	3	1.073	2.0	0	0	0	0	40	3.5	2.4		

continued on following page:

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 9, 2002 (131 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL				
ENTRY	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]	BRUISE[6]	MERIT[7]
continued:																		
ND3196-1R	218	239	91	7	82	9	2	1.055	3.0	0	0	0	1	40	0.7	1.0		5RD
MN15620LR	206	266	77	19	73	4	4	1.069	1.0	1	5	0	0	40	2.0	3.6		
RUSSET BURBANK	**202**	**285**	**71**	**17**	**66**	**5**	**12**	**1.064**	**2.5**	**6**	**0**	**0**	**0**	**40**	**1.0**	**2.6**		**5RUS**
RUSSET NORKOTAH	**162**	**245**	**66**	**33**	**64**	**2**	**1**	**1.060**	**2.0**	**1**	**2**	**0**	**0**	**40**	**1.2**	**1.1**		**4RUS**
V04981-1R	141	172	82	10	82	0	8	1.045	3.5	0	0	0	0	10	-	1.0		
V0498-9R	137	160	86	4	77	9	10	1.049	1.5	0	0	0	0	40	2.0	1.5		
V0497-1	134	157	85	13	80	5	2	1.064	1.0	1	0	0	0	40	3.5	1.6		
MEAN	171	218						1.058										
$LSD_{0.05}$	70	69						0.003										

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.

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

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

[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering).

[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.

[7]MERIT: A Merit rating was given for the best 5 entries in each market class (rank order, 1 = best).

Planted May 1, 2002

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

YELLOW FLESH and EUROPEAN TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 23, 2002 (145 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	NURSERY	TRIAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	SCAB[4]	MAT[5]	BRUISE[6]
MSI005-20Y	377	438	86	10	76	11	4	1.066	-	0	2	0	0	40	2.0	1.9	3.5	
MSE149-5Y	350	373	94	5	77	17	1	1.061	1.0	2	0	1	0	40	1.3	1.3	2.5	
MSJ033-10Y	325	390	83	11	82	2	6	1.060	-	0	3	0	0	40	1.0	0.6	2.8	
MSJ453-4Y [LBR]	318	402	79	14	77	2	6	1.079	1.0	5	2	13	1	40	2.7	2.3	4.1	SUSC.
SAGINAW GOLD	**277**	**331**	**84**	**12**	**82**	**2**	**4**	**1.063**	**1.5**	**0**	**0**	**0**	**0**	**40**	**1.0**	**1.4**	**1.1**	
MSE048-2Y	261	277	94	3	79	15	2	1.067	-	1	0	5	4	40	1.5	1.8	3.4	SUSC.
MSJ033-6Y	260	305	85	7	75	10	7	1.060	-	0	9	0	0	40	2.0	1.6	2.9	
TORRIDON [LBR]	250	392	64	24	59	5	12	1.079	-	0	1	23	0	40	4.3	5.1	3.6	SUSC.
YUKON GOLD	**234**	**262**	**89**	**5**	**79**	**11**	**6**	**1.066**	**-**	**0**	**5**	**0**	**0**	**40**	**4.0**	**2.8**	**1.0**	
MSJ459-2Y	185	206	90	5	64	25	5	1.076	1.0	3	6	3	1	40	2.5	2.1	4.6	
MSJ472-4P	164	253	65	33	65	0	2	1.074	2.0	1	0	0	0	40	2.0	1.8	2.3	
MEAN	273	330						1.068										
$LSD_{0.05}$	92	87						0.005										

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.
[3]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/25/02); Ratings: 1-5; 1: Excellent, 5: Poor.
[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)
[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.
Planted May 1, 2002

Table 8A

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADAPTATION TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 24, 2002 (146 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	NURSERY	TRIAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	SCAB[4]	MAT[5]	BRUISE[6]
W2062-1	476	540	88	11	85	3	1	1.086	1.5	4	0	0	0	40	2.3	1.0	3.0	SUSC.
B1240-1	460	471	98	2	80	18	0	1.076	2.0	6	6	0	0	40	2.0	0.8	3.8	SUSC.
MSJ167-1	441	476	93	6	91	2	1	1.086	1.5	0	0	0	0	40	2.0	0.8	4.1	SUSC.
A91790-13	422	455	93	5	73	20	2	1.074	1.5	3	4	0	0	40	3.5	0.8	3.6	SUSC.
MSH228-6	377	398	95	5	81	13	1	1.066	1.0	5	3	3	0	40	1.3	0.5	2.9	
MSH067-3	375	389	96	2	78	19	1	1.077	1.5	4	0	1	0	40	3.0	1.0	2.3	
W1773-7	370	403	92	7	82	10	1	1.075	1.5	0	0	0	0	40	2.7	1.1	3.0	
MSJ080-1	368	393	94	6	79	15	0	1.064	1.5	0	3	0	0	40	2.5	0.5	2.4	
MSH112-6	347	428	81	18	79	2	0	1.080	1.0	0	1	0	0	40	-	1.0	2.6	SUSC.
MSJ147-1	343	382	90	10	88	2	1	1.073	1.0	0	0	0	0	40	2.0	0.9	3.0	
W1980-4	342	379	90	6	77	13	3	1.081	1.5	7	3	0	0	40	2.0	1.2	2.4	
ATLANTIC	**336**	**357**	**94**	**4**	**78**	**16**	**2**	**1.077**	**1.5**	**8**	**1**	**0**	**0**	**40**	**2.7**	**1.4**	**2.5**	
AC87340-2W	331	402	83	17	81	2	0	1.065	1.0	0	0	0	0	40	2.3	1.3	2.4	
DAKOTA PEARL	325	356	91	8	87	4	1	1.064	1.5	1	7	0	2	40	-	0.3	1.4	
MSJ197-1	318	342	93	6	80	13	1	1.069	2.0	0	3	0	0	40	2.7	0.5	3.1	
MSH098-2	318	330	96	3	82	14	0	1.073	1.0	0	1	0	0	40	2.7	1.4	2.6	
A90490-1	318	332	96	4	71	25	1	1.065	1.5	8	0	1	2	40	2.3	0.7	3.6	
MSJ456-4 **LBR**	316	384	82	17	82	1	1	1.077	1.5	0	2	0	0	40	2.0	1.0	3.5	SUSC.
MSJ319-1 **LBR**	309	345	90	9	83	7	1	1.075	1.0	8	1	0	0	40	2.0	1.3	3.0	
MSH360-1	301	327	92	7	88	4	1	1.074	2.0	2	4	1	0	40	2.0	0.5	3.1	SUSC.
MSJ126-9Y	284	318	89	11	85	4	0	1.063	1.0	0	1	1	0	40	0.3	0.1	2.5	
MSJ080-8	275	299	92	7	86	6	1	1.073	1.0	7	1	0	0	40	2.0	0.5	1.9	
BC0894-2W	266	300	89	10	88	0	1	1.059	1.5	1	0	0	0	40	2.3	0.6	1.1	

continued on following page:

ADAPTATION TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 24, 2002 (146 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	NURSERY	TRIAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	SCAB[4]	MAT[5]	BRUISE[6]
continued:																		
SNOWDEN	**265**	**311**	**85**	**15**	**83**	**2**	**0**	**1.072**	**1.0**	**1**	**2**	**0**	**0**	**40**	**2.0**	**1.3**	**2.6**	
W2033-8	263	319	82	16	82	1	1	1.071	1.0	0	0	0	0	40	1.3	0.5	1.9	
MSH356-A	255	278	92	7	85	7	1	1.070	2.0	10	0	0	0	40	1.0	0.3	2.5	SUSC.
W1782-5	245	270	91	9	88	3	0	1.072	1.0	0	0	0	0	40	1.5	1.4	2.1	SUSC.
MSJ170-4	217	270	81	18	80	1	1	1.077	2.0	0	0	0	0	40	2.0	0.9	2.6	
MEAN	249	290						1.072										
$LSD_{0.05}$	56	54						0.003										

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.

[3]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/25/02); Ratings: 1-5; 1: Excellent, 5: Poor.

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

[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.

Planted May 1, 2002

Table 8B

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ADAPTATION TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
SEPTEMBER 18, 2002 (139 DAYS)

LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	NURSERY SCAB[3]	TRIAL SCAB[3]	MAT[4]	BRUISE[5]
MAZAMA	442	480	92	8	85	7	0	1.063	0	28	1	0	40	1.3	0.9	2.4	
ATX85404-8W	409	443	92	6	83	9	2	1.072	10	0	0	0	40	1.7	1.1	3.0	
NDTX4930-5W	401	429	94	4	83	10	2	1.067	3	4	0	0	40	3.3	1.3	1.6	
NDTX4304-1R	396	430	92	6	89	3	1	1.044	0	3	0	1	40	2.7	0.8	1.1	
DURANGO RED	387	422	92	8	86	6	1	1.063	2	3	0	0	40	-	0.5	3.4	
CAL RED	380	439	86	13	86	1	0	1.062	0	0	3	0	40	1.3	0.5	3.0	
MSI077-4	372	389	96	3	69	27	1	1.069	1	8	0	0	40	2.3	2.4	3.6	
CO89097-2RED	362	399	91	7	81	9	3	1.063	0	12	0	2	40	3.0	1.0	1.9	
MSI049-A [MLBR]	359	397	90	6	69	21	4	1.060	2	2	2	3	40	2.5	1.7	2.9	
MSJ317-1 [LBR]	332	357	93	7	89	4	0	1.070	1	6	1	0	40	2.5	1.8	4.6	
NDTX4271-5R	326	355	92	8	87	5	0	1.057	0	1	0	0	40	2.0	0.9	1.1	
NDC5281-2R	320	371	86	11	84	2	3	1.060	0	1	0	0	40	3.3	1.4	1.5	
ONAWAY	**313**	**353**	**88**	**6**	**81**	**8**	**6**	**1.058**	**0**	**3**	**0**	**0**	**40**	**1.7**	**0.1**	**1.4**	
MSJ319-7 [LBR]	309	347	89	11	82	7	0	1.067	0	3	0	0	40	3.0	1.9	2.6	
MSJ307-2 [LBR]	301	344	87	7	79	8	6	1.056	0	2	0	0	40	2.3	1.3	3.5	
SUPERIOR	**275**	**292**	**94**	**4**	**90**	**5**	**2**	**1.060**	**1**	**9**	**0**	**0**	**40**	**0.3**	**0.0**	**1.0**	
MSJ204-3	272	291	93	5	81	12	2	1.059	0	1	0	0	40	2.0	0.4	3.1	
CHERRY RED	257	327	79	17	78	1	4	1.064	4	1	0	0	40	2.0	0.9	1.0	
MSI032-6	239	279	86	13	85	0	1	1.071	0	1	0	0	40	2.7	0.9	2.8	
MEAN	339	376						1.062									
$LSD_{0.05}$	43	49						0.004									

[LBR] Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.
[3]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[4]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)
[5]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002. *No lines in this trial were bruise susceptible in 2002.*
Planted May 2, 2002

Table 9A

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, CHIP-PROCESSING LINES
MONTCALM RESEARCH FARM
SEPTEMBER 23, 2002 (139 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	NURSERY	TRIAL			PEDIGREE	
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	SCAB[4]	MAT[5]	BRUISE[6]	FEMALE	MALE
MSJ316-A	485	501	97	3	81	16	0	1.073	1.5	4	0	1	0	20	1.0	0.5	4.0		Pike	B0718-3
MSK498-1Y	421	452	93	7	91	2	0	1.071	2.0	0	0	8	0	20	1.3	0.8	2.8		Saginaw Gold	Brodick
ATLANTIC	**314**	**345**	**91**	**7**	**80**	**11**	**2**	**1.074**	**1.0**	**12**	**1**	**1**	**0**	**20**	**2.7**	**2.0**	**3.0**			
MSK061-4	306	354	86	13	84	3	1	1.076	1.5	0	3	0	0	20	2.0	0.8	3.3		C148-A	ND2676-10
MSK188-AY	304	311	98	2	78	20	0	1.068	1.5	1	0	0	0	20	2.0	1.5	3.5	SUSC.	NY101	H142-2
MSK476-1	280	329	85	14	85	0	0	1.082	1.5	0	0	0	0	20	1.0	1.0	3.5		H361-1	H228-6
NY120	271	322	84	16	84	0	0	1.064	2.0	0	1	0	0	20	1.0	1.5	2.3			
MSK469-1	263	309	85	15	83	2	0	1.074	1.5	1	0	1	0	20	2.7	1.8	3.5		H216-1	H228-6
MSH015-2	256	285	90	7	87	3	3	1.076	1.5	2	0	2	0	20	1.0	0.8	1.8		Atlantic	OP
SNOWDEN	**254**	**302**	**84**	**16**	**82**	**2**	**0**	**1.072**	**1.0**	**1**	**2**	**0**	**0**	**20**	**2.0**	**2.0**	**2.0**			
R3-105	237	253	94	5	80	14	1	1.085	1.0	7	0	0	0	20	3.7	2.0	2.8			
MSK409-1	228	265	86	13	84	2	1	1.074	1.5	1	0	0	0	20	2.0	1.5	2.5		C148-A	A091-1
MSG301-9	207	242	85	14	84	1	1	1.064	1.5	1	2	0	0	20	1.0	0.3	2.0		Spartan Pearl	S440
MSI061-B	186	214	87	11	83	4	2	-	1.5	0	0	0	1	20	1.5	1.8	1.8		Brodick	ND01496-1
MEAN	287	320						1.073												
$LSD_{0.05}$	124	121																		

[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.
[3]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/25/02); Ratings: 1-5; 1: Excellent, 5: Poor.
[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)
[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.
Planted May 7, 2002

Table 9B

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL, TABLESTOCK LINES
MONTCALM RESEARCH FARM
SEPTEMBER 18, 2002 (134 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	NURSERY	TRIAL			PEDIGREE	
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	SCAB[3]	SCAB[3]	MAT[4]	BRUISE[5]	FEMALE	MALE
MSL766-1 LBR	517	544	95	3	38	58	2	1.069	10	0	0	0	20	3.5	2.3	3.8		B0718-3	A91846-5R
MSK106-B LBR	497	591	84	11	78	6	5	1.085	8	0	0	1	20	4.0	3.3	4.5	SUSC.	F128-C	G274-3
MSK125-3	448	486	92	7	80	12	1	1.070	1	0	3	0	20	2.7	1.0	3.5		G214-1	G274-3
MSK217-3P	437	459	95	3	50	45	2	1.065	1	0	0	0	20	1.0	0.3	3.3		Russian Blue	Picasso
SILVERTON RUS	435	470	93	7	65	28	0	1.063	0	0	0	0	20	0.0	0.0	3.3			
MSK214-1R	390	411	95	4	72	23	1	1.062	0	0	0	0	20	1.0	0.3	3.3		Prestile	Picasso
MSL757-1 LBR	383	450	85	13	63	22	2	1.077	2	0	0	0	20	3.0	0.3	3.8		AWN86514-2	A84180-8
MSK106-A LBR	352	406	87	12	72	15	1	1.082	6	0	4	0	20	3.0	3.0	4.5		F128-C	G274-3
MSK117-A	346	386	90	10	79	11	1	1.071	2	0	0	0	20	3.0	1.5	3.8		H142-2	OP
MSJ036-A	335	355	94	6	84	10	0	1.071	2	1	2	1	20	0.5	0.0	3.0		A7961-1	Zarevo
MSK004-2Y	309	342	90	7	90	1	3	1.064	0	0	0	0	20	1.5	0.0	3.3	SUSC.	A097-1Y	Picasso
MSG050-2	294	328	90	10	86	4	0	1.062	0	0	0	0	20	3.0	0.8	1.5		Eramosa	L235-4
MSK247-9Y	294	316	93	7	83	10	0	1.064	3	0	0	0	20	1.3	0.8	3.0		Yukon Gold	Picasso
ONAWAY	**285**	**320**	**89**	**7**	**80**	**9**	**3**	**1.056**	**0**	**0**	**0**	**0**	**20**	**1.7**	**0.0**	**1.3**			
MSH308-2Y	224	267	84	16	84	0	0	1.071	0	0	0	1	20	2.7	1.3	2.5		F077-7	OP
MSI092-3RY	149	220	68	31	67	1	1	1.064	3	0	0	0	20	4.7	1.5	2.0		D040-4RY	Chaleur
MSK004-AY	100	119	83	17	83	0	0	1.071	0	0	0	0	20	1.0	0.0	3.3		A097-1Y	Picasso
MSK101-2 LBR	83	99	83	17	83	0	0	1.066	0	0	0	0	20	3.0	0.5	2.0	SUSC.	F059-1	G274-3
MEAN	326	365						1.069											
$LSD_{0.05}$	137	143						0.006											

LBR Line(s) demonstrated foliar resistance to Late Blight (*Phytopthora infestans*) in inoculated field trials in 2002 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.

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

[4]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)

[5]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002.

Planted May 7, 2002

Table 10

MICHIGAN STATE UNIVERSITY

POTATO BREEDING and GENETICS

FRITO LAY CHIP-PROCESSING TRIAL
MONTCALM RESEARCH FARM
OCTOBER 7, 2002 (143 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL	TRIAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]	BRUISE[6]
FL1867	323	354	91	8	87	4	1	1.071	1.0	3	0	0	0	40	2.4	1.5	
LIBERATOR	301	347	87	7	79	8	6	1.078	1.0	0	2	1	0	40	0.4	3.1	
ATLANTIC	**294**	**317**	**93**	**5**	**70**	**23**	**3**	**1.079**	**1.0**	**23**	**2**	**0**	**0**	**40**	**2.1**	**2.6**	
FL1879	278	288	97	3	75	21	1	1.066	1.5	10	3	0	0	40	2.5	2.1	
SNOWDEN	**265**	**285**	**93**	**7**	**84**	**9**	**0**	**1.073**	**1.5**	**7**	**14**	**0**	**1**	**40**	**2.4**	**2.8**	
FL1833	255	263	97	2	57	41	1	1.074	1.5	19	1	1	0	40	0.6	3.0	
MEAN	286	309						1.074									
	NS	59						0.004									

[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.
[3]CHIP SCORE: Snack Food Association Scale (Out of the field, 9/25/02); Ratings: 1-5; 1: Excellent, 5: Poor.
[4]SCAB DISEASE RATING: MSU Scab Nursery; 0: No Infection; 1: Low Infection <5%; 3: Intermediate; 5: Highly Susceptible.
[5]MATURITY RATING: Taken August 21, 2002; Ratings 1-5; 1: Early (vines completely dead); 5: Late (vigorous vine, some flowering)
[6]BRUISE: These lines demonstrated blackspot bruise susceptibility in simulated bruise testing in 2002. *No lines in this trial were bruise susceptible in 2002.*
Planted May 17, 2002

Table 11

2002 SCAB DISEASE TRIAL
SCAB NURSERY, EAST LANSING, MI

Potato Line	Mean Rating* (0-5)	Worst Rating (0-5)	N[†]	Potato Line	Mean Rating (0-5)	Worst Rating (0-5)	N
RESISTANT CATEGORY:				*MODERATELY RESISTANT CATEGORY:*			
A8893-1	0.0	0	3	CAL RED	1.3	2	3
AC89536-5Rus	0.0	0	2	MSE149-5Y	1.3	2	3
AC92009-4Rus	0.0	0	3	MSE221-1	1.3	3	6
MSE202-3Rus	0.0	0	5	MSH228-6	1.3	2	3
LIBERATOR	**0.0**	**0**	**2**	MSK247-9Y	1.3	2	3
MN18710Rus	0.0	0	3	MSK498-1Y	1.3	2	3
SILVERTON RUS	0.0	0	3	MAZAMA	1.3	2	3
W1836-3	0.0	0	3	NY112	1.3	2	3
A9014-2Rus	0.3	1	3	W1201	1.3	3	6
MSE192-8Rus	0.3	0	3	W2033-8	1.3	2	3
GOLDRUSH	**0.3**	**1**	**3**	B0766-3	1.5	2	4
MSJ126-9	0.3	1	3	CO92077-2Rus	1.5	2	2
SUPERIOR	**0.3**	**1**	**3**	MSE048-2Y	1.5	2	2
MSG227-2	0.5	1	2	MSG004-3	1.5	2	2
MSJ036-A	0.5	1	2	MSI061-B	1.5	2	2
KEYSTONE RUS	0.5	1	2	MSK004-2Y	1.5	2	4
CO85026-4	0.7	2	3	W1782-5	1.5	2	2
ND3196-1R	0.7	1	3	ATX85404-8W	1.7	2	3
TC1675-1Rus	0.7	2	3	CO86218-2R	1.7	2	3
MSB106-7	1.0	2	3	MSE080-4	1.7	2	3
DR NORLAND	**1.0**	**2**	**3**	**ONAWAY**	**1.7**	**3**	**7**
MSG301-9	1.0	1	2				
MSH015-2	1.0	2	3				
MSH356-A	1.0	2	3				
MSJ033-10Y	1.0	1	3				
MSJ316-A	1.0	1	2				
MSK004-AY	1.0	1	1				
MSK214-1R	1.0	1	3				
MSK217-3P	1.0	2	2				
MSK476-1	1.0	2	2				
MN19525	1.0	1	3				
NDC5372-1Rus	1.0	2	3				
NY120	1.0	1	2				
RUSSET BURBANK	**1.0**	**1**	**2**				
SAGINAW GOLD	**1.0**	**1**	**3**				
PIKE	**1.1**	**2**	**9**				
RUSSET NORKOTAH	**1.2**	**3**	**6**				

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

[†]N = Number of plots evaluated.

Table 11 continued

2002 SCAB DISEASE TRIAL
SCAB NURSERY, EAST LANSING, MI

Potato Line	Mean Rating (0-5)	Worst Rating (0-5)	N[†]	Potato Line	Mean Rating (0-5)	Worst Rating (0-5)	N	Potato Line	Mean Rating (0-5)	Worst Rating (0-5)	N
SUSCEPTIBLE CATEGORY:				*SUSCEPTIBLE CATEGORY:*				*SUSCEPTIBLE CATEGORY:*			
AF1775-2	2.0	2	2	MSF313-3	2.3	3	4	CO89097-2R	3.0	4	3
B1240-1	2.0	2	3	A90490-1	2.3	4	3	CV89023-2R	3.0	3	3
CHERRY RED	2.0	3	3	AC87340-2W	2.3	3	3	MSE030-4	3.0	4	2
MSH095-4	2.0	3	3	BC0894-2W	2.3	3	3	MSG050-2	3.0	4	3
MSH360-1	2.0	2	2	MSD040-4RY	2.3	4	3	MSH067-3	3.0	5	3
MSI005-20Y	2.0	2	1	MSG147-3P	2.3	3	3	MSJ319-7	3.0	3	3
MSI152-A	2.0	3	3	MSH031-5	2.3	3	3	MSK061-A	3.0	3	3
MSJ033-6Y	2.0	2	3	MSH041-1	2.3	3	3	MSK101-2	3.0	4	3
MSJ080-8	2.0	3	3	MSH094-8	2.3	3	3	MSK106-A	3.0	3	2
MSJ147-1	2.0	2	3	MSI077-4	2.3	3	3	MSK117-A	3.0	4	3
MSJ167-1	2.0	3	2	MSJ307-2	2.3	3	3	MSK128-1	3.0	4	3
MSJ170-4	2.0	3	3	MSK059-A	2.3	3	3	MSL757-1	3.0	4	3
MSJ204-3	2.0	2	2	W1386	2.3	4	3	ND2470-27	3.0	4	2
MSJ319-1	2.0	2	3	W2062-1	2.3	3	3	**RED PONTIAC**	**3.0**	**3**	**3**
MSJ456-4Y	2.0	3	2	MSF373-8	2.5	3	2	MSI083-5	3.3	4	3
MSJ457-2	2.0	3	2	MSI049-A	2.5	3	2	MSI582-A	3.3	4	3
MSJ458-2	2.0	3	3	MSJ080-1	2.5	3	2	NDC5181-2R	3.3	4	3
MSJ472-4P	2.0	3	2	MSJ317-1	2.5	3	2	NDTX4930-5W	3.3	4	6
MSK061-4	2.0	2	1	MSJ459-2Y	2.5	3	2	A90586-11	3.5	4	2
MSK188-AY	2.0	3	3	MSK033-C	2.5	3	2	A91790-13	3.5	4	6
MSK409-1	2.0	2	2	MSK223-5	2.5	3	2	MSL766-1	3.5	4	2
ND5084-3R	2.0	3	3	MSH063-2	2.7	4	3	V0497-1	3.5	4	2
NDTX4271-5R	2.0	2	2	MSH098-2	2.7	3	3	MSE018-1	3.6	4	5
NORVALLEY	2.0	2	3	MSH308-2Y	2.7	3	3	AF1424-7	3.7	4	3
SNOWDEN	**2.0**	**2**	**5**	MSI032-6	2.7	3	3	MSF099-3	3.7	4	3
V0498-9	2.0	3	3	MSJ197-1	2.7	3	3	MSI201-2PY	3.7	4	3
W1980-4	2.0	2	3	MSJ308-BY	2.7	3	3	MSK049-2	3.7	4	3
				MSJ453-4Y	2.7	3	3	MSR3-105	3.7	4	3
				MSJ456-2	2.7	3	3	MSH017-C	4.0	5	3
				MSJ461-1	2.7	3	3	MSI002-3	4.0	5	2
				JACQUELINE LEE	2.7	3	3	MSI077-5	4.0	4	3
				MSK031-A	2.7	3	3	MSK106-B	4.0	4	3
				MSK034-1	2.7	3	3	**YUKON GOLD**	**4.0**	**5**	**3**
				MSK068-2	2.7	3	3	TORRIDON	4.3	5	3
				MSK123-5	2.7	3	3	MSI092-3RY	4.7	5	3
				MSK244-6	2.7	4	3				
				MSK469-1	2.7	4	3				
				MICHIGAN PURPLE	2.7	3	3				
				ND5822C-7	2.7	4	3				
				NDTX4304-1R	2.7	3	3				
				W1355	2.7	3	3				
				W1773-7	2.7	3	3				
				ATLANTIC	**2.7**	**4**	**11**				
				W1431	2.8	4	6				

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

[†]N = Number of plots evaluated.

Table 12A

2002 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
SIMULATED BRUISE SAMPLES*

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ROUND WHITES: CHIP-PROCESSING LINES									
MSF099-3	20	5					25	80	0.200
MSG227-2	18	7					25	72	0.280
MSH094-8	18	6	1				25	72	0.320
PIKE	**19**	**4**	**2**				**25**	**76**	**0.320**
LIBERATOR	15	8	2				25	60	0.480
MSI083-5	13	10	2				25	52	0.560
MSJ461-1	13	10	2				25	52	0.560
SNOWDEN	**16**	**4**	**4**	**1**			**25**	**64**	**0.600**
MSI002-3	12	10	3				25	48	0.640
MSE018-1	13	8	2	2			25	52	0.720
B0766-3	10	12	2	1			25	40	0.760
MSF373-8	13	5	5	1		1	25	52	0.920
W1201	10	5	5	5			25	40	1.200
ATLANTIC	**6**	**10**	**4**	**4**	**1**		**25**	**24**	**1.360**
MSH095-4	6	5	4	5	3	2	25	24	2.000
ROUND WHITES: TABLESTOCK LINES									
MSE080-4	22	3					25	88	0.120
MSH031-5	23	1		1			25	92	0.160
ONAWAY	**22**	**2**	**1**				**25**	**88**	**0.160**
MSF313-3	19	6					25	76	0.240
MSI152-A	19	6					25	76	0.240
MSG004-3	18	6	1				25	72	0.320
MSE221-1	8	9	7	1			25	32	1.040
JACQUELINE LEE	9	7	8	1			25	36	1.040

* 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 October 24, 2002. The table is presented in ascending order of average number of spots per tuber.

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
LONG WHITES and RUSSETS									
CO85026-4	24	1					25	96	0.040
MSE192-8RUS	24	1					25	96	0.040
RUSSET NORKOTAH	**23**	**2**					**25**	**92**	**0.080**
MSE202-3RUS	22	3					25	88	0.120
KEYSTONE RUSSET	22	3					25	88	0.120
AC89536-5RUS	21	4					25	84	0.160
GOLDRUSH	21	4					25	84	0.160
A8893-1RUS	20	5					25	80	0.200
RUSSET BURBANK	**20**	**4**	**1**				**25**	**80**	**0.240**
AC92009-4R	18	6	1				25	72	0.320
CO92077-2RUS	17	6	1	1			25	68	0.440
TC1675-1RUS	13	9	2		1		25	52	0.680
NDC5372-1RUS	6	12	4	3			25	24	1.160
NORTH CENTRAL REGIONAL TRIAL									
V04981-1R	25						25	100	0.000
RUSSET NORKOTAH	**24**	**1**					**25**	**96**	**0.040**
D.R. NORLAND	22	3					25	88	0.120
MSE202-2Rus	21	4					25	84	0.160
MSF313-3	22	2	1				25	88	0.160
V0497-1	21	4					25	84	0.160
ND3196-1R	20	5					25	80	0.200
ND5084-3R	20	5					25	80	0.200
RUSSET BURBANK	**20**	**5**					**25**	**80**	**0.200**
RED PONTIAC	**21**	**3**	**1**				**25**	**84**	**0.200**
A9014-2Rus	20	4	1				25	80	0.240
CV89023-2R	20	4	1				25	80	0.240
MN19525R	19	6					25	76	0.240
MSE221-1	20	4	1				25	80	0.240
ATLANTIC	**18**	**7**					**25**	**72**	**0.280**
MN18710Rus	19	5	1				25	76	0.280
MN15620LR	17	8					25	68	0.320
MN18747Rus	18	5	1	1			25	72	0.400
W1836-3Rus	16	7	2				25	64	0.440
A90586-11Rus	16	6	3				25	64	0.480
B0766-3	16	6	3				25	64	0.480
W1201	15	7	3				25	60	0.520
ND2470-27	14	8	3				25	56	0.560
SNOWDEN	**12**	**9**	**4**				**25**	**48**	**0.680**
W1431	12	9	3	1			25	48	0.720
ND5822C-7	12	7	3	3			25	48	0.880
NORVALLEY	9	10	6				25	36	0.880
NY112	9	7	6	2	1		25	36	1.160
W1386	8	9	5	1		2	25	32	1.280
MSE018-1	6	8	4	3	2	2	25	24	1.720

	NUMBER OF SPOTS PER TUBER						TOTAL	PERCENT (%) BRUISE	AVERAGE
VARIETY	0	1	2	3	4	5+	TUBERS	FREE	SPOTS/TUBER
YELLOW FLESH and EUROPEAN TRIAL									
MSJ472-4P	24	1					25	96	0.040
MSJ033-6Y	24		1				25	96	0.080
YUKON GOLD	**23**	**2**					**25**	**92**	**0.080**
MSI005-20Y	21	2		2			25	84	0.320
MSJ033-10Y	18	6	1				25	72	0.320
MSE149-5Y	15	9	1				25	60	0.440
MSJ459-2Y	15	6	3	1			25	60	0.600
SAGINAW GOLD	**13**	**8**	**3**	**1**			**25**	**52**	**0.680**
MSJ453-4Y	12	6	5	1	1		25	48	0.920
MSE048-2Y	5	15	4	1			25	20	1.040
TORRIDON	7	8	6	2	1	1	25	28	1.400
ADAPTATION TRIAL, CHIP-PROCESSING LINES									
AC87340-2W	25						25	100	0.000
A90490-1	24	1					25	96	0.040
MSH098-2	23	1	1				25	92	0.120
MSH228-6	23	1	1				25	92	0.120
MSJ170-4	22	3					25	88	0.120
W2033-8	22	3					25	88	0.120
BC0894-2W	21	4					25	84	0.160
DAKOTA PEARL	22	2	1				25	88	0.160
W1773-7	22	2	1				25	88	0.160
MSJ319-1	20	5					25	80	0.200
MSH067-3	19	6					25	76	0.240
MSJ080-1	19	5	1				25	76	0.280
MSJ080-8	18	6	1				25	72	0.320
MSJ197-1	17	7	1				25	68	0.360
ATLANTIC	**16**	**8**	**1**				**25**	**64**	**0.400**
MSJ126-9	18	4	2	1			25	72	0.440
W1980-4	15	9	1				25	60	0.440
MSJ147-1	13	8	4				25	52	0.640
SNOWDEN	**14**	**7**	**2**	**2**			**25**	**56**	**0.680**
W1782-5	13	8	3	1			25	52	0.680
MSH360-1	12	9	3	1			25	48	0.720
A97190-13	12	7	5	1			25	48	0.800
MSH112-6	16	2	3	3	1		25	64	0.840
MSH356-A	13	6	4		1	1	25	52	0.920
MSJ456-2	12	7	2	4			25	48	0.920
B1240-1	10	7	4	2	2		25	40	1.160
MSJ167-1	8	6	8	3			25	32	1.240
MSJ456-4	8	7	6	2	2		25	32	1.320
W2062-1	7	7	7	1	2	1	25	28	1.480

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
ADAPTATION TRIAL, TABLESTOCK LINES									
CHERRY RED	25						25	100	0.000
MSI049-A	25						25	100	0.000
DURANGO RED	24	1					25	96	0.040
MSI032-6	24	1					25	96	0.040
NDC5281-2R	24	1					25	96	0.040
NDTX4271-5R	24	1					25	96	0.040
ONAWAY	**24**	**1**					**25**	**96**	**0.040**
SUPERIOR	**24**	**1**					**25**	**96**	**0.040**
MAZAMA	24		1				25	96	0.080
CO89097-2RED	22	3					25	88	0.120
MSJ319-7	22	3					25	88	0.120
MSJ307-2	21	4					25	84	0.160
MSJ317-1	21	4					25	84	0.160
NDTX4304-1R	20	5					25	80	0.200
CAL RED	19	6					25	76	0.240
MSJ204-3	19	6					25	76	0.240
NDTX4930-5W	20	4	1				25	80	0.240
ATX85404-8W	19	5	1				25	76	0.280
MSI077-4	15	7	2	1			25	60	0.560
PRELIMINARY TRIAL, CHIP-PROCESSING LINES									
MSI061-B	25						25	100	0.000
MSK061-4	22	3					25	88	0.120
MSG301-9	21	4					25	84	0.160
MSK409-1	20	5					25	80	0.200
MSK476-1	19	5		1			25	76	0.320
MSK498-1Y	21	3				1	25	84	0.320
MSNY120	19	5		1			25	76	0.320
ATLANTIC	**16**	**8**	**1**				**25**	**64**	**0.400**
MSR3-105	16	8	1				25	64	0.400
MSK469-1	17	6	1	1			25	68	0.440
SNOWDEN	**14**	**8**	**2**	**1**			**25**	**56**	**0.600**
MSJ316-A	11	12	2				25	44	0.640
MSK188-AY	11	9	3	2			25	44	0.840

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
PRELIMINARY TRIAL, TABLESTOCK LINES									
SILVERTON RUSSET	25						25	100	0.000
MSI092-3RY	24	1					25	96	0.040
ONAWAY	**24**	**1**					**25**	**96**	**0.040**
MSK125-3	23	1	1				25	92	0.120
MSG050-2	20	5					25	80	0.200
MSJ036-A	19	5	1				25	76	0.280
MSK004-AY	19	5	1				25	76	0.280
MSK117-A	20	3	2				25	80	0.280
MSK217-3P	18	7					25	72	0.280
MSK106-A	20	4			1		25	80	0.320
MSL757-1	17	8					25	68	0.320
MSH308-2Y	15	8	2				25	60	0.480
MSL766-1	19	1	3	2			25	76	0.520
MSK247-9Y	14	9	1	1			25	56	0.560
MSK101-2	15	4	4	2			25	60	0.720
MSK004-2Y	9	8	4	2	2		25	36	1.200
MSK106-B	6	8	10	1			25	24	1.240
FRITO-LAY TRIAL									
LIBERATOR	22	3					25	88	0.120
SNOWDEN	**21**	**4**					**25**	**84**	**0.160**
FL1879	19	4	1		1		25	76	0.400
FL1867	18	3	3	1			25	72	0.480
FL1833	15	8	2				25	60	0.480
ATLANTIC	**12**	**11**		**1**		**1**	**25**	**48**	**0.760**

2002 LATE BLIGHT VARIETY TRIAL
MUCK SOILS RESEARCH FARM

LINE	N	RAUDPC[1] MEAN	Table[2]	LINE	N	RAUDPC[1] MEAN
Foliar Resistance Category:				***Foliar Susceptibility Category (select lines)*** [3] **:**		
MSJ456-2	**3**	**0.0**		ZAREVO	3	7.3
MSJ461-1	**3**	**0.0**	**Table 1,2**	BANNOCK RUSSET	3	8.1
JACQUELINE LEE	**3**	**0.0**	**Table 3,4**	ALTURAS RUSSET	3	8.4
LBR8	3	0.0		MSK125-3	1	9.2
MSL766-1	**3**	**0.0**	**Table 9B**	GEM RUSSET	3	9.3
LBR9	3	0.0		LBR5	3	9.6
MSK106-A	**6**	**0.0**	**Table 9B**	MSI049-A	3	10.6
MSK101-2	**2**	**0.1**	**Table 9B**	IDA ROSE	3	10.8
MSJ457-2	**3**	**0.1**		LBR3	3	12.6
MSK106-B	**6**	**0.1**	**Table 9B**	CAL WHITE	3	12.8
B0767-2	3	0.1		MSJ036-A	3	13.7
B0692-4	3	0.2		LBR4	3	14.4
MSK128-A	**3**	**0.3**		LBR2	3	15.2
MSJ453-4Y	**3**	**0.4**	**Table 7**	KEYSTONE RUSSET	3	16.3
MSJ456-4	**3**	**0.4**	**Table 8A**	**RED PONTIAC**	**3**	**16.8**
B0718-3	3	0.7		MSJ316-AY	3	17.2
MSK128-1	**3**	**0.8**		**YUKON GOLD**	**6**	**17.4**
MSJ458-2	**3**	**0.9**		**SNOWDEN**	**3**	**18.4**
AWN86514-2	3	1.1		DURANGO RED	2	18.9
TORRIDON	3	1.1	Table 7	MAZAMA	3	19.3
MSL757-1	**3**	**2.5**	**Table 9B**	**RUSSET BURBANK**	**6**	**20.6**
MSJ307-2	**6**	**2.7**	**Table 8B**	**RUSSET NORKOTAH**	**3**	**22.5**
MSJ319-7	**3**	**2.8**	**Table 8B**	**ATLANTIC**	**6**	**22.8**
MSL211-3	**3**	**2.8**		**DR NORLAND**	**3**	**23.8**
MSJ317-1	**3**	**2.9**	**Table 8B**	**PIKE**	**3**	**24.2**
MSJ319-1	**3**	**4.0**	**Table 8A**	CAL RED	3	24.2
MSK027-C	**3**	**4.0**		**SUPERIOR**	**3**	**25.0**
A79543-4R	3	4.6		IVORY CRISP	3	25.1
MSK049-A	**6**	**5.1**	**Table 8B**	**ONAWAY**	**1**	**27.0**
MSK136-2	**3**	**5.9**		CHERRY RED	3	29.4
MSK034-1	**3**	**6.1**				
C085026-4	2	6.2				
A90586-11	3	6.3	Table 6			
$LSD_{0.05}$		7.0				7.0

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

[2] Agronomic performance data of this line may be found on the referenced table.

[3] 160 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 7.0 and less are considered resistant in 2002.

Phytopthora infestans isolate 95-7 was inoculated 26 July 2002.

Planted as a randomized complete block design consisting of 3 replications of 4 hill plots on 7 June 2002.

TABLE 14

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

2002 *FUSARIUM* DRY ROT TRIAL

LINE	Average Lesion Depth (mm)	Average Lesion Width (mm)	LINE	Average Lesion Depth (mm)	Average Lesion Width (mm)
W1836-3RUS	0.6	1.8	V0498-1R	6.4	10.5
MICHIGAN PURPLE	0.7	1.0	ND5084-3R	6.4	8.5
RUSSET NORKOTAH	**0.9**	**1.3**	MSE192-8RUS	6.4	9.3
W1386	1.3	6.3	B0766-3	6.4	20.7
MN15620LR	1.6	3.1	MSJ080-8	6.5	18.4
MSK106-A	1.9	8.6	MN18710 RUS	6.5	9.0
MSK409-1	1.9	5.9	NDTX4271-5R	6.6	15.8
SILVERTON RUSSET	2.2	4.6	NDTX4304-1R	6.7	15.4
BC0894-2W	2.4	3.9	**RUSSET BURBANK**	**6.7**	**16.0**
NY112	2.4	8.0	FL1867	6.9	15.1
MSI077-4	2.5	6.9	FL1833	6.9	16.7
CAL RED	2.5	4.3	MSG050-2	7.1	17.3
GOLDRUSH	**2.5**	**4.2**	LIBERATOR	7.1	19.9
MSJ147-1	2.6	7.4	MSH356-A	7.2	22.9
MSJ036-A	2.6	4.9	MSH094-8	7.3	24.2
CHERRY RED	2.7	4.2	MSK498-1Y	7.3	18.9
MSK217-3P	2.9	8.2	MSJ033-6Y	7.5	18.9
MSG004-3	3.2	9.3	CO85026-4	7.6	8.7
MSG301-9	3.2	12.5	NY120	7.7	17.3
NORVALLEY	3.3	5.6	TC1675-1RUS	7.7	11.7
A8893-1RUS	3.4	6.5	W1201	7.8	13.9
MSH067-3	3.4	11.9	V0497-1	7.8	13.5
CO92077-2RUS	3.6	3.8	MSJ204-3	8.1	24.7
W2062-1	3.9	11.2	MSJ197-1	8.4	19.3
MSJ170-4	3.9	11.3	FL1879	8.4	15.2
SUPERIOR	**4.0**	**3.3**	KEYSTONE RUSSET	8.6	16.9
DR NORLAND	**4.0**	**15.2**	MSK476-1	8.7	21.1
W1980-4	4.1	12.8	A90490-1	8.9	18.5
ND2470-27	4.1	7.6	W2033-8	9.0	8.8
ND3196-1R	4.2	5.7	CO89097-2R	9.3	17.4
DURANGO RED	4.3	6.0	MSF099-3	9.3	18.7
MSJ080-1	4.4	11.7	MN19525R	9.5	18.4
W1773-7	4.6	15.8	A9014-2RUS	9.6	12.1
MSE221-1	4.8	5.9	B1240-1	9.6	19.7
RED PONTIAC	**4.9**	**6.6**	MSG227-2	10.0	18.7
CV89023-2R	4.9	11.1	**ATLANTIC**	**10.5**	**20.5**
MSI005-20Y	4.9	8.2	MSH112-6	10.6	21.5
SNOWDEN	**5.0**	**15.8**	AC89536-5RUS	10.6	10.0
ONAWAY	**5.2**	**8.4**	MSJ033-10Y	10.8	22.6
MSE202-3RUS	5.3	6.7	A91790-13	10.9	18.3
W1201	5.5	15.7	MSH228-6	11.0	16.4
MSJ126-9Y	5.5	16.0	AC87340-2W	11.9	30.2
ATX85404-8W	5.6	8.7	MSK117-A	12.6	17.6
MSK061-4	5.7	19.7	MAZAMA	12.7	22.1
W1782-5	5.7	20.1	MSH095-4	12.8	21.2
MSK469-1	5.9	17.8	W1431	13.7	16.3
MSK214-1R	5.9	10.7	NDC5372-1RUS	13.8	16.0
MN18747RUS	6.0	7.9	**PIKE**	**14.4**	**23.8**
MSH015-2	6.2	10.2	NDC5821-2R	15.0	22.9
AC92009-4R	6.2	11.3	NDTX4930-5W	15.9	16.5
MSJ167-1	6.3	16.9	MSI002-3	15.9	21.0
$LSD_{0.05}$	6.2	9.3		6.2	9.3

Innoculated on 11/27/02. Readings taken on 12/16/02.

2002 POTATO SEED INVENTORY
MSU Potato Breeding Program Introductions
Availability of Michigan Certified Seed
A Cumulative Inventory

LINE	MINI-TUBERS[2] (UNITS)	Y1[3] (CWT)	Y2[3] (CWT)	Y3[3] (CWT)
LIBERATOR (MSA091-1)	9638	64	-	80
JACQUELINE LEE (MSG274-3)	-	2.5	16	-
MICHIGAN PURPLE	6855	16	75	-
MSE192-8RUS	-	18	72	-
MSE202-3RUS	-	2	60	-
MSF099-3	7520	31	-	40
MSG227-2	868	90	-	-
MSH031-5	6800	-	-	-
MSH067-3	5377	-	-	-
MSH095-4	2373	-	-	-
MSI152-A	456	-	-	-
MSJ319-1	2390	-	-	-
MSJ461-1	7401	16	-	-

Information listed above is a cumulative count from Golden Seed Farms, Iott Seed Farms Inc., Krueger Seed Farm, Marker Farms, and Sklarczyk Seed Farm.

Table courtesy of Chris Long.

Funding: Federal Grant, MPIC and SFA/USPB

2002 On-Farm Potato Variety Trials

Chris Long, Dr. Dave Douches, Dr. Dick Chase, Don Smucker (Montcalm), Dave Glenn (Presque Isle), Jim Breinling (West Region) and Dr. Doo-Hong Min

Introduction

On-farm potato variety trials were conducted with 16 farms in 2002 at a total of 17 locations. Eight of the locations evaluated processing entries and nine evaluated fresh market entries. The processing cooperators were Crooks Farms Inc. (St. Joseph / Montcalm), L. Walther & Sons, Inc. (St. Joseph), Lennard Ag. Co. (Monroe), Fertile Valley Farms (Allegan), Main Farms (Montcalm) and Townview Farms (Montcalm). The SFA chip trial was at V & G Farms (Montcalm). Fresh market trial cooperators were Crawford Farms Inc. (Montcalm), DuRussel's Potato Farms, Inc. (Washtenaw), Erke Farms (Presque Isle), Fedak Farms (Bay), Heiss Farms (Muskegon), Horkey Bros. (Monroe), Krummrey & Sons, Inc. (Ingham), M.J. Van Damme Farms (Marquette)and Newberry Correctional Facility (Luce).

Procedure

There were two types of processing trials conducted this year. The first type contained nine entries which were compared with check varieties Atlantic, Snowden and Pike. This trial type was conducted at Main Farms, Lennard Ag. Co., Fertile Valley Farms, and L. Walthers & Sons. 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 three replicated plots and harvested at two harvest dates of 98 and 119 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 seven to ten lines which were compared to the variety in the field. In these trials each variety was planted in a 15' row plot. Seed spacing was 10 inches.

Within the fresh market trials, there were 22 entries evaluated. There were 12 lines planted at each of the following locations; Bay, 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 6 to 14 inches depending upon grower production and variety.

Three fresh market "Select" trials were planted. They were located at Heiss Farms, Krummrey & Son, Inc. and Newberry Correctional Facility. These trials ranged from four to twelve varieties. Material from two trials was sent to processors for quality testing.

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 L. Walther & Sons in St. Joseph County is shown separately in Table 3 (first harvest, 98 days) and Table 4 (second harvest, 119 days). The overall averages of the "Select" processing trial, which is averaged across two growers, two counties and a total of three locations, are in Table 5.

Processing Variety Highlights

B0766-3, an introduction by Kathleen Haynes U.S.D.A. Beltsville, Maryland has shown some promise this year. It was the top overall yielder of the chip processing lines in 2002. This introduction has a nice, uniform shape and moderate scab tolerance. The size distribution is appealing with 95% of the production being marketable. B0766-3 appears to be an early bulking / early maturing variety, with estimated maturity later than Atlantic and slightly earlier than Pike. The Specific Gravity (SG) of this line may pose some concern here in Michigan, but in a normal year B0766-3 has had a SG of 1.085. Specific Gravity of this line ranged from 1.069 to 1.085 in Michigan. B0766-3 also exhibited the ability to store at 50 °F into January, with potential to ship in March.

Other lines that are showing some traits of interest are W1201, with the ability to bulk early and the potential for above average US#1 yield. MSG227-2 has scab tolerance and yield potential. Many off-types were noted this year in MSG227-2. Liberator has good out of the field chip quality and scab tolerance. MSH094-8 is proving to have excellent storage quality.

B. SFA / USPB Chip Trial Results

The Michigan location of the SFA / USPB chip trial was on the V & G Farm in Montcalm county. 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 Jays Foods, LLC, Chicago.

C. Fresh Market and "Select" Fresh Market 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 six locations; Bay, Marquette, Monroe, Presque Isle and Washtenaw counties. Tables 10, 11 and 12 are "Select" trial locations from Heiss Farms (Muskegon Co.), Krummrey & Sons, Inc. (Ingham Co.) and Newberry Correctional Facility (Luce Co.), respectively.

Fresh Market Variety Highlight

Michigan Purple continues to show its adaptability to perform in many environments. This variety is near the top in almost all fresh market yield trials across the state. Averaging 427 cwt /A US#1 over a three year period with only one hollow-heart out of sixty oversize cut. It is susceptible to common scab, silver surf and other skin disorders. The flesh is a beautiful uniform white color. The purple skin is vibrant when harvested. Field selection is an important decision when raising a crop of Michigan Purple. It is important to avoid pathogens that would effect the appearance of this line. This variety has appealed to a wide ranging audience from Soup and Potato Salad processors to Table and Farm Market Producers.

Keystone Russet, a Colorado russet introduction, which performed well this year in our russet trails and will be evaluated further. It does not seem to have a processing gravity, averaging only 1.064 across the state. The appearance and yield potential are acceptable, with a 355 US#1 yield and 77% of total yield being US#1 production.

Other varieties of interest were Dakota Rose and MSF373-8. Dakota Rose was a moderate yielder at 322 US#1, with a nice red skin in most locations. MSF373-8 continues to perform well across locations, producing tubers that are low in internal defects with 97% US#1 production of which 42% were oversized. Overall US#1 yield for MSF373-8 was 347 cwt/A.

Table 1.

2002 MSU Processing Potato Variety Trials

Entry	Pedigree	Scab Rating*	Characteristics
Atlantic	-	3.0	Early check variety.
Liberator (MSA091-1)	MS702-80 X Norchip	0.5	Mid season maturity, average yield, tubers round with some tendency to form Norchip off-types, chips best from 50 °F.
Pike	-	1.5	Early/storage check variety.
Snowden	-	3.0	Late/storage check variety
B0766-3	B0243-18 X B9792-157 (Coastal Chip)	1.0	Early maturing, high yield, cold chip potential, resistant to golden nematode, some heat sprouts have been noted.
MSF099-3	Snowden X Chaleur	3.0	Oval to oblong and slightly flattened, above average yield: low internal defects and excellent chip color from 42-46 °F.
MSF373-8	MS702-80 X NY88	2.8	High yield, large tubers, low internal defects, medium deep eyes, out-of –field chipper.
MSG227-2	Prestile X MSC127-3	0.8	Average yield potential: flattened round shape, shallow eyes, low internal defects and excellent chip color from 48 °F.
MSH094-8	MSE251-1 X W877	2.0	Mid season maturity, cold chipping potential 42 °F, low internal defects,
MSH095-4	MSE266-2 OP	2.5	Mid season maturity, bruise susceptibility equal to Snowden
MSI002-3	Liberator X MSF134-1	-	Round White chipper
MSI083-5	MSC135-5 X B0718-3	2.5	Late maturing, average yield, good chip color, low internal defects.
NY120	Kanona X AF186-2	1.5	Late Maturity, round, high yield potential, resistant to race Ro1 of golden nematode, dormancy like Atlantic.
W1201	Wischip X FyF 85	1.0	Late maturing, high yield, cold chipper 45 °F, deep eyes
W1386	W876 X LD20-6	2.5	Late maturing, high yield, cold chipper 45 °F, like Snowden

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

Table 2.

2002 Processing Potato Variety Trial
Overall Average - Three Locations
Allegan, Montcalm, Monroe Counties

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	COMMENTS	CWT/A
B0766-3	356	377	95	4	83	12	1	1.069	1.0	1	1	0	0	30	Uniform Shape, Trace Scab	361*
MSF373-8	350	362	96	3	61	35	1	1.073	1.2	0	0	0	0	30	Scab, Sheep Nose	446*
MSF099-3	340	388	87	10	86	1	3	1.073	1.0	0	1	0	0	30	Pitted Scab, Long Type	366
MSH095-4	316	357	87	10	74	13	3	1.070	1.0	2	2	0	0	30	Trace Scab, Good Shape	300*
Atlantic	**308**	**363**	**84**	**16**	**81**	**3**	**0**	**1.072**	**1.0**	**0**	**1**	**1**	**0**	**30**	Scab	**355**
W1201	305	354	85	12	80	5	3	1.082	1.0	0	0	0	0	30	Trace Surface Scab	-
Snowden	**301**	**377**	**76**	**24**	**72**	**4**	**0**	**1.072**	**1.0**	**2**	**2**	**0**	**0**	**30**	Pitted Scab	**340**
MSG227-2	258	341	73	14	70	3	13	1.066	1.2	0	0	0	0	30	Scab, Flat Type, Misshapen, Points	298
Liberator	242	293	82	16	81	1	2	1.068	1.0	0	3	0	0	30	Oblong, Points, Heat Necrosis	-
MSH094-8	239	285	84	16	84	0	0	1.065	1.2	0	0	0	0	30	Trace Scab, Oval Oblong Shape	255*
Pike	**216**	**288**	**76**	**24**	**76**	**0**	**0**	**1.072**	**1.0**	**0**	**2**	**0**	**0**	**30**	Trace Scab	**220***
NY120	193	296	60	40	60	0	0	1.055	1.2	0	0	0	0	30	Small Size	252*
MEAN	285	340	82					1.070								

[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

Table 3.

2002 Potato Processing Variety Trial
L. Walther & Sons, Inc. (Three Rivers, MI)

First Harvest[1] August 7, 2001 (98 Days)

	CWT/A		PERCENT OF TOTAL[2]						Number of
			US#1		Small	Large			Internal
LINE	US#1	TOTAL	As	Bs	As	As	SP GR	HH[3]	Discolorations[3]
Atlantic	**437**	**472**	**93**	**7**	**34**	**59**	**1.075**	**4**	**1**
B0766-3	435	460	95	5	35	60	1.071	1	0
MSF099-3	422	456	91	9	35	56	1.076	0	0
MSG227-2	366	421	87	13	46	41	1.074	1	0
MSF373-8	364	384	95	5	21	74	1.070	2	0
W1201	363	397	92	8	46	46	1.082	1	0
NY120	360	433	83	17	58	25	1.065	0	0
Liberator	349	395	88	12	52	36	1.074	0	3
Pike	**345**	**401**	**86**	**14**	**61**	**25**	**1.075**	**1**	**0**
Snowden	**343**	**400**	**86**	**14**	**57**	**29**	**1.072**	**0**	**0**
MSH094-8	333	385	87	13	44	43	1.075	0	0
MSH095-4	303	367	83	17	53	30	1.076	1	0
MEAN	368	414	89				1.074		

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

[2]Percent of Total (Size)
US#1: 1.8 - 4 in.
Large As: 2.5 - 4 in.
Small As: 1.8 - 2.5 in.
Bs: < 1.8 in.

Planted May 1, 2002

[3]Based on 30 tuber sample

9" seed spacing

Vine Kill September 4, 2002

Table 4.

2002 Potato Processing Variety Trial
L. Walther & Sons, Inc. (Three Rivers, MI)

Second Harvest[1] August 28, 2001 (119 Days)

	CWT/A		PERCENT OF TOTAL[2]						Number of
			US#1		Small	Large			Internal
LINE	US#1	TOTAL	As	Bs	As	As	SP GR	HH[3]	Discolorations[3]
MSF099-3	497	530	93	7	30	63	-	-	-
Snowden	**471**	**513**	**92**	**8**	**55**	**37**	-	-	-
Atlantic	**467**	**508**	**92**	**8**	**38**	**54**	-	-	-
B0766-3	456	484	94	6	36	58	-	-	-
W1201	435	464	94	6	36	58	-	-	-
MSF373-8	434	447	98	2	13	85	-	-	-
MSH094-8	418	480	87	13	36	51	-	-	-
MSH095-4	398	465	85	15	47	38	-	-	-
Liberator	388	431	90	10	47	43	-	-	-
MSG227-2	385	439	88	12	40	48	-	-	-
NY120	347	431	81	19	66	15	-	-	-
Pike	**346**	**409**	**85**	**15**	**53**	**32**	-	-	-
MEAN	420	467	90						

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

[2]Percent of Total (Size)
US#1: 1.8 - 4 in.
Large As: 2.5 - 4 in.
Small As: 1.8 - 2.5 in.
Bs: < 1.8 in.

Planted May 1, 2002

[3]Based on 30 tuber sample

9" seed spacing

Vine Kill September 4, 2002

Table 5.

2002 "Select" Potato Processing Variety Trial
Overall Average - Two Growers, Two Counties
Montcalm & St. Joseph Counties

NUMBER OF		CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	
LOCATIONS	LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	COMMENTS
3	MSI002-3	489	536	92	7	87	5	1	1.074	10	0	0	0	25	Trace Scab, Nice Type
2	W1201	451	551	82	5	64	18	13	1.081	5	2	0	0	15	Sheep Nose
2	MSH094-8	376	408	92	7	90	2	1	1.080	2	0	0	0	15	Flat Blocky, Trace Pitted Scab
3	B0766-3	345	359	96	3	80	16	1	1.076	5	1	0	0	25	Uniform Size
3	MSI083-5	342	383	90	8	85	5	2	1.071	4	0	0	0	25	Trace Scab, Nice Type
3	**Snowden**	**339**	**375**	**91**	**9**	**85**	**6**	**0**	**1.076**	**7**	**2**	**1**	**1**	**25**	
3	NY120	272	361	75	24	74	1	1	1.064	0	0	0	0	25	Trace Scab
	MEAN	373	425	88					1.075						

[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

Table 6.

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2002 SFA / USPB Potato Variety Trial

V & G Farms - Montcalm County

October 18, 2002 Harvest / 148 Days

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		3-YR AVG US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	CWT/A
AF1775-2	495	510	97	1	76	21	2	1.077	1.5	7	0	0	0	30	0.7	479*
W1431	468	487	96	4	79	17	0	1.076	1.0	21	0	0	0	30	0.7	385*
NDTX4930-5W	453	480	94	3	75	19	3	1.075	1.0	1	0	0	0	30	3.2	360*
MSF099-3	418	440	95	5	84	11	0	1.077	1.0	0	0	0	0	30	1.3	-
Atlantic	**414**	**429**	**97**	**2**	**84**	**13**	**1**	**1.081**	**1.0**	**8**	**0**	**0**	**0**	**30**	**0.5**	344
B0766-3	383	398	96	4	88	8	0	1.074	1.0	1	0	0	1	30	0.0	340
Snowden	**375**	**406**	**92**	**8**	**85**	**7**	**0**	**1.078**	**1.5**	**0**	**3**	**0**	**0**	**30**	**0.3**	319
NY120	356	396	90	9	88	2	1	1.073	1.0	0	0	0	0	30	0.2	350
MSG227-2	353	390	91	4	78	13	5	1.075	1.0	4	0	0	0	30	0.2	-
AF1424-7	315	354	88	12	88	0	0	1.074	1.0	0	3	0	0	30	2.8	-
A91790-13	279	311	89	7	70	19	4	1.082	1.0	2	3	0	0	30	1.8	-
W1355-1	246	354	69	31	69	0	0	1.077	1.0	0	0	0	0	30	0.5	-
MEAN	380	413	91					1.077								

[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

* Two-Year Average

Planted: 23, 2002
Seed Spacing : 10.5"

Table 7.

MICHIGAN STATE UNIVERSITY

2002 SFA / USPB - V & G FARMS

Post Harvest Chip Quality Evaluation*

October 18, 2002 (148 DAYS AFTER PLANTING)

LINE	SPECIFIC GRAVITY	CHIP COLOR	PERCENT CHIP DEFECTS		
			INTERNAL	EXTERNAL	TOTAL
AF1775-2	1.077	61.1	3.2	19.8	23.0
W1431	1.076	60.9	1.8	12.3	14.0
NDTX4930-5W	1.075	60.0	3.1	8.6	11.7
MSF099-3	1.077	60.0	4.4	26.5	30.9
Atlantic	**1.081**	**61.3**	**2.6**	**19.3**	**21.8**
B0766-3	1.074	61.8	4.7	16.3	21.0
Snowden	**1.078**	**61.4**	**3.1**	**7.6**	**10.7**
NY120	1.073	62.1	6.6	8.8	15.4
MSG227-2	1.075	62.8	1.3	8.2	9.5
AF1424-7	1.074	61.5	1.2	8.0	9.2
A91790-13	1.082	62.3	2.0	7.8	9.8
W1355-1	1.077	62.2	1.5	8.8	10.3

*Samples processed and scored by Jays Foods, LLC., Chicago October 25, 2002

Table 8.

2002 MSU Freshpack Potato Variety Trials

Entry	Pedigree	Scab Rating*	Characteristics
Cal Red	-	-	-
Cherry Red (DT-6063-1R)	-	-	Moderate response to blackspot and shatter bruise, skin set 21 days after vine kill, stores well, moderately resistant to fusarium day rot.
Dakota Pearl (ND2676-10)	ND1118-1 X ND944-6	0.7	Early maturing, low internal defects, average yield, cold chipping potential at 42 °F.
Dakota Rose (ND3574-5R)	ND1196-2R X NorDonna	-	High yield, nice appearance, resistant to silver scurf, maintains color in storage, good size tubers, short dormancy, skinning
Durango Red (CO86218-2)	Sangre X NDTX9-1068-11R	-	Medium maturity, high yield, holds red skin in storage, sticky stolons may result in high nitrogen use areas.
Goldrush	-	-	Long to oval tubers, heavy russet, check variety
Jacqueline Lee (MSG274-3)	Tollocan X Chaleur	3.5	Oval shape, light yellow flesh, low internal defects, heavy tuber set (15-18/hill), strong foliar resistance to US8 late blight.
Keystone Russet (AC83064-1)	CalWhite X A7875-5	-	Medium maturity, high yield, resistant to scab, good storability, good internals, resistant to blackspot, short dormancy
Mazama (NDO2686-6R)	ND1196-2R X Redsen	-	Low defects, high yield of small size tubers, skin color holds in storage
Michigan Purple	W870 X Maris Piper	3.0	Mid season, attractive purple skin, white flesh, high yield potential, low incidence of internal defects
Onaway	-	1.2	Early maturing check variety.

Entry	Pedigree	Scab Rating*	Characteristics
Reba (NY 87)	Monona X Allegany	2.5	High yield, bright tubers, low incidence of internal defects, mid to late season.
Russet Burbank	-	1.0	Long tubers, russet check variety
Russet Norkotah	-	2.5	Long to oval tubers, heavy russet, check variety
Silverton Russet (A083064-6)	CalWhite X A7875-5	-	Oblong to long, medium russet skin, medium to high yield.
Superior	-	1.5	Average yielding check variety
MSB106-7	LaBelle X Lemhi Russet	1.6	Long white skin tubers, high yield and low internal defects.
MSE192-8 Rus	A81163 X Russet Norkotah	1.2	Long russet tubers, low internal defects, bright white flesh, good cooking quality, SG similar to R. Norkotah.
MSE202-3 Rus	Frontier Russet X A8469-5	0.5	Long russet, lighter russet like R. Burbank.
MSF373-8	MS702-80 X NY88	2.8	High yield, large tubers, low internal defects, medium deep eyes.
MSG004-3	Mainestay X MS702-80	3.0	Average yield, bright skin, low internal defects.
MSH031-5	MSB110-3 X MSC108-3	2.7	Medium maturity, medium yield, low SG, nice appearance, tolerant to black spot

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

Table 9.

2002 Potato Variety Freshpack Trial
Overall Averages - Six Locations
Bay, Marquette, Monroe, Montcalm, Presque Isle, Washtenaw Counties

NUMBER OF LOCATIONS	LINE	CWT/A US#1	CWT/A TOTAL	PERCENT OF TOTAL[1] US#1	Bs	As	OV	PO	SP GR	TUBER QUALITY[2] HH	VD	IBS	BC	TOTAL CUT	COMMENTS	3-YR AVG US#1 CWT/A
6	Michigan Purple	408	460	89	6	69	20	5	1.067	1	0	0	0	60	Pitted Scab, Off types in Oversize	427*
4	MSH031-5	373	424	88	11	85	3	1	1.074	0	1	0	0	40	Trace Pitted Scab, Bright Appearance	-
4	Keystone R.	355	451	77	15	67	10	8	1.064	0	14	0	0	40	Oblong to Long	-
4	**Onaway**	**348**	**382**	**91**	**6**	**78**	**13**	**3**	**1.064**	**0**	**4**	**2**	**0**	**40**	Sheep Nose, Deep Eyes	**421**
4	MSF373-8	347	356	97	3	55	42	0	1.073	0	0	0	0	40	Slight Surface Scab	492
2	MSG004-3	331	359	92	7	73	19	1	1.063	1	0	0	0	20	Slight Surface Scab	310*
6	Dakota Rose	322	349	91	8	80	11	1	1.057	3	5	1	0	60	Growth Crack	-
4	Durango Red	316	388	81	17	75	6	2	1.064	0	4	2	0	40	Sticky Stolons, Netting on Skin	-
3	Dakota Pearl	308	331	93	6	88	5	1	1.073	0	0	0	5	30	Uniform Size	-
2	**Reba**	**300**	**322**	**93**	**7**	**79**	**14**	**0**	**1.064**	**0**	**0**	**0**	**1**	**20**	Good Appearance	-
4	Silverton R.	292	351	83	15	64	19	2	1.069	3	0	0	3	40	Blacksurf	284*
2	**Superior**	**277**	**300**	**92**	**7**	**82**	**10**	**1**	**1.060**	**0**	**0**	**0**	**0**	**20**		-
4	Jacqueline Lee	272	431	63	33	63	0	4	1.077	0	1	0	0	40	Trace Scab, Small Size	326
4	**R. Norkotah**	**264**	**360**	**68**	**28**	**59**	**9**	**4**	**1.066**	**1**	**2**	**0**	**0**	**40**	Trace Scab	**230***
3	Mazama	260	313	82	16	73	9	2	1.068	0	8	1	0	30	Light Red Skin	-
4	MSE202-3Rus	235	317	75	16	68	7	9	1.074	4	2	1	0	40	Trace Scab, Knobs	184*
2	Cal. Red	228	335	68	31	68	0	1	1.061	0	0	0	0	20	Sticky Stolons, Netting on Skin	-
4	MSE192-8Rus	205	264	77	19	64	13	4	1.068	0	7	0	0	40	Stem End Points, Trace Pitted Scab	208*
3	**Goldrush**	**162**	**224**	**72**	**23**	**68**	**4**	**5**	**1.064**	**0**	**0**	**0**	**0**	**30**	Nice Russet Color, Small Size	**190***
	MEAN	295	353	83					1.067							

[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

Table 10.

2002 "Select" Potato Variety Freshpack Trial
Heiss Farms - Muskegon County
October 17, 2002 Harvest / 147 Days

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	COMMENTS
Michigan Purple	630	665	95	2	74	21	3	1.069	0	1	0	0	5	
MSF373-8	470	471	100	0	70	30	0	1.077	0	0	0	0	5	Sheep Nose
Dk. Red Norland	**375**	**422**	**88**	**7**	**82**	**6**	**5**	**1.054**	**0**	**0**	**0**	**0**	**5**	
Jacqueline Lee	293	411	71	24	71	0	5	1.077	0	0	0	0	5	
MEAN	442	492	89					1.069						

[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
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

Planted: May 24, 2002
Seed Spacing: Jacqueline was planted at a 14" spacing.
All other varieties were planted at 9".

Table 11.

2002 "Select" Potato Variety Freshpack Trial
Krummrey & Sons, Inc. - Ingham County
September 21, 2002 Harvest / 123 Days

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	COMMENTS
MSF373-8	223	245	91	3	48	43	6	1.068	0	0	0	0	10	Trace Pitted Scab, Skinning
Michigan Purple	181	225	81	14	68	13	5	1.065	0	0	0	0	10	Growth Crack, Misshapen
Dakota Pearl	167	233	71	26	71	0	3	1.062	0	4	0	0	10	Misshapen
MSH031-5	152	201	75	16	75	0	9	1.063	0	0	0	0	10	Trace Surface Scab, Misshapen
Cal Red	125	189	66	34	66	0	0	1.059	0	2	0	0	10	Growth Crack, Sticky Stolon, Netted Skin
Dakota Rose	119	170	70	19	70	0	11	1.054	0	0	0	0	10	Misshapen
Red Norland	**86**	**132**	**66**	**31**	**59**	**7**	**3**	**1.055**	**0**	**0**	**0**	**0**	**10**	Growth Crack
MEAN	150	199	74					1.061						

[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
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

Planted: May 24, 2002
Vines Killed: September 4, 2002 (104 Days)
Seed Spacing: 6"

Table 12.

2002 "Select" Potato Variety Freshpack Trial
Newberry Correctional Facility - Luce County
October 23, 2002 Harvest / 149 Days

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	COMMENTS
Dakota Rose	316	330	96	4	88	8	0	1.069	0	1	0	0	10	Nice Skin, Good Color
Reba	237	256	93	7	91	2	0	1.078	1	0	0	0	10	Deep Eyes
MSH031-5	221	253	87	13	87	0	0	1.083	0	0	0	0	10	
Dakota Pearl	221	253	87	10	87	0	3	1.082	0	1	0	0	10	
MSF373-8	202	221	91	9	85	6	0	1.084	0	0	0	0	10	
R. Norkotah	**189**	**248**	**76**	**23**	**63**	**13**	**1**	**1.074**	**0**	**0**	**0**	**0**	**10**	
Michigan Purple	139	183	76	17	73	3	7	1.085	0	0	0	0	10	Small Size
MSB106-7	126	170	74	15	74	0	11	1.080	0	0	0	0	10	
Superior	**126**	**142**	**89**	**9**	**76**	**13**	**2**	**1.081**	**0**	**1**	**0**	**0**	**10**	
MSE192-8Rus	120	170	70	30	70	0	0	1.073	0	0	0	0	10	
Silverton R.	114	230	49	51	49	0	0	1.075	0	0	0	0	10	
Jacqueline Lee	95	328	29	65	29	0	6	1.083	0	0	0	0	10	Small Size
Goldrush	**69**	**177**	**39**	**57**	**35**	**4**	**4**	**1.079**	**0**	**0**	**0**	**0**	**10**	
R. Burbank	**54**	**155**	**35**	**57**	**35**	**0**	**8**	**1.084**	**0**	**0**	**0**	**0**	**10**	
Keystone R.	51	168	30	70	30	0	0	1.071	0	6	0	0	10	
MSE202-3Rus	32	95	33	67	33	0	0	1.082	0	0	0	0	10	
MEAN	144	211	66					1.079						

[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
VD: Vascular Discoloration
IBS: Internal Brown Spot
BC: Brown Center

Planted: May 28, 2002
Vines Killed: September 6, 2002 (102 Days)
Seed Spacing: 11.5"
Nitrogen Level: 228 lb/A

POTATO (*Solanum tuberosum* L.'Pike')
Black scurf and stem canker*; Rhizoctonia solani*

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Seed treatments, in-furrow and seed plus foliar treatments for control of potato stem canker and black scurf, 2002.

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 29 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 five-foot unplanted row. Dust formulations were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for two minutes 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 p.s.i.) 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 29 days after planting. 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 49 DAP (about 100% canopy closure), (max = 100). Severity of stem canker was estimated as the percentage of stems per plant with greater than 5% girdling caused by *R. solani*, measured 70 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 20 Sep). Plots (25-ft row) were harvested on 29 Oct and individual treatments were weighed and graded. Samples of 50 tubers per plot were harvested 14 days after dessication (approximately 135 DAP). Tubers were washed and assessed for black scurf (*R. solani*) incidence (%) and severity 40 days after harvest. 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 >16%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.

No seed treatment (ST) or fungicide applied at planting in-furrow (IF) was significantly different from the untreated control or from the Maxim MZ 0.5 lb (ST) commercial standard treatment in terms of the final plant stand (91 - 100%). Maxim MZ 0.75 lb (ST) emerged at a significantly lower rate [relative rate of emergence (RAUEPC)] than the untreated control. No other treatments emerged at a rate significantly different from the untreated control or from the Maxim MZ 0.5 lb (ST) commercial standard treatment. Messenger 1.4 oz/1000 ft (IF) had a significantly lower rate of canopy formation (RAUCPC) than the untreated control but no other treatments were significantly different form the untreated control or from the Maxim MZ 0.5 lb (ST) commercial standard. Seed treatments and in-furrow applications of fungicides were not phytotoxic. All treatments significantly reduced the percentage of stolons with greater than 5% girdling due to *R. solani* in comparison with the untreated control. Headsup 0.002 lb (ST) had significantly more stolon girdling (29.2%) in comparison to the commercial standard. No treatments significantly reduced the percent incidence of black scurf on tubers in comparison with the untreated control or the commercial seed treatment standard. All treatments significantly reduced incidence of black scurf on tubers in comparison with the untreated control. There was no significant difference in incidence of black scurf between treatments with 7.5% [Moncoat MZ 0.75 lb (ST)] to 16.3% [Maxim MZ 0.75 lb ST)] and included the commercial standard [Maxim MZ 0.5 lb (ST), 11.3%]. Messenger 1.4 oz/1000 ft (IF) and Headsup 0.002 lb (ST) had significantly greater incidence (%) of black scurf on tubers than the commercial standard. All treatments significantly reduced the severity of tuber black scurf in comparison with the untreated control. There was no significant difference in the index of severity of black scurf between treatments with indices between 1.9 [Moncoat MZ 0.75 lb (ST)] to 4.7 the commercial standard [Maxim MZ 0.5 lb (ST), 4.7]. Messenger 1.4 oz/1000 ft (IF) and Headsup 0.002 lb (ST) had significantly more severe tuber black scurf then the commercial standard but all other treatments were not significantly different in terms of severity of tuber black scurf from the commercial standard. No treatments were significantly different from the untreated control or the commercial seed treatment standard in terms of marketable or total yield.

Treatment and rate/cwt (seed treatment) rate/A (in furrow)	Application timing[z]	Plant number (%) emerged 29 days after planting		Emergence (RAUEPC)[y]		Canopy development (RAUCPC)[x]	
1 Tops MZ 0.75 lb	ST.........	99.5	a[w]	0.26	ab	0.56	ab
2 Quadris 2.08SC 0.05 fl.oz/1000 ft	IF..........	97.0	a	0.27	ab	0.53	ab
3 Moncoat MZ 0.75 lb	ST.........	100.0	a	0.28	ab	0.55	ab
4 Moncut 70DF 0.79 oz/1000 ft	IF..........	96.0	a	0.25	bc	0.56	ab
5 Moncut 70DF 1.18 oz/1000 ft	IF..........	95.0	a	0.25	bc	0.50	cd
6 6% Mancozeb 1lb	ST.........	100.0	a	0.28	ab	0.55	ab
7 Maxim MZ 0.5 lb	ST.........	94.5	a	0.25	bc	0.53	ab
8 Maxim MZ 0.75 lb	ST.........	91.0	a	0.24	c	0.48	cd
9 Messenger 1.4 oz/1000 ft	IF..........	92.5	a	0.25	bc	0.46	d
10 Headsup 0.002 lb	ST.........	99.0	a	0.26	ab	0.53	abc
11 Untreated	NA........	99.5	a	0.27	ab	0.53	abc

Treatment and rate/cwt (seed treatment) rate/A (in furrow)	Application timing[z]	Percent stolons with greater than 5% 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 Tops MZ 0.75 lb	ST.........	21.6	cdefg[w]	12.5	de	3.4	ef	357	a	387	a
2 Quadris 2.08SC 0.05 fl.oz/1000 ft	IF..........	18.7	defg	10.0	de	3.1	ef	347	a	372	a
3 Moncoat MZ 0.75 lb	ST.........	15.6	fg	7.5	e	1.9	f	349	a	374	a
4 Moncut 70DF 0.79 oz/1000 ft	IF..........	24.9	bcd	12.5	de	3.4	ef	356	a	384	a
5 Moncut 70DF 1.18 oz/1000 ft	IF..........	14.8	g	13.8	de	4.1	ef	346	a	377	a
6 6% Mancozeb 1lb	ST.........	28.4	bc	21.3	d	6.9	e	336	a	364	a
7 Maxim MZ 0.5 lb	ST.........	22.5	cdef	11.3	de	4.7	ef	351	a	384	a
8 Maxim MZ 0.75 lb	ST.........	18.3	defg	16.3	de	4.7	ef	358	a	385	a
9 Messenger 1.4 oz/1000 ft	IF..........	22.7	bcde	50.0	bc	18.4	b	345	a	368	a
10 Headsup 0.002 lb	ST.........	29.2	b	41.3	c	14.1	cd	354	a	382	a
11 Untreated	NA........	40.5	a	70.0	a	22.8	a	336	a	366	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 calculated from the day of planting to full emergence at 29 days after planting.
[x] RAUCPC (max = 100), relative area under the canopy development curve calculated from day of planting to key reference point, 50 days after planting (about 100% canopy closure).
[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 5% girdling caused by *R. solani*, average of 5 plants taken 70 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.

POTATO (*Solanum tuberosum* L.'Pike' and 'FL1879')
Fusarium dry rot; *Fusarium sambucinum*

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Timing of application of seed treatments, for control of fusarium dry rot in potatoes, 2002.

Potato seed cvs. Pike and FL1879 was prepared for planting by cutting and inoculating with *Fusarium sambucinum* (dry rot) and treating with fungicidal seed treatments 2, 5 and 10days before planting (DBP). A treatment with no inoculation was included at each of the cutting dates. Potatoes free from dry rot were selected for the trials. Cut seed was inoculated with an aggressive isolate of *F. sambucinum* which was grown on potato-dextrose agar for 14 days. Conidia were harvested from the plates and concentration, determined by hemacytometer was adjusted to 3.4 x 10^3 conidia/fl.oz.. The seed pieces (160/treatment) were sprayed with 4 fl.oz. of the pathogen suspension, for a final dosage of about 0.03 fl.oz applied per tuber. Dust formulations of seed treatments were measured and added to cut seed pieces in a Gustafson revolving drum seed treater and mixed for two minutes to ensure even spread of the fungicide. In a second trial, potato seed cv. Pike was prepared for planting by cutting and inoculating with *Fusarium sambucinum* (dry rot) and treating with fungicidal seed treatments 2DBP. 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 seed treater. Foliar applications were applied with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. Seed was planted at the Michigan State University Montcalm Potato Research Farm, Edmore, MI on 15 May into single-row by 30-ft plots (ca. 9-in. between plants to give a target population of 40 plants at 34-in. row spacing) replicated four times in a randomized complete block design. 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 (eight 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 fl. oz/A 48 DAP. For both trials, samples from each treatment (n = 25) were incubated at 50°F (95% RH) in controlled environment chambers for 14 days and the total number of healthy and dry rot affected sprouts was calculated in addition to the development of dry rot on the seed piece measured as percent decay. Three way analysis of variance was run for all combinations of treatments common to the two varieties, i.e. variety, presence of seed treatment, timing of treatment and presence of inoculum. Treatments were compared using two way ANOVA. Emergence was rated as the cumulative 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 22 days after planting. The rate of canopy development was measured as the RAUCDC, relative area under the canopy development curve, calculated from day of planting to a key reference point taken as 58 DAP (about 100% canopy closure), (max = 100). Vines were killed with Reglone 2EC (1 pt/A on 5 Sep). Plots (40-ft row) were harvested on 9 Oct and individual treatments were weighed and graded.

A three-way ANOVA showed that the effect of timing of cutting, presence of seed treatment and variety all significantly affected sprout development, percent incidence of diseased sprouts and seed-piece decay as well as stand and canopy development, however there was no effect on final marketable yield. The timing of seed cutting and application of the seed treatment Maxim MZ significantly affected the total number of developing sprouts in both varieties (Table 1). In cv. FL1879 preparing seed 5 days before planting (DBP) resulted in significantly fewer sprouts in the absence of a Maxim MZ seed treatment but was not significantly different from the corresponding non-inoculated control. Cutting and treating 2 DBP had overall less effect on sprout development in FL1879. In Pike, only the non-inoculated control prepared 2 DBP planting had significantly fewer sprouts than any of the other treatments between which was no significant difference. The effect of timing of cutting, presence of seed treatment and variety significantly affected the percentage of sprouts with symptoms of dry rot caused by *F. Sambucinum* (dark lesions with loss of sprout viability). Non-inoculated seed had no sprouts infected and Maxim MZ had significantly fewer diseased sprouts at 2 and 5DBP planting treatments than non-treated inoculated comparisons but at 10 DBP there was no significant effect of the seed treatment in FL1879. In Pike, non-inoculated seed had no sprouts infected and Maxim MZ had significantly fewer diseased sprouts at 2, 5 and 10 DBP planting treatments than non-treated inoculated comparisons. Non-inoculated seed had no seed-piece decay and Maxim MZ had significantly less seed-piece decay at 10 DBP planting treatments than non-treated inoculated comparisons but at 2 and 5 DBP there was no significant effect of the seed treatment in FL1879. In Pike, non-inoculated seed had no seed-piece decay and Maxim MZ had significantly less seed piece decay at 2, 5 and 10 DBP planting treatments than non-treated inoculated comparisons. Final plant stand was significantly lower in non-treated inoculated comparisons 10 DBP but no other treatments differed significantly in terms of plant stand in FL1879. In Pike, final plant stand was significantly lower in non-treated inoculated comparisons 5 and 10 DBP but no other treatments differed significantly in terms of plant stand. Rate of emergence

(RAUEPC) in FL1879 was significantly lower in non-treated inoculated comparisons at 10 DBP but no other treatments differed significantly in terms of RAUEPC. In Pike, RAUEPC was significantly lower in non-treated inoculated comparisons at 5 and 10 DBP but no other treatments differed significantly. Rate of canopy closure (RAUCC) in FL1879 was significantly lower in non-treated inoculated comparisons at 5 and 10 DBP but no other treatments differed significantly in terms of RAUEPC. In Pike, RAUCC was significantly lower in non-treated inoculated comparisons at 5 and 10 DBP but no other treatments differed significantly. There was no significant difference in yield between any treatments.

The total number of developing sprouts was least in the non-inoculated non-treated control and the treatment 8 and was significantly less than all other treatments. Maxim MZ (treatment 1) had the most developing sprouts but not significantly different from the non-treated inoculated control. No other treatments were significantly different form the non-treated inoculated control. The percentage of diseased sprouts was highest in the non-treated inoculated control, Evolve and Myconate (which was also non-treated). All other treatments had significantly fewer diseased sprouts in comparison to the non-treated inoculated control. Maxim MZ had significantly less seed-piece decay in comparison to the non-treated inoculated control but no other treatments were significantly different from the non-treated inoculated control. Myconate (foliar treatment) had maximum plant stand significantly more than the non-treated non-inoculated and the non-treated inoculated controls. No other treatments had significantly different plant stands from either control. The RAUEPC of the Myconate treatment was significantly greater than all treatments except 6% Mancozeb however no other treatments were significantly different for the non-treated non-inoculated and the non-treated inoculated controls. The RAUCC of the Myconate, 6% Mancozeb and Headsup treatments was significantly greater than the non-treated non-inoculated and the non-treated inoculated controls. No other treatments were significantly different in terms of canopy development from the non-treated non-inoculated and the non-treated inoculated controls. There was no significant difference in yield between any treatments.

Although no significant on yield was determined in these trials, the non-treated inoculated control often had the numerically lowest yield. The use of a seed treatment effective against *Fusarium sambucinum* appears to be justified when cutting seed in advance of planting, however, cutting five DBP appears to have an effect on sprout development. This may be explained by the recovery of apical dominance in seed cut 10 DBP, in sprouts where the effect of apical dominance was removed by cutting. The effect is less easy to explain in seed cut 2DBP, in which sprout development was apparently unaffected by cutting. This effect also appears to be variety specific as it was not observed in Pike. Maxim MZ was the most effective seed treatment, significantly more effective against *F. sambucinum* than Moncoat MZ, Headsup and Mancozeb.

Table 1. Effect of timing of seed treatment application, cutting time (days before planting) and inoculation with Fusarium sambucinum on sprout health and development and potato seed-piece viability in two potato varieties.

Treatment rate/cwt (seed treatment)	Timing of seed treatment application, cutting time (days before planting)	and inoculation (±)[z]	Variety	Total number of developing sprouts[y]	Diseased sprouts (%)[x]	Seed piece decay (%)[w]	Final plant stand (%)	Rate of emergence (RAUEPC)[v]	Rate of canopy closure (RAUCC)[u]	Marketable yield[t] (cwt/A)
1 Maxim MZ 0.5	10	yes	FL1879	2.24 bc[s]	30.3 cde	0.8 efg	100 a	7.9 a	39.0 a	342 a
2 None	10	yes	FL1879	2.6 a	39.7 bc	5.7 ab	87 cd	5.5 ef	31.0 de	324 a
3 None	10	no	FL1879	2.6 a	0.0 h	0.0 g	98 ab	7.4 ab	36.0 ab	340 a
4 Maxim MZ 0.5 lb	5	yes	FL1879	2.44 abc	10.3 ef	0.9 efg	91 abcd	6 de	36.0 ab	346 a
5 None	5	yes	FL1879	1.6 e	25.3 e	2.0 de	91 abcd	5.9 de	28.0 de	348 a
6 None	5	no	FL1879	1.92 de	0.0 h	0.0 g	95 abc	7.5 ab	38.0 a	368 a
7 Maxim MZ 0.5 lb	2	yes	FL1879	2.44 abc	6.7 def	1.0 efg	99 a	7.6 ab	33.0 bcd	345 a
8 None	2	yes	FL1879	2.48 abc	22.7 e	1.6 ef	94 abcd	6.5 bcde	32.0 cde	322 a
9 None	2	no	FL1879	2.12 cd	0.0 h	0.0 g	97 ab	7.3 abc	36.0 abc	379 a
10 Maxim MZ 0.5 lb	10	yes	Pike	2.4 abc	2.3 gh	0.5 fg	94 abcd	7 abcd	35.0 abc	332 a
11 None	10	yes	Pike	2.56 ab	63.0 a	5.8 ab	75 d	4.8 f	26.0 e	303 a
12 None	10	no	Pike	2.6 a	0.0 h	0.0 g	96 abc	7 abcd	35.0 abc	375 a
13 Maxim MZ 0.5 lb	5	yes	Pike	2.6 ab	4.0 gh	0.7 efg	94 abcd	7 abc	40.0 a	366 a
14 None	5	yes	Pike	2.68 a	32.3 cde	4.2 c	73 d	4.5 f	31.0 de	311 a
15 None	5	no	Pike	2.68 a	0.0 h	0.0 g	92 abcd	6.6 bcde	35.0 abc	358 a
16 Maxim MZ 0.5 lb	2	yes	Pike	2.64 a	2.7 ij	0.1 g	92 abcd	6 de	33.0 bcd	328 a
17 None	2	yes	Pike	2.4 abc	38.0 def	3.4 cd	88 bcd	6 de	31.0 cde	302 a
18 None	2	no	Pike	1.92 d	0.0 h	0.0 g	85 d	6.1 de	32.0 cd	350 a

[z] Potato seed cvs. Pike and FL1879 was prepared for planting by cutting and inoculating with *Fusarium sambucinum* (dry rot) and treating with fungicidal seed treatments 2, 5 and 10days prior to planting. A treatment with no inoculation was included at each of the cutting dates.

[y] Total number of developing sprouts per seed piece (n = 20) after 14 days incubation at 50°F.

[x] Percentage dry rot affected sprouts per seed piece (n = 20) after 14 days incubation at 50°F.

[w] Percentage development of dry rot on the seed piece (n = 20) after 14 days incubation at 50°F.

[v] RAUEPC, relative area under the plant emergence progress curve calculated from the day of planting to full emergence at 29 days after planting (max = 100).

[u] RAUCPC, relative area under the canopy development curve calculated from day of planting to key reference point taken as 50 days after planting (about 100% canopy closure)

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

[s] means followed by same letter are not significantly different at $P < 0.05$ (Fisher's LSD).

[r] Foliar application of Myconate 0.02 oz/A at 95% emergence on 5 Jun in 25 gal water/A at 60 psi.

Table 2. Effect of seed treatment and inoculation with *Fusarium sambucinum* on sprout health and development and potato seed-piece viability in potato variety Pike.

Treatment rate/cwt (seed treatment) rate/A (foliar)	Inoculation (±)[z]	Total number of developing sprouts[y]	Diseased sprouts (%)[x]	Seed piece decay (%)[w]	Final plant stand (%)	Rate of emergence (RAUEPC)[v]	Rate of canopy closure (RAUCC)[u]	Marketable yield[t] (cwt/A)
1 Maxim MZ 0.5 lb	yes	2.64 a	2.7 d	0.1 c	92 abcd	6 de	33.0 bcd	328 a
2 None	yes	2.4 abc	38.0 b	3.4 b	88 bcd	6 de	31.0 cde	302 a
3 None	no	1.92 d	0.0 d	0.0 c	85 d	6.1 de	32.0 cd	350 a
4 Evolve 0.5 lb/cwt	yes	2.24 bc	46.0 b	1.0 bc	91 abcd	6.3 cde	36.0 ab	372 a
5 Moncoat MZ 0.75 lb	yes	2.44 abc	12.0 c	1.8 bc	89 bcd	6.2 cde	34.0 abc	333 a
6 Myconate 0.02 oz[j]	yes	2.32 abc	61.3 a	5.6 ab	100 a	7.5 ab	38.0 ab	380 a
7 Headsup 3WDG 0.1 lb	yes	2.2 c	13.7 c	1.2 bc	92 abcd	6.4 cde	38.0 a	387 a
8 6% Mancozeb 1lb	yes	1.88 de	16.0 c	0.8 bc	95 abc	6.6 bcde	36.0 ab	379 a

[z] Potato seed cvs. Pike was prepared for planting by cutting and inoculating with *Fusarium sambucinum* (dry rot) and treating with fungicidal seed treatments 2 days prior to planting.

[y] Total number of developing sprouts per seed piece (n = 20) after 14 days incubation at 50°F.

[x] Percentage dry rot affected sprouts per seed piece (n = 20) after 14 days incubation at 50°F.

[w] Percentage development of dry rot on the seed piece (n = 20) after 14 days incubation at 50°F.

[v] RAUEPC, relative area under the plant emergence progress curve calculated from the day of planting to full emergence at 29 days after planting (max = 100).

[u] RAUCPC, relative area under the canopy development curve calculated from day of planting to key reference point taken as 50 days after planting (about 100% canopy closure)

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

[s] means followed by same letter are not significantly different at $P < 0.05$ (Fisher's LSD).

[r] Foliar application of Myconate 0.02 oz/A at 95% emergence on 5 Jun in 25 gal water/A at 60 psi.

POTATO (*Solanum tuberosum* L.'Snowden')

Pink rot; *Phytophthora erythroseptica*
Pythium leak; *Pythium ultimum*
Late blight; *Phytophthora infestans*

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Evaluation of fungicides as soil applications at planting and foliar applications for pink rot and Pythium leak control, 2002.

Soil was inoculated with mefenoxam-sensitive *Pythium ultimum* and *Phytophthora erythroseptica* at the Michigan State University Botany Farm, East Lansing, MI on 11 May 2000 and again on 17 May 2001; no further inoculum was applied in 2002. Potatoes (cut seed) were planted at the Michigan State University Botany Farm, East Lansing, MI on 17 May into four-row by 50-ft plots (34-in. row spacing) replicated three times in a randomized complete block design. The four-row beds were separated by a five-foot unplanted row. Plots were irrigated at planting and soil moisture was monitored with tensiometers. Water was applied as needed with seep-hose to maintain soil moisture at a minimum of 80% field capacity. After desiccation, plots were continuously watered to encourage tuber disease development caused by the inoculated pathogens. Plots were hilled immediately before foliar sprays began. Fungicides were applied in-furrow at planting at a rate of 5 gal/A (40 p.s.i.) applied at a rate using the conversion factor: Band rate per acre = [Band width (inches)/Row spacing (inches)] * Broadcast Rate per Acre. Thereafter fungicide treatments were applied as scheduled and late blight prevention maintenance treatments of Previcur 6SC 1.2 pt/A were applied weekly from 5 Jun to 15 Aug (10 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. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 28May) and Poast (1.5 pt/A on 17 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 17 May) and Sevin 80S (1.25 lb on 1 and 17 Jul). Plots were rated visually for percent emergence and percent canopy closure from planting to full emergence and full canopy closure respectively and a relative rate of development was calculated for both emergence and canopy formation. Prior to application of fungicides on 19 Jun, five plants were harvested from each replicate and the number of tubers greater than 0.25" (any plane) per plant was counted. Harvests were repeated on 16 Jul (Harvest 2); 14 Aug (Harvest 3) and11 Sep (Harvest 4) and tuber number and percent of tubers with symptoms of pink rot and/or Pythium leak were assessed. Symptomatic tubers were tested with Phytophthora and Pythium specific ELISA assays. Tuber number per plant and percentage of tubers per four-plant sample were compared using two-way ANOVA for comparison of treatments at individual harvest dates and two-way repeated measures ANOVA were used to compare if the metrics changed between harvests. Vines were killed with Reglone 2EC (1 pt/A on 15 Aug). Plots (50-ft row) were harvested on 11 Sep and individual treatments were weighed and graded (tubers less than 2.5 in width in any plane were discarded and only total marketable yield was reported). A further sub sample of 10 tubers per plot were challenge inoculated with each of *Pythium ultimum*, *Phytophthora erythroseptica*, *Phytophthora infestans*(all mefenoxam-sensitive isolates) or a sterile rye agar core by placing an 1/8" diameter core, taken from an axenic culture of each pathogen grown on rye agar, on the surface of the tuber at its apical end. The core was covered with a 1/4" diameter Eppindorf tube, the lid of which was cut off and dipped in petroleum jelly to adhere the tube to the tuber surface, to ensure a humid microenvironment. Tubers were cut open 28 days after inoculation and the percentage of tubers with symptoms of the diseases were calculated.

Taking 35 days after planting (DAP) as a key reference point, no fungicide applied in-furrow delayed emergence in comparison with treatments that were not applied in-furrow in terms of the RAUEPC. Canopy formation (RAUCDC) was not affected by any in-furrow application of any fungicide. The in-furrow applications of fungicides were not phytotoxic. At harvest 1, prior to applications of foliar fungicides, there were about 10.3 $\pm$ 0.91 (n = 300 plants) tubers per plant (greater than 0.25" any plane) and no significant differences between any treatments. The total number of tubers decreased in all treatments to 6.2 $\pm$ 0.71, 5.8 $\pm$ 1.00 and 4.5 $\pm$ 0.66 after harvests 1, 2 and 3, respectively (n = 300 plants, average of all treatments) , but there were no significant differences between treatments at harvests 2 to 4. At the final harvest (h4), all treatments except 10 and 17 had significantly more tubers than the untreated control. Tuber number decline was compared within treatments. There was a significant decline in tuber number in all treatments from harvest 1 to 4. There was generally no significant difference between harvest 2 and 3 for any treatment and treatments 3, 4, 6, 7, 8, 9, 11 and 19 did not significantly decline in tuber number between harvests 2 and 4.The percentage incidence of tubers with symptoms of pink rot or Pythium leak increased to harvest 3 then decreased at harvest 4 in all treatments. The untreated control had significantly more diseased tubers than all other treatments at harvests 2 and 3 but not at harvest 1 or 4. At harvest 2, treatment 5 had significantly more diseased tubers than treatments 1,7,9,10,11,12,13, 14, 15 and 18 but was not significantly different from any other treatment. At harvest 3, treatments 8 and 12 had significantly fewer diseased tubers than treatments 3 and 17 but were not significantly different from any other treatment. Percent incidence of diseased tubers was compared within treatments. A significant increase in percentage diseased tubers at harvest three occurred in treatments 1,4, 7, 9, 10, 11, 14, 15, 16, 17 and 18. The high incidence of diseased tubers at harvest 3 and subsequent decline at harvest 4 may have been a result of complete deterioration of infected tubers between the two harvests. Although a significant increase in incidence of diseased tubers was reported at harvest 3 within treatments, the overall incidence [average of the h1 - 4 within treatments, Table 2)] was numerically lower than the non-treated control for all treatments. All treatments had significantly greater marketable and total yield than the nontreated control (Table 3). Treatments 10, 17 and 18 had significantly lower marketable yield than treatments with yield greater than 212 cwt/A. Treatment 10 and 17 had significantly lower total yield than treatments with yield greater than 283 cwt/A. Some disease developed in tubers challenge inoculated with each of *Pythium ultimum*, *Phytophthora erythroseptica*, *Phytophthora infestans* but no treatments had significantly different percentage incidence of diseased tubers in comparison with the nontreated control for any of the pathogens (Table 4).

Mefonaxam-based products generally reduced the amount of tuber disease and tuber loss regardless of application timing or formulation type. Other products also reduced the amount of tuber loss and incidence of tuber disease. Tuber loss and incidence of tuber disease even in the best treatments in this trial, under highly conducive conditions for development of Pythium leak and pink rot , was still high with up to 60% tuber loss resulting in low yields. The use of mefenoxam not indeed any product for control of Pythium leak and pink rot under highly conducive conditions remains an issue and recommendations for application of any products aimed at controlling these diseases remains speculative..

Table 1.

Treatment and rate/acre		Emergence and Canopy development	
	% final[z]	RAUEPC[y]	RAUCDC[x]
1 Ridomil Gold 4EC 0.1 pt (A)[w]	91.4	0.33	0.20
2 Ridomil Gold 4EC 0.1 pt (A) Ridomil Gold Bravo 6WP 2.0 lb (D)	95.6	0.36	0.19
3 Ridomil Gold Bravo 6WP 2.0 lb (D,F)	96.4	0.36	0.20
4 Ridomil Gold Bravo 6WP 2.0 lb (F,H)	93.3	0.38	0.19
5 Ultra Flourish 2EC 0.2 pt (A)	93.3	0.35	0.20
6 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)	93.1	0.39	0.20
7 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Fluorinil 76.4WP 2.0 lb (D)	94.4	0.35	0.21
8 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Fluorinil 76.4WP 2.0 lb (D,F)	90.0	0.38	0.19
9 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Phostrol 4SC 4.0 pt (D); 6.0 pt (F)	90.0	0.35	0.20
10 Gavel 75WDG 0.48 lb (A); 2.0 lb (B,C,F,H)	93.9	0.36	0.19
11 Messenger 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	89.4	0.37	0.20
12 Ridomil Gold 4EC 0.1 pt + Messenger 3WDG 0.1 lb (A)	91.9	0.38	0.20
13 Ultra Flourish 2EC 0.2 pt (A)	94.4	0.37	0.21
14 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt + Acrobat 50WP 0.08 lb(A)	93.3	0.37	0.20
15 Acrobat 50WP 0.08 lb (A)	92.2	0.38	0.20
16 Headsup 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	93.9	0.36	0.21
17 Summerdale I + II RATE 1 (A)	91.9	0.38	0.20
18 Summerdale I + II RATE 2 (A)	92.2	0.37	0.19
19 Summerdale I + II RATE 3 (A)	91.7	0.38	0.19
20 Untreated	96.7	0.38	0.19
sem P = 0.05[w]	1.9	0.013	0.008

[z] Percent emergence calculated as percent of maximum possible emergence in 2 x 50' rows.
[y] Relative Area Under the Emergence Progress Curve from planting until 95% emergence [35 days after planting (dap)] in untreated control (max = 1).
[x] Relative Area Under the Canopy Development Curve from planting until 100% canopy cover (53 dap) in untreated control (max = 1).
[w] Application dates: A= 17 May (in-furrow at planting, Band rate per acre = [Band width (inches)/Row spacing (inches)] * Broadcast Rate per Acre) in 5 gal water/A; (foliar applications B - K), B= 5 Jun; C= 12 Jun; D= 19 Jun; E= 3 Jul; F= 17 Jul; G= 4 Aug; H= 15 Aug.
[u] Standard error of mean included if no significant difference was calculated in ANOVA.

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Table 2

Treatment and rate/acre	Tuber number per plant[z] harvest 1[z]		harvest 2		harvest 3		harvest 4		Tubers with Pythium and/or Pink Rot (%)[z] harvest 1		harvest 2		harvest 3		harvest 4		average harvest 1 to 4 (standard error)
1 Ridomil Gold 4EC 0.1 pt (A)[x]	10.5 a[w]	A[v]	6.2 a	B	5.4 a	B	4.2 ab	C	0.0 a	B	1.3 c	B	12.7 bcd	A	1.4 a	B	3.9 5.95
2 Ridomil Gold 4EC 0.1 pt (A) Ridomil Gold Bravo 6WP 2.0 lb (D)	9.5 a	A	6.0 a	B	6.3 a	B	4.2 ab	C	3.7 a	A	6.2 bc	A	9.7 cd	A	1.2 a	A	5.2 3.64
3 Ridomil Gold Bravo 6WP 2.0 lb (D,F)	9.7 a	A	6.4 a	B	5.5 a	B	4.6 ab	B	13.4 a	A	0.0 bc	A	9.3 cd	A	1.4 a	A	6.0 6.40
4 Ridomil Gold Bravo 6WP 2.0 lb (F,H)	10.3 a	A	6.5 a	B	5.3 a	BC	4.9 a	C	0.0 a	B	2.7 bc	B	14.6 bc	A	1.5 a	B	4.7 6.69
5 Ultra Flourish 2EC 0.2 pt (A)	10.9 a	A	7.0 a	B	6.8 a	BC	4.5 ab	C	0.0 a	A	7.7 b	A	8.2 cd	A	1.5 a	A	4.4 4.22
6 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)	9.9 a	A	6.3 a	B	6.4 a	B	5.1 a	B	0.0 a	A	2.5 bc	A	12.7 bcd	A	1.6 a	A	4.2 5.74
7 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Fluorinil 76.4WP 2.0 lb (D)	10.2 a	A	6.0 a	B	5.6 a	B	5.1 a	B	0.0 a	B	0.0 c	B	9.2 cd	A	2.1 a	B	2.8 4.36
8 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Fluorinil 76.4WP 2.0 lb (D,F)	10.3 a	A	5.8 a	B	5.3 a	B	5.0 a	B	3.7 a	A	1.5 bc	A	4.8 d	A	1.4 a	A	2.9 1.67
9 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Phostrol 4SC 4.0 pt (D); 6.0 pt (F)	11.4 a	A	6.0 a	B	5.3 a	B	4.7 a	B	5.6 a	AB	0.0 c	B	12.6 bcd	A	1.4 a	B	4.9 5.64
10 Gavel 75WDG 0.48 lb (A); 2.0 lb (B,C,F,H)	10.3 a	A	5.8 a	B	6.3 a	B	3.9 bc	C	6.4 a	AB	0.0 c	C	8.3 cd	A	2.3 a	BC	4.2 3.78
11 Messenger 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	10.5 a	A	6.2 a	B	6.8 a	B	4.4 ab	B	3.5 a	A	0.0 c	A	5.3 cd	A	2.1 a	A	2.7 2.25
12 Ridomil Gold 4EC 0.1 pt + Messenger 3WDG 0.1 lb (A)	9.8 a	A	7.2 a	B	6.3 a	BC	4.6 ab	C	0.0 a	C	0.0 c	C	3.9 d	A	1.9 a	B	1.5 1.88
13 Ultra Flourish 2EC 0.2 pt (A)	9.8 a	A	6.2 a	B	6.5 a	B	4.6 ab	C	0.0 a	B	0.0 c	B	5.0 d	A	1.7 a	B	1.7 2.36
14 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt + Acrobat 50WP 0.08 lb(A)	10.9 a	A	6.1 a	B	6.3 a	B	4.4 ab	C	3.1 a	A	1.5 bc	A	6.4 cd	A	1.0 a	A	3.0 2.43
15 Acrobat 50WP 0.08 lb (A)	10.0 a	A	6.4 a	B	5.3 a	C	4.8 a	C	3.2 a	B	1.2 c	B	10.7 cd	A	2.1 a	B	4.3 4.35
16 Headsup 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	11.0 a	A	6.1 a	BC	6.7 a	B	4.8 a	C	0.0 a	B	0.0 c	B	9.1 cd	A	2.1 a	B	2.8 4.30
17 Summerdale I + II RATE 1 (A)	11.0 a	A	6.4 a	B	4.8 a	BC	3.8 bc	C	0.0 a	B	2.7 bc	B	20.4 b	A	1.5 a	B	6.1 9.55
18 Summerdale I + II RATE 2 (A)	10.3 a	A	6.4 a	B	6.0 a	B	4.3 ab	C	0.0 a	B	0.0 c	B	11.3 bcd	A	1.0 a	B	3.1 5.49
19 Summerdale I + II RATE 3 (A)	10.4 a	A	5.5 a	B	5.1 a	B	4.7 a	B	0.0 a	B	3.1 bc	B	13.3 bcd	A	1.7 a	B	4.5 5.98
20 Untreated	10.1 a	A	5.5 a	B	4.3 a	BC	3.0 c	BC	6.9 a	A	15.5 a	A	30.8 a	A	3.0 a	A	14.1 12.3
sem P = 0.05[u]	0.49		0.41		0.54				2.21						0.58		

[z] Five plants were selected at random from outside rows of each treatment plot on 18 Jun (Harvest 1, 1day prior to application of foliar fungicide on 19 Jun); 16 Jul (Harvest 2); 14 Aug (Harvest 3)and11 Sep (Harvest 4), tuber number and percent of tubers with symptoms of pink rot and/or Pythium leak were assessed. Symptomatic tubers were tested with Phytophthora and Pythium specific ELISA assays.

[y] Total and marketable yield (cwt/A), tubers >2.5" width in any plane (estimated from 2 x 50ft row).

[x] Application dates: A= 17 May (in-furrow at planting, Band rate per acre = [Band width (inches)/Row spacing (inches)] * Broadcast Rate per Acre) in 5 gal water/A; (foliar applications B - K), B= 5 Jun; C= 12 Jun; D= 19 Jun; E= 3 Jul; F= 17 Jul; G= 4 Aug; H= 15 Aug.

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

[v] Values followed by the same upper case letter are not significantly different for harvest comparisons at P = 0.05 (Tukey Multiple Comparison); analyses completed after significant interactions computed in comparison s of tuber number and percent incidence of diseased tubers using a two-way repeated measures ANOVA.

[u] Standard error of mean included if no significant difference was calculated in ANOVA.

Table 3.

Treatment and rate/acre	Yield cwt/A[z] Market-able		Total	
1 Ridomil Gold 4EC 0.1 pt (A)[y]	226	ab[x]	254	ab
2 Ridomil Gold 4EC 0.1 pt (A)				
Ridomil Gold Bravo 6WP 2.0 lb (D)	212	ab	253	ab
3 Ridomil Gold Bravo 6WP 2.0 lb (D,F)	228	ab	278	ab
4 Ridomil Gold Bravo 6WP 2.0 lb (F,H)	248	a	296	a
5 Ultra Flourish 2EC 0.2 pt (A)	244	a	273	ab
6 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)	254	a	303	a
7 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)				
Fluorinil 76.4WP 2.0 lb (D)	261	a	304	a
8 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)				
Fluorinil 76.4WP 2.0 lb (D,F)	250	a	297	a
9 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)				
Phostrol 4SC 4.0 pt (D); 6.0 pt (F)	235	a	284	a
10 Gavel 75WDG 0.48 lb (A); 2.0 lb (B,C,F,H)	198	b	235	bc
11 Messenger 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	216	ab	267	ab
12 Ridomil Gold 4EC 0.1 pt + Messenger 3WDG 0.1 lb (A)	239	a	278	ab
13 Ultra Flourish 2EC 0.2 pt (A)	232	ab	279	ab
14 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt +				
Acrobat 50WP 0.08 lb(A)	220	ab	264	ab
15 Acrobat 50WP 0.08 lb (A)	239	a	288	a
16 Headsup 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	236	a	288	a
17 Summerdale I + II RATE 1 (A)	181	bc	226	bc
18 Summerdale I + II RATE 2 (A)	205	b	255	ab
19 Summerdale I + II RATE 3 (A)	224	ab	283	a
20 Untreated	146	c	183	c

[z] Total and marketable yield (cwt/A), tubers >2.5" width in any plane (estimated from 2 x 50ft row).

[y] Application dates: A= 17 May (in-furrow at planting, Band rate per acre = [Band width (inches)/Row spacing (inches)] * Broadcast Rate per Acre) in 5 gal water/A; (foliar applications B - K), B= 5 Jun; C= 12 Jun; D= 19 Jun; E= 3 Jul; F= 17 Jul; G= 4 Aug; H= 15 Aug.

[x] Values followed by the same lower case letter are not significantly different for treatment comparisons at P = 0.05 (Tukey Multiple Comparison).

Table 3.

Treatment and rate/acre	Percent tubers with disease symptoms after challenge inoculation[z]		
	Late blight *P. infestans*	Pink rot *P. erythroseptica*	Pythium leak *Pythium ultimum*
1 Ridomil Gold 4EC 0.1 pt (A)[y]	6.7	6.7	3.3
2 Ridomil Gold 4EC 0.1 pt (A) Ridomil Gold Bravo 6WP 2.0 lb (D)	6.7	10.0	3.3
3 Ridomil Gold Bravo 6WP 2.0 lb (D,F)	6.7	10.0	6.7
4 Ridomil Gold Bravo 6WP 2.0 lb (F,H)	3.3	10.0	0.0
5 Ultra Flourish 2EC 0.2 pt (A)	6.7	6.7	0.0
6 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A)	6.7	6.7	6.7
7 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Fluorinil 76.4WP 2.0 lb (D)	6.7	6.7	3.3
8 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Fluorinil 76.4WP 2.0 lb (D,F)	13.3	13.3	10.0
9 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt (A) Phostrol 4SC 4.0 pt (D); 6.0 pt (F)	3.3	10.0	3.3
10 Gavel 75WDG 0.48 lb (A); 2.0 lb (B,C,F,H)	13.3	13.3	10.0
11 Messenger 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	3.3	10.0	3.3
12 Ridomil Gold 4EC 0.1 pt + Messenger 3WDG 0.1 lb (A)	6.7	6.7	3.3
13 Ultra Flourish 2EC 0.2 pt (A)	10.0	10.0	10.0
14 Ultra Flourish 2EC 0.2 pt + Phostrol 4SC 1.44 pt + Acrobat 50WP 0.08 lb(A)	10.0	13.3	6.7
15 Acrobat 50WP 0.08 lb (A)	6.7	6.7	3.3
16 Headsup 3WDG 0.1 lb (A); 0.28 lb (D,F,H)	6.7	6.7	3.3
17 Summerdale I + II RATE 1 (A)	6.7	10.0	3.3
18 Summerdale I + II RATE 2 (A)	13.3	13.3	6.7
19 Summerdale I + II RATE 3 (A)	6.7	6.7	6.7
20 Untreated	10.0	16.7	10.0
sem P = 0.05[x]	3.66	4.02	3.28

[z] Sub samples of 10 tubers per plot were challenge inoculated with each of *Phytophthora infestans*, *Phytophthora erythroseptica* and *Pythium ultimum*(all mefenoxam-sensitive isolates) or a sterile rye agar core by placing an 1/8" diameter core, taken from an axenic culture of each pathogen grown on rye agar, on the surface of the tuber at its apical end. The core was covered with a 1/4" diameter Eppindorf tube, the lid of which was cut off and dipped in petroleum jelly to adhere the tube to the tuber surface, to ensure a humid microenvironment. Tubers were cut open 28 days after inoculation and the percentage of tubers with symptoms of the diseases were calculated.

[y] Application dates: A= 17 May (in-furrow at planting, Band rate per acre = [Band width (inches)/Row spacing (inches)] * Broadcast Rate per Acre) in 5 gal water/A; (foliar applications B - K), B= 5 Jun; C= 12 Jun; D= 19 Jun; E= 3 Jul; F= 17 Jul; G= 4 Aug; H= 15 Aug.

[x] Inclusion of the sem (P=0.05) indicated that there was no significant difference among treatments.

Funding: MPIC

Control of Volunteer Potato (*Solanum tuberosum*) in a Corn (*Zea mays*) Rotation With Postemergence Herbicide Treatments.

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Introduction

Volunteer potatoes are an increasing problem in the lower peninsula of Michigan. One of the reasons that volunteer potatoes are an increasing problem is because there is the potential for 262,000 to 1,136, 000 tubers per acre to remain in the field after harvest (R. A. Boydston, unpublished data; Lumkes 1974; Lutman 1977; Perombelon 1975). Another reason for volunteer potato survival is winter soil temperatures above freezing. Soil temperatures in mid-Michigan during the 1999-2000, 2000-2001and 2001-2002 winters have not been below 32°F for a long enough period of time to freeze potato tubers (data from Montcalm County Extension). Volunteer potatoes may harbor diseases, nematodes and insects, which may infest subsequent potato crops. This concern is heightened in areas where the crop rotation interval is only two years. When volunteer potato plants are allowed to persist in rotational crops, many of the positive effects of crop rotation are lost (Boydston 2001). Volunteer potatoes are very detrimental to the Michigan seed potato industry as well. The potential for crop mixtures and virus vectoring by latent insects poses a problem for seed certification. The need for control measures to reduce or eliminate volunteer potatoes is critical. The volunteer potato lifecycle can extend over several years. The cycle begins in the initial crop year when potato tubers are deposited back into the field at harvest by a number of different avenues. There, the tubers over-winter due to the insulation of snow cover or due to the depth at which they are buried in the soil. The volunteer potatoes then sprout the following year unprotected by insecticide or fungicide in the rotational crop. If successful, the volunteer potatoes will reproduce and daughter tubers will over-winter again, leading to another generation of unwanted volunteer potatoes in the following crop. In many areas the following crop will be potato. Any possible pathogens that were contracted during the rotational year by the volunteer potatoes are now in the midst of the new potato crop.

There are many different stages of the volunteer potato lifecycle. This suggests the possibility for various control tactics to reduce or prevent daughter tuber production. We examined one aspect of the volunteer potato lifecycle. We determined we could disrupt the daughter tuber lifecycle at emergence and growth prior to tuber set by herbicide applications. This led to the reduction or elimination of volunteer daughter tuber production during the current season of infection.

Objectives

Determine which herbicides are the most effective at controlling volunteer daughter tuber production.

To achieve this objective, eight herbicides with activity on volunteer potatoes were examined. The herbicides used in this study are listed in Table 1. Most of these herbicides were evaluated alone and in a tank mixture with atrazine. Response of volunteer potatoes to these herbicide applications were evaluated 7 and 28 days after treatment. Tuber weights and numbers were recorded in September to determine herbicide impact on daughter tuber production.

Table 1. Herbicides evaluated for control of volunteer potatoes.

	Herbicide		**Herbicide**
1	Distinct	9	Distinct + atrazine
2	Tough	10	Tough + atrazine
3	Buctril	11	Aim + atrazine
4	Roundup	12	2,4-D + atrazine
5	2,4-D	13	Callisto + atrazine
6	Starane	14	Starane + atrazine
7	Callisto	15	Aim
8	Atrazine	16	Untreated

Results

Michigan State University evaluated the effectiveness of 15 postemergence herbicide treatments for volunteer potato control in corn in 2002. There are herbicides registered to control volunteer potatoes in wheat, such as Starane. (Starane is <u>not</u> registered for use in corn in Michigan). Callisto + atrazine and Distinct + atrazine provided the greatest volunteer potato control 7 days after application. By 28 days after application Callisto, Callisto + atrazine, Distinct and Distinct + atrazine provided the best control. These treatments stopped daughter tuber production. Therefore Callisto or Distinct, with or without atrazine, will help control volunteer potatoes in corn (Table 2).

A fact sheet titled "VOLUNTEER POTATO MANAGEMENT" was published in December of 2002 and distributed to the Michigan Potato Industry. This fact sheet contains the findings from this project, as well as, general volunteer potato management strategies.

Table 2. Postemergence herbicide applications in corn for volunteer potato control. Herbicides were applied on June 6, 2002 to volunteer potatoes that were 4-6 inches in height.

HERBICIDE TREATMENT	APPLICATION RATE	POTATO DEFOLIATION AFTER 28 DAYS	DAUGHTER TUBERS PER PLANT*	DAUGHTER TUBER WEIGHT (OZ.)
CALLISTO COC + AMS	3 OZ/A 1% V/V + 17 LB/100 GAL	80	0.0	0.00
CALLISTO + ATRAZINE COC + AMS	3 OZ/A + 0.5 LB A/A 1% V/V + 8.5 LB/100 GAL	72	0.0	0.00
DISTINCT + ATRAZINE NIS + AMS	6 OZ/A + 0.5LB A/A 0.125% V/V + 17LB/100 GAL	70	1.1	0.13
DISTINCT NIS + AMS	6 OZ/A 0.125% V/V + 17LB/100 GAL	63	0.4	0.03
STARANE** ATRAZINE	1.33 PT/A 0.5 LB A/A	57	0.4	0.02
TOUGH ATRAZINE	24 FL OZ/A 0.5 LB A/A	33	1.5	0.48
STARANE**	1.33 PT/A	27	0.3	0.10
2,4-D AMINE	0.5 LB A/A	22	2.7	0.70
ROUNDUP ULTRAMAX AMS	19 FL OZ/A 17 LB/100 GAL	16	2.1	0.86
2,4-D AMINE ATRAZINE	0.5 LB A/A 0.5 LB A/A	15	2.1	0.77
AIM + NIS	0.33 OZ/A + 0.25% V/V	8	1.7	0.93
AIM ATRAZINE + NIS	0.33 OZ/A 0.5 LB A/A + 0.25% V/V	8	2	0.56
BUCTRIL	1.5 PT/A	8	2.3	0.53
ATRAZINE + COC	0.5 LB A/A + 1% V/V	7	2.4	1.07
TOUGH	24 FL OZ/A	5	2.4	0.61
UNTREATED	-	0	3.8	1.20
$LSD_{0.05}$		24	1.6	0.41

* An average number of tubers derived from three plants per replication and three replications per treatment.

** STARANE is not registered for use in corn.

OZ/A = ounces per acre

A/A = pounds of active ingredient per acre

PT/A = pint per acre

1% V/V = 1 gallon per 100 gallons of spray solution

0.25% V/V = 1 quart per 100 gallons of spray solution

0.125% V/V = 1 pint per 100 gallons of spray solution

Integrated Control of Common Scab (*Streptomyces scabies*) in Potato
I. Cultivar Resistance and Soil Moisture Treatments in Greenhouse and Field Experiments
II. Inducing Resistance in Potato to Common Scab in Field Experiment
III. Quantification of Pathogenic *S. scabies* in Greenhouse Experiment

2002 Report to MPIC

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Introduction

The incidence and severity of common scab in North America is increasing due to the use of susceptible cultivars, and conducive cultural and environmental factors, such as rotation and soil moisture. Common scab of potato is caused by several gram-positive filamentous species of *Streptomyces*, but *Streptomyces scabies* is the predominant causal agent. *S. scabies* is an aerobic, soil-borne bacterium that causes a range of symptoms on the surface of potato tubers including superficial cork-like lesions, erumpent cushion-like raised scab, or pitted lesions, which extend through the tuber periderm into the cortex and vascular storage parenchyma. This bacterium is the most important plant pathogen in the genus *Streptomyces* worldwide and common scab of potato ranks fourth in severity of potato diseases.

Although it has a relatively small yield impact, it significantly reduces marketability. The bacterium is introduced into fields on infected seed potatoes, but is persistent and survives indefinitely in soil, and can be distributed by soil water, wind and farm equipment. *S. scabies* can infect root crops such as radish, carrot, beets, turnip etc. and survives best in soils at pH 5.5 - 7.5, which is also the optimal pH for growing underground vegetable crops. Short rotations between susceptible crops increase the pathogen population and severity of the disease. Potato tubers are most susceptible to infection during early tuber development, since tubers are infected through stomata and immature lenticels yet to form a protective barrier. Mature tubers with well-developed skin are not susceptible to infection. However, infections established when the tubers are immature, expand as the tubers enlarge and lesions increase in severity over the season. *S. scabies* is favored by warm, dry soil at the time of tuber infection.

The environmental influences on cultivar susceptibility to different strains are unknown. One of the most important management strategies in controlling potato scab is maintenance of adequate soil moisture. Irrigation impacts control of plant pathogens through effects on the physical environment of the soil and the plant surface[1]. Water applied early in the season to soil was shown to reduce common scab on susceptible cultivars[4]. Maintaining adequate soil moisture near field capacity during tuber initiation and early tuber development may aid in control. The interaction between irrigation practices and cultivar resistance on scab incidence and severity of tubers, and their affects on the population dynamics of the strains of the *Streptomyces* sp. in the soil is not well understood. Additionally, quantification of the pathogen in soils has not been determined in relation to inoculum associated with infection.

Although there are no effective chemicals available for controlling common scab, there are biological agents used on other plant-pathogen systems that have been effective in providing immunity against infection by a broad range of pathogens. This phenomenon is known as systemic acquired resistance (SAR). SAR occurs when a plant is treated with a chemical, an elicitor, or an incompatible pathogen, and the plant is subsequently able to send signals to biochemical pathways that are related to plant defense. These non-specific defensive symptoms can be effective in suppressing pathogens, changing the chemistry of the cell wall and cuticle, and producing antimicrobial compounds for additional protection against a broad range of pathogens. It has been well documented in cucumbers with protection against a wide range of pathogens and as well in the Solanaceous plant family, with protection of tobacco against tobacco mosaic virus[5]. It has not yet been determined if there are any biological agents that may reduce the occurrence and severity of common scab of potato.

I. Objectives

1. Investigate the effect of varying soil moisture levels on scab incidence and severity of tubers in a controlled environment and the field.
2. Investigate the effect of cultivar resistance on scab incidence and severity of tubers in a controlled environment and the field.

II. Objectives

1. Investigate the effect of four biological agents on common scab incidence and severity.
2. Investigate the effect of two different application methods of the biological agents on common scab incidence and severity.

III. Objectives

1. Quantify the amount of pathogenic *S. scabies* in soil populations from greenhouse experiment.

Methods

I. Objectives

1. Investigate the effect of varying soil moisture levels on scab incidence and severity of tubers in a controlled environment and the field.
2. Investigate the effect of cultivar resistance on scab incidence and severity of tubers in a controlled environment and the field.

In greenhouse experiments, soil boxes compartmentalized into sections (1'x 2'x3') were filled with sand. The boxes were subjected to one of four soil moisture regimes varying from very low soil moisture to very high soil moisture in a completely randomized design. Soil was sterilized and subsequently inoculated with virulent *S. scabies* strains or treated with sterile water as a control prior to the experiment. Soil moisture probes, CS 615 Water Content Reflectometers (Campbell Scientific® Instruments), were used to measure soil moisture and the data was recorded with CR10X data loggers. The boxes were planted to three varieties, two of which have been developed by the MSU Potato Breeding and Genetics Program, differing in susceptibility to common scab were: susceptible, cv Atlantic; moderately resistant, cv MSF373-8; and most resistant, cv Liberator. Tubers were sampled after the skin had been fully developed for assessment of scab incidence and severity.

In field experiment, potatoes (cut seed, cv. Atlantic, MSF373-8, and Liberator) were planted at the Michigan State University Botany and Plant Pathology Experimental Station, East Lansing, MI on 21 May into one-row by 120 ft-plots replicated 3 times and covered in black plastic to exclude additional rainfall in a split block design. All rows were irrigated until emergence and were inoculated (17 fl oz/120-ft row) with a suspension of *Streptomyces* strains at 10^6 CFU/fl oz on 30 May and repeated on 5 June. After emergence, irrigation schedules were empirically optimized to match greenhouse experiment irrigation treatments and volumetric soil moisture was verified with CS 615 Water Content Reflectometers (Campbell Scientific® Instruments). Soil volumetric water content data was collected bi-weekly. Weeds were controlled by weeding, 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. Fungicides were applied weekly from 4 June to 7 September with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles 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). Plots were harvested on 10 September and individual treatments were evaluated based on scab incidence and severity.

II. Objectives

1. Investigate the effect of four biological agents on common scab incidence and severity.
2. Investigate the effect of two different application methods of the biological agents on common scab incidence and severity.

Potatoes (cut seed; cv. Snowden) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 7 June into two-row by 25-ft plots (34-in row spacing) replicated four times in a randomized complete block design. The two-row beds were separated by a five-foot unplanted row. All rows were irrigated until emergence and were inoculated (3.4 fl oz/25-ft row) with a suspension of *Streptomyces* strains at 10^6 CFU/fl oz on 13 August. Weeds and insects were controlled as described above at similar times. Applications of Messenger® (Eden® Bioscience), Elexa®4 (Glycogenesis, Inc.®), Myconate® (VAMTech, L.L.C. ®), and Heads Up® (Northern Quinoa Corp. ®) were applied according to specified labeled rate as in furrow and foliar treatment methods: In furrow applications of Messenger (0.42 lbs/A in 25 gal of water), Myconate (0.08 lbs/A in 25 gal of water), Elexa (11.83 pts/A in 25 gal of water) and Heads Up (0.15 lbs/A in 25 gal of water) were made over the seed at planting, applied with a single nozzle R&D spray boom delivering 5 gal/A (80 p.s.i.) and using one XR11003VS nozzle per row. Foliar applications of Messenger (1.7 lbs/A in 25 gal of water), Elexa (47.3 pts/A in 25 gal of water), Heads Up (.0.60 lbs/A in 25 gal of water) and Myconate (0.31 lbs/A in 25 gal of water) were made over the rows, applied with a single nozzle R&D spray boom delivering 25 gal/A (80 p.s.i.) and using one XR11003VS nozzle per row on 15 and 22 July. Vines were killed with Reglone 2EC (1 pt/A on 20 September). Vines were killed with Reglone 2EC (1 pt/A on 20 September). Plots (25-ft row) were harvested on 27 September and individual treatments were evaluated based on scab incidence and severity.

III. Objectives

1. Quantify the amount of pathogenic *S. scabies* in soil populations from greenhouse experiment.

Soil samples were collected from each compartmentalized greenhouse box by obtaining approximately 300 g soil from tuber zone depth of soil. Large stones and plant debris were removed from each sample and DNA was extracted directly from 1 g of soil by the method of McVeigh *et al*. Primers derived from *nec1*, a pathogenicity factor gene in *Streptomyces* spp., were developed using Primer Express® Software (Applied Biosystems®). Primer and template concentrations were empirically optimized with SYBR Green® PCR Master Mix and each sample was replicated 4 times and the trial was executed twice.

Results

In the greenhouse experiment, Atlantic at 10 percent volumetric water had average of approximately 10-25 percent of the surface area covered with scab. When the soil moisture was increased to 14 percent volumetric water content, the incidence of scab was reduced to an average cover of 8 percent. The 21 percent volumetric soil water demonstrated further reduction to less than 5 percent average scab per tuber, and the disease was eliminated at the highest soil moisture content. The average scab incidence for the intermediately susceptible cultivar, MSF373-8, at the 9 percent soil moisture had slightly more than 5 percent scab cover. The infections were less than 5 percent when the soil moisture was increased to 14 percent. When the volumetric soil moisture was increased to 21 percent and 29 percent, scab infection was absent. The least susceptible cultivar, Liberator had no scab infection at all four soil volumetric water contents.

The field trial that mimicked the greenhouse experiments had less scab infection, but similar trends. The volumetric water contents were similar to the greenhouse experiments as the four irrigation treatments were within 2 percent of the corresponding treatment (Figure 2). Atlantic, the susceptible cultivar, had an average scab incidence of approximately 14 percent at the 10 percent volumetric soil moisture. When the soil moisture is increased to 16 percent, the average scab infections on the tubers was decreased to 9 percent. With 21 percent soil moisture, the average scab incidence was further decreased to approximately 6 percent, and with the 27 percent soil moisture, scab infections were decreased on average to less than 5 percent. The intermediately susceptible cultivar, MSF373-8, had an average scab cover of only 4 percent at the 10 percent volumetric water content. Scab infections were decreased by half when the water content was increased to 16 percent volumetric soil water. At 21 and 27 percent volumetric soil moisture, the average scab incidence was less than 1 percent. Scab infections on the least susceptible cultivar, Liberator, were less than 1 percent at all soil

Figure 1. Effects of volumetric water treatments on average scab development for susceptible (Atlantic), intermediately susceptible (MSF373-8) and least susceptible (Liberator) in greenhouse experiment.

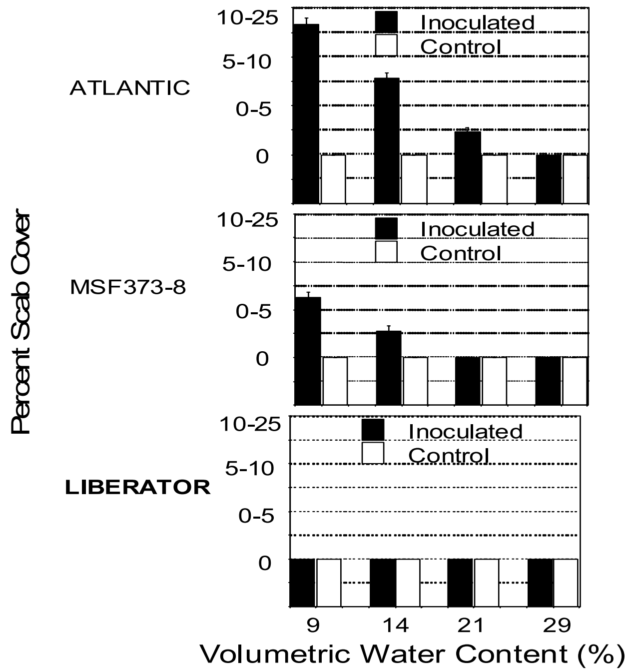


Figure 2. Effects of volumetric water treatments on average scab development for susceptible (Atlantic), intermediately susceptible (MSF373-8) and least susceptible (Liberator) in field experiment.

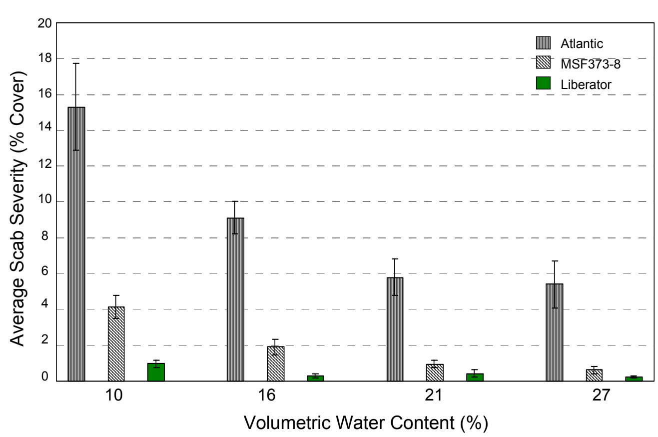
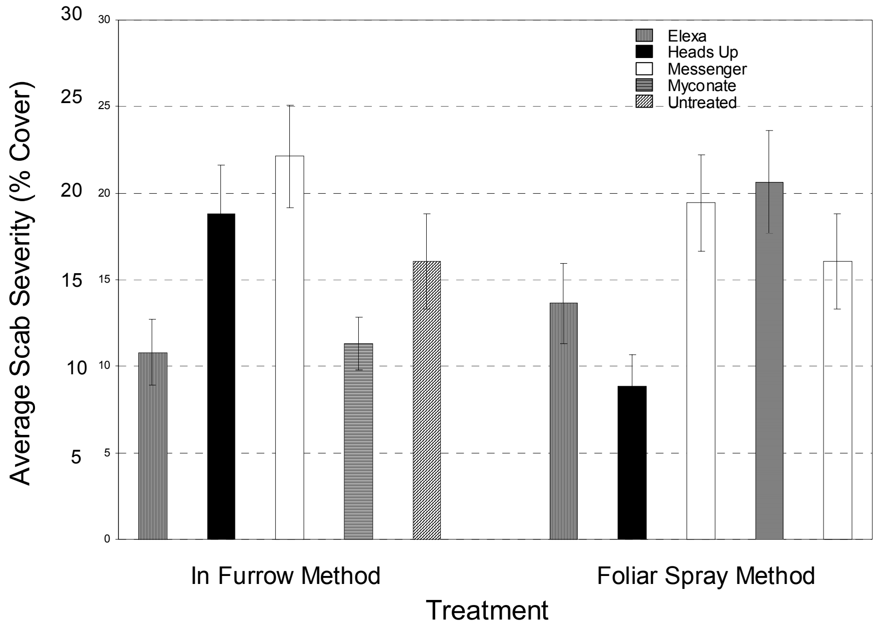


Figure 3. Effects of four plant defense compounds and two application methods on average severity of scab on susceptible cultivar Atlantic.



moisture contents. At 10 percent volumetric water content, the average scab cover was approximately 1 percent. The average scab severity was slightly decreased with the 16 percent volumetric soil water, and slightly increased with the 21 percent soil moisture treatment. When the soil moisture was further increased to 27 percent, the average scab incidence approached zero percent.

In the natural chemical field trial, the in furrow application methods for Elexa and Myconate showed a slight decrease in scab infection when compared to the control, reducing the average scab severity from approximately 17 percent (infection of the control) to 11 and 12 percent cover, respectively (Figure 3). The in furrow applications of Heads Up and Messenger did not decrease the incidence of scab, but rather increased infections to 18 and almost 23 percent scab cover, respectively. The foliar spray method of Heads Up demonstrated a decrease in infection incidence by nearly half, to approximately 8 percent. The foliar applications of Elexa, Messenger, and Myconate either did not decrease scab incidence or increased the average scab severity of tubers.

The preliminary results of quantification of pathogenic *Streptomyces scabies* from the greenhouse experiment showed that the samples clustered into two groups, where the mean quantity of DNA of the pathogen was low, $1e^{-7}$ pg/mL or was slightly higher at $1e^{-5}$ pg/mL. The soils that clustered in the low DNA group were either uninoculated treatments or were inoculated and treated with high soil moisture. The soils that were inoculated and treated with the two lower soil volumetric water contents had more DNA according to the preliminary assay.

Conclusion

The greenhouse experiment validates previous experiments and what others have shown, which is irrigation provides an effective means to control potato common scab[4]. It is evident that applying soil moisture will reduce the infection by the pathogen (Figures 1 and 2). For both the greenhouse experiment and the field experiment, increasing the percentage of soil moisture reduced the infection. Also, the criticalness of cultivar selection has been demonstrated. The use of more resistant cultivars reduced scab infections when irrigation alone could not (Figure 2). In the greenhouse, the resistant cultivar showed no signs of infection by *S. scabies* at all soil moistures. This may infer that the least susceptible cultivars may need less irrigation than the more susceptible cultivars to avoid infection. In the field experiment, the resistant cultivar had little infection, regardless of scab infection. At this time the interaction of genotype x environment has not yet been determined at what soil moisture the least susceptible cultivar would become susceptible to scab infection. More experiments must be conducted to further understand this phenomenon between the host, pathogen, and the environment. These must be continued in the controlled environment and also in the field to assure applicability to the industry.

The biological agents used in the field to induce resistance against the pathogen provided no protection. All treatments of the four natural elicitors did not prove to be efficacious and in fact, some control treatments had less scab infection than the biological treatments. Although these were not effective, there should be more tests of other products that may induce resistant to common scab. Additionally, the effects of experiments using more frequent applications and in conjunction with irrigation to suppress the pathogen may provide effective have not been demonstrated. The preliminary quantification results suggest that the pathogen seems to grow better in the drier environment, as evidenced by DNA quantification.

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2002 Nematode Research Annual Report
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Potato Early-Die Resistance/Tolerance Research.- Twenty-one potato lines/varieties were evaluated in 2002 for tolerance or resistance to potato early-die. F 349-Y (Rose Gold x WI 877) exhibited resistance characteristics in 1998, 2000 and 2001. It yielded well in 2002 under early-die conditions; however, there was more nematode reproduction than in previous years. There is a possibility that the early-die resistance could be related to the Actinomycetes associated with this line. E 228-1 exhibited characteristics of tolerance in 1998, 1999, 2000 and 2001. It was not evaluated in 2002. The parents, Russet Nugget and Spartan Pearl need to be evaluated in relation to resistance to potato early-die.

Eight additional lines/varioeties appeared to be tolerant to potato early-die in the 2002 trial (Tables 1,2,4 and 5). These include Bannock Russett and Michigan Purple in addition to lines from New York, Wisconsin and Michigan. All three of these states have similar potato early-die disease complexes Seven lines designated as potentially tolerant in previous years were not evaluated in 2002.

Nine varieties (Atlantic, Goldrush, Jacqueline Lee, Liberator, Onaway, Pike, Russett Norkotah, Snowden and Superior) and two lines (E-149-Y5 and F099-3) have been designated as susceptible to potato early-die (Table 5). Two additional lines tested in 2002 were put in the probably susceptible category and eleven additional lines not tested in 2002. Observations related to six other lines are inconclusive. An additional three lines in this category were not evaluated in 2001. Based on multiple-year performance, data for four of the varieties/lines evaluated were inconclusive. Four lines not evaluated in 2001 have previously been placed in the inconclusive category. Observations about all of the lines/varieties tested since 1998 are recorded in Table 6.

Cover Crop Research.- Various cover crops were evaluated in 2002 in relation to their suitability for control of root-lesion (*Pratylenchus penetrans*), northern root-knot (*Meloidogyne hapla*) and sugar beet cyst (*Heterodera schachtii*) nematodes. Nematode reproduction on cover crops is variety specific (Tables 7-9). Cover crop breeding programs designed to develop nematode trap crops have resulted in spectacular results for control of the sugar beet cyst nematode (Table 10).

Tillage System/Soil Quality Research.- The 10-Year-Term Potato Crop rotation trial funded by MPIC from 1991 through 2000 resulted in a new classification system for soil quality. This was presented to MPIC in 2002. Considerable interested has been generated in the system, which is the basis for much of the current MSU Nematology Research Program. It appears that much of the land at the Montcalm Potato Research Farm would be classified in Category IV (degraded soil that responds to management) and some sites as Category V (degraded soil that does not respond to management. A long-term strategy needs to be developed at this site for soil quality restoration. Without potato early-die management, many areas on the farm yield 200 cwt or less. Based on these findings, a potato, wheat/clover, corn/clover system was initiated in 2001 to enhance the soil quality over a period of six-years. Alternative tillage systems (mold board plow vs chisel plow) was used as the major variable for the research project. It is beginning to appear that the highest tuber yields are associated with the chisel plow system (Table 11). This may be reflected by changes in the soil food web induced by the tillage system. 2002 data from the MSU Nematology Program indicates that most of the microbes and associated nematodes are located in the litter layer (Figures 1 and 2). Nematode population density data are inclusive and will probably require complete nematode community structure assessment for an understanding the dynamics of the soil biology (Table 12).

Soil Quality Research.- A long-term soil quality research project was started in 2001 in cooperation with Dr. Snapp. The project uses two ranges at the Montcalm Potato Research Farm and consists of site consists of 72 plots. The 2001 objectives were to establish base-line information about the quality of the soil using a system of nematode community structure analysis. Research conducted by the MSU Nematology Program throughout Michigan, Iowa, Pennsylvania and Canada has shown this procedure to be highly sensitive in detection of soil quality differences among farming practices and locations. Because nematodes are involved in many different aspects of the below-ground food webs, their reproduction amplifies what is going on in the system and can be used for assessment of soil quality. The current hypothesis is that most Michigan soils should have a total nematode population density of between 500 and 3,000 per 1000 cm^3 soil. The population, however, must be composed of a mixture of the different types of feeding groups, including significant number of bacterial and fungal feeding nematodes. After the initial baseline analysis of the research site, the entire area was fumigated with 75 gpa of metham. This was done so the research could be initiated under uniform soil conditions.

Total nematode population densities were reduced more than 50% with the soil fumigation (Figure 3). By the end of the growing season, population densities were about twice what they were prior to soil fumigation. There was a significant decline in the population density during the winter months. The population dynamics associated with the bacterial feeding nematodes was similar to that of the total population (Figure 4). Although it took longer for the fungal feeding nematodes to rebound, the 2002 early-season population density was higher than the final 2001 fall density (Figure 5). The soil fumigation reduced to plant feeding nematodes to an almost non-detectable level (Table 6). They had, however, recovered by the end of the 2001 growing season. The omnivores (Figure 7) and the carnivores (Table 8) were most seriously impacted by soil fumigation. This was expected because of their food chain roles and overall nature of their life cycles.

The research site was also used to evaluate the research sampling protocol used at the Montcalm Potato Research Farm. Six soil cores combined into a single sample was adequate for determination of the population densities of most types of nematodes (Figures 8-9). Population densities of plant feeding nematodes; however, were under estimated using this procedure (Figure 10). The nematode population density information from dividing each 4-row by 50 foot plot into two subplots was not significantly different from dividing the research unit into four subplots.

Precision Agriculture Research.- Most of the progress on the potato precision agriculture research project was associated with the soil quality/rotation site at the Montcalm Potato Farm. It is imperative that the project be completed in the near future. Resources exist for a conference. AS indicated at the MPIC meeting last summer, ist is possible that the meeting could have a water resources component.

Table 1. 2002 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research Late Season Foliage Index.

Variety/Line		Late Season Foliage Index (0-5)		
		Non-Fumigated	Fumigated	Difference
1.	MSE202-3 Rus	3.0c	4.25cd	+1.25(0.04)
2.	Jacqueline Lee	2.5bc	3.25bc	+0.74(0.15)
3.	Goldrush	1.0a	1.5a	+0.50(0.09)
4.	**Bannock Russet**	**4.8d**	**5.0a**	**+0.20(0.20)**
5.	Russet Norkotah	1.0a	4.5cd	+3.50(0.09)
6.	**MSF349 1RY**	**4.3d**	**4.5cd**	**+0.20(0.36)**
7.	Atlantic	2.8c	3.25bc	+0.45(0.09)
8.	NY 120	2.8c	3.75bc	+0.95(0.13)
9.	MSG227-2	3.0cd	3.5bc	+0.50(0.09)
10.	ND5084-3R	3.5cd	4.75cd	+1.25(0.11)
11.	MSF099-3	3.0c	3.75bc	+0.75(0.11)
12.	Liberator	2.5bc	3.75bc	+1.25(0.10)
13.	Michigan Purple	2.8c	4.0c	+1.20(0.10)
14.	MSH094-8	3.0c	3.0b	+0.00(0.50)
15.	NY112	3.3c	4.0c	+0.70(0.11)
16.	Onaway	1.8ab	1.75a	-0.05(0.50)
17.	Snowden	2.3bc	3.25bc	+0.95(0.05)
18.	Pike	2.5bc	3.5bc	+1.00(0.13)
19.	MSH095-04	2.5bc	3.25bc	+0.75(0.03)
20.	**W1201**	**4.0d**	**4.0c**	**+0.00(n.a.)**
21.	Superior	1.0a	1.75a	+0.75(0.11)

Table 2. 2002 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research Tuber Yields.

Variety/Line	Tuber Yield		
	Non-Fumigated	Fumigated	Difference
1. MSE202-3 Rus[1,3]	22.2	28.8	+6.6(0.002)
2. Jacqueline Lee	31.6	47.9	+16.3(0.02)
3. Goldrush[1,2,3]	24.0	32.3	+7.3(0.04)
4. Bannock Russet	**32.3**	**40.9**	**+8.6(0.13)**
5. Russet Norkotah	19.0	22.6	+3.6(0.19)
6. MSF349 1RY	**38.0**	**46.9**	**+8.9(0.12)**
7. Atlantic	25.3	28.7	+3.4(0.25)
8. NY 120[2]	**29.9**	**32.1**	**+2.3(0.34)**
9. MSG227-2	16.0	17.8	+1.9(0.29)
10. ND5084-3R	31.0	41.7	+10.7(0.07)
11. MSF099-3[1,3]	21.1	27.4	+6.3(0.03)
12. Liberator[1]	22.6	32.4	+9.8(0.08)
13. Michigan Purple	32.2	42.6	+10.4(0.0.06)
14. MSH094-8[1]	18.4	21.9b	+3.5(0.07)
15. NY112	**22.0**	**21.7**	**-0.07(0.47)**
16. Onaway[1,2,3]	31.1	46.5	+15.4(0.0005)
17. Snowden[2]	24.2	27.6	+3.2(0.14)
18. Pike	15.5	19.5	+4.0(0.12)
19. MSH095-04[1,2,3]	27.1	38.0	+10.9(0.05)
20. W1201	**29.3**	**27.0**	**-2.3(0.32)**
21. Superior[1,2,3]	20.6	29.9	+9.3(0.02)

[1]Soil fumigation significantly (P = <0.05) A size tuber yield.
[2]Soil fumigation significantly (P = <0.05) Oversize tuber yield.
[3]Soil fumigation significantly (P = <0.05) total marketable tuber yield.

Table 3. 2002 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research
Scab Index.

Variety/Line	Scab Index (0-5)		
	Non-Fumigated	Fumigated	Difference
1. MSE202-3 Rus	1.00	0.75	- 0.25(0.31)
2. Jacqueline Lee	3.75	3.25	-0.50(0.10)
3. Goldrush	**0.25**	**0.00**	**-0.25(0.04)**
4. Bannock Russet	0.50	0.50	0.00(0.50)
5. Russet Norkotah	2.00	3.00	+1.00(0.07)
6. MSF349 1RY	5.00	5.00	0.00(0.50)
7. Atlantic	3.75	3.50	-0.25(0.27)
8. NY 120	2.0	2.5	+0.50(0.34)
9. MSG227-2	1.75	1.25	+0.50(0.10)
10. ND5084-3R	3.75	4.00	+0.25(0.17)
11. MSF099-3	3.00	3.25	+0.25(0.31)
12. Liberator	**2.25**	**0.75**	**-1.50(0.003)**
13. Michigan Purple	4.00	3.63	-0.37(0.08)
14. MSH094-8	1.75	1.63	-0.12(0.40)
15. NY112	2.50	2.75	+0.25(0.34)
16. Onaway	**1.75**	**3.00**	**+1.25(0.001)**
17. Snowden	3.25	3.25	0.00(0.50)
18. Pike	2.25	1.25	-1.00(0.10)
19. MSH095-04	2.50	2.25	-0.25(0.34)
20. W1201	2.00	2.00	0.00(0.50)
21. Superior	**2.00**	**0.50**	**-1.50(0.001)**

Table 4. 2002 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research Mid-Season Root-Lesion Nematode Population Densities.

Variety/Line	*Pratylenchus penetrans* per 1.0 gram of root tissue[1]		
	Non-Fumigated	Fumigated	Difference
1. MSE202-3 Rus	13.5	1.5	-12.0
2. Jacqueline Lee	27.0	0.0	-27.0
3. Goldrush	16.5	0.0	-16.5
4. Bannock Russet	20.0	0.0	-20.0
5. Russet Norkotah	28.0	0.0	-28.0
6. MSF349 1RY	19.0	0.0	-19.0
7. Atlantic	27.8	0.0	-27.8
8. NY 120	33.3	0.0	-33.3
9. MSG227-2	5.5	0.0	-5.5
10. ND5084-3R	26.0	0.0	-26.0
11. MSF099-3	23.8	0.0	-23.8
12. Liberator	18.5	0.0	-18.5
13. Michigan Purple	19.8	0.0	-19.8
14. MSH094-8	21.5	0.0	-21.5
15. NY112	16.5	0.0	-16.5
16. Onaway	31.5	0.0	-31.5
17. Snowden	19.5	0.0	-19.5
18. Pike	16.3	0.0	-16.3
19. MSH095-04	42.8	0.0	-42.8
20. W1201	22.3	0.0	-22.3
21. Superior	30.5	0.0	-30.5

[1]Soil fumigation (P = < 0.001)
Varieties/Lines (P = 0.994)
Replicates (P= <0.001)

Table 5. Summary of 2001 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research.

Probable Resistance

High yield in presence of potato early-die conditions and limited root-lesion nematode reproduction.

MSF349-1RY (98, 00, 01, 02)

Needs an additional year of data. Rose Gold x WI 877
Working with Dave Douches on the potentials of these lines since MSF349-1RY is highly susceptible to scab. It is possible that the extensive presence of the scab Actinomycetes could be related to the Potato Early-Die Disease Complex Response.

Tolerant

High yield in presence of potato early-die conditions with normal root-lesion nematode reproduction

MSE228-1 (98, 99, 00, 01)

Four years of consistent data. Russet Nugget x Spartan Pearl.
Need to work with Dave Douches in detail on the parents.

Probable Tolerance

Two additional years of PED evaluation are needed for the following six potato lines/varieties.

Bannock Russett (02)
W1201 (02)
NY 120 (01, 02)
NY 112 (01, 02)
MSG 227-2 (00 susceptible, 01 tolerant, 02 tolerant)
MSH 094-8 (01, 02)
MI Purple (00 tolerant, 01 susceptible, 02 tolerant)

Lines/varieties not evaluated in 2002

MSE 028-1 (00)
MSE 273-8 (00)
MSF 018-1 (99, 00)
MSF 060-6 (00)
MSF 373-8 (98, 00)
MSH 333-3 (01
W1431 (01)

Table 5 (continued).

Susceptible

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)
MSE 149-5Y (98, 99, 00,01)
MSF 099-3 (99, 00, 01, 02)
Goldrush (02)
Jacqueline Lee, MSG 274-3 (99, 00, 01, 02)
Liberator, MSA 091 (01, 02)
Onaway (01, 02)
Pike (02)
Russet Norkotah (02)
Snowden (97, 99, 00, 01, 02)
Superior (01, 02)

Probable Susceptibility

MSE 202-3 Rus (00, 01, 02)
MSH 095-4 (01, 02)

Not tested in 2002

MSB 076G-3 (01)
MSB 106-7 (00)
MSE 221-1 (00, 01)
MSG 015-C (01)
MSG 124-85 (00)

MSH 026-3 Rus (01)
MSP 81-11-5 (00)
W1368 (01)
W1386 (01)

Inconclusive

MSG 004-3 (00 susceptible, 01 tolerant)
MSH 031-5 (00 tolerant, 01 susceptible)

Not evaluated in 2001

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)

Table 6. Potato early-die line/variety observations.

Possible Resistance

- MSF349-1RY (98, 00, 01, 02) Lowest root-lesion nematode reproduction in trial. Extremely high scab susceptibility.

Tolerant

- MSE228-1 (98, 99, 00, 01, 02) Second lowest root-lesion nematode reproduction in trial.

Probable Tolerance

- Bannock Russett (02)
- MSB 107-1 (98 inconclusive, 99 susceptible, 00 tolerant)
- MSE 028-1 (00) Scab tolerant.
- MSE 273-8 (00) Root-knot nematode host.
- MSF 018-1 (99, 00)
- MSF 060-6 (00) Scab tolerant.
- MSF 313-3 (98 susceptible, 00 tolerant) Scab susceptible.
- MSF 373-3 (98, 00) Root knot nematode host.
- MSG 227-2 (00, susceptible, 01 tolerant, 02 tolerant)
- MSH 031-5 (00) Scab susceptible.
- MSH094-8 (01, 02)
- MSH 333-3 (01)
- MI Purple (00, susceptible, 01 tolerant, 02, tolerant) Scab susceptible
- NY 112 (01, 02)
- NY 120 (01, 02)
- W1201 (02)

Highly Susceptible

- MSE-149-5Y (98, 99, 00) Scab tolerant.

Susceptible

- Atlantic (97, 99, 00, 02) Very good root-lesion nematode host
- F099-3 (99, 00, 01, 02)
- Goldrush (02)
- Jacqueline Lee (02)
- Liberator (02)
- Onaway (01, 02)
- Pike (02)
- Russet Norkotah (02)
- Snowden (97, 99, 00, 02) Very good root-lesion nematode host
- Superior (01, 02) The standard of PED susceptibility!

Probable Susceptibility

- MSA 091-1 (01)
- MSB 076G-3 (01)
- MSB106-7 (00) Root knot nematode host. Scab tolerant.
- MSE 202-E Rus (00) Root knot nematode host. Scab tolerant.
- MSE 221-1 (00) Excellent root knot nematode host.
- MSF 099-3 (99, 00, 02) Scab susceptible.
- MSG 050-2 (99 possible resistance, 00) Good root-lesion host.

Table 6. Continued.

- MSG124-85 (00)
- MSG274-3 (99, 00) Scab susceptible.

Probable High Susceptibility

- **MS**E 048-2Y (98 possible tol., 99, 00)
- MSG 004-3 (00) Excellent root-lesion nematode host. RK host. Scab tolerant.
- MSP 81-11-5 (00) Excellent root knot nematode host. Scab susceptible.

Table 7. Influence of cover crop varieties on the reproduction of sugar beet cyst nematode (*Heterodera schachtii*).

Cover Crop (Variety)	*H. schachtii* per 100 cm^3 soil		
	Females	Cysts	Total
Alfalfa			
WC 282	0.0 a	0.0 a	0.0 a
Vernal	0.0 a	0.0 a	0.0 a
Clover			
Crimson	0.4 a	0.2 a	0.6 a
Sweet Yellow, Blossom	0.2 a	0.0 a	0.2 a
Oil Seed Radish			
Adagio	2.6 ab	3.2 a	5.8 a
Arena	1.2 ab	2.4 a	3.6 a
Colonel	1.0 ab	0.6 a	1.6 a
Rimbo	2.4 ab	6.0 a	8.4 a
Dackon Common	47.4 bc	65.4 c	112.8 bc
Generic	31.2 ab	51.6 bc	64.8 b
Cowpea			
Red Ripper	0.7 a	0.0 a	0.7 a
Cabbage			
Early Jersey Wakefield	134.8 c	27.4 ab	160.2 c
Soybean,			
Kenwood 94	0.0 a	0.0 a	0.0 a
Sugar Beet			
Beta 5977	87.8 c	173.4 d	265.2 d

Table 8. Influence of cover crop varieties on the reproduction of the northern root-knot nematode (*Meloidogyne hapla*..

Cover Crop (Variety)	*M. hapla* per 100 cm^3 soil		
	Trial A	Trial B	Mean
Alfalfa			
WC 282	28 a	20 ab	24
Vernal	6 a	95 b	51
Clover			
Crimson	10 a	0 a	5
Sweet Yellow, Blossom	421 b	1,050 c	736
Oil Seed Radish			
Adagio	158 ab	510 bc	334
Arena	143 ab	480 bc	312
Colonel	1,128 bc	2,340 c	1,734
Rimbo	50 a	160 b	105
Dackon Common	281 b	330 bc	306
Generic	407 b	445 bc	425
Cowpea			
Red Ripper	15,638 d	10,720 d	13,179
Soybean			
Kenwood 94	3,360 c	2,925 c	3,143
Tomato,			
Rutgers	1,107 bc	8,150 d	4,629

Notes on the host status of Potato and Sudax for *M. hapla*.

- In general, most varieties of potato are similar to tomato in their suitability for reproduction of *M. hapla*

- Sudax is a non-host for *M. hapla*. There should be no reproduction.

Table 9. Influence of cover crop varieties on the reproduction of the root-lesion nematode, *Pratylenchus penetrans*.

Cover Crop (Variety)	*P. penetrans*1		
	100 cm^3 soil	1.0 g root	Sum
Alfalfa			
WC 282	37 b	6 a	43 b
Vernal	81 bc	5 a	86
Clover			
Crimson	24 ab	2 a	26 ab
Yellow Blossom Sweet	9 a	5 a	14 a
Oil Seed Radish			
Adagio	55 ab	29 ab	84 bc
Colonel	136 c	81 c	217 c
Rimbo	51 ab	49 b	100 bc
Dackon Common	46 ab	90 c	36 ab
Generic	27 ab	3 a	30 ab
Cowpea			
Red Ripper	26 ab	3 a	29 ab
Cabbage			
Early Jersey Wakefield	72 bc	29 ab	101 bc

Notes on the host status of Potato and Sudax for *P. penetrans*.

- In general, most varieties of potato are fair hosts for reproduction of P. penetrans. This nematode, however, is pathogenic and also a predisposition agent for diseases complexes.

- Sudax incorporated as a green manure crop at green pod stage *provides P. penetrans* control through its chemical degradation products.

Table 10 2001-2002 Oilseed Radish Sugar Beet Cyst Nematode Research Trial.[1]

Cropping Sequence (2001)	Yield (tons/acre)	No. Beets	Wt./Beet (lbs)
Dry Beans/Oilseed Radish	5.4 a	61.0 a	1.0 a
Dry Beans	6.7 ab	72.8 ab	1.1 ab
OSR/Dry Beans	11.3 b	83.8 bc	1.2 bc
OSR/Fallow/OSR	14.96 c	125.3 d	1.3 bc
Fallow/OSR/OSR	15.01 c	99.7 cd	1.6 cd
Oilseed Radish/OSR/OSR	18.1 d	119.8 d	1.7 d

[1]Data based on six replications of two 50 ft rows spaced 30 inches apart.

Table 11. Influence of soil tillage on 2001 and 2002 potato tuber yields.

Tillage	Tuber yield (cwt)			
	A	B	J	Total
2001				
Mold board plow	106.5	20.4	0.4	196.0
Chisel plow	142.5	17.5	0.4	247.0
T-test statistics	0.307	0.233	1.000	0.333
2002				
Mold board plow	380.2	40.3	1.2	381.6
Chisel plow	451.7	35.3	0.5	487.4
T-test statistics	0.067	0.2253	0.299	0.064

Table 12. Influence of soil tillage and three agronomic crops on the population dynamics of the root-lesion nematode (*Pratylenchus penetrans*).

Tillage/Crop	Root-Lesion Nematodes					
	100 cm3 soil			1.0 g root tissue		
	7/19/01	10/15/01	5/13/02	7/19/01	10/15/01	10/3/02
Moldboard plow						
Potato	23a	344a	124bc	130 a	1,550	-----
Wheat/clover	65a	185a	8a	270 ab	------	1,975
Corn/clover	28a	99a	78b	316 b	1,820	-----
Chisel plow						
Potato	39a	351a	62b	169 a	1,730	-----
Wheat/clover	52 a	261a	6a	278 ab	------	1,841
Corn/clover	37a	284a	160c	529 b	960	-----

Figure 1. Vertical distribution of selected soil microbes.

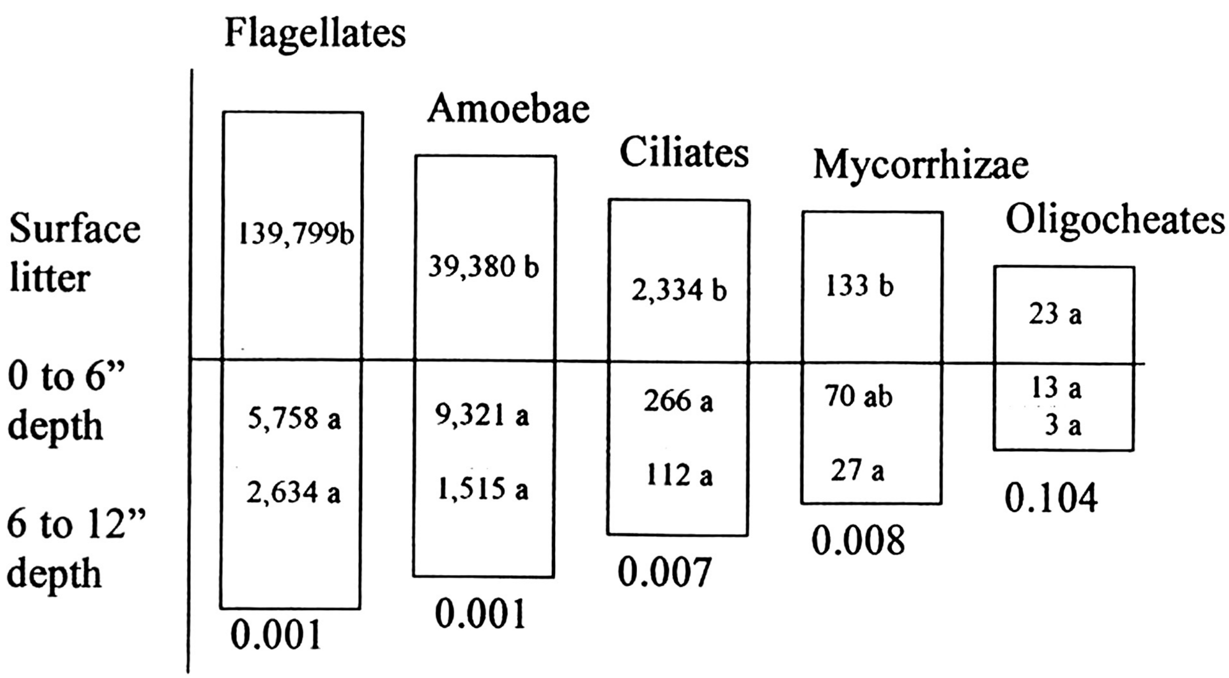
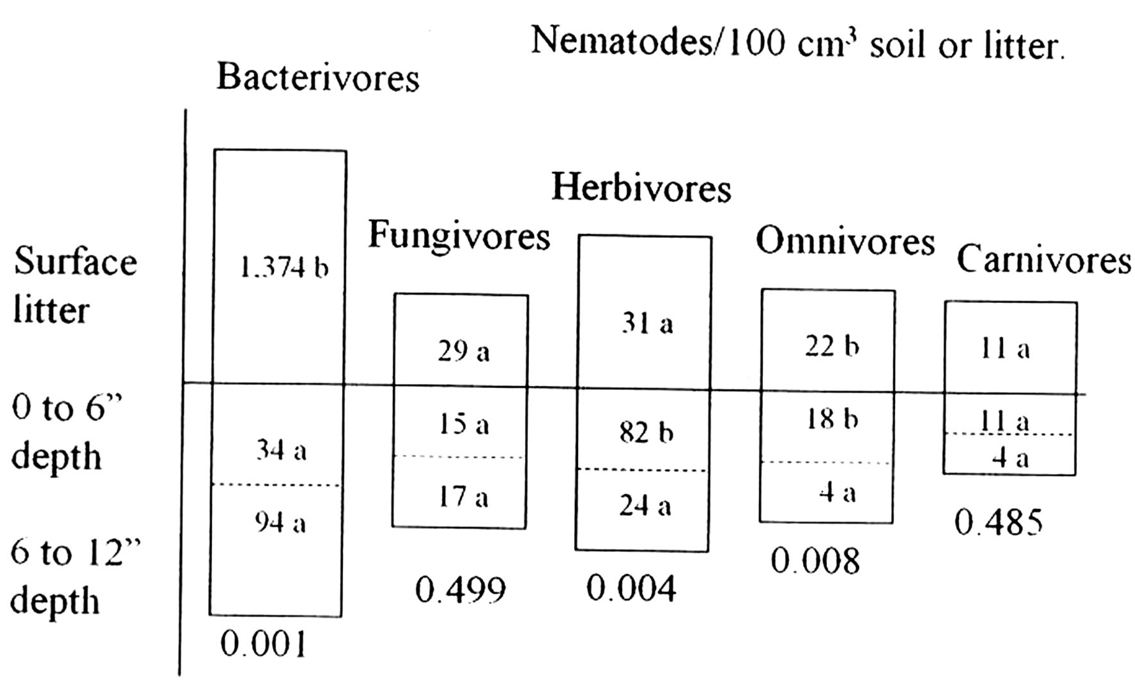
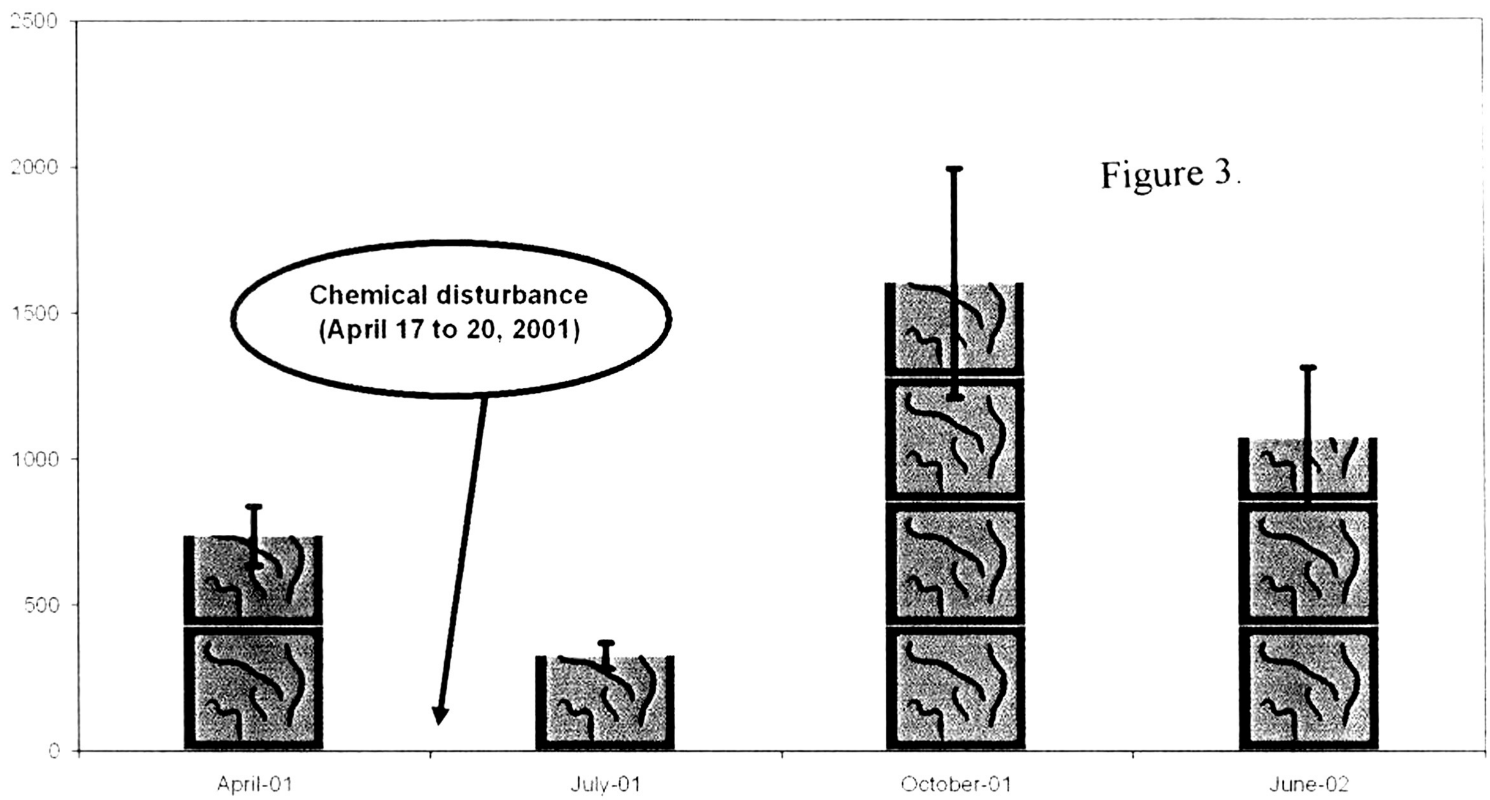


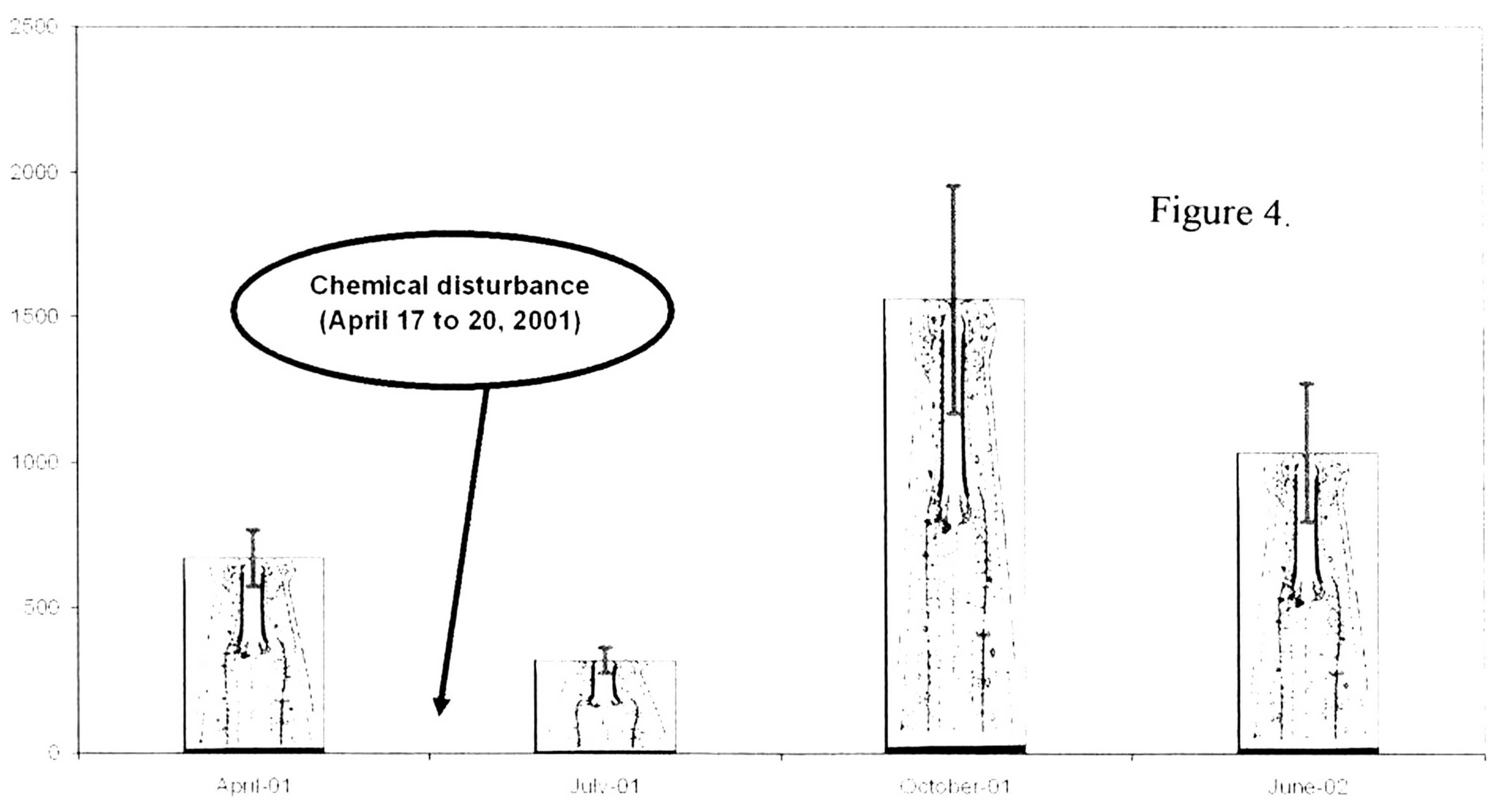
Figure 2. Vertical distribution of nematodes.



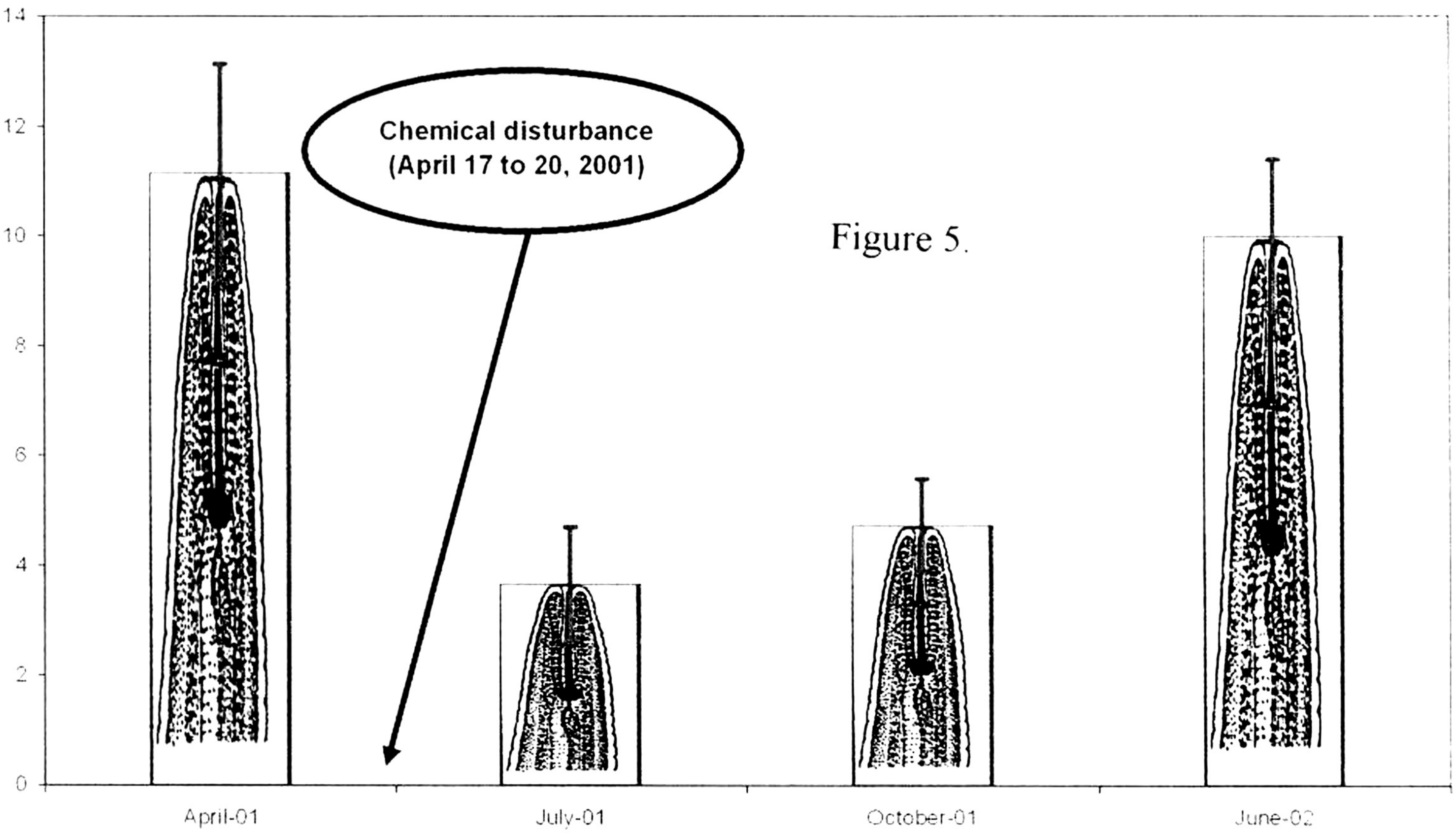
Impact of chemical disturbance on the population dynamics of the total nematode community associated with vegetable/cover crop systems.



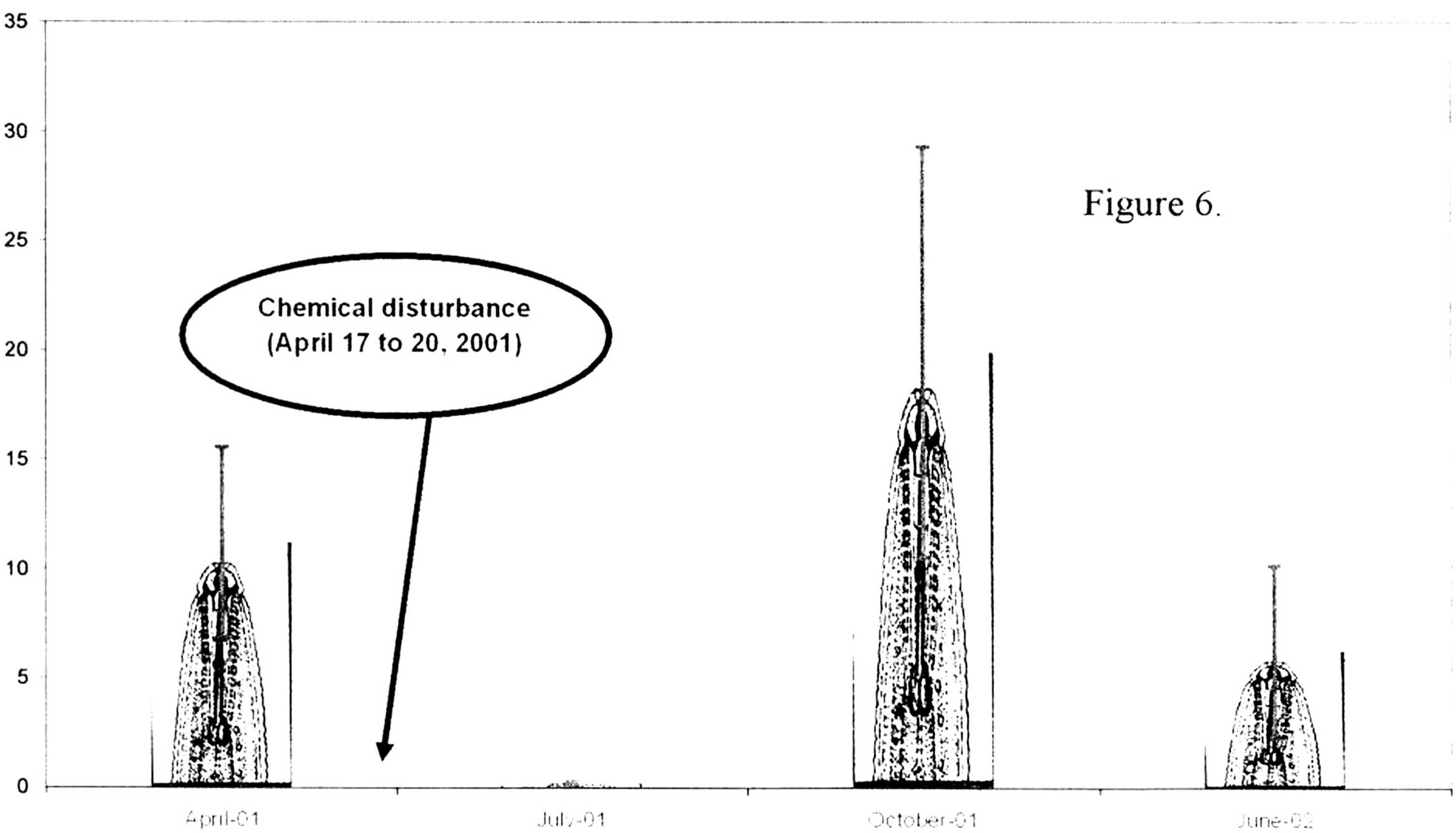
Impact of chemical disturbance on the population dynamics of bacteral feeding nematodes associated with vegetable/cover crop systems.



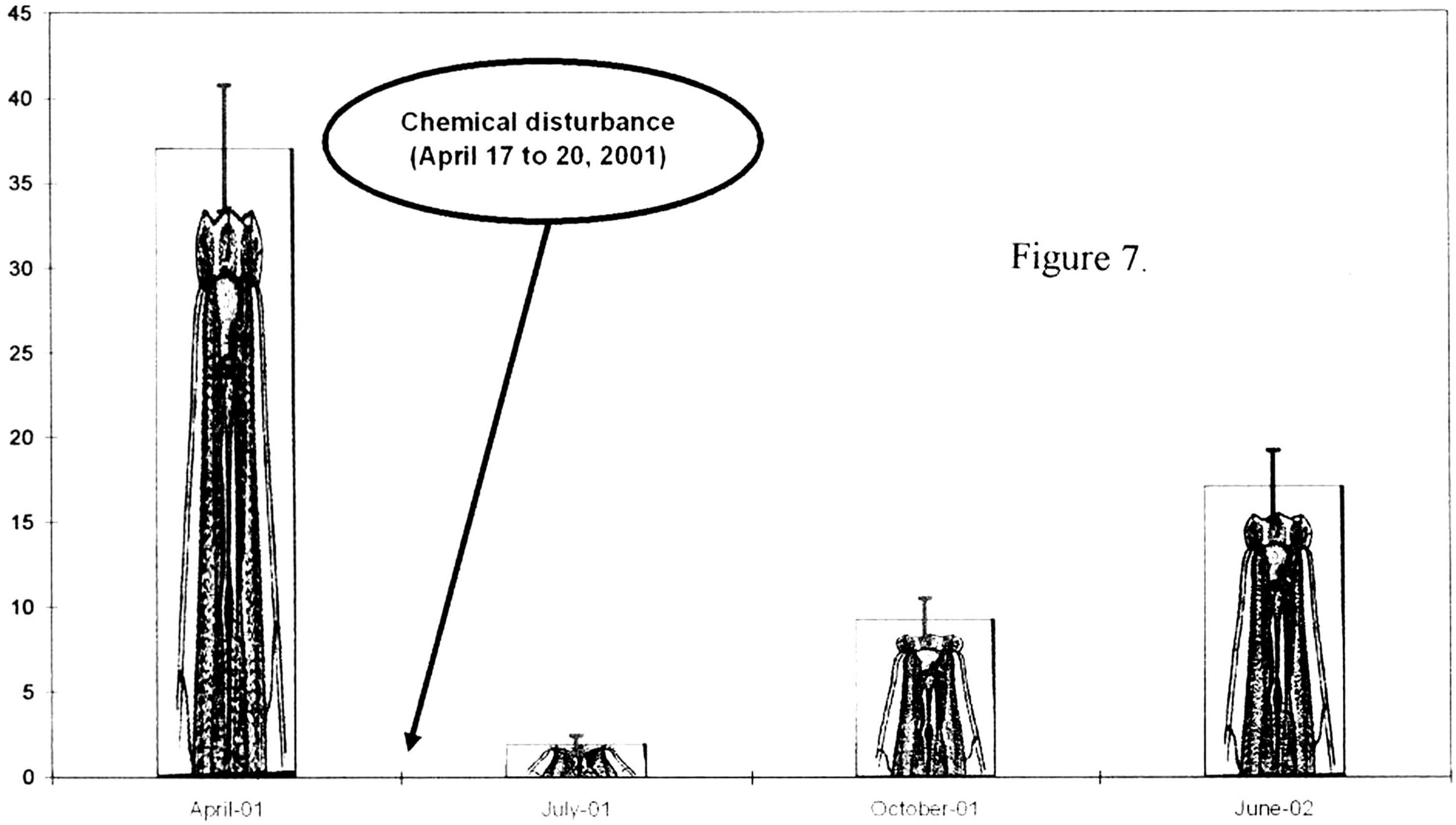
Impact of chemical disturbance on the population dynamics of fungal feeding nematodes associated with vegetable/cover crop systems.



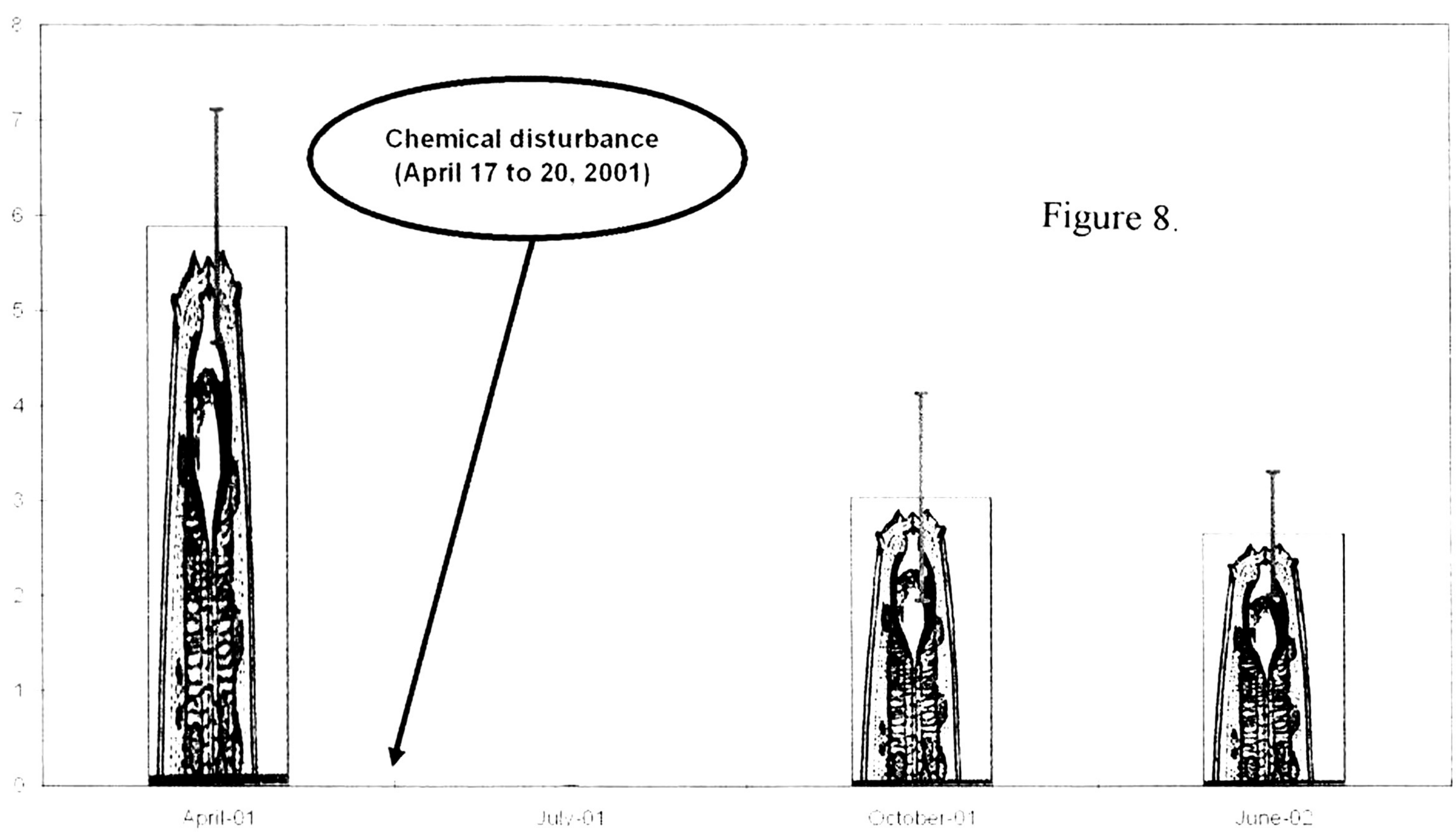
Impact of chemical disturbance on the population dynamics of plant feeding nematodes associated with vegetable/cover crop systems.



Impact of chemical disturbance on the population dynamics of dorylaimids associated with vegetable/cover crop systems.



Impact of chemical disturbance on the population dynamics of Monochoids associated with vegetable/cover crop systems.



Bacterivores: April 10, 2001

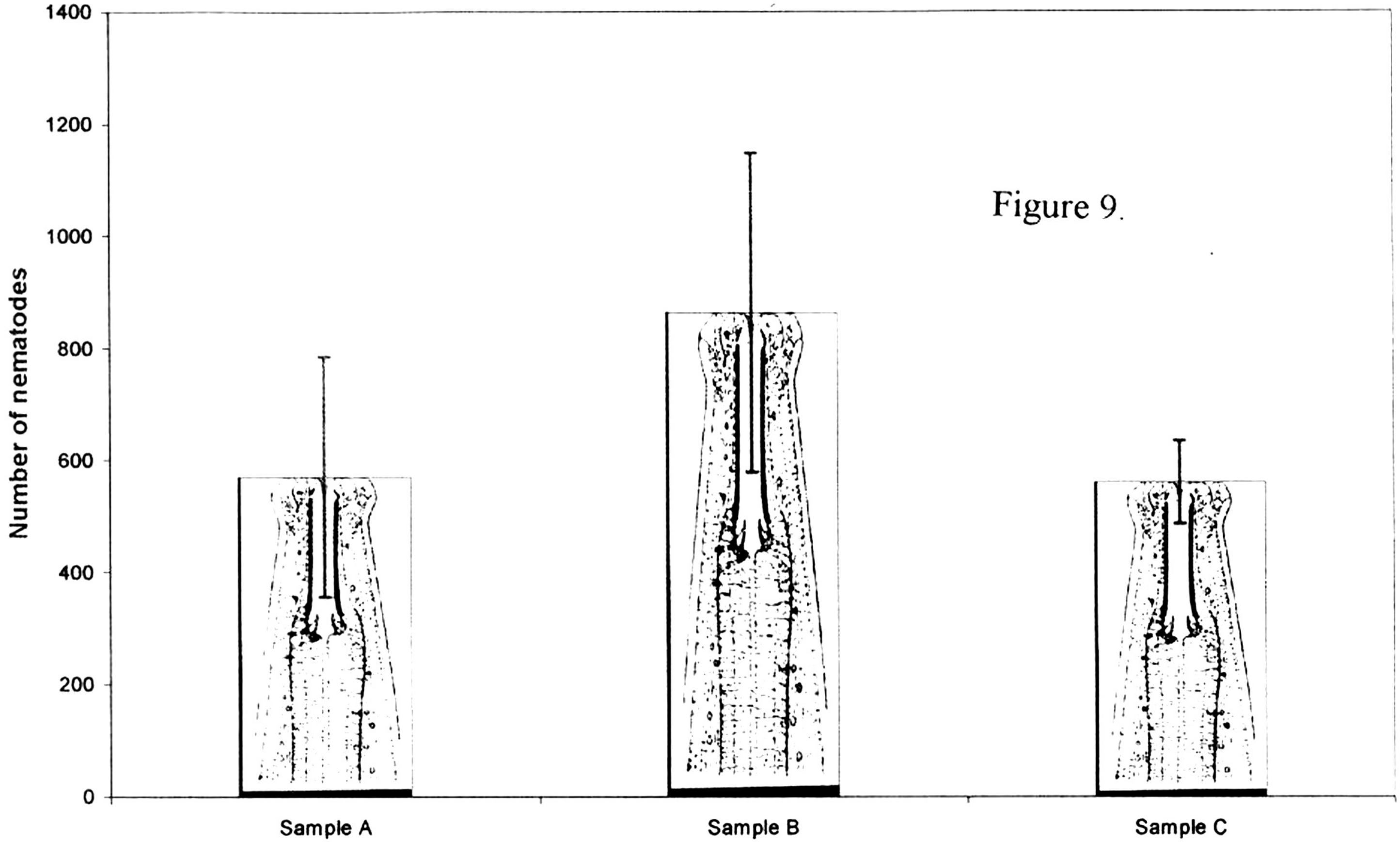


Figure 9.

Herbivores: April 10, 2001

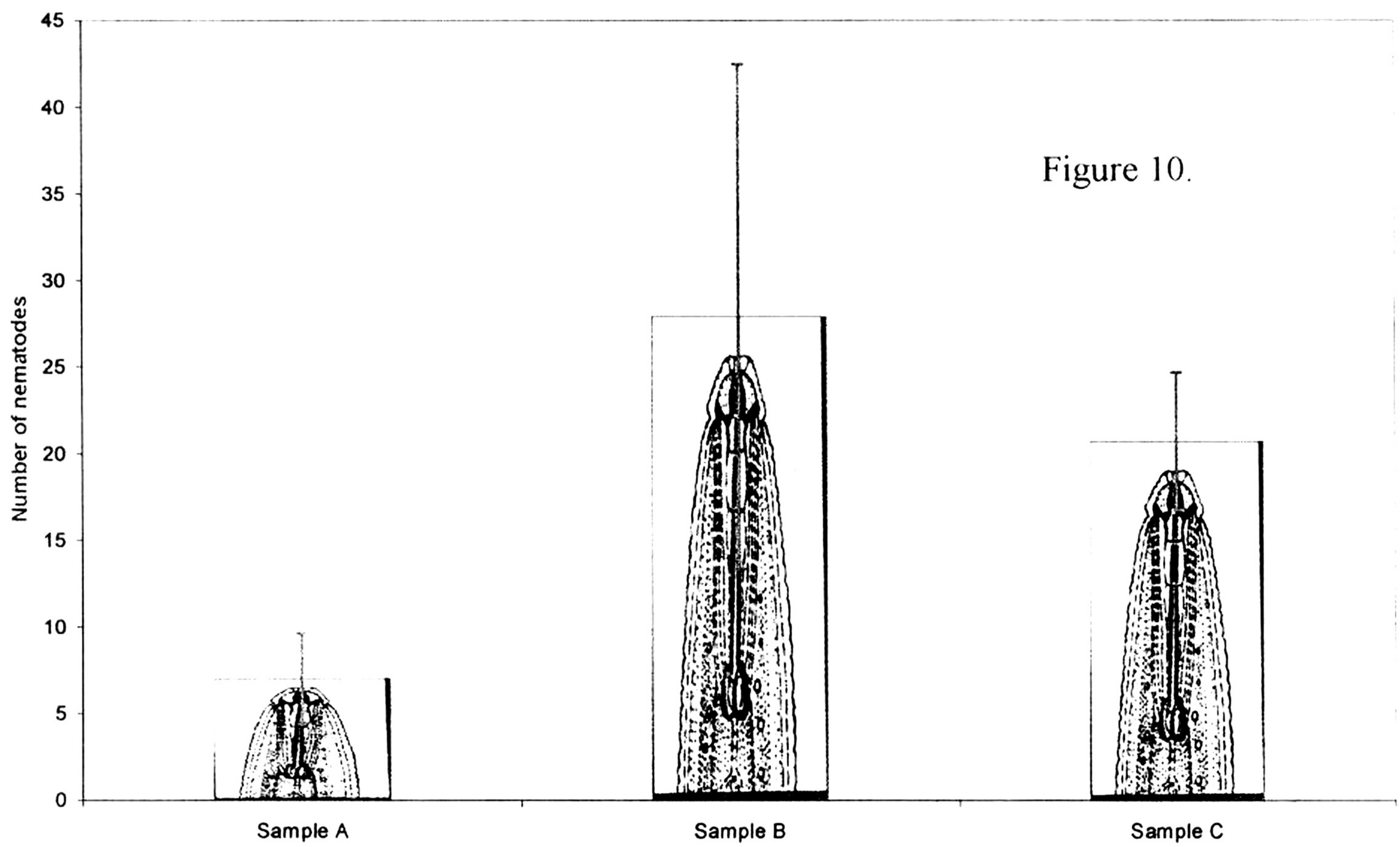


Figure 10.

Funding: USDA/MPIC

Potato Insect Biology and Management

Report to the Michigan Potato Industry Commission
January 16, 2003

Beth Bishop, Ed Grafius, Adam Byrne, Walt Pett, and Eric Bramble

Summary

Resistance to imidacloprid and thiamethoxam. For the first time, high levels of resistance to imidacloprid were found outside of Long Island NY. Colorado potato beetles from a commercial site in Delaware were over 100 fold resistant to imidacloprid and over 10 fold resistant to thiamethoxam compared to susceptible beetles and beetles from a commercial site in Pennsylvania were over 25 fold resistant to imidacloprid compared to susceptible beetles. Beetles originally collected in Montcalm Co. MI and selected for approximately 20 generations in the laboratory are over 100 fold resistant to imidacloprid compared to susceptible beetles, indicating the potential for resistance development in Michigan. Resistance to imidacloprid was highly correlated with resistance to thiamethoxam, although thiamethoxam resistance was at a much lower level, indicating that the benefits of rotating between the two for resistance management purposes will be limited.

Effectiveness of registered and experimental insecticides. A number of registered and new insecticides provided excellent control of Colorado potato beetle. Mean numbers of large larvae per plant were reduced from 5.2 to 5.7 per plant in untreated plots to 0.3 larvae per plant or less in all treatments. Yields were 50 to 74 lb/45 ft in treated plots compared to 27 to 35 lb/45 ft in untreated plots.

Duration of effectiveness of imidacloprid and thiamethoxam. Effective length of control for adult Colorado potato beetles was much longer on mineral soil than muck, as expected. Thiamethoxam, applied either to the seed or in furrow, provided somewhat longer control than imidacloprid on mineral soil. On muck soil, seed treatments provided longer control than in furrow applications for either product. A number of mid to late season problems were reported in 2002; these may relate to length of control as it is affected by rainfall and level of susceptibility of the Colorado potato beetle and the timing of movement of beetles into fields from overwintering sites or volunteers.

Controlling aphids on potatoes with Fulfill® (pymetrozine). Significant mortality was caused by Fulfill treatment even for aphids placed on plants 8 days after application. Mortality did not reach high levels until 4 days after exposure. However, feeding stopped within 1 day of exposure to Fulfill in most situations. Fulfill is a highly effective material for aphid control but the delayed mortality will need to be considered when fields are sampled for effectiveness following treatment.

Resistance to Imidacloprid and Thiamethoxam

Imidacloprid (Admire®, Provado®) has been the predominant 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®), a neonicotinoid like imidacloprid, but in a different chemical subclass, became available for commercial use. The similarities between these two compounds warrant careful scrutiny for resistance and cross-resistance development.

The objectives of this study were to continue gathering data on baseline susceptibility to imidacloprid and thiamethoxam in Colorado potato beetle populations collected from 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, 24 Colorado potato beetle populations (7 Michigan populations, 13 populations collected in other states, and 4 laboratory populations) were bioassayed with imidacloprid and/or thiamethoxam (Table 1).

Methods

During 2002, seven Colorado potato beetle populations were collected from five different Michigan counties (Houghton, Mecosta, Montcalm, Newaygo, and St. Joseph). Syngenta representatives and other cooperators also provided one population each from Delaware, Maine, Pennsylvania, and Washington, two populations from Minnesota and New York and five populations from Wisconsin. Four populations maintained in the laboratory were also tested. One was a susceptible strain collected from the Upper Peninsula of Michigan in 1999 (Hughes). The second was a resistant strain collected from Long Island, New York in 1997 and maintained without selection. The third was a highly resistant strain collected from Long Island, New York in 1999 (Jamesport), also maintained without selection. The fourth was collected in 1997 from Montcalm County, Michigan and emergent adults from each generation were selected with imidacloprid (doses adjusted to target 60-80% mortality).

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

Each population was first screened to determine relative susceptibility to imidacloprid and thiamethoxam by testing 10 beetles each with three 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, 10-15 beetles were treated with each concentration (three to five beetles per dish and two to three dishes per concentration).

The responses of the beetles were 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 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. Data were analyzed using probit analysis (SAS® System v8.01).

<u>Results</u>

The LD_{50} values for imidacloprid, 7 days post treatment, ranged from 0.016 μg/beetle (Hughes Farm) to 0.097 μg/beetle (Montcalm Farm) for Michigan populations and 0.029 μg/beetle (Hancock, WI) to 6.100 μg/beetle (Kujawski, NY) for out-of-state populations (Table 2). The values for the Michigan and out-of-state populations were consistent with those obtained for Colorado potato beetles in the same areas in previous years. The population from Little Creek, DE had an LD_{50} of 5.051 μg/beetle, which was the highest we have recorded away from Long Island, NY; it should be noted that we had not tested beetles from this area prior to this season. Laboratory population LD_{50} values for imidacloprid ranged from 0.031 μg/beetle (Hughes) to 2.809 μg/beetle (Evans). Resistance in the Little Creek DE population was 163 fold, compared to the susceptible Hughes laboratory strain (Figure 1).

LD_{50} values for thiamethoxam, 7 days post treatment, ranged from 0.018 μg/beetle (Hughes Farm) to 0.077 μg/beetle (Rodney) for Michigan populations and 0.025 μg/beetle (Hancock, WI) to 0.468 μg/beetle (Deerfield, MA) for out-of-state populations (Table 3). The values for Deerfield, MA (0.468 μg/beetle), Kujawski, NY (0.431 μg/beetle) and Little Creek, DE (0.383 μg/beetle) were all much higher than the highest value recorded in previous seasons (0.194 μg/beetle from Kujawski, NY in 2001). Confidence limits were not obtained for these populations due to low sample size or high heterogeneity within the populations. All other field populations were consistent with previous seasons. Laboratory population LD_{50} values for thiamethoxam ranged from 0.044 μg/beetle (Hughes) to 0.241 μg/beetle (Jamesport).

The relative susceptibility to imidacloprid (as measured by LD_{50}) in Colorado potato beetle populations was significantly correlated with the relative susceptibility to thiamethoxam (Figure 2). That is, if an individual beetle strain had a high LD50 to imidacloprid, the LD50 to thiamethoxam was also somewhat high. This result was also found in 1998, 1999, and 2000. Now that thiamethoxam is registered and becoming widely used, we expect to see LD50s for thiamethoxam increase more rapidly.

Table 1. Colorado potato beetle populations bioassayed for susceptibility to imidacloprid and thiamethoxam in 2002.

Michigan populations
<u>Grant</u> Adults were collected from volunteer potato plants in a commercial corn field in Newaygo Co. on 21 June 2002.
<u>Hughes Farm</u> Adults were collected from an organic potato farm near Calumet, Houghton Co. on 2 July 2002.
<u>Johnson</u> Adults were collected from a commercial potato field in St. Joseph Co. on 18 July 2002.
<u>Montcalm Farm</u> Adults were collected from the MSU Potato Research Farm in Montcalm Co. on 11 and 13 June 2002.
<u>Rodney</u> Adults were collected from a commercial potato field in Rodney, Mecosta Co. on 11 July 2002.
<u>St. Joseph</u> Adults were collected from a commercial potato field in St. Joseph Co. on 18 July 2002.
<u>Syngenta</u> Fourth instars were collected from the same commercial field in St. Joseph Co. as the St. Joseph population on 18 July 2002.
Out-of-state populations
<u>Chetek, Wisconsin</u> Adults were collected from a soy bean field, planted with potatoes in 2001, near Chetek, WI on 8 August 2002.
<u>Deerfield, Massachusetts</u> Adults were collected from Savage Farm of South Deerfield, MA on 31 July 2002.
<u>Dilworth, Minnesota</u> Adults were collected from untreated potatoes in a research plot near Dilworth, MN on 8 August 2002.
<u>Ephrata, Washington</u> Adults were from a commercial farm near Ephrata, WA on 8 August 2002.
<u>Hancock, Wisconsin</u> Adults were collected from the University of Wisconsin Hancock Research Farm on 20 August 2002.
<u>Kujawski, New York</u> Adults were collected from Kujawski Farms of Jamesport, NY on 3 June 2002.
<u>Little Creek, Delaware</u> Adults were collected from a field in Little Creek, DE on 25 June 2002.
<u>Miller, Wisconsin</u> Adults were collected from Miller Farms, WI on 20 August 2002.
<u>Penn, Pennsylvania</u> Adults were collected from a field in Sacramento, PA on 22 July 2002.
<u>Rose, New York</u> Adults were collected from a research field in North Rose, NY on 29 July 2002.
<u>Rosemount, Minnesota</u> Adults were collected from the Rosemount Research Station, Rosemount, MN on 13 June 2002.
<u>WC, Wisconsin</u> Adults were received on 15 August 2002.
<u>WI-BC, Wisconsin</u> Adults were received on 15 August 2002.
Laboratory populations
<u>Evans</u> Collected from Montcalm Co., MI in summer 1997. Adults from each generation were selected with imidacloprid doses targeting 60-80% mortality.
<u>Hughes</u> Collected from an organic potato farm near Calumet, MI in July 1999. Maintained in the laboratory without selection.
<u>Jamesport</u> Collected in the field on Long Island, NY in August 1999. Maintained in the laboratory without selection.
<u>Long Island</u> Collected in the field on Long Island, NY in summer 1997. Maintained in the laboratory without selection.

Table 2. LD_{50} values (µg/beetle, amount lethal to 50% of the population) and 95% fiducial limits for Colorado potato beetle populations treated with imidacloprid at 7 days after treatment.

Strain	7 days post-treatment	
	LD_{50}	95% fiducial limits
Michigan populations		
Grant	0.023	0.018-0.027
Hughes Farm	0.016	0.014-0.018
Montcalm Farm	0.097	0.077-0.137
Rodney	0.056	*
out-of-state populations		
Chetek, WI	0.127	0.003-0.218
Dilworth, MN	0.092	0.080-0.105
Ephrata, WA	0.034	0.024-0.041
Hancock, WI	0.029	0.022-0.036
Kujawski, NY	6.100	*
Little Creek, DE	5.051	2.874-428.670
Miller, WI	0.132	0.099-0.229
Penn, PA	0.704	0.375-0.969
Rose, NY	0.091	0.074-0.108
Rosemount, MN	0.039	0.033-0.052
WC, WI	0.096	*
laboratory populations		
Evans	2.809	2.001-5.252
Hughes	0.031	0.026-0.039
Long Island	2.196	1.388-4.460

* 95% fiducial limits not available to do either low sample size or high heterogeneity

Table 3. LD_{50} values (µg/beetle, amount lethal to 50% of the population) and 95% fiducial limits for Colorado potato beetle populations treated with thiamethoxam at 7 days after treatment.

Strain	7 days post-treatment	
	LD_{50}	95% fiducial limits
Michigan populations		
Hughes Farm	0.018	0.008-0.039
Johnson	0.048	0.035-0.059
Montcalm Farm	0.064	0.036-0.097
Rodney	0.077	0.066-0.089
St. Joseph	0.054	0.044-0.063
Syngenta	0.039	0.027-0.049
out-of-state populations		
Chetek, WI	0.054	0.046-0.064
Deerfield, MA	0.468	*
Dilworth, MN	0.060	0.049-0.079
Ephrata, WA	0.049	*
Hancock, WI	0.025	0.019-0.034
Kujawski, NY	0.431	*
Little Creek, DE	0.383	*
Miller, WI	0.053	0.004-0.087
Rose, NY	0.082	*
Rosemount, MN	0.034	0.030-0.039
WI-BC, WI	0.065	0.047-0.119
laboratory populations		
Evans	0.140	$1.64E^{-09}$-0.318
Hughes	0.044	0.038-0.050
Jamesport	0.241	0.055-0.634
Long Island	0.204	0.169-0.250

* 95% fiducial limits not available due to either low sample size or high heterogeneity

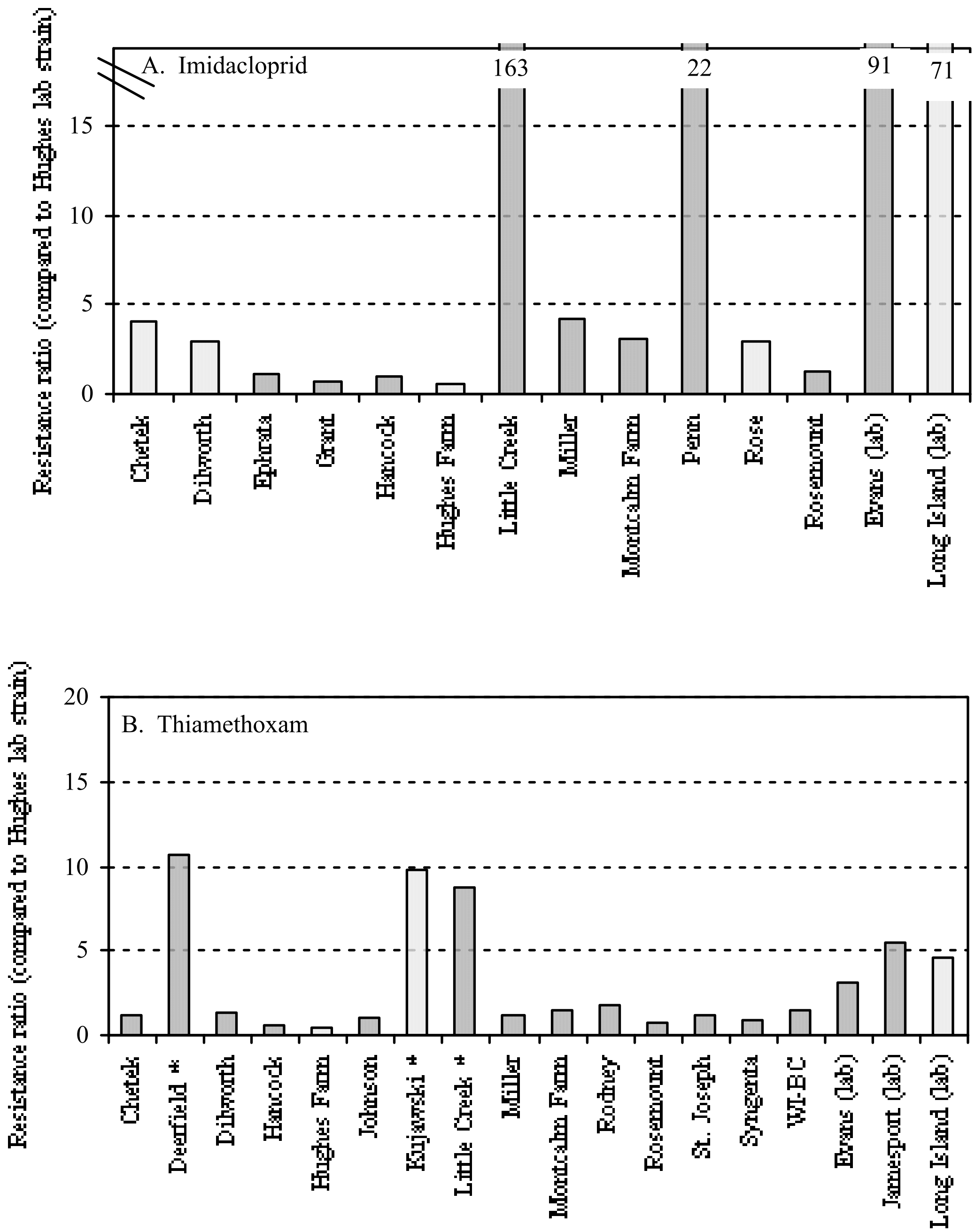


Figure 1. Resistance ratios of Colorado potato beetle strains to imidacloprid and thiamethoxam compared to the susceptible Hughes laboratory strain.
* denotes high variability

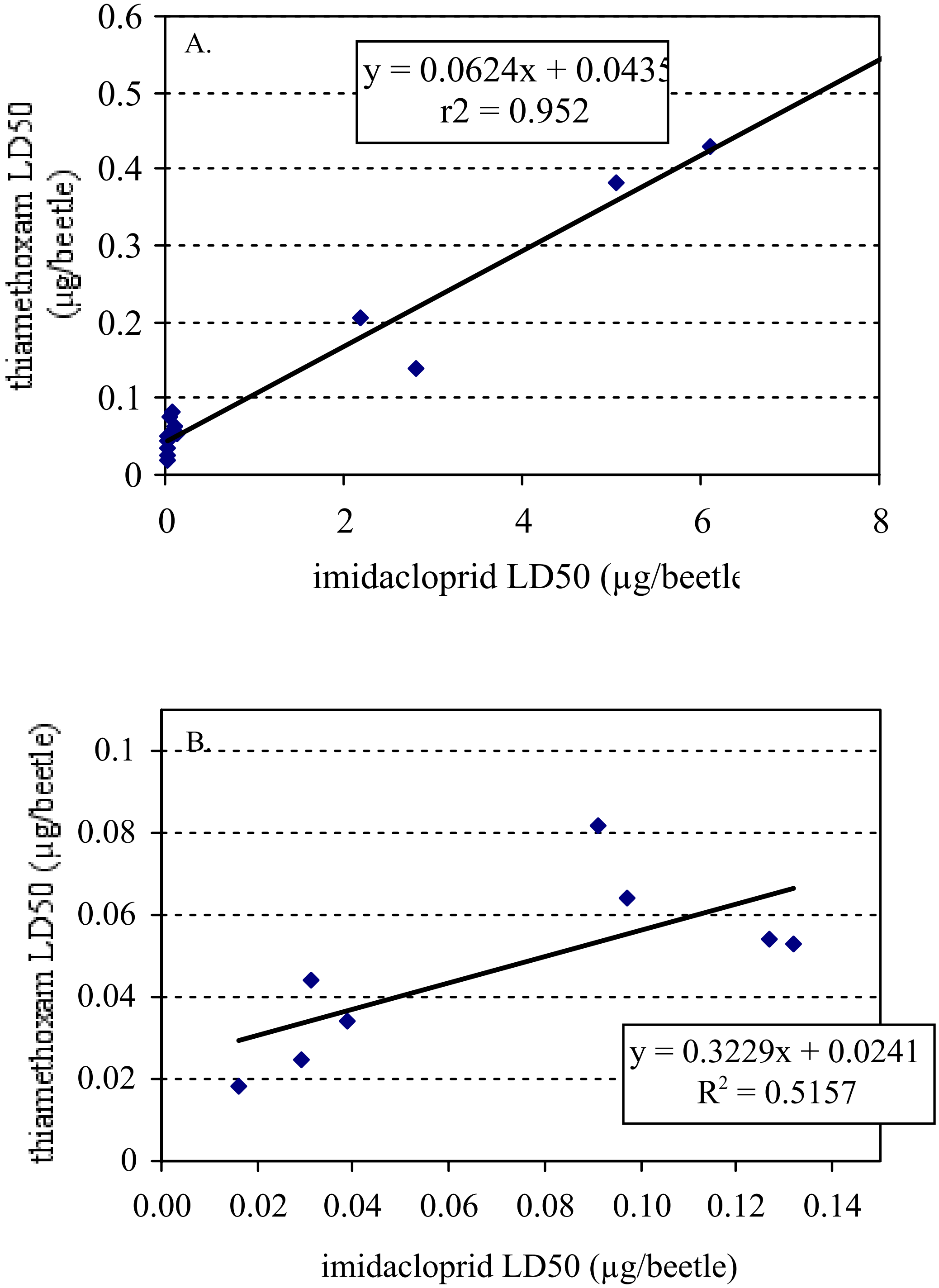


Figure 2. Correlation between susceptibility to imidacloprid and thiamethoxam. A. All populations. B. Only populations outside of Long Island with minimal variability and calculated fiducial limits (see Tables 2 and 3).

Effectiveness of Registered and Experimental Insecticides

Eighteen insecticide treatments (Table 4) were tested at the MSU Montcalm Research Farm, Entrican, MI for control of CPB. 'Snowden' potatoes were planted 12 inches apart with a 34-inch row spacing on 15 May. Treatments were replicated four times in a RCB design. Plots were 45 ft long and three rows wide. Eleven treatments were applied at planting. Admire 2F, Platinum 2SC, Platinum Ridomil Gold, and V10112 20SG(100 + 150 g ai/ acre) were applied as in-furrow sprays using a single nozzle hand held boom (30 gpa, 35 psi). Tops-MZ-Gaucho was applied as a dust to seed pieces prior to planting (in a plastic tub). Cruiser and Genesis were applied to seed pieces with 200 ml of water using a spray bottle, also prior to planting. Foliar treatments were first applied at approximately 80% CPB hatch on 18 Jun. Subsequent first-generation sprays for most treatments were applied on 25 Jun, 2 Jul, and 9 Jul (depending on treatment, Table 4).

Post-spray counts of CPB adults and larvae (small and large) on five randomly selected plants from the middle row of each plot were made 2 days after each application. Defoliation ratings were taken on 1 Jul and 17 Jul by assessing five randomly chosen plants from the middle row of each plot. A maintenance spray of Agrimek (16 oz./A) was applied to all plots on 1 Aug to control summer adult CPB. On 10 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 at the 0.05 level with Fisher's Protected LSD test.

Populations on the four sample dates averaged 5.2 to 5.7 large larvae per plant in untreated plots and 0.3 adults per plant. There were significant differences between treated and untreated plots in the seasonal means of small larvae, large larvae, and adults (Table 4). Treatments resulted in significantly fewer small and large larvae than in the untreated plots in nearly all cases. There were also significant differences between treatments in total yield and yield of size A potatoes (Table 5). Defoliation ratings were significantly lower for all treatments than for untreated plots on 1 Jul and 17 Jul.

Table 4. Seasonal mean number of Colorado potato beetle egg masses, small larvae, large larvae, and adults per plant.

		Seasonal mean number of 1st-generation CPB/plant				
Treatment/formulation	Rate	Application dates	Egg Masses	Small Larvae	Large Larvae	Adults
Actara 25WG	1.5 oz./acre	18 Jun, 9 Jul	0.5 gh	1.2a	0.1a	0.1ab
Actara 25WG	3.0 oz./acre	18 Jun	0.5 fgh	0.4a	0.1a	0.1a
Admire 2F[a]	12 fl. oz./acre	at planting	0.0ab	0.2a	0.1a	0.1a
Admire 2F[a]	15 fl. oz./acre	at planting	0.1abc	0.0a	0.0a	0.1a
Admire 2F[a]	19 fl. oz./acre	at planting	0.0ab	0.0a	0.0a	0.0a
Cruiser 5FS[c]	0.15 fl. oz./cwt.	at planting	0.0a	0.0a	0.1a	0.1a
Genesis[c] + TOPS MZ[b]	0.60 fl oz./cwt. 0.75 lbs./cwt.	at planting	0.0ab	0.0a	0.0a	0.0a
Platinum 2SC[a]	0.45 oz./1000 row ft.	at planting	0.0ab	0.0a	0.0a	0.0a
Platinum 2SC[a]	0.55 oz./1000 row ft.	at planting	0.0a	0.0a	0.0a	0.0a
Platinum Ridomil Gold[a]	34 fl. oz./acre	at planting	0.0ab	0.0a	0.0a	0.0a
Spintor 2SC	4.5 fl. oz./acre	18 Jun, 25 Jun, 2 Jul	0.4 efgh	0.7a	0.0a	0.0a
Tops-MZ-Gaucho[b]	12 oz./cwt.	at planting	0.0ab	0.0a	0.2a	0.1a
V10112 20 SG[a]	100 g ai/acre	at planting	0.0ab	0.0a	0.0a	0.1ab
V10112 20 SG[a]	150 g ai/acre	at planting	0.0ab	0.0a	0.0a	0.0a
V10112 20 SG	20 g ai/acre	18 Jun, 2 Jul, 9 Jul	0.3 def	0.5a	0.3b	0.0a
V10112 20 SG + Silwet L-77	20 g ai/acre 0.07% v/v	18 Jun, 2 Jul, 9 Jul	0.2 bcd	0.7a	0.3b	0.1a
V10112 20 SG	40 g ai/acre	18 Jun, 2 Jul	0.3 defg	1.3ab	0.2a	0.1a
V10112 20 SG + Silwet L-77	40 g ai/acre 0.07%v/v	18 Jun, 2 Jul	0.3 defg	1.0a	0.1a	0.1a
Untreated check 1			0.5 efgh	2.5 bc	5.7 b	0.3 c
Untreated check 2			0.6 h	3.5 c	5.2 b	0.3 bc

Means within a column followed by different letters are significantly different (P<0.05, Fisher's Protected LSD).
[a]treatment applied in furrow at planting
[b] treatment applied to seed pieces as dust before planting
[c]treatment sprayed onto seed pieces with a spray bottle and 200 ml water before planting

Table 5. Mean yield (weight/45 row ft) harvested and defoliation ratings taken on two sampling dates.

Treatment/formulation	Rate	Application dates	Yield (lb/45 row ft) Size A	Size B	Total	Defoliation rating[c] 1 Jul	17 Jul
Actara 25WG	1.5 oz./acre	18 Jun, 9 Jul	51.3 cd	3.1	54.4 cde	1.0a	1.0a
Actara 25WG	3.0 oz./acre	18 Jun	61.1 cdef	3.8	64.9 cdef	1.1ab	1.1a
Admire 2F[a]	12 fl. oz./acre	at planting	60.3 cdef	2.8	63.1 cdef	1.0a	1.0a
Admire 2F[a]	15 fl. oz./acre	at planting	69.4 ef	3.6	73.0 f	1.0a	1.0a
Admire 2F[a]	19 fl. oz./acre	at planting	64.6 def	3.8	68.4 def	1.0a	1.0a
Cruiser 5FS[c]	0.15 fl. oz./cwt.	at planting	64.4 def	3.3	67.7 def	1.0a	1.0a
Genesis + TOPS MZ[b]	0.60 fl oz./cwt. 0.75 lbs./cwt.	at planting	67.3 def	4.5	71.8 ef	1.1ab	1.0a
Platinum 2SC[a]	0.45 oz./1000 row ft.	at planting	57.3 cdef	4.1	61.4 cdef	1.0a	1.0a
Platinum 2SC[a]	0.55 oz./1000 row ft.	at planting	70.4 f	3.5	73.9 f	1.0a	1.0a
Platinum Ridomil Gold[a]	34 fl. oz./acre	at planting	58.8 cdef	4.3	63.1 cdef	1.0a	1.0a
Spintor 2SC	4.5 fl. oz./acre	18 Jun, 25 Jun, 2 Jul	46.0 bc	3.5	49.5 bc	1.0a	1.2a
Tops-MZ-Gaucho[b]	12 oz./cwt.	at planting	70.0 ef	3.4	73.4 f	1.0a	1.0a
V10112 20 SG[a]	100 g ai/acre	at planting	52.9 cde	3.6	56.5 cdef	1.0a	1.0a
V10112 20 SG[a]	150 g ai/acre	at planting	66.0 def	3.9	69.9 def	1.0a	1.0a
V10112 20 SG	20 g ai/acre	18 Jun, 2 Jul, 9 Jul	54.1 cdef	3.3	57.4 cdef	1.3 b	1.1a
V10112 20 SG + Silwet L-77	20 g ai/acre 0.07 % v/v	18 Jun, 2 Jul, 9 Jul	59.1 cdef	4.4	63.5 cdef	1.6 c	1.0a
V10112 20 SG	40 g ai/acre	18 Jun, 2 Jul	49.9 cd	3.8	53.7 cd	1.1ab	1.0a
V10112 20 SG + Silwet L-77	40 g ai/acre 0.07% v/v	18 Jun, 2 Jul	58.5 cdef	3.1	61.6 cdef	1.2ab	1.2a
Untreated check 1			31.9ab	2.9	34.8ab	2.2 d	2.4 b
Untreated check 2			23.9a	2.8	26.7a	2.4 d	3.1 b

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

[a] treatment applied in-furrow at planting

[b] treatment applied to seed pieces as dust before planting

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

Duration of Effectiveness of Imidacloprid and Thiamethoxam

Imidacloprid and thiamethoxam are mainly used at planting, either as in-furrow applications or seed treatments prior to planting. As for any soil insecticide, effectiveness declines as time goes by. The length of control will depend on initial application rate, the susceptibility of the pest, and environmental factors such as soil type and rainfall or irrigation. Our objectives were to see if the chemical used, the type of application, and the soil type interact to affect length of control.

Methods

Potatoes were planted at the Montcalm Potato Research Farm, on 15 May, as a part of the insecticide trial described above. A second planting was made at the Michigan State University Muck Crops Research Farm, Bath Michigan, on 21 May. Soil was McBride Sandy Loam at the Montcalm Farm and Houghton Muck (77% organic matter) at the Muck Crops Research Farm. Potatoes were planted and grown following standard commercial practices of fertilization, hilling, irrigation, and herbicide treatment.

Treatment	Active ingredient	Application method	Rate
Admire 2F	imidacloprid	in furrow	15 fl oz/A
Gaucho	imidacloprid	seed treatment	12 oz/cwt
Genesis	imidacloprid	seed treatment	0.6 fl oz/cwt
Platinum 2SC	thiamethoxam	in furrow	0.55 fl oz/1000 row ft
Cruiser 5FS	thiamethoxam	seed treatment	0.15 fl oz/cwt

Application rates used were the maximum recommended commercial rates of imidacloprid or thiamethoxam, either applied in furrow at planting or as seed treatments, as described in the insecticide evaluation section above. Foliage was picked from treated plants in the field, placed in a cooler with ice and kept refrigerated until used on the next day. Foliage was also collected from untreated plants to correct for beetle mortality not due to insecticide. At the Montcalm Farm, foliage was collected to start the assays on12 and 26 June and 10 and 17 July (28, 42, 56, and 63 days after planting). At the Muck Farm, foliage was collected to start the assays on 19 June and 3 July (29 and 43 days after planting). Leaves with petioles in vials of distilled water were placed in petri dishes (5 dishes per treatment) and five CPB were added to each dish. Foliage was collected again from the field and replaced in the petri dishes after 2 days. Mortality was assessed after 4 days. Beetles were judged as dead or poisoned if they were unable to walk forward one body length.

Results

At the Montcalm Farm, initial mortality at 28 days after planting (12 June) was 70 to 100% (Figure 3). Mortality declined rapidly in all but the Platinum treatment (thiamethoxam, in furrow). By 63 days after planting (17 July), mortality was less than 50% for all treatments.

At the Muck Farm, with highly organic soil, control was less than 30% in the in furrow treatments even on the first sample date, 29 days after planting (19 June). Mortality in all treatments was at or near zero by 43 days after planting (3 July). This short residual activity is common for soil insecticides in muck soil; the organic material in the soil often binds with the insecticide, reducing effectiveness. In the muck soil, the seed treatments of both imidacloprid and thiamethoxam gave much better control than in furrow applications, likely due to less opportunity for soil binding.

The interactions between application method and soil type indicate the complicated nature of soil/insecticide interactions. Usually, under commercial situations, any of the treatments studied would give effective control of overwintered adults, which generally arrive shortly after plant emergence. Small larvae are much more sensitive than adults, so larval control would be longer than the length of adult control observed in this study. Thus, control through the first generation would be expected. If there was little or no immigration of beetles into the field later in the season, no further insecticide treatment for Colorado potato beetle would be necessary.

In 2002, there were a number of reports of mid to late season problems in Michigan and throughout the US. These may have been situations where adults arrived late into the field because of late emergence from overwintering or previous feeding on volunteer potatoes. Length of adult control would also be reduced if low levels of insecticide resistance were present in late-emerging adults. In addition, heavy rainfall shortly after planting could result in leaching of the chemical below the root zone and reduced length of control. In 2003 we hope to continue research into these interactions.

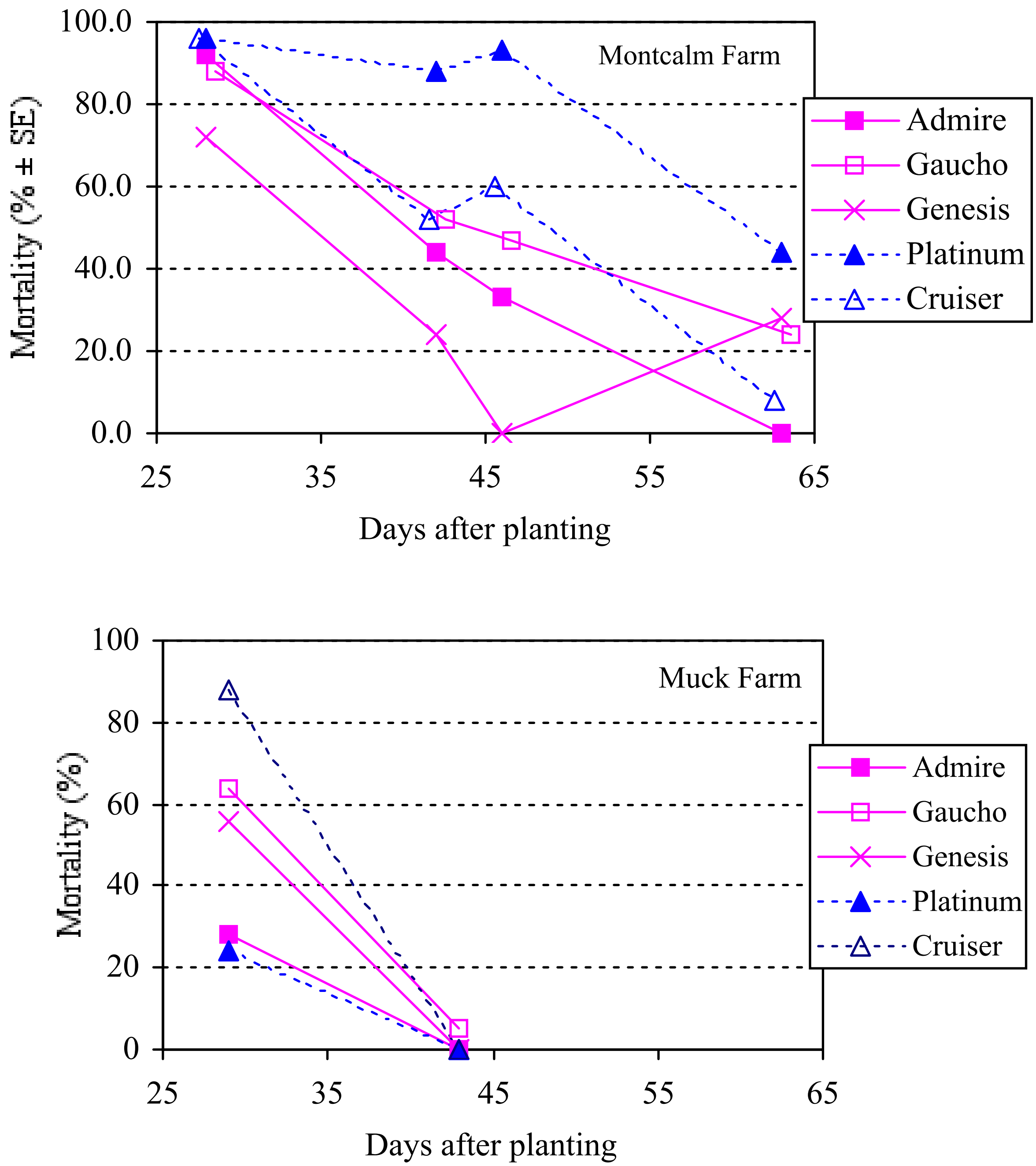


Figure 3. Length of control of adult CPB for imidacloprid and thiamethoxam formulations and application methods in sandy loam and muck soil. Length of larval control would be significantly longer.

Controlling aphids on potatoes with Fulfill (pymetrozine).

Several species of aphids colonize and flourish on potatoes, including the potato aphid (*Macrosiphum euphorbiae*) and the green peach aphid (*Myzus persicae*). Aphids are a sporadic pest; their numbers vary considerably from year to year. Aphid problems often begin late in the growing season. Overuse of insecticides such as pyrethroids, which kill natural enemies while only minimally impacting aphids, can lead to outbreaks. Green peach aphids especially, can quickly develop resistance to conventional insecticides, also leading to population build-ups. Once established, aphids reproduce rapidly on potato plants. They suck plant juices, deform foliage, reduce photosynthetic capacity and reduce yield. Aphids also transmit viruses, including potato leafroll virus and potato virus Y. Both are vectored by feeding of infected aphids. Potato virus Y is a nonpersistent virus, which means it is transmitted very quickly by many species of aphids and insecticides do not prevent its spread. Potato leafroll virus is a persistent virus which requires a period of incubation in the green peach aphid before transmission.

Fulfill®, (pymetrozine, Syngenta) is a novel chemical control product that specifically targets aphids. Unlike conventional insecticides it paralyzes the muscles that allow the aphid to suck plant juices. Consequently, aphids exposed to Fulfill quickly cease feeding. After several days, aphids eventually starve to death. Because it has such a specific effect on a specific group, Fulfill does not affect natural enemies or beneficial insects.

However, assessing efficacy of Fulfill is challenging since aphids may still be alive on the plant even though the insecticide is working. Several questions arise because of this novel mode of action—how long does it take for aphids exposed to treated foliage to die? How long after application is Fulfill effective against newly-colonizing aphids? —how long after application does the material inhibit feeding?

The objective of this study was to address these questions by artificially infesting treated foliage with aphids at different time intervals after treatment and to evaluate the effects of Fulfill on feeding and mortality over time.

Methods

Aphids were obtained from a natural infestation on potted potato plants growing in a greenhouse. Foliage was obtained from six-week old potato plants (planted 24 Apr) that were grown in a separate (pest free) greenhouse.

On 4 Jun 2002, 10 potted potato plants were sprayed with Fulfill 50 WG (2.75 fl. oz at 30 gpa using a hand-held CO_2 sprayer). An additional 10 plants were set aside as untreated controls.

After the spray had dried, five leaves (one from each of five different plants) were collected from both Fulfill-treated and untreated potato plants. The foliage was brought back to the lab and leaves were individually placed in water-picks. Each leaf was placed in a separate petri dish lined with filter paper (10 dishes total, five containing untreated foliage, five containing Fulfill-treated foliage. Aphids were transferred individually with paint brushes from infested plants onto leaves in petri dishes. Ten aphids were placed in each dish. After aphids were transferred, the dishes were sealed with parafilm.

Additional sets of 10 dishes each were set up, as described above, on 5 June (1 day after treatment), 6 June (2 days after treatment), 7 June (3 days after treatment), 11 June (7 days after treatment) and 12 June (8 days after treatment).

Aphids were examined each weekday after set up. The number of dead and live aphids were counted and dead aphids were removed. Each live aphid was classified, where possible, as feeding (mouthparts [stylets] inserted into leaf), walking on foliage, on foliage, but not feeding, or off of foliage. Foliage was replaced and necessary.

The number of dead vs. live aphids each day was compared between Fulfill and untreated foliage using a X^2 test (JMP statistical software). The number of live aphids feeding vs. not feeding was also tested.

Results:

In all cases, aphid mortality was higher on Fulfill-treated foliage than on untreated foliage (Table 6). Mortality was minimal on both treated and untreated foliage for the first day after exposure, but increased dramatically on the Fulfill-treated foliage after 3 to 4 days. After the first few days, mortality was significantly higher on Fulfill-treated foliage than on untreated foliage.

Mortality on untreated and treated foliage increased significantly when dishes were left unchecked for several days (Table 6—after consecutive NE (not evaluated). Fulfill treatment had good residual and continued to cause significant aphid mortality even in aphids that were placed on foliage 7-8 days after the application was made (Figure 4).

Fulfill inhibited aphid feeding dramatically (Table 7). In all cases, the percentage of live aphids that were feeding was lower (in many cases much, much lower) on Fulfill-treated foliage than on untreated foliage. In most cases, this difference was statistically significant. Feeding was inhibited for the entire period they were on the foliage. Even aphids that were placed on treated foliage 8 days after the application was made did not feed. The percentage of aphids feeding on Fulfill-treated foliage increased with time on foliage, but considering the high mortality on treated foliage (Table 6, Figure 4) very few aphids actually fed.

All and all, Fulfill had good efficacy on aphids, including mortality and feeding inhibition. It had residual effectiveness of at least 10 days. Further studies using techniques to reduce control mortality (which were learned in the previous study) would further clarify the efficacy and residual activity of Fulfill (pymetrozine).

Table 6. Cumulative percent mortality of aphids placed on Fulfill-treated and untreated potato foliage. Aphids were placed on foliage 0 to 8 days after foliage was treated.

	Days after treatment when aphids were placed on foliage									
Days on Foliage	0		1		2		7		8	
	Fulfill	Untr	Fulfill	Untr	Fulfill	Untr	Fulfill	Untr	Fulfill	Untr
1	0.0%	0.0%	8.0%	4.9%	4.2%	1.8%	2.4%	0.0%	8.1%	0.0%*
2	2.2%	2.1%	19.1%	7.4%*	NE	NE	22.2%	2.5%*	24.4%	13.0%*
3	27.9%	13.0%			NE	NE	59.3%	3.8%*	NE	NE
4					88.5%	48.7%*	NE	NE	NE	NE
5					90.4%	45.7%*	NE	NE	82.3%	69.4%
6					94.7%	48.9%*	90.3%	59.4%*		
7					95.2%	68.1%*				
8					100.0%	67.9%*				

Untr =untreated

NE= mortality not evaluated

* Percent mortality is significantly different between Fulfill and untreated foliage (P<0.05).

Table 7. Percent of live aphids placed on Fulfill-treated and untreated potato foliage that were feeding (stylet inserted into plant tissue). Aphids were placed on foliage 0 to 8 days after pymetrozine application was made.

	Days after treatment when aphids were placed on foliage									
Days on Foliage	<u>0</u>		<u>1</u>		<u>2</u>		<u>7</u>		<u>8</u>	
	Fulfill	Untr	Fulfill	Untr	Fulfill	Untr	Fulfill	Untr	Fulfill	Untr
1	0.0%	61.5%*	0.0%	96.6%*	0.0%	96.3%*	0.0%	83.3%*	4.4%	83.8%*
2							7.1%	87.0%*	13.8%	81.9%*
3	48.4%	77.5%*					54.5%	98.0%*		
4					0.0%	70.0%*				
5			0.0%		60.0%	96.0%*			45.5%	73.1%
6					0.0%	62.5%	16.7%	41.5%		
7					0.0%	66.7%				
8					none alive	82.4%				

Untr =untreated

NE= mortality not evaluated

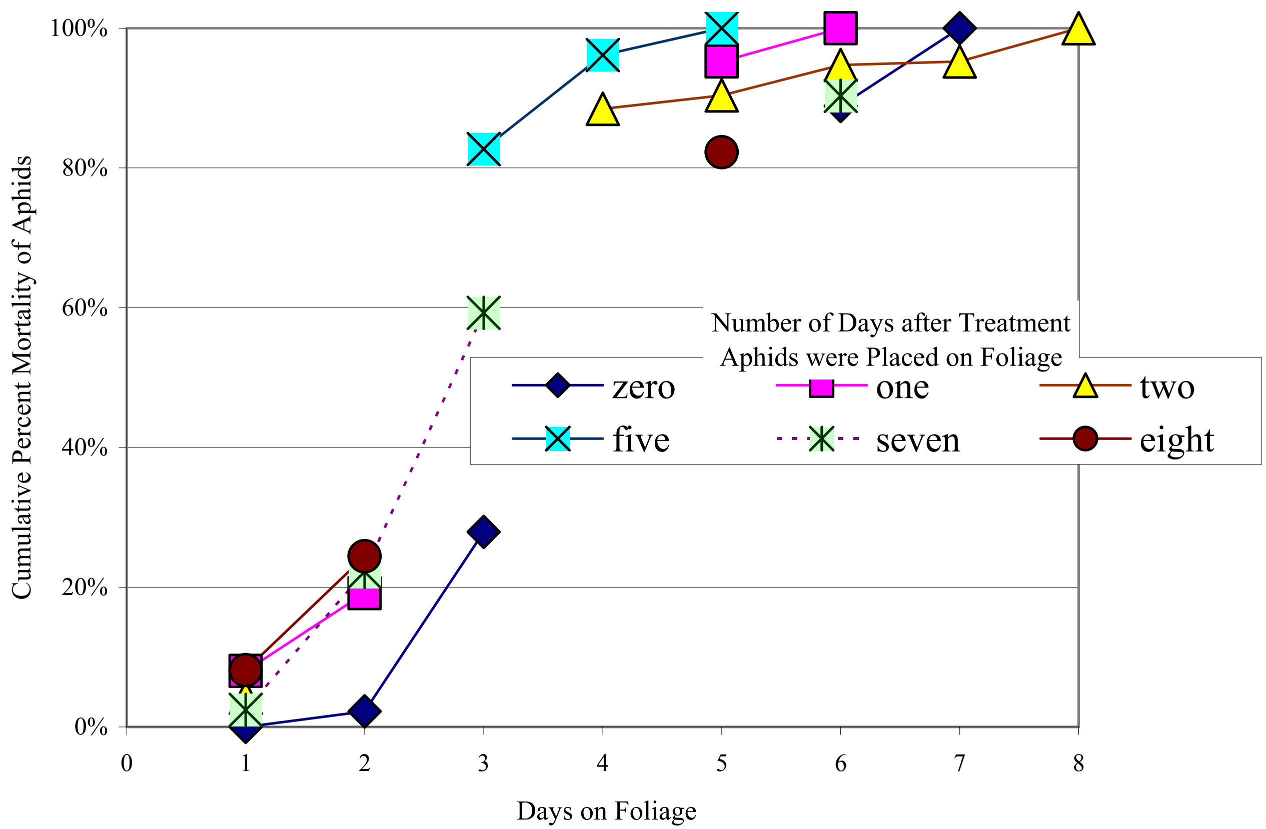


Figure 4. Mortality of aphids compared to days left on treated foliage. Different symbols represent different delays after treatment before aphids were placed on the foliage.

Funding: Federal Grant and GREEEN

Nitrogen and Spacing as Factors in Production of Advanced Breeding Lines (Tablestock and Chip Processing) From Michigan State University

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Introduction

A profile of plant response to nitrogen (N) management and spacing is crucial information for the rapid assessment and uptake of new varieties by the potato industry. The objectives of this study were to investigate the response of promising new lines to plant population density (narrow and wide within-row spacing, from 8 to 15 inches and fertilizer levels from 180 to 360 lb/ A. The response of four new lines from the Michigan State University potato breeding program were compared to the chip-processor Snowden over a two year period (2001-2002 growing seasons).

Materials and Methods

Nitrogen and spacing profiles were developed for the following varieties:

Liberator, (MSA091-1, Chip Processor)
Snowden (Check, Chip Processor)
MSG227-2 (Chip Processor)
Jacqueline Lee (MSG274-3, Tablestock)
MSE192-8Rus (Tablestock)

Liberator (MSA091-1), a 50 ºF storage chipper with tolerance to common scab (*Streptomyces scabies* Thaxter), MSG227-2, a cold storage (45 ºF) chipper with common scab tolerance, MSE192-8Rus, a russet tablestock line with excellent internal quality and MSG274-3, a European type tablestock line tolerant to the US 8 genotype of *Phytophthora infestans*. A randomized split-split design trial was conducted at the Montcalm Research Farm in Central Michigan on a Alfic Fragiorthod loamy sand soil during the summers of 2001 and 2002. Treatments are listed below in Table 1.

Table 1. Treatment List.

LINE	N LEVEL	NARROW SPACING	WIDE SPACING
	lb/A	Inches	Inches
Liberator	180, 270, 360	8”	13”
MSG227-2	180, 270, 360	8”	13”
Snowden	180, 270, 360	8”	13”
MSE192-8Rus	180, 270, 360	8”	13”
Jacqueline Lee	180, 270, 360	10”	15”

Results

Leaf canopy cover was measured in two ways: vigor score and light transmission through canopy, correlated with leaf area index (LAI). Both methods indicated that wider spacing reduced vigor and canopy closure. Overall, Liberator had the most vigorous vine (Table 2.). As shown in Tables 2, 4, 6, and 7, respectively the narrow (8”) spacing and 180 lb. N/A level produced the highest US#1 yield levels which are as follows: Liberator 374 cwt/A, MSG227-2 450 cwt/A, Snowden 391 cwt/A and Michigan Purple 379 cwt/A. Table 3 and 5 show MSE192-8Rus and Jacqueline Lee obtaining their highest US#1 yields at 270 lb. N/A. Compared to wide spacing, narrow spacing consistently increased yields of the chip processing lines by approximately 10 to 25% (Tables 2, 4 and 6). Nitrogen level had the greatest influence on yield for the tablestock lines.

During the 2001 season, petiole nitrate status reflected nitrogen responses of the two tablestock lines, where an increase in yield and higher petiole nitrate was observed when comparing 180 N to 270 N levels. However, in 2002 “luxury” uptake of nitrogen occurred as shown by the petiole nitrate levels associated with the 360 N treatment, which was not reflected in a yield increase (Figures 1-11).

Conclusions

- There appears to be a trade-off between plant population density and nitrogen fertility management for these varieties, where a narrow row spacing (higher plant population density) provides maximum yield potential at lower and recommended nitrogen levels (180 lb N/A). This optimizes N efficiency.
- Petiole N level late in the growing season indicates plant nitrogen status. This indicates that petiole nitrate monitoring is a useful indicator of efficiencies of nitrogen management strategies, but not necessarily an early indicator which can be used to help mid-season nitrogen fertility decisions.
- The highest yield levels for Snowden, Liberator and MSG227-2 were recorded at the 180 N level and high planting density (8” spacing).
- Jacqueline Lee and MSE192-8Rus exhibited a yield increase when the nitrogen level was increased from 180 to 270 lb N/A. No yield increase was observed when the level was increased to 360 lb N/A.
- No response was observed for any variety when the nitrogen level was increased to 360 lb N/A and is not recommended in any fertility, production program.
- The three chipping varieties are stored in the Cargill Demonstration storage and will be evaluated for storage quality over the 2002-2003 storage season with the results being reported at a later date.
- An additional trade-off exists between nitrogen level, plant population and tuber size distribution which is evident in the Snowden variety. The highest yield for this variety was reported at low N and 8” spacing, but the optimum size distribution occurs at low nitrogen and wide spacing. Commercial producers have chosen a reduction in yield to gain a larger percent of production in the US#1 size category.

Yield and Quality Performance of Avanced Breeding Lines and Snowden Control in a Nitrogen Management Profile at the Montcalm Research Farm Averaged Over 2001 and 2002. Nitrogen Level in Pounds Per Acre; In-furrow Spacing, Narrow (8" OR 10") and Wide (13" OR 15")

TABLE 2.

LINE	NITROGEN LEVEL	SPACING	US#1 YIELD (CWT/A)	PERCENT OF TOTAL YIELD "B" SIZE	PICKOUTS	OVERSIZE	SPECIFIC GRAVITY	PERCENT* INTERNAL DEFECTS	NUMBER OF TUBERS PER PLANT "B" SIZE	PICKOUTS	OVERSIZE	"A" SIZE	US#1	VIGOR** RATING	LAI***
LIBERATOR	**180**	**NARROW**	**374**	**8.6**	**2.7**	**9.2**	**1.076**	**30**	**1.51**	**0.16**	**0.20**	**4.68**	**4.87**	**5.00**	**3.15**
LIBERATOR	270	NARROW	361	8.2	3.7	9.3	1.075	25	1.45	0.18	0.23	4.69	4.92	4.75	3.25
LIBERATOR	360	NARROW	343	10.0	5.1	9.4	1.073	24	1.75	0.25	0.23	4.89	5.11	5.00	3.05
LIBERATOR	180	WIDE	309	7.9	4.3	12.5	1.074	24	2.02	0.21	0.40	5.86	6.25	4.25	2.25
LIBERATOR	270	WIDE	331	6.8	5.9	14.6	1.074	29	1.74	0.29	0.52	6.16	6.68	5.00	2.98
LIBERATOR	360	WIDE	307	7.8	5.9	15.6	1.073	16	1.90	0.35	0.50	5.26	5.77	5.00	2.95
	$LSD_{0.05}$		41				0.002		0.43	0.13	0.17	0.91	0.88	0.48	1.07

TABLE 3.

LINE	NITROGEN LEVEL	SPACING	US#1 YIELD (CWT/A)	PERCENT OF TOTAL YIELD "B" SIZE	PICKOUTS	OVERSIZE	SPECIFIC GRAVITY	PERCENT* INTERNAL DEFECTS	NUMBER OF TUBERS PER PLANT "B" SIZE	PICKOUTS	OVERSIZE	"A" SIZE	US#1	VIGOR** RATING	LAI***
MSE192-8Rus	180	NARROW	247	31.1	2.6	3.7	1.063	5	4.03	0.12	0.09	3.51	3.60	4.00	2.10
MSE192-8Rus	**270**	**NARROW**	**258**	**28.2**	**3.5**	**5.4**	**1.062**	**5**	**3.56**	**0.16**	**0.13**	**3.72**	**3.85**	**4.00**	**2.88**
MSE192-8Rus	360	NARROW	202	35.2	6.6	5.2	1.061	5	4.21	0.23	0.12	2.96	3.08	3.75	3.20
MSE192-8Rus	180	WIDE	230	24.1	5.4	10.2	1.062	0	4.29	0.31	0.34	4.91	5.25	3.00	1.30
MSE192-8Rus	**270**	**WIDE**	**257**	**20.6**	**6.5**	**10.9**	**1.063**	**3**	**4.04**	**0.36**	**0.41**	**5.23**	**5.64**	**3.25**	**2.18**
MSE192-8Rus	360	WIDE	234	22.3	10.6	9.9	1.061	6	4.30	0.65	0.32	4.61	4.93	3.25	2.60
	$LSD_{0.05}$		40				0.001		0.88	0.22	0.14	0.86	0.86	0.57	0.39

TABLE 4.

LINE	NITROGEN LEVEL	SPACING	US#1 YIELD (CWT/A)	PERCENT OF TOTAL YIELD "B" SIZE	PICKOUTS	OVERSIZE	SPECIFIC GRAVITY	PERCENT* INTERNAL DEFECTS	NUMBER OF TUBERS PER PLANT "B" SIZE	PICKOUTS	OVERSIZE	"A" SIZE	US#1	VIGOR** RATING	LAI***
MSG227-2	**180**	**NARROW**	**450**	**8.5**	**3.7**	**6.8**	**1.071**	**15**	**1.77**	**0.20**	**0.22**	**6.28**	**6.50**	**3.75**	**2.73**
MSG227-2	270	NARROW	436	8.2	3.8	3.9	1.072	3	1.60	0.20	0.12	5.93	6.05	4.00	2.43
MSG227-2	360	NARROW	378	10.8	8.0	6.0	1.070	10	2.07	0.43	0.18	5.03	5.21	4.00	2.83
MSG227-2	180	WIDE	369	5.7	6.2	13.3	1.071	15	1.63	0.45	0.54	7.15	7.70	2.75	2.35
MSG227-2	270	WIDE	378	4.9	10.8	10.2	1.070	8	1.53	0.74	0.45	6.49	6.94	3.25	2.63
MSG227-2	360	WIDE	352	6.8	10.5	8.0	1.070	5	2.00	0.81	0.34	6.93	7.27	3.25	2.03
	$LSD_{0.05}$		56				0.002		0.70	0.36	0.22	1.09	1.13	0.55	0.85

* PERCENT INTERNAL DEFECTS are based on an average across four reps each rep containing ten tubers each.

** VIGOR RATING is a 1 - 5 rating where 5 represents a flower plant canopy and a 1 represents a dead canopy. 2001 Data Only.

*** LEAF AREA INDEX is a quantitative measure of leaf canopy. The greater the LAI number the more vigorous the canopy. 2001 Data Only.

**** 2002 Data only.

BOLD indicates highest yield

Yield and Quality Performance of Avanced Breeding Lines and Snowden Control in a Nitrogen Management Profile at the Montcalm Research Farm Averaged Over 2001 and 2002. Nitrogen Level in Pounds Per Acre; In-furrow Spacing, Narrow (8" OR 10") and Wide (13" OR 15")

TABLE 5.

LINE	NITROGEN LEVEL	SPACING	US#1 YIELD (CWT/A)	PERCENT OF TOTAL YIELD "B" SIZE	PICKOUTS	OVERSIZE	SPECIFIC GRAVITY	PERCENT* INTERNAL DEFECTS	NUMBER OF TUBERS PER PLANT "B" SIZE	PICKOUTS	OVERSIZE	"A" SIZE	US#1	VIGOR** RATING	LAI***
JACQUELINE LEE	180	NARROW	269	36.9	4.1	0.9	1.071	3	7.74	0.34	0.04	5.95	5.99	4.50	1.83
JACQUELINE LEE	270	NARROW	284	33.7	4.9	1.6	1.071	4	8.27	0.41	0.11	5.95	6.07	4.75	2.53
JACQUELINE LEE	360	NARROW	243	37.9	7.4	1.2	1.071	1	8.81	0.59	0.13	5.95	6.08	4.50	2.68
JACQUELINE LEE	180	WIDE	263	31.9	7.1	1.2	1.072	5	10.25	0.69	0.06	8.52	8.58	3.75	1.90
JACQUELINE LEE	**270**	**WIDE**	**296**	**28.3**	**5.8**	**2.7**	**1.071**	**4**	**9.02**	**0.60**	**0.16**	**8.45**	**8.60**	**4.00**	**2.38**
JACQUELINE LEE	360	WIDE	256	30.2	6.6	2.2	1.071	4	7.07	0.62	0.12	7.30	7.41	3.75	1.75
	$LSD_{0.05}$		50				0.002		3.12	0.38	0.13	1.33	1.33	0.76	1.11

TABLE 6.

LINE	NITROGEN LEVEL	SPACING	US#1 YIELD (CWT/A)	PERCENT OF TOTAL YIELD "B" SIZE	PICKOUTS	OVERSIZE	SPECIFIC GRAVITY	PERCENT* INTERNAL DEFECTS	NUMBER OF TUBERS PER PLANT "B" SIZE	PICKOUTS	OVERSIZE	"A" SIZE	US#1	VIGOR** RATING	LAI***
SNOWDEN	**180**	**NARROW**	**391**	**15.6**	**0.3**	**2.7**	**1.073**	**23**	**3.01**	**0.03**	**0.07**	**6.42**	**6.49**	**4.00**	**2.88**
SNOWDEN	270	NARROW	352	18.0	0.9	2.1	1.073	15	3.42	0.04	0.07	6.01	6.07	4.25	2.73
SNOWDEN	360	NARROW	332	21.9	0.7	1.5	1.072	16	3.94	0.05	0.04	6.12	6.17	4.00	2.63
SNOWDEN	180	WIDE	343	11.1	1.1	3.6	1.072	19	2.84	0.07	0.15	9.10	9.25	3.25	1.65
SNOWDEN	270	WIDE	333	12.0	0.9	4.5	1.072	20	2.92	0.06	0.16	8.19	8.31	3.75	1.23
SNOWDEN	360	WIDE	328	13.2	1.3	5.2	1.071	24	3.24	0.11	0.19	7.93	8.12	3.50	2.48
	$LSD_{0.05}$		46				0.002		0.74	0.08	0.10	1.11	1.11	0.76	1.45

TABLE 7.****

LINE	NITROGEN LEVEL	SPACING	US#1 YIELD (CWT/A)	PERCENT OF TOTAL YIELD "B" SIZE	PICKOUTS	OVERSIZE	SPECIFIC GRAVITY	PERCENT* INTERNAL DEFECTS	NUMBER OF TUBERS PER PLANT "B" SIZE	PICKOUTS	OVERSIZE	"A" SIZE	US#1
MICHIGAN PURPLE	**180**	**NARROW**	**379**	**3.7**	**7.0**	**9.1**	**1.061**	**3**	**0.82**	**0.18**	**0.26**	**4.84**	**5.10**
MICHIGAN PURPLE	180	WIDE	353	2.8	8.3	15.9	1.061	5	0.82	0.40	0.52	5.81	6.33
	$LSD_{0.05}$		69				0.004		0.77	0.19	0.25	0.75	0.88

* PERCENT INTERNAL DEFECTS are based on an average across four reps each rep containing ten tubers each.
** VIGOR RATING is a 1 - 5 rating where 5 represents a flower plant canopy and a 1 represents a dead canopy. 2001 Data Only.
*** LEAF AREA INDEX is a quantitative measure of leaf canopy. The greater the LAI number the more vigorous the canopy. 2001 Data Only.
**** 2002 Data only.
BOLD indicates highest yield

Figure 1.

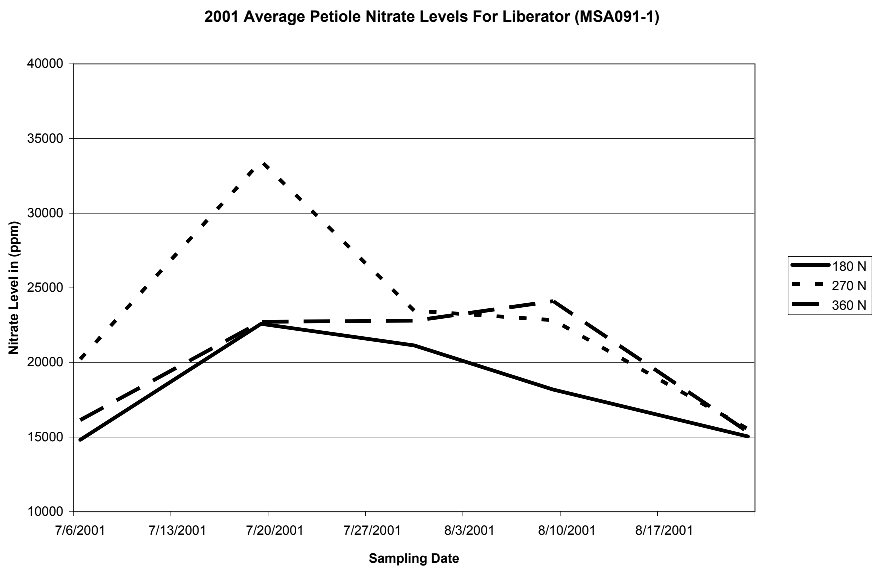


Figure 2.

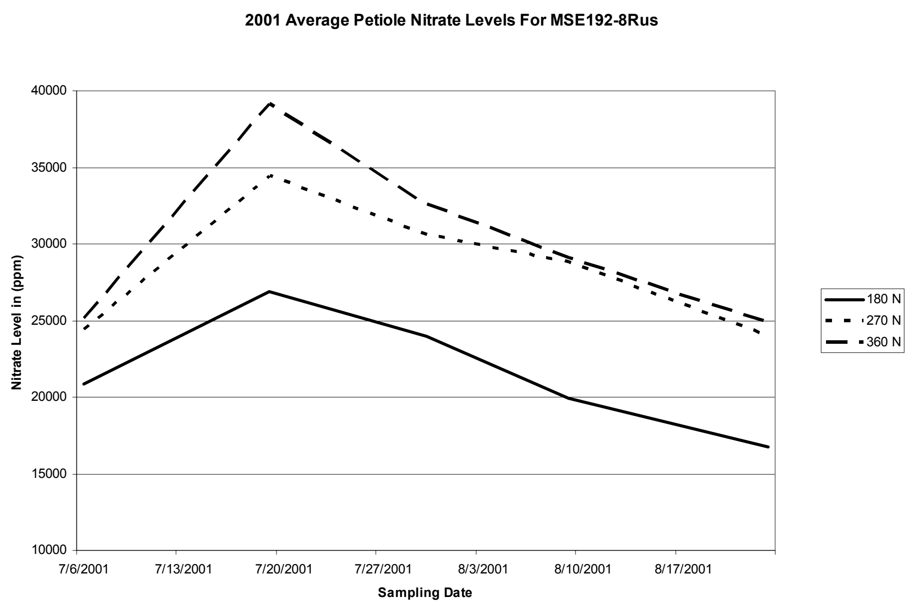
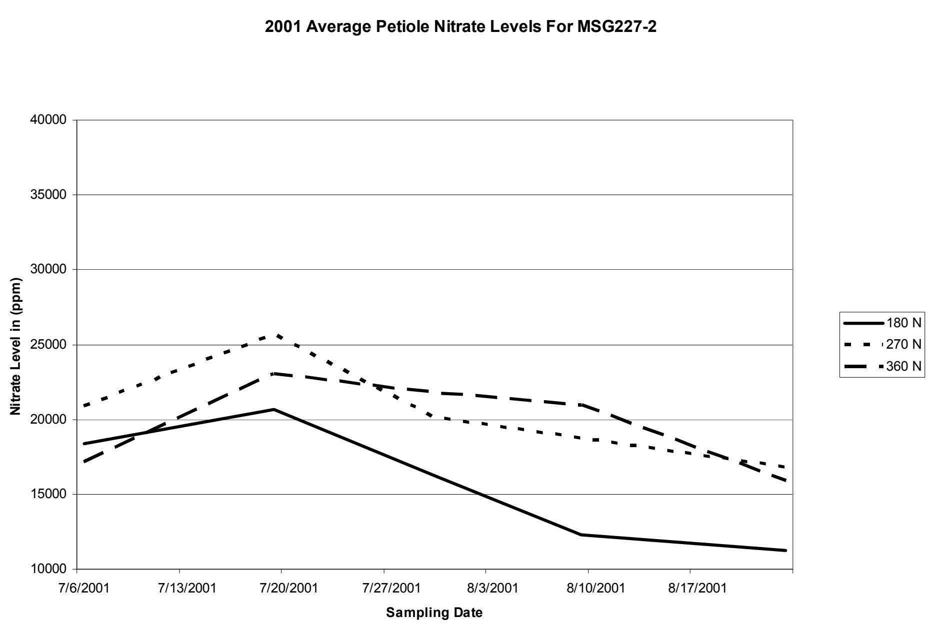


Figure 3.



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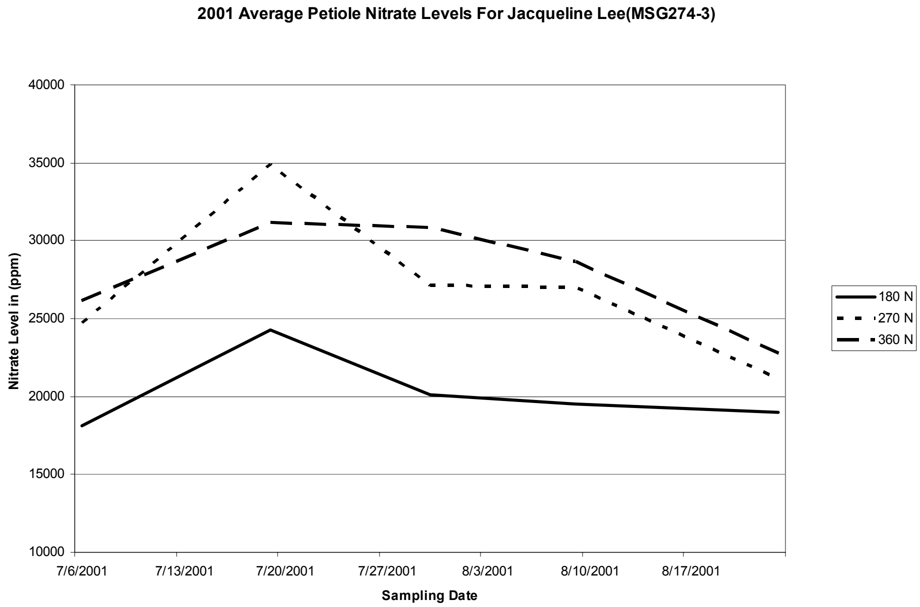

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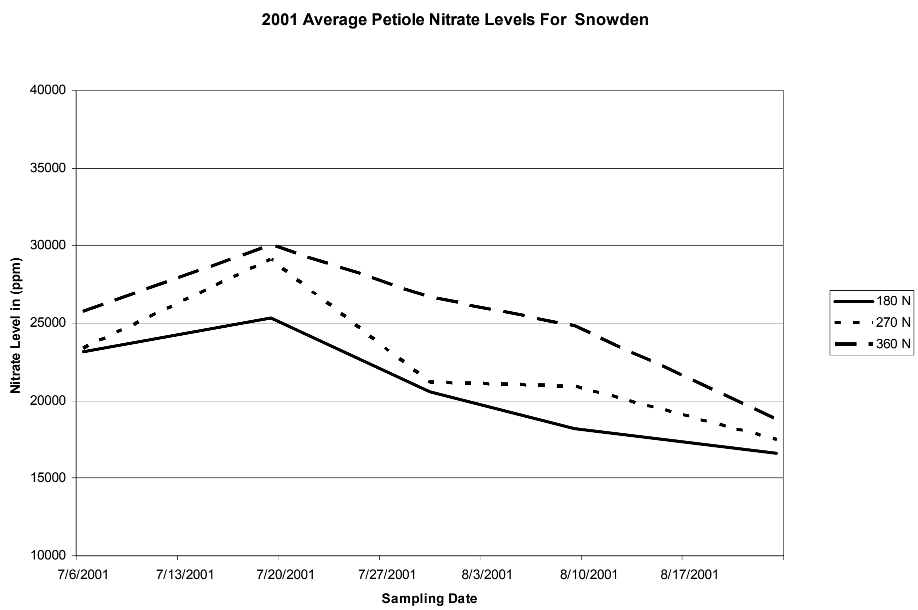

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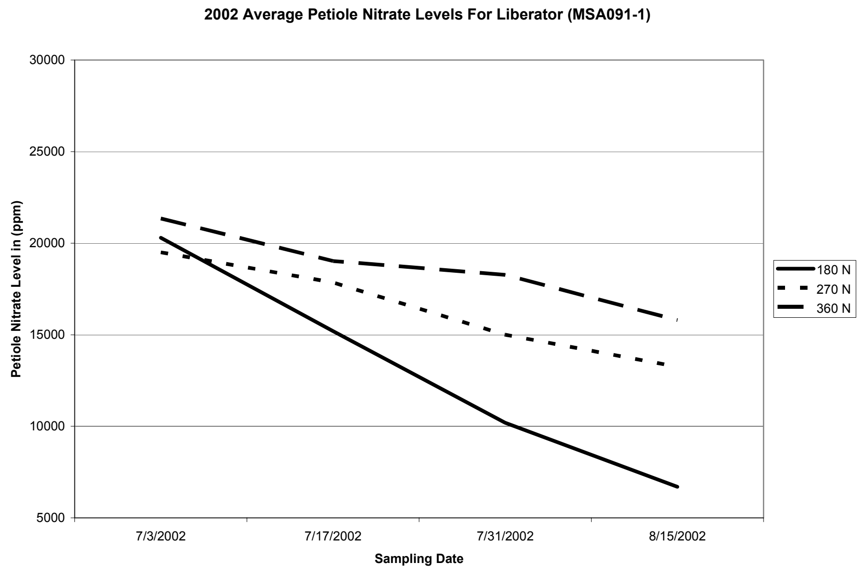

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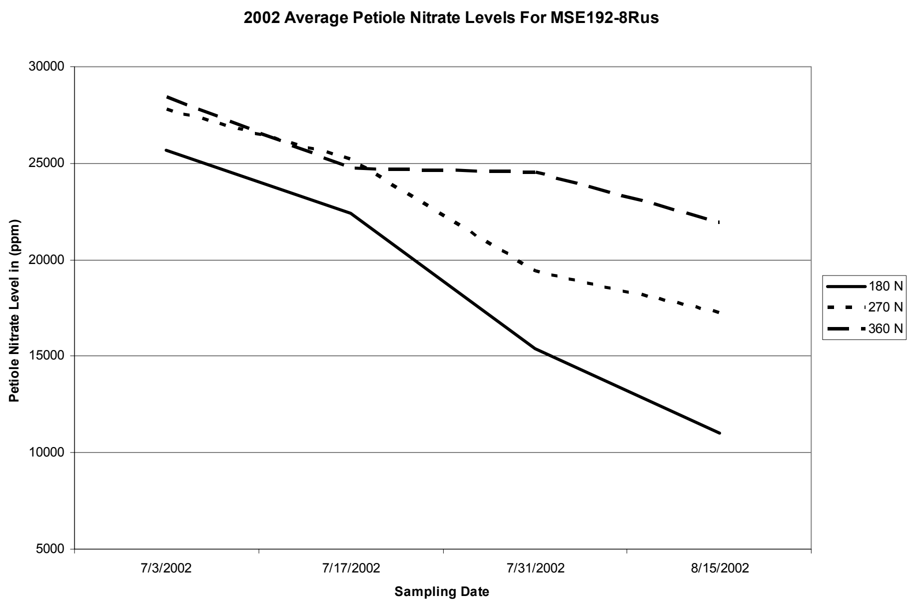

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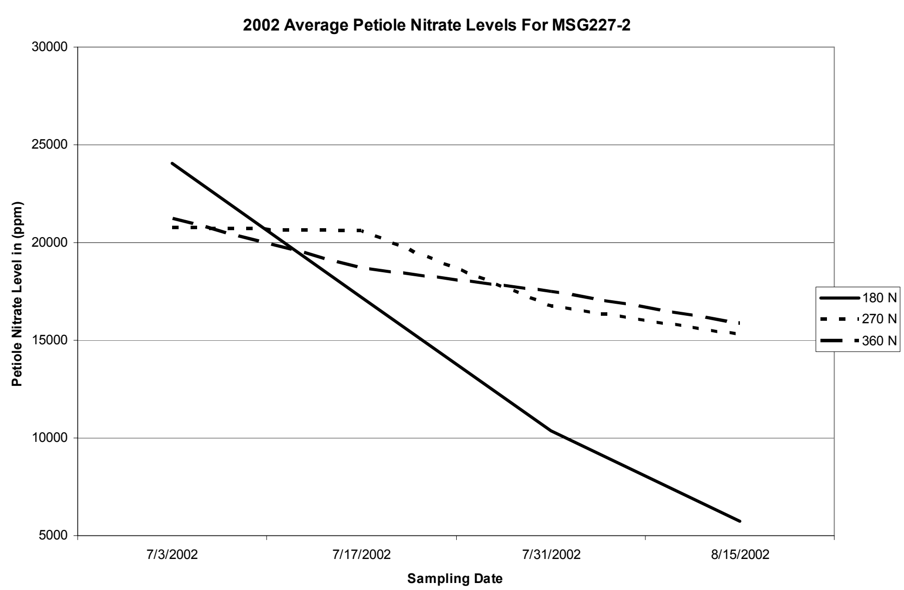

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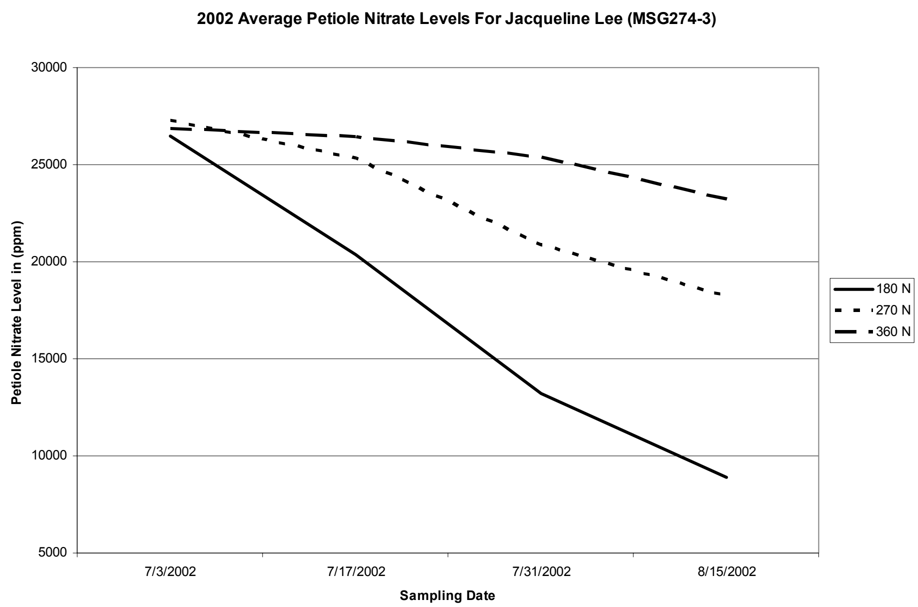

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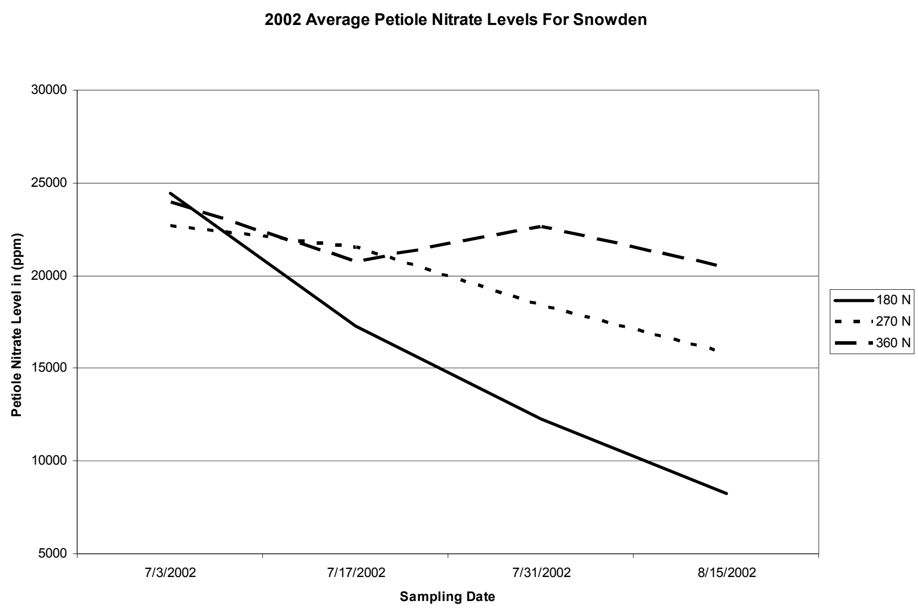

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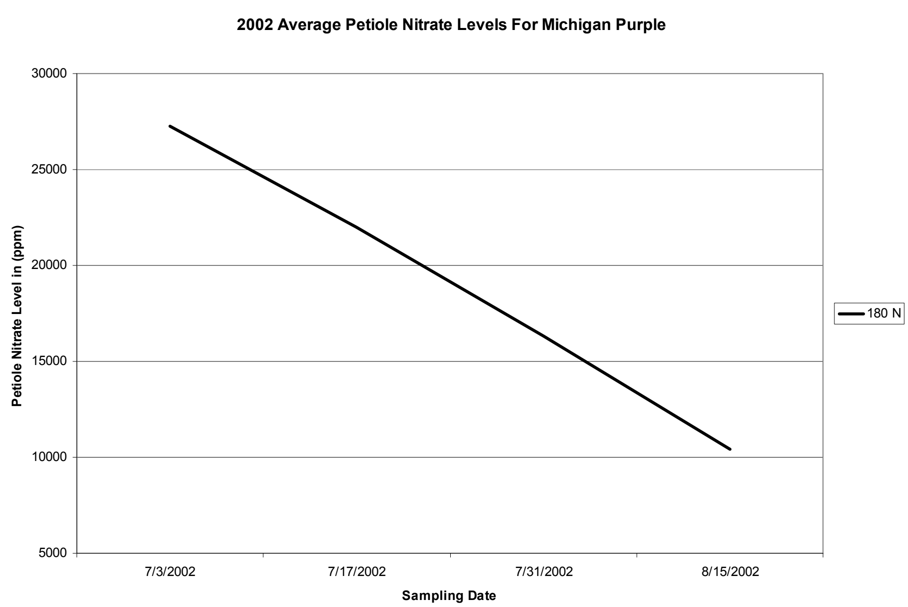

Funding: GREEEN, IFAFS

Improving Productivity and Soil Quality in Short Potato Rotations
2002 Research Report

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Summary

A 6-year study of short potato rotations and cover crops was implemented in 2001 at 2 locations in Michigan, at the Montcalm Research Farm near Entrican, and at the Southwest Michigan Research Extension Center near Benton Harbor. Potatoes are rotated with snap beans, corn or wheat with or without one of 3 different cover crops. Some rotations are also split for a composted poultry manure comparison. Objectives of the experiment are to monitor yield and quality of crops harvested and to monitor improvements in soil quality over time. This report presents findings from the 2002 growing season at the Montcalm Research Farm location.

Potato and snap bean yields were increased with the application of 2.5 T/acre composted poultry manure. Compost application did not affect incidence of common scab on potato tubers. Rye or rye + hairy vetch cover crop increased potato and snap bean yield compared with a bare winter fallow (no cover crop).

Introduction

Potato production in Michigan has become more intensive as urbanization and land values have increased in potato producing areas. This has led to increased use of short two-year rotations, alternating potatoes with corn, wheat, beans or other vegetables. Depletion of organic matter in these rotations is a problem, particularly on well-drained sandy soils. Growers widely use winter cereals as cover crops in Michigan to protect soil from wind erosion, and to help maintain soil organic matter (SOM).

Maintenance of SOM is critical for successful long-term production. Depletion of SOM results in reduction of soil water holding capacity. Researchers have estimated that for each 0.5% loss of organic matter, water holding capacity is reduced by 10%. Loss of SOM also results in a reduction in nutrient availability and nutrient buffering capacity which increases fertilization requirements. Soil structure, texture and tilth are damaged with loss of SOM and more problems with soil crusting and poor drainage occur. Increased requirements for fumigation have also been associated with losses of SOM.

Growers must actively manage for maintenance and improvement of SOM to compensate for intensive tillage and minimal residues associated with potato rotations. Effective methods for improving soil organic matter are regular application of livestock manure or compost, use of cover crops between principle crops, use of green manure crops, and maximizing return of crop residues. Rotating potatoes with reduced tillage crops such as winter wheat or no-till soybeans will also help maintain SOM.

Methods

Field Experiments: A 6-year trial was initiated in 2001 at the Montcalm Research Farm in Entrican and at the Southwest Michigan Research and Extension Center (SWMREC) near Benton Harbor. Both sites have well-drained, loamy sand to sandy loam soils that are common soil types used to produce a wide range of vegetable crops. At the Montcalm Research Farm the soil is a Montcalm/McBride loamy sand and at SWMREC the soil is an Oakville series fine sand transition to loamy sand (Table 1.). The two sites provide information about performance under a conventional potato production environment at a southern Michigan location with a warmer spring, and a cooler central Michigan location.

Table 1. Soil texture and chemical properties for 0-8" depth at the Montcalm Research Farm plot

Organic C, %	Average	1.5
	Range	0.4 – 3.6
Texture, % sand	Average	78
	Range	63 - 89
Calcium, ppm	Average	388
	Range	200 - 1000

The trial includes seven 2-year potato rotations and one 3-year rotation system with 3 cover crop options (see Table 2).

Table 2. Rotation, cover crop and compost treatments used in long-term potato rotation experiment at Montcalm Research Farm and SWMREC

		Rotation	Cover Crop	Manure
1.	2Y	Potato / Snap Bean	Bare (no cover crop)	+ or - compost
2.	2Y	Potato / Snap Bean	Rye	+ or - compost
3.	2Y	Potato / Snap Bean	Rye + Hairy Vetch	+ or - compost
4.	2Y	Potato / Corn	Rye after Potatoes, Bare after Corn	
5.	2Y	Potato / Corn	Rye + Hairy Vetch	
6.	2Y	Potato / Wheat	Wheat after Potatoes, Rye after Wheat	
7.	2Y	Potato / Wheat	Wheat / Red Clover (frost seeded)	
8.	3Y	Potato / Corn / Wheat	Rye+Hairy Vetch or Wheat+Clover	

Rotation treatment 1 represents a worst-case system where soil is left bare after potato harvest. Treatment 8 is included as a best-case option with a 3 year rotation using less tillage and cereal+legume cover crops. Rotation treatments 2 and 4 represent commonly used rotations and winter cover crops for Michigan potato growers.

Three snap bean rotation treatments were split for a composted poultry manure treatment comparison. Dry poultry manure compost was applied to split plots at 2.5 T / acre in the spring before planting. Principle crops and cover crops were planted with standard commercial equipment. Varieties and hybrids used are listed in Table 3. Fertilizer was applied to potato plots at the recommended rate of 180 lb N/acre. Plots were irrigated as needed. Cover crops were planted after principle crops were harvested in the fall except for red clover which was frost-seeded into wheat in the spring. Standard pest and weed control measures were used.

Table 3. Varieties of principle and cover crops used in long-term potato rotation experiment at Montcalm Research Farm and SWMREC

Crop	Variety or Hybrid
Potato	Snowden
Snap Bean	HiStyle
Sweet Corn	Jackpot
Wheat	Caledonia
Rye	Wheeler
Hairy Vetch	Common
Red Clover	Mammoth

This report focuses on the 3 snap bean rotation treatments (numbered 1 through 3 in Table 1) at the Montcalm Research Farm location for the 2002 growing season.

Potatoes were harvested on 26 September 2002. Tubers were graded manually into size and cull categories and weighed. Snap beans were harvested on 26 August 2002. Row sections were harvested and were manually separated into bean pods and stems and weighed.

Results and Discussion

Application of composted poultry manure increased yield in both potatoes and snap beans. Rye and rye + hairy vetch cover crops also increased yields of potatoes and snap beans over no cover crop (see Figures 1 and 2). The combination of cover crop and compost application had an additive effect for potatoes, resulting in the highest yields of US No. 1 tubers (Figure 1). Scab was unaffected by compost application in this experiment (Figure 3), but in a related container experiment, poultry manure compost did increase incidence of common scab (Nyiraneza and Snapp, unpublished data).

In a related experiment, we found that the rye cover crop released nitrogen very late in the growing season, while the combination of rye cover crop and poultry manure constantly released nitrogen at an optimal time for potato production (Figure 4).

Effects of cover crop and composted poultry manure on soil quality parameters are being examined. Detectable improvements are expected to take 2 or 3 years.

Table 3. Yields of US No. 1 potato tubers and fresh bean pods in long-term potato rotation experiment at Montcalm Research Farm and SWMREC

	Potato Yield			Snap Bean Yield		
	US No. 1 cwt/A	N	SE	Fresh lb./A	N	SE
Bare (no cover crop)	230	23	15	6760	16	1632
Cereal (rye or wheat)	243	23	15	11845	16	716
Rye + Hairy Vetch	273	24	16	11476	16	950
Wheat + Clover	251	11	18			

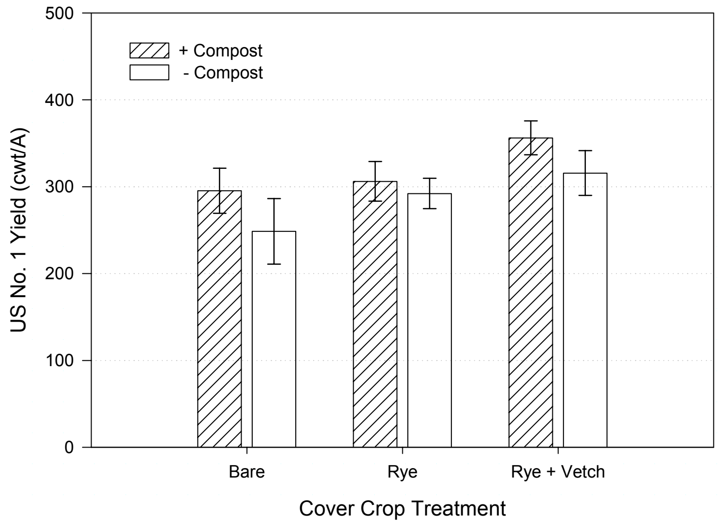

Figure 1. US No. 1 tuber yield (cwt/acre) by cover crop and compost treatment

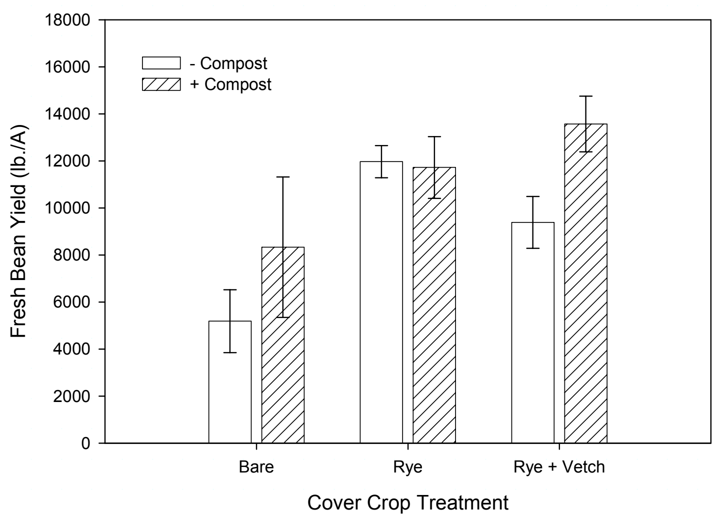

Figure 2. Fresh snap bean yield (lb./acre) by cover crop and compost treatment

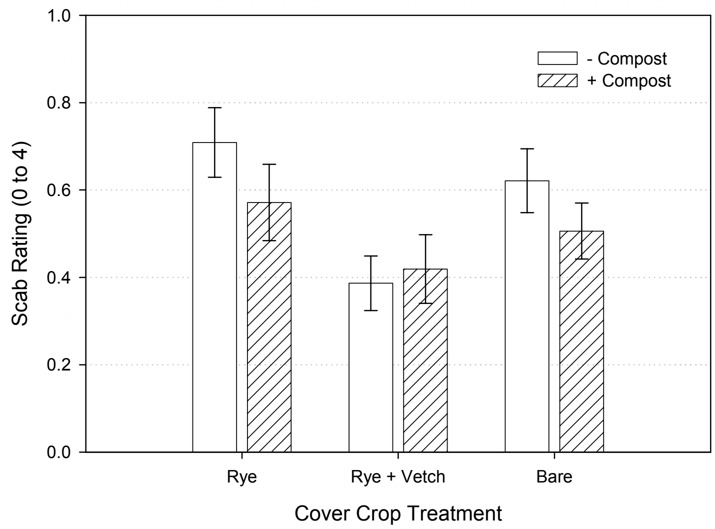

Figure 3. Scab Rating (0 to 4) of tubers by cover crop and compost application

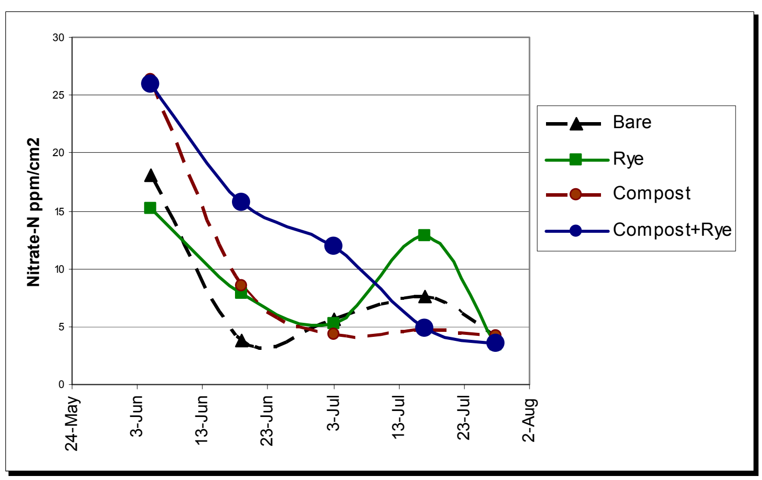

Figure 4. Nitrogen mineralization curve for cover crops and composted poultry manure. (Nyiraneza and Snapp, unpublished data)

Additional Resources

Additional information regarding manure and compost application is available online from the Michigan Manure Resources Network (web2.msue.msu.edu/manure) and from the Michigan Agriculture Environmental Assurance Program (www.maeap.org).

Cover crop information is available from the Kellogg Biological Station Cover Crops program (www.kbs.msu.edu/Extension/Covercrops/home.htm) and from the Sustainable Agriculture Network (www.sare.org/htdocs/pubs/mccp)

Funding: MPIC

Calcium Nutrition for Improved Quality and Storage of Potatoes

2002 Research Report

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Summary

Improvements in potato yield, quality and storability remain primary objectives for Michigan potato growers and researchers. Experiments were designed and implemented in 2002 to monitor yield, quality and storability responses of Pike and 1879 varieties with differing nitrogen and calcium fertilization management.

No significant treatment effects were observed in the 1879 experiment. In the Pike experiment, no significant nitrogen treatment effects were observed, however calcium treatments resulted in several significant effects. Poultry manure compost improved yield of total, US No. 1, A and B size tubers and increased specific gravity compared with the untreated control. Compost and $CaNO_3$ applied once did not reduce tuber defects, but gypsum and split-applied $CaNO_3$ reduced internal brown spot and total tuber defects. Compost increased scab rating of Pike tubers. Storage effects of calcium and nitrogen treatments will be monitored for both varieties through winter months.

Introduction

National potato markets have become increasingly competitive for Michigan potato growers. As chip and tablestock potato buyers continue to raise minimum acceptable quality standards, Michigan potato growers must respond by continuing to improve the quality of their produce to meet and exceed these higher acceptability standards. Growers can gain competitive advantage if they can achieve and maintain outstanding potato quality and if they are able to store high quality tubers longer into the spring months.

Proper management of nitrogen (N) and calcium (Ca) nutrition in the field can directly affect these fundamental goals. For optimal yield and quality, these 2 nutrients must be available in adequate levels at the critical stages of plant growth and tuber development.

The 'Pike' variety has commonly been susceptible to internal necrosis, internal brown spot or brown center tuber defects. Calcium fertilization has been shown to be a critical element for optimal tuber development, resistance to post-harvest soft rots and for improved storage reconditioning. (Chase et al, 1990; Erribhi et al, 1998; Palta, 1996). Results of trials have not been uniformly conclusive, however.

Methods

Two field experiments were conducted on sandy loam soil at the Montcalm Research Farm, Entrican, MI. Soil properties are listed in Table 1. Four-row plots were applied with fertilizer treatments before planting and split N and Ca applications were applied at hilling and at blossom stage as specified by treatment design. Plots were planted on 1 May and harvested 155 days later on 3 October, 2002.

Table 1.	Soil profile organic carbon, texture and chemical characteristics of trial site for calcium nutrition study, Montcalm Research Farm, 2002.								
	Organic C	Sand	Silt	Clay	pH	P	K	Ca	Mg
	- - - - - - - - - -	%	- - - - - - - - - -			- - - - - - - -	lb/acre	- - - - - - - -	
Topsoil (0-8 in)	0.62	78	13	9	6.25	313	228	690	246
Subsoil (8-20 in)	0.22	77	12	11	6.95	80	145	850	290
Deep subsoil (20-32in)	0.23	63	16	1	6.88	33	163	1480	322

<u>Experiment 1</u> was designed to compare N and Ca nutrient sources for 'Pike' variety potatoes. Each Ca treatment provided 200 lb. Ca:

1. Calcium nitrate ($CaNO_3$) in a single pre-plant application,
2. $CaNO_3$ in a split application (1/3 pre-plant, 1/3 at hilling, and 1/3 at blossom stage),
3. Poultry manure compost (10% Ca) applied pre-plant at 2.5 tons / acre,
4. Gypsum applied in a single pre-plant application, and
5. Untreated control receiving no Ca fertilization.

Each Ca treatment was combined with N fertilizer for a total of 180 or 360 lb. N/acre Nitrogen credits were given for the $CaNO_3$ and the poultry manure compost.

<u>Experiment 2</u> was designed to Ca sources for Frito Lay '1879' variety potatoes. Calcium treatments were:

1. $CaNO_3$ to provide 200 lb. / A in a single pre-plant application,
2. $CaNO_3$ to provide 200 lb. / A in a split application (1/3 pre-plant, 1/3 at hilling, and 1/3 at blossom stage),
3. Poultry manure compost (10% Ca) to provide 200 lb./A applied pre-plant at 2.5 tons / A,
4. Gypsum at 200 lb. Ca / A applied in a single pre-plant application,
5. Gypsum at 400 lb. Ca / A applied in a single pre-plant application, and
6. Untreated control receiving no Ca fertilization.

Nitrogen fertilization was 200 lb. /A for all treatments with credits given for the $CaNO_3$ and poultry manure compost. A 40 lb. credit was used for poultry manure compost assuming 30% release of N through mineralization.

Tubers were harvested and graded into A size, B size, oversize and grade-out categories. A subsample of tubers were inspected for internal defects and several samples were designated for laboratory analyses and for long-term storage in the Cargill Demonstration Storage building.

Results and Discussion

<u>Experiment 1.</u> Nitrogen treatment had no significant effects on yield or quality of Pike tubers. Calcium treatments did not affect tuber Ca concentrations significantly (Figure 1). Calcium concentrations averaged 0.035% across treatments, lower than 2001 levels.

Average yield for all treatments in the Pike experiment was 301 cwt/acre. Average yield of US No. 1 tubers was 276 cwt/A. Yield of total, US No. 1, A size, B size and oversize tubers was significantly affected by Ca treatment (Figure 2). Poultry manure compost improved yield of total, US No. 1, A and B size tubers and increased specific gravity compared with control (Figures 3 and 4).

Poultry manure compost and a single application of 200 lb. $CaNO_3$ did not reduce tuber defects. Gypsum and split-applied CaNO3 reduced internal brown spot and total tuber defects ($p<.15$) (Figure 5). Compost increased scab rating ($p<.06$) (Figure 6).

Storage effects will be monitored through winter months

Experiment 2. Calcium treatments had no significant effects on yield or quality of 1879 tubers (Figures 7 and 8).

Storage effects will be monitored through winter months

Conclusions

The effects of poultry manure compost on yields and quality look promising. Yield was increased by 50 cwt / acre compared to control for 4 out of 5 trials using compost. Other calcium treatments did not increase yields or improve tuber quality. Calcium content of tubers was not affected though this is often difficult to achieve especially during a dry season such as 2002. Questions remain about the mode of action of poultry manure compost. It is unclear at this point whether poultry compost effects are due to Ca, as a slow-release N source or as a more physical soil quality effect. Similar effects have been observed in other experiments by our lab. We are continuing to monitor quality in the demonstration storage and will report later on these results.

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Errebhi, M. C.J. Rosen, S.C. Gupta and D.E. Birong. 1998. Potato yield response and nitrate leaching as influenced by nitrogen management. Agron. J. 90:10-15.

Palta, J.P. 1996. Role of calcium in plant responses to stresses: Linking basic research to the solution of practical problems. HortScience 31:51-57.

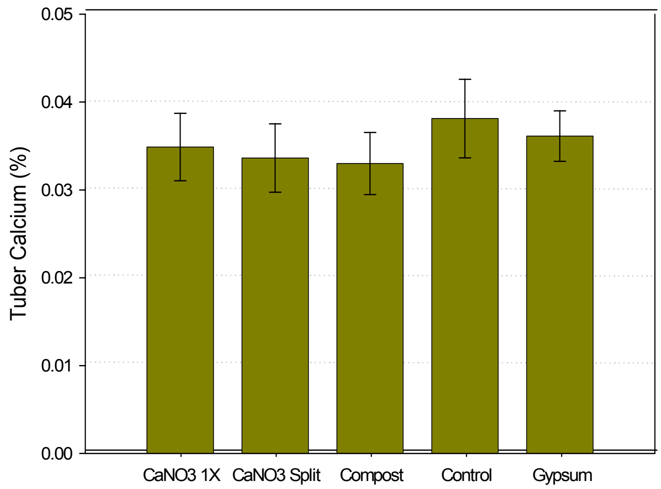


Figure 1. Pike experiment. Tuber Ca concentrations (%) for different Ca treatments. Each Ca treatment provided 200 lb./A Ca except control which received 0 Ca.

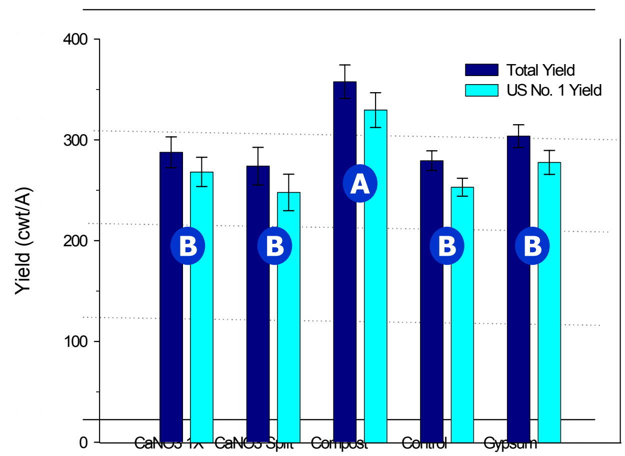


Figure 2 Pike experiment. Yield of total and US No. 1 tubers for different Ca treatments. Each Ca treatment provided 200 lb./A Ca except control which received 0 Ca. ABC=different letters indicate significant difference (P<.01)

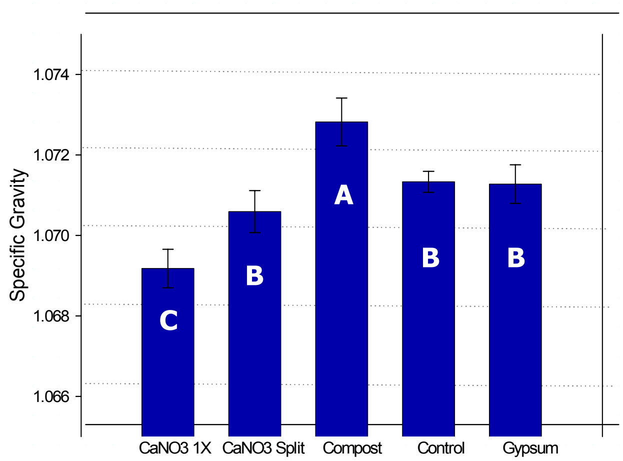


Figure 3. Pike experiment. Tuber specific gravity for different Ca treatments. Each Ca treatment provided 200 lb./A Ca except control which received 0 Ca. ABC=different letters indicate significant difference (P<.01)

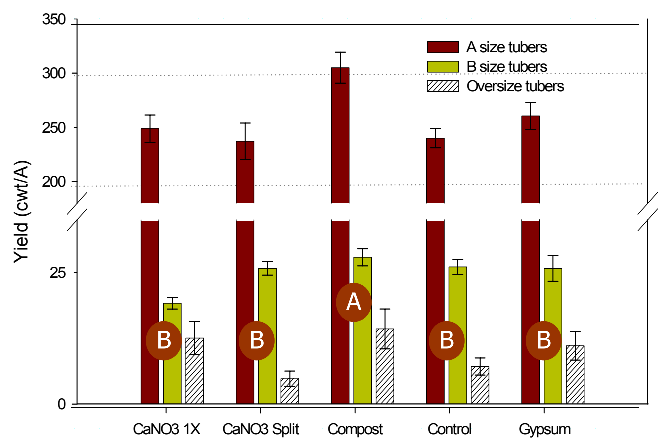
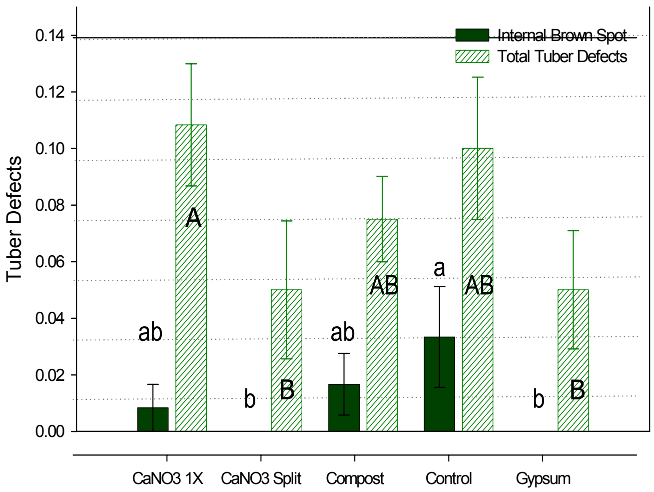


Figure 4. Pike experiment. Yield of A size, B size and oversize tubers for different Ca treatments. Each Ca treatment provided 200 lb./A Ca except control which received 0 Ca. ABC=different letters indicate significant difference (P<.01)



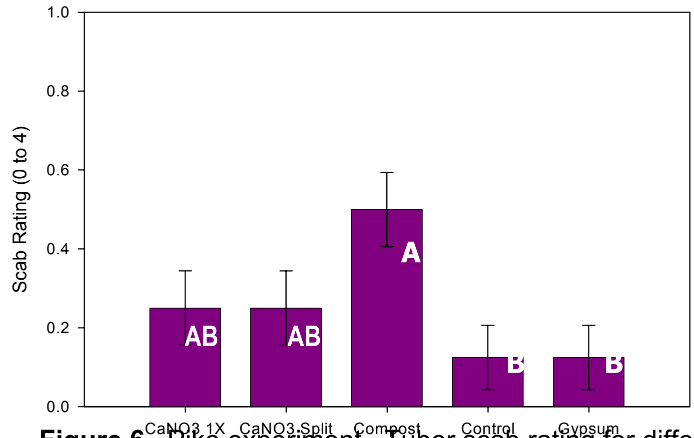


Figure 5. Pike experiment. Frequency of total tuber defects and internal brown spot for different Ca treatments. Each Ca treatment provided 200 lb./A Ca except control which received 0 Ca. ABC, abc=different letters indicate significant difference (P<.15)

Figure 6. Pike experiment. Tuber scab rating for different Ca treatments. Each Ca treatment provided 200 lb./A Ca except control which received 0 Ca. ABC=different letters indicate significant difference (P<.06)

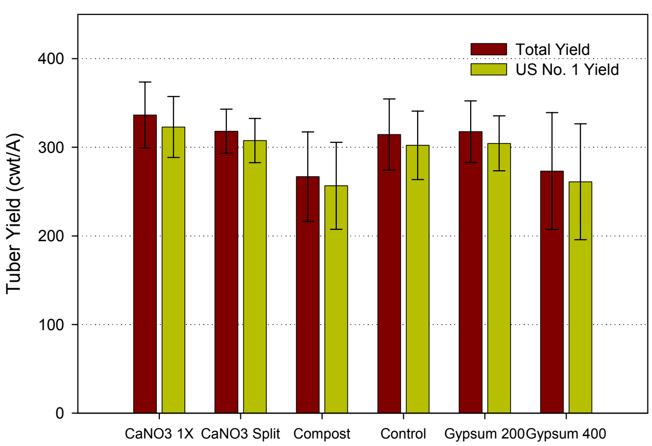


Figure 7. 1879 experiment. Yield of total and US No. 1 tubers for different Ca treatments. Yields were not different for different treatments.

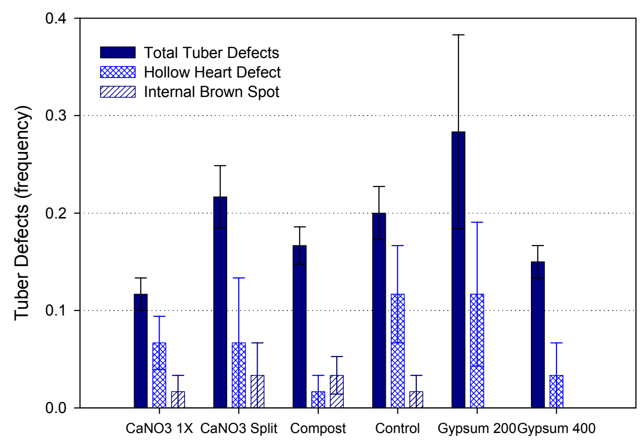


Figure 8. 1879 experiment. Frequency of total tuber defects, hollow heart and internal brown spot for different Ca treatments. Defect frequencies were not different for different treatments.

Tolerance of Mycelium of Different Genotypes of *Phytophthora Infestans* (Mont.) De Bary to Exposure to Temperature below 0°C for Extended Durations.

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INTRODUCTION

Late blight of potato, caused by *Phytophthora infestans* (Mont.) de Bary, is a devastating disease that affects all potato growing regions in the world and has become a major factor adversely affecting potato production in the Northern United States (9). The source of annual epidemics of late blight of potato caused by *P. infestans* has lead to debate as to the relative importance of over wintering sources of inoculum (23). Late blight over winters in potato tubers that are intended for replanting as seed (5,11,16,27), but the infection may also be harbored in waste or cull potato tubers (3,29) or within late blight infected volunteer potatoes returned to the soil during harvest the previous season, although it is generally agreed this source is of minor importance (8,29).

In North America, the probability that infected potato stems or foliage will emerge from an infected tuber is difficult to estimate as several factors can influence the fate of the infected tuber (20,24), temperature being one of the most important (18). The survival of viable host tissue from infection through dormancy to re-emergence the following spring is vital for survival of *P. infestans* (29).

Many investigators have used *in vitro* and soil assays to study the optimal and lethal upper temperatures for growth of *Phytophthora* spp. (2,4,15,28). The survival of *P. nicotianae* chlamydospores in soil was reduced considerably when temperatures were raised above 45°C (4). No studies have been found that examine the ability for *P. infestans* mycelium to survive at temperatures below zero. *P. infestans* can survive within infected tubers at 3°C as stored seed (18), however the fate of mycelium of *P. infestans* within potato tubers exposed to temperatures below 0°C has not been monitored. The objectives of this study were to investigate the ability of different genotypes of *P. infestans* to survive *in vitro* at temperatures below 0°C and to determine the duration of exposure at a range of temperatures below 0°C that was lethal to mycelium.

MATERIALS AND METHODS

Isolate descriptions. Isolates of four genotypes of *P. infestans* were obtained from foliage of potatoes with symptoms of late blight. The genotypes were determined by isozyme analysis (10), mefenoxam sensitivity (6) and mating type and were obtained from Kirk, MI (US1, mefenoxam sensitive, A1 mating type, MI95-6), Kirk, MI (US8, mefenoxam insensitive, A2 mating type, MI95-7, ATCC MYA-1769), Gudmestad, ND (US11, mefenoxam insensitive, A1 mating type, ND207-4) and Kirk, MI (US14, mefenoxam insensitive, A2 mating type, MI96-1). The isolates were maintained on sterile rye seed stock cultures and re-propagated from the long-term storage stock for each experiment on rye agar.

Substrate optimization. Prior to the experiment, several calibrations were performed. Determination of the optimal volume of clarified rye agar added to the 60 mm petri dishes that could be used to optimize the reflectance characteristics for the digital image analysis procedure (described below) was conducted. Clarified rye agar was prepared by washing 100g organically produced rye seed which was boiled for 1 h in dH_2O, strained through cheese cloth to which was added 15g agar, 7.5g sucrose and dH_2O to bring the solution to 1L final volume. Volumes of 5, 10, 15 and 20 ml rye agar were pored into Petri dishes (60 mm diameter) and the reflectance intensity determined by digital image analysis. The scanned images were the rye petri plates without cover lids. The petri plates were placed open-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 glass plate was transferred to a flatbed scanner (HP ScanJet 4c, Hewlett-Packard Co., Houston, TX) controlled by an IBM-compatible PC. A 486DX2-80 CPU and a RAM capacity of 32 MB were adequate for the image processing. Scanner control software (DeskScan II ver. 2.4, Hewlett-Packard, Co., Houston, TX) generated an image of the petri plate agar surfaces against a black background. The image was formed from light reflected from the agar 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 area of the pale rye agar surfaces against the black background, the settings were manually set to 180 units (brightness) and 200 units (contrast) to ensure consistent readings. A photograph-quality image was taken and stored for analysis. A typical image in Tagged Image Format (*.tif) occupies about 1 megabyte. The image files created with the scanner software were loaded into the image analysis software (SigmaScan Pro ver. 5.0.0 build number 3981, **SPSS Science,** 233 S. Wacker Drive, 11th floor, Chicago, IL 60606-6307). The black background has 0 light intensity units (LIU), while pure white has 255 LIU. The clarified rye was pale gray. The image of the clarified rye surface was selected for analysis, and isolated from the adjacent regions of the image. The image was unedited. The area was selected with the “fill” 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 the plate without any growth of the sample. The calibrations resulted in optimal agar volumes of 10 ml substrate/60 mm diameter petri plates with mean ARI = 90.

Determination of developmental stage of sporangia on mycelial plugs after transfer from parent cultures. As the objective of the experiment was to determine the influence of duration of exposure of temperatures less than 0ºC on mycelial survival, it was necessary to determine the length of time for all sporangia to germinate after transfer of mycelial plugs from parent cultures. *P. infestans* cultures of each isolate were grown on sterol-free rye agar plates for 14 days in the dark at 12ºC. Ten 5 mm diameter cores were removed from the growing edge of each of 10 plates. The cores were placed into 10 ml distilled H_2O in test tubes and stirred on a magnetic stirrer for 1 hour to dislodge sporangia. The suspension was strained through four layers of cheesecloth and the concentration of sporangia was calculated using a haemacytometer. The number of non-germinated and germinated sporangia was counted at the time of transfer and again two days after incubation at 4ºC. After two days only empty sporangia were observed in any of the isolates tested and a pre-treatment of two days incubation at 4ºC in the dark was imposed on all freshly transferred cores prior to exposure to temperature treatments.

Temperature exposure studies. The first set of temperature exposure experiments were conducted over a 24 h period. Fifty plates of each isolate were prepared 48 h prior to introduction to the temperature treatment. The plates were labeled with culture ID numbers and exposure times and bound together with parafilm and placed together on a fitted plastic loading tray transferred to a PTC-1 Peltier-effect temperature cabinet controlled by a PELT-3 Peltier-effect temperature controller (Sable Systems International, 2887 Green Valley Parkway #299, Henderson, NV 89014). The PTC-1 chambers were positioned in temperature-controlled environment chambers, 1.8 m^3 volume (Environmental Growth Chambers, Chagrin Falls Ohio, USA) at 5ºC. The PELT-3 Peltier-effect temperature controller was set for the exposure temperature 2 h prior to the start of the experiment. The tray with the culture plates was placed into the PTC-1 Peltier-effect temperature cabinet quickly to minimize temperature increase. Temperature equilibration was measured after the door of the chamber was opened, and at 0ºC set temperature, temperature rose to 5ºC after the door was opened and dropped to -0.3ºC in 1.5 hr. At -3, -5, -10 and -20ºC set temperatures, temperature rose to -1.2, -1.5, -3.5 and -4.8ºC and recovered in 1.1, 1.3, 1.5 and 1.4 h respectively. Exposure times were measured from when the set temperature was reached.

Plates were removed after exposures of 1, 4, 8, 12 and 24 h. Temperature treatments were 0, -3, -5, -10 and -20ºC. After plates were removed from the PTC-1 Peltier-effect temperature cabinet they were stored in the light at 12ºC. After 14 days a sample (replication 1 of the experiment only) of 5 plates was scanned to determine amount of growth of mycelium. The second set of plates (n = 5) was retained for 28 days prior to evaluation. The lids were removed from the plates and the plates were placed face down and images generated (as described above). The experiment was repeated twice over the period from December 2000 to February 2001. The second and third replications of the experiment were evaluated 28 days after the temperature treatments.

The second set of temperature exposure experiments were conducted over a 7 day period. Temperature exposure treatments were selected after analysis of the first experiments (exposure over a 24 h period). The experiment was set up as described above except plates were removed from the PTC-1 Peltier-effect temperature cabinet after exposures of 1, 2, 3, 4 and 5 days. Temperature treatments were 0, -3 and -5ºC. The experiment was repeated twice over the period from March to April 2001. Plates were scanned 28 days after removal from the temperature exposure treatment.

Data analysis. The relation between the ARI and weight of individual cultures was determined by linear regression (SigmaStat ver. 2.03, Jandel Scientific, San Rafael, CA). Interactions between temperature and duration of exposure were determined by three-way ANOVA for each replication of both experiments (24 h and 120 h maximum exposure) and if the replications were not significantly different at $p = 0.05$ the data were combined into a single analysis and an LSD generated for comparison of all treatments. To determine if mycelium survived exposure to the thermal treatment, the ARI of treated mycelium were compared to the ARI of a non-inoculated control (negative control) which was added to each exposure treatment using Bonferri analysis (SigmaStat ver. 2.03, Jandel Scientific, San Rafael, CA).

RESULTS

Temperature exposure studies. Survival of isolates of different genotypes of *P. infestans* exposed to temperatures from 0 to -20ºC for different durations up to 24 hours measured as ARI (LIU) of images of cultures incubated for 4 weeks after exposure at 12ºC is shown in Table 1. All isolates survived exposure to 0 and -3ºC for up to 24 h exposure except isolate 207-4 (US 11, A1) which did not survive exposure to -3ºC for 12 or 24 h. Exposure to -5ºC for up to 24 h was not lethal for the US8 genotype but 24 h exposure was lethal to the US14 genotype which survived exposure up to 12 h. The A1 genotype US1 was not able to survive exposure of greater than 1 h at -5oC but the genotype US11 survived after exposure of up to 8 h. All genotypes except US11 survived 1 h exposure to –10 ºC and both A2 genotypes survived exposure to –10 ºC up to 4 h. No genotypes survived exposure to -20ºC.

All isolates of the genotypes of *P. infestans* survived *in vitro* exposure up to 120 h at 0 ºC (Table 2). Both A1 genotypes survived exposure of up to 48 h at –3ºC and the US8 genotype survived exposure to 72 h but the US14 genotype survived after 120 h exposure. A1 genotypes did not survive exposure of 24 h at –5ºC but both A2 genotypes showed some potential for recovery up 24 h after exposure to -5ºC and US14 sometimes recovered even after 96 h exposure (Table 2).

DISCUSSION

The digital method of assessment of survival of mycelium of *Phytophthora infestans in vitro* relies on light reflectance from developing mycelium and therefore an increased average reflective intensity (ARI). Other studies have made use of light reflectance from biological materials that differ in the darkness of the sample e.g. Niemira et al., (1999) compared the differences between a common non-destructive visual rating system with the destructive digital method showed the potential for the use of computerized image generation and analysis for estimation of the amount and rate of tuber tissue infection caused by *P. infestans*. Image analysis is quantitative and objective and scanned images can be stored for future comparisons. Consistency of sample preparation was an essential element in the scanning method.

The relation between the ARI and mycelium weight was direct and established that ARI is a good estimation of survival of the temperature exposed samples. Radial growth of mycelium on plates may overestimate survival potential especially if the mycelium is growing sparsely. In this analysis, only the difference from non-inoculated plates was determined as an indicator of survival potential after exposure of mycelium to a range of temperatures for different durations. Although it is not possible to determine beyond doubt that some sporangia survived the pre-treatments prior to temperature exposure, all steps to ensure minimal production of sporangia in the parent cultures was attempted i.e. incubation in the dark at 12ºC on sterol-free growth medium and then acclimatization at 4ºC prior to exposure to the temperature treatment. As only empty sporangia were detected after this pre-treatment it was concluded that the plugs exposed to the temperature treatments consisted only of mycelium. No encysted zoospores were observed with the microscopic investigations.

The apparent increased tolerance of the two A2 genotypes of *P. infestans* to lower temperatures is cause for concern. Reports of increased average temperature in the Great Lakes region of the US has resulted in greater potential for survival of volunteer potatoes in fields and culled potatoes (1) which can potentially harbor inoculum of *P. infestans*.

As the environment in which the mycelium of *P. infestans* survives (potato tubers) is less frequently exposed to temperatures which normally cause substrate breakdown (about –3ºC) the risk of survival of blighted tubers surviving winter also increases. Tolerance to temperature in the range of 0 to -3ºC and the continued use of foliar applications of mefenoxam in potatoes for control of tuber disease such as pink rot caused by *Phytophthora erythroseptica* (25) may have resulted in the predominance of the US8 (A2, mefenoxam resistant) genotype in the Midwestern potato production areas of the US. Different genotypes of *P. infestans* vary in aggressiveness and virulence in foliar infections (19,21). This study supports the view that the US8 genotype is more virulent than those biotypes isolated prior to 1994 (17) and may partially contribute to a mechanism by which this increased virulence can be explained. As few commercial cultivars have substantive field resistance to foliar infection caused by US8 biotypes of *P. infestans* (7,12) the potential for survival of mycelium in tubers and production of initial inoculum in succeeding years is ominous for potato production.

The estimated base temperature for the development of *P. infestans* infection of tuber tissue has been reported to be about 3ºC when tuber tissue was used as substrate (18). Base temperatures refer to the temperature at which development ceases (22)but are not good indicators of survival potential as mechanisms for tolerance to temperatures below the base temperature for development are known to exist in other fungi(26). Tubers are thought to be at greatest risk from infection by *P. infestans*, and perhaps other primary and secondary pathogens, immediately after harvest when tuber pulp temperatures are highest. Tuber vulnerability may persist into the first few weeks of storage prior to adjustment of the tuber tissue to the ambient temperature in store (11). A similar mechanism may occur for volunteer tubers left in fields after harvest.

Further work on the tolerance of mycelium from a wider range of isolates of *P. infestans* representative of genotypes not tested in this study and also of genotypes already tested is underway to determine if this tolerance is typical of the genotypes that have largely replaced the clonal lineage (US1) found prior to 1990. Attempts so far to determine survival of mycelium of *P. infestans* within tubers has failed due to degradation of tuber tissue at -3ºC. In addition, as potato growers have commented on the apparent tolerance to ambient temperature in excess of 30ºC and recovery potential of lesions after exposure to arid conditions (13,14)the tolerance of mycelium to temperatures in excess of 30ºC is also being determined.

ACKNOWLEDGMENTS

This material was prepared with the support from the Michigan Potato Industry Commission.

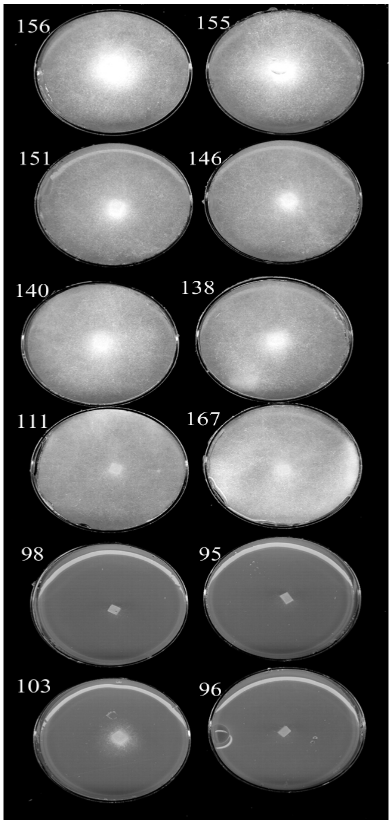

Figure 1. Example of images of *Phytophthora infestans* incubated on plates for 28 days after exposure to different durations of temperature. These are images of Pi95-7 (US8) exposed to -3ºC for different durations then incubated at 12ºC for 28 days. The values are the average reflective intensities (ARI) in light intensity units (LIU) as measured with Sigma Scan. Plates with no detectable growth of mycelium had ARI values of less than 100 LIU. Note the plate at the bottom left of the figure with minimal growth of mycelium and an ARI > 100.

Table 1. Survival of isolates of different genotypes of *P. infestans* exposed to temperatures from 0 to -20°C for different durations up to 24 hours measured as average reflective intensity of images of cultures incubated for 4 weeks after exposure at 12°C.

Isolate identification	Exposure time[a]	Average Reflective Intensity (LIU[b]) of Images Exposure temperature (°C) 0		-3		-5		-10		-20	
95-6	neg con[c]	89		90		90		89		89	
(US 1, A1)	pos con[d]	147	*[e]	146	*	147	*	142	*	142	*
	1	147	*	138	*	139	*	109	*	91	
	4	149	*	136	*	123	*	87		81	
	8	149	*	134	*	108	*	90		92	
	12	146	*	129	*	100		91		91	
	24	142	*	124	*	89		93		89	
$LSD_{0.05}$		8.6		13.0		12.4		9.2		9.4	
95-7	neg con	91		91		93		89		90	
(US 8, A2)	pos con	154	*	149	*	143	*	141	*	144	*
	1	151	*	131	*	133	*	127	*	95	
	4	152	*	136	*	128	*	107	*	82	
	8	150	*	133	*	135	*	96		89	
	12	155	*	123	*	134	*	93		90	
	24	150	*	118	*	104	*	94		90	
$LSD_{0.05}$		8.4		12.1		8.4		9.4		7.4	
207-4	neg con	88		90		90		91		87	
(US 11, A1)	pos con	136	*	126	*	141	*	133	*	120	*
	1	132	*	119	*	122	*	100		85	
	4	137	*	113	*	95		86		80	
	8	131	*	102	*	95		90		79	
	12	125	*	100		95		93		80	
	24	130	*	100		90		92		89	
$LSD_{0.05}$		12.5		11.7		14.9		10.7		6.1	
671	neg con	90		90		90		90		92	
(US 14, A2)	pos con	158	*	145	*	129	*	127	*	128	*
	1	156	*	132	*	128	*	120	*	92	
	4	156	*	131	*	122	*	105	*	88	
	8	147	*	128	*	123	*	97		82	
	12	150	*	119	*	124	*	94		82	
	24	149	*	120	*	97		95		83	
$LSD_{0.05}$		7.3		9.7		7.4		8.0		6.7	

[a] Exposure time (hours) of cultures to treatment temperatures.
[b] Light intensity units of image, 0 = black and 255 = white.
[c] neg con = negative control (non-inoculated agar plug, incubated at 12°C for 24 h).
[d] pos con = positive control (inoculated agar plug, incubated at 12°C for 24 h).
[e] * = Significantly different from negative control calculated for each genotype, temperature and exposure interaction.

Table 2. Survival of isolates of different genotypes of *P. infestans* exposed to temperatures from 0 to -5°C for different durations up to 120 hours measured as average reflective intensity of images of cultures incubated for 4 weeks at 12°C after exposure.

Isolate identification	Exposure time[a]	Average Reflective Intensity (LIU[b]) of Images					
		Exposure temperature (°C)					
		0		-3		-5	
95-6	neg con[c]	92		89		94	
(US 1, A1)	pos con[d]	140	*[e]	152	*	149	*
	24	138	*	145	*	95	
	48	138	*	133	*	98	
	72	136	*	113	*	99	
	96	134	*	97		98	
	120	133	*	97		99	
$LSD_{0.05}$		14.9		11.5		6.9	
95-7	neg con	91		93		94	
(US 8, A2)	pos con	142	*	164	*	140	*
	24	147	*	150	*	112	*
	48	145	*	144	*	95	
	72	143	*	128	*	96	
	96	142	*	99		99	
	120	142	*	100		98	
$LSD_{0.05}$		8.3		12.2		7.6	
207-4	neg con	93		91		93	
(US 11, A1)	pos con	150	*	149	*	144	*
	24	146	*	133	*	98	
	48	149	*	125	*	98	
	72	154	*	103		98	
	96	150	*	103		99	
	120	150	*	105	*	99	
$LSD_{0.05}$		8.2		10.6		5.8	
671	neg con	84		90		91	
(US 14, A2)	pos con	144	*	149	*	139	*
	24	142	*	140	*	106	*
	48	142	*	135	*	98	
	72	140	*	132	*	99	
	96	137	*	110	*	103	*
	120	140	*	109	*	98	
$LSD_{0.05}$		8.0		8.2		5.5	

[a] Exposure time (hours) of cultures to treatment temperatures.
[b] Light intensity units of image, 0 = black and 255 = white.
[c] neg con = negative control (non-inoculated agar plug, incubated at 12°C for 24 h).
[d] pos con = positive control (inoculated agar plug, incubated at 12°C for 24 h).
[e] * = Significantly different from negative control calculated for each genotype, temperature and exposure interaction.

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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 2002).

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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 (12). Unchecked, *P. infestans* can rapidly defoliate plants in the field and can infect potato tubers when spores are washed into the soil (15). Potato late blight control strategies changed following the migration of mefenoxam/metalaxyl-resistant populations of *P. infestans* from Mexico to North America (12) and necessitate cultural control methods and crop protection strategies that rely primarily on protectant foliar fungicide applications (12, 18). 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. In addition, Fry (10, 11) observed that a combination of cultivar resistance and regular applications of protective fungicides reduced foliar late blight infection in potato. There are currently no late blight resistant potato cultivars that meet commercial standards in the United States. However, controlled environment and field trials at Michigan State University have identified certain foreign cultivars and advanced breeding lines (ABL) that are less susceptible to foliar late blight in the absence of fungicides than important cultivars grown and developed in the United States (e.g. Snowden, Atlantic, Russet Burbank) (4, 5, 6, 7). 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.

In April 2001, it was agreed to form an alliance in potato research areas between North Dakota, Minnesota, Wisconsin and Michigan, this has been formally recognized as the Quad State group (now an NCT 190). In 2001, a pilot study was carried out at MSU by Kirk to determine the feasibility of the co-operation. The four breeding programs submitted varieties and a late blight field trial was implemented at the Muck Soils Research Farm, Laingsburg, MI. The results of this co-operation were very positive and have highlighted some of the constraints that growers have on accepting new varieties into their programs. It was agreed to repeat the experiment in 2002.

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. Jacqueline Lee has consistently been one of the most late blight resistant ABL in five years of testing at Michigan State University and was released in 2001 whereas; Snowden has consistently been one of the most susceptible (5,6,7,8). In the present study, any cultivar/ABL with foliar late blight severity measured as the Relative Area Under the Disease Progress Curve [RAUDPC (1)] value that was not significantly higher than that of Jacqueline Lee 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 Snowden 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 Jacqueline Lee but significantly lower than that of Snowden. The potato cultivars/ABL used to assess the efficacy of reduced fungicide application rate varied among years but always included late blight susceptible controls (e.g. Snowden and Atlantic) and cultivars/ABL classified as moderately resistant or resistant to late blight (5,6,7,8). The susceptible cultivar Snowden and the resistant cultivar Jacqueline Lee was used to assess the efficacy of increased fungicide application intervals in combination with reduced application rates of chlorothalonil against potato late blight. The cultivars/ABL included in the trials from 2002 are listed in Table 1.

Residual Contact Fungicides

Field experiments to evaluate the efficacy of various fungicide protection strategies against late blight were conducted during 2001. Fluazinam 5SC (non-commercial formulation, ISK Biosciences Corporation, 5966 Heisley Road, PO Box 8000, Mentor, OH 44061-8000) was used. The manufacturer's recommended application rate (MRAR) was 0.15 ai/ha/application and 1.5 kg ai/ha/season for fluazinam (23). Fungicides were applied with an ATV rear-mounted spray boom (R&D Sprayers, Opelousas, LA, U.S.A.) that traveled at 1 m/s, delivered 230 l H_2O/ha (3.5 kg/cm^2 pressure) with three XR11003VS nozzles per row positioned 30 cm apart and 45 cm above the canopy. In the fungicide application interval and reduced dose rates trial, fluazinam 5SC was applied at 5, 10 and 15 day intervals at 0, 50 and 100% MRAR (16) to the ABL and cultivars described in Table 1. The first fungicide application occurred at 27 days after planting (DAP) (June 27 2002) when potato plants were approximately 15 cm tall. Fungicides were applied until non-treated plots of susceptible controls reached about 100% diseased foliar area. The 5, 10 and 15-day interval treatments received twelve, eight and six applications in 2002, 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 9, 2002 in two-row by 8 m plots (0.9 m row spacing). Fertilizers were applied in accordance with results from soil testing carried out in the spring of each year and about 250 kg N/ha (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 kg/ha boron, manganese and magnesium, respectively were applied as chelated formulations. Cut and whole seed pieces (75-150g) 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 Jacqueline Lee 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 (16) with turbine rotary garden sprinklers (Gilmour Group, Somerset, PA, U.S.A.) at 1055 l H_2O ha/hr and managed under standard potato agronomic practices. Weeds were controlled by hilling and with metolachlor at 2.3 l/ha 10 days after planting (DAP), bentazon salt at 2.3 l/ha, 20 and 40 DAP and sethoxydim at 1.8 l/ha, 60 DAP. Insects were controlled with imidacloprid at 1.4 kg/ha at planting, carbaryl at 1.4 kg/ha, 31 and 55 DAP, endosulfan at 2.7 l/ha, 65 and 87 DAP and permethrin at 0.56 kg/ha, 48 DAP.

Pathogen Preparation and Inoculation.

Zoospore suspensions were made from *P. infestans* cultures of a single isolate, [MI 95-7, US8 genotype, insensitive to mefenoxam/metalaxyl, A2 mating type (13)], the predominant biotype present in the major potato growing regions of North America (12), grown on rye agar plates (3) 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 1×10^3 sporangia/ml using a hemacytometer. Sporangial cultures were incubated for 2-3 hours at 4 C to stimulate zoospore release. All plots were inoculated simultaneously through an overhead sprinkler irrigation system, on July 27, 2002; by injecting the zoospore suspension of *P. infestans* into the irrigation water feed pipeline under 0.5 kg/cm^2 CO_2 pressure and applied at a rate of about 150 ml of inoculum solution/m^2 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 (39 DAI in 2001). Days after inoculation were used as a key reference point for calculation of Relative Area Under the Disease Progress Curve [RAUDPC (1)].

Microclimate Measurement

Climatic variables were measured with a Davis Weather Station equipped with air temperature and humidity sensors located within the potato canopy on site (Spectrum Groweather ET Station, Spectrum Technologies, Inc., 23839 W. Andrew Road, Plainfield, IL 60544). 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 (22) 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 39 DAI. Accumulated DSV from inoculation to 100% senescence of healthy plants was 121. This indicated that environmental conditions were conducive to late blight development (DSV > 18) (22).

2002

Varieties were included from the Quad State potato breeding programs. The RAUDPC values are shown in Table 1. The cultivars and ABL are ranked in order of increasing RAUDPC in untreated plots. Application of fluazinam at full rate of application at a 5-day interval resulted in effective control in all varieties. The mean RAUDPC for non-treated Jacqueline Lee and Torridon was about 0.03, which were classified as resistant. Fungicide treatments did not significantly effect late blight development in either Jacqueline Lee or Torridon

The thresholds used to determine the efficacy of the fungicide and variety combination programs were RAUDPC = 1.79 and 33.1. Therefore, fungicide treatment and variety combinations with an RAUDPC $\leq$ 5.52 (NSD from Snowden, 100% MRAR, 5-day application interval, $RAUDPC_{SF5}$) were defined as effective (E); combinations NSD from the non-treated Snowden control (RAUDPC $\geq$ 29.6) were defined as non-effective (NE); and combinations with RAUDPC values significantly different from both standards were defined as partially effective (PE); (Table 1).

ABL W1355-1 and WI 1386 were effectively protected by application of the fungicide at 100% MRAR on 5 and 10-day intervals and control was PE on a 15-day interval. At the 50% MRAR, treatments were effective on a 5-day interval and PE at a 10 and 15-day intervals. These ABL was the most responsive of the susceptible cultivars/ABL to fungicide applications.

Snowden, MN19515 and MN19350 were effectively protected by the fungicide at 50 and 100% of the fungicide applied at 5-day intervals and PE at 50 and 100% MRAR at 10 and 15-day intervals.

Dakota Pearl and Dakota Rose were effectively protected by the fungicide at 100% MRAR at a 5-day interval. At all other rates and application intervals the fungicide was partially effective (PE).

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 (10,11,21). When conditions were moderately conducive to late blight development (as in 2002), reduced amounts of fluazinam were either fully or partially effective at all application rates tested on all cultivars/ABL compared to the non-treated controls. In some cultivars/ABL, 50% of the MRAR of either 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 usualyr partially effective for controlling late blight at the doses tested. However, in the resistant cultivars Torridon and Jacqueline Lee the fungicides did not reduce the RAUDPC in comparison with untreated plots of these cultivars.

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 (1). 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 2002.

Cultivar/ABL	Rate of fluazinam[1]	Application frequency (days)									
		0			5			10			15		
		RAUDPC[2]									
Torridon	0	0.0	w[3]	R[4]									
	50				0.0	E[5]	w	0.0	E	w	0.0	E	w
	100				0.0	E	w	0.0	E	w	0.0	E	w
Jacqueline Lee	0	0.27	vw	R									
	50				0.06	E	vw	0.13	E	vw	0.13	E	vw
	100				0.13	E	vw	0.06	E	w	0.06	E	
Dakota Pearl	0	28.46	b	I									
	50				10.18	PE	ij	17.68	PE	d	18.97	PE	d
	100				3.94	E	pqrst	15.92	PE	f	14.81	PE	g
W1355-1	0	28.49	b	I									
	50				1.83	E	tuvw	6.08	PE	nopq	7.08	PE	klmno
	100			I	0.94	E	vw	3.92	E	qrst	6.25	PE	mnop
MN19350	0	29.56	b										
	50				3.69	E	rstu	6.60	PE	lmno	10.00	PE	j
	100				2.92	E	stuv	6.71	PE	lmno	9.38	PE	jk
Dakota Rose	0	29.63	b	I									
	50				5.15	PE	opqrs	15.77	PE	e	22.63	PE	c
	100				2.98	E	stuv	14.25	PE	f	18.02	PE	de
WI 1386	0	32.35	a	S									
	50				2.27	E	tuvw	5.52	PE	opqr	8.02	PE	jklmn
	100				1.44	E	uvw	3.44	E	rstu	6.08	PE	nopq
MN19515	0	33.00	a	S									
	50				2.04	E	tuvw	14.54	PE	h	17.98	PE	d
	100				1.65	E	tuvw	8.42	PE	jklm	12.38	PE	hi
Snowden	0	33.19	a	S									
	50				3.44	E	rstu	13.04	PE	g	23.04	PE	j
	100				1.79	E	tuvw	8.88	PE	jkl	9.67	PE	c

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

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

[3] 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.

[4] Susceptibility of nontreated control to late blight; R = Resistant, not significantly different from Jacqueline Lee (nontreated); S = Susceptible, not significantly different from Snowden (nontreated); I = Intermediate, significantly different from both Jacqueline Lee and Snowden (nontreated).

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

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Funding: Industry

POTATO (*Solanum tuberosum* L.'FL1879')
Late blight; *Phytophthora infestans*

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Evaluation of Headline programs for potato late blight control, 2002.

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 5 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 27 Jul. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 21 Aug (9 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. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 20 Jun), Basagran (2 pt/A on 20 Jun and 15 Jul) and Poast (1.5 pt/A on 28 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 Jun), Sevin 80S (1.25 lb/A on 1 and 28 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). Plots were rated visually for percentage foliar area affected by late blight on 27 Jul; 6, 12, 20, 27 Aug [6 days after final application (DAFA)] and 7 Sep (17 DAFA) 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, 27 Jul to 7 Sep, a period of 42 days. Vines were killed with Reglone 2EC (1 pt/A on 8 Sep). Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 7 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation.

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 7 Sep. From 50% emergence to harvest, 100 late blight disease severity values were accumulated (base 80% ambient relative humidity). Taking 31 days after inoculation (DAI) as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Taking 42 DAI as a key reference point, there was almost 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 6 and 8 had significantly greater foliar late blight than all other programs. Program 7 had significantly greater foliar late blight than programs with 5.3% or less foliar late blight. All other programs were not significantly different from each other. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC) compared to the untreated control. Application programs 6 and 8 had significantly higher RAUDPC values than all other programs. All other programs had RAUDPC values less than 1.70 and were not significantly different from each other. Phytotoxicity was not noted in any of the treatments.

Treatment and rate/acre	Foliar late blight (%) 31 DAI[z] 6 DAFA[y]		Foliar late blight (%) 42 DAI 17 DAFA		RAUDPC[x] 0 - 42 DAI	
1 Headline 2SC 0.58 pt (A,B,C,D,E,F,G,H,I)[w]..	1.5	b[v]	3.3	d	0.58	c
2 Headline 2SC 0.77 pt (A,B,C,D,E,F,G,H,I)..	1.6	b	4.5	d	0.72	c
3 Headline 2SC 0.58 pt (A,C,E,G,I) BAS510 70WDG 0.14 lb + BAS545 400SC 0.17 pt + Silwet 0.13 pt (B,D,F,H)..	1.8	b	5.3	d	0.78	c
4 BAS536F 18.7 WP 1.66 lb (A,B,C,D,E,F,G,I)..	2.9	b	6.8	cd	1.12	c
5 BAS536F 18.7 WP 1.66 lb + Silwet 70SC 0.13 pt (A,B,C,D,E,F,G,H,I).........	1.0	b	6.0	cd	0.71	c
6 BAS536F 18.7 WP 1.66 lb (A,C,E,G,I) BAS510 70WDG 0.14 lb + BAS545 400SC 0.17 pt + Silwet 0.13 pt (B,D,F,H)..	7.0	b	25.0	b	3.31	b
7 BAS536F 18.7 WP 1.66 lb (A,C,E,G,I); Bravo WS SC 1.5 pt (B,D,F,H)........	3.6	b	12.0	c	1.70	c
8 Quadris 2.08SC 0.96 pt (A,C,E,G,I); Bravo WS SC 1.5 pt (B,D,F,H)............	8.3	b	23.8	b	3.53	b
9 Untreated..	87.5	a	100.0	a	34.92	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. Maximum value = 100.
[w] Application dates: A= 23 Jun; B= 1 Jul; C= 8 Jul; D= 15 Jul; E= 22 Jul; F= 30 Jul; G= 7 Aug; H= 14 Aug; I= 21Aug.
[v] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Funding: Industry

POTATO (*Solanum tuberosum* L.'FL1879')
Late blight; *Phytophthora infestans*

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Evaluation of Reason, Scala, Gavel, and EBDC-based programs for potato late blight control, 2002.

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 5 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 27 Jul. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 21 Aug (9 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. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 20 Jun), Basagran (2 pt/A on 20 Jun and 15 Jul) and Poast (1.5 pt/A on 28 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 Jun), Sevin 80S (1.25 lb/A on 1 and 28 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). Plots were rated visually for percentage foliar area affected by late blight on 27 Jul; 6, 12, 20, 27 Aug; 3 Sep [13 days after final application (DAFA)] and 7 Sep (DAFA) 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, 27 Jul to 7 Sep, a period of 42 days. Vines were killed with Reglone 2EC (1 pt/A on 8 Sep). Plots (2 x 25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 7 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation.

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 7 Sep. From 50% emergence to harvest, 100 late blight disease severity values were accumulated (base 80% ambient relative humidity). Taking 38 days after inoculation (DAI) as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Program 10 had significantly greater foliar late blight than all other programs. All other programs were not significantly different from each other. Taking 42 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. Program 6 had significantly greater foliar late blight than all other programs. Programs 1 and 4 had significantly less foliar late blight than all other programs except 7 and 9. All remaining programs were not significantly different from each other. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 42 DAI) compared to the untreated control. Application program 6 had a significantly higher RAUDPC value than all other programs with values of 4.17 or lower. Program 10 had a significantly higher RAUDPC value than programs with values of 2.31 or lower. All other programs were not significantly different from each other. Programs 5, 6, 7, 8 and 9 had significantly higher US1 yield than the untreated control and programs 5, 7 and 9 had significantly higher US1 yield than program 2. No other programs had US1 yields significantly different than the untreated control. There were no significant differences among treatments in terms of total yield. Phytotoxicity was not noted in any of the treatments.

Funding: Industry

Treatment and rate/acre	Foliar late blight (%) 38 DAI[z] 13 DAFA[y]	42 DAI 17 DAFA	RAUDPC[x] 0 - 42 DAI	Yield (cwt/A) US1	Total
1 Bravo WS 6SC 0.76 pt (A,B,C); 1.5 pt (D,E,F,G,H,I)[w]............................	4.5 d[v]	13.8 d	2.72 cd	237 abc	324 a
2 Bravo WS 6SC 0.76 pt (A,B,C) Reason 4SC 0.75 pt + Bond 3.8SC 0.25 pt (D,E,F,G,H,I).........................	4.5 D	22.5 c	3.44 cd	230 ab	301 a
3 Bravo WS 6SC 0.76 pt (A,B,C) Reason 4SC 0.51 pt + Scala 3.2SC 0.64 pt (D,E,F,G,H,I)..........................	4.5 D	13.8 d	1.83 d	248 abc	339 a
4 Bravo WS 6SC 0.76 pt (A,B,C) Reason 4SC 0.51 pt + Bond 3.8SC 0.25 pt (D,E,F,G) Bravo WS 6SC 0.76 pt + Previcur 6SC 1.2 pt (H,I)...................................	7.8 cd	21.3 c	2.48 cd	240 abc	322 a
5 Bravo WS 6SC 0.76 pt (A,B,C,H,I) Bravo WS 6SC 0.76 pt + Previcur 6SC 1.2 pt (H,I)...................................	8.3 cd	21.3 c	3.50 cd	274 c	346 a
6 TD 2390 5.8WDG 6.0 lb (A,B,C,D,E,F,G,H,I)..	8.3 cd	48.8 b	6.87 b	261 bc	331 a
7 Penncozeb 75WP 2.0 lb (A,B,C,D,E,F,G,H,I)...	9.0 cd	20.0 cd	3.01 cd	271 c	335 a
8 Gavel 75WDG 6.0 lb (A,B,F,G,H,I) Dithane RS 75DF 2.0 lb (C,D,E)...	9.5 cd	23.8 c	3.22 cd	251 bc	336 a
9 Gavel 75WDG 6.0 lb (A,B,C,D,E,F,G,H,I)...	10.8 C	17.5 cd	2.31 d	277 c	353 a
10 Dithane RS 75DF 2.0 lb (A,B,C,D,E,F,G,H,I)..	16.3 B	23.8 c	4.17 c	239 abc	314 a
11 Untreated..	91.5 A	100.0a	27.60a	210 a	280 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. Maximum value = 100.
[w] Application dates: A= 23 Jun; B= 1 Jul; C= 8 Jul; D= 15 Jul; E= 22 Jul; F= 30 Jul; G= 7 Aug; H= 14 Aug; I= 21Aug.
[v] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Funding: Industry

POTATO (*Solanum tuberosum* L.'Pike')
Late blight; *Phytophthora infestans*
Early blight; *Alternaria solani*
White mold; *Sclerotinia sclerotiorum*
Gray mold; *Botrytis cinerea*

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Evaluation of Sonata-based products and fungicide programs for foliar disease control, 2002

Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 5 Jun into two-row by 25-ft plots (34-in row spacing) replicated four times in a randomized complete block design. The two-row beds were separated by a five-foot unplanted row. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 21 Aug (total 9 applications) from 1 Jul to 27 Aug with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 20 Jun), Basagran (2 pt/A on 20 Jun and 15 Jul) and Poast (1.5 pt/A on 28 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 Jun), Sevin 80S (1.25 lb/A on 1 and 28 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). Plots were rated visually for percentage foliar area affected by early blight and white mold on 18, 31 Jul; 24 Aug and 26 Sep. A single evaluation of foliar late blight and Botrytis foliar blight was made on 26 Sep. The relative area under the disease progress curve was calculated for each treatment from 30 day after planting (DAP) until 113 DAP, a period of 83 days. Vines were killed with Reglone 2EC (1 pt/A on 3 Oct). Plots (25-ft row) were harvested on 12 Oct and individual treatments were weighed and graded. Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 7 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation.

Early blight developed slowly during Jul and Aug then increased during Sep, but untreated controls only reached about 20% foliar area affected for early blight 113 DAP. Taking 113 DAP as a key reference point all application programs reduced the early blight foliar infection significantly compared to the untreated control. Programs 9 and 10 had significantly less foliar early blight than programs with 9.5% or more foliar early blight. Taking 30 - 113 DAP as a disease development period, all programs had significantly less foliar early blight than the untreated control. Program 9 had the least early blight over the evaluation period and significantly less than programs 1, 2, 3, 4, 5 and 7. Program 10 had significantly less early blight over the evaluation period than programs 1, 2, 3, 4 and 7. Programs 1, 2 and 7 had the most early blight over the evaluation period but were not significantly different from programs 3, 4 and 5. White mold developed slowly during Jul and Aug then increased during Sep, but untreated controls only reached about 16% stem area affected 113 DAP. Taking 113 DAP as a key reference point all application programs reduced stem white mold significantly compared to the untreated control. Application program 8 had the least stem white mold (2.5% severity) but was not significantly different from programs 1, 2, 3, 5 and 6. There was no significant difference among programs with 3.8 to 7.5% stem white mold (programs 1, 2, 3, 5, 6, 7 and 10). There was no significant difference among programs with 7.5 to 9.5% stem white mold (programs 4, 9 and 10). Taking 30 - 113 DAP as a disease development period, all programs had significantly less stem white mold than the untreated control. Program 8 had the least white mold over the evaluation period and significantly less than programs 4, 7, 9 and 10 but not significantly different from programs 1, 2, 3, 5 and 6. Late blight spread to the trial area from adjacent trials in which late blight was present about 90 DAP. Untreated control plots had an average of 31.3% foliar late blight 113 DAP. All programs except program 1 had significantly less foliar late blight compared to the untreated control. Programs 6, 7 and 9 had significantly less foliar late blight than all other programs. Gray mold reached about 35% in the untreated control 113 DAP and all application programs reduced the gray mold foliar infection significantly compared to the untreated control. Programs 8 and 9 had significantly less gray mold than programs with 10.8% or more gray mold. Program 7 had significantly greater gray mold than all other programs except program 2. Yield was not correlated with increasing severity of foliar early blight, white mold, late blight or gray mold and there was no significant difference among any treatments in terms of marketable yield. Phytotoxicity was not noted in any of the treatments.

Funding: Industry

Treatment and rate/acre	Foliar early blight (%) 113 DAP[z]	Foliar early blight (%) RAUDPC[y] 30 - 113 DAP	Stem white mold (% severity) 113 DAP	Stem white mold (% severity) RAUDPC 30 - 113 DAP	Foliar late blight (%)[x] 113 DAP	Foliar gray mold (%)[w] 113 DAP	Yield (cwt/A) US1
1 QRD 286 1SC 4 pt (A,B,C,D,E,F,G,H,I)[v]..............	12.5 b[u]	5.0 b	3.8 de	2.5 d	26.3 ab	6.0 def	315 a
2 QRD 286 1SC 8 pt (A,B,C,D,E,F,G,H,I)................	12.5 b	5.0 b	4.0 de	2.8 cd	21.3 bcd	13.3 bc	321 a
3 QRD 137 1WP 2 lb + Kocide 2000 50DF 2 lb (A,B,C,D,E,F,G,H,I)..........	9.5 b	3.9 bc	4.3 cde	2.7 cd	18.8 bcd	11.3 cd	351 a
4 QRD 137 1WP 4 lb + Kocide 2000 50DF 2 lb (A,B,C,D,E,F,G,H,I)..........	9.5 bc	3.8 bcd	9.5 b	5.3 b	22.5 bc	11.3 cd	353 a
5 Quadris 2SC 0.38 pt + Bravo WS 2SC 1.5 pt (A,C) QRD 286 1SC 8 pt (B,D) Bravo WS 2SC 1.5 pt (E,F,G,H,I)...........................	8.8 bcd	3.5 bcde	5.0 cde	3.3 bcd	13.8 d	10.8 cd	350 a
6 Quadris 2SC 0.38375 pt + Bravo WS 2SC 1.5 pt (A,C) Bravo WS 2SC 1.5 pt (D,E,F,G,H,I)......................	7.5 cd	2.9 cdef	4.3 cde	2.9 cd	2.5 e	10.0 cde	323 a
7 Penncozeb 75DF 2 lb (A,B) Topsin-M 70WP 1 lb + Penncozeb 75DF 2 lb (C,D) Bravo WS 2SC 1.5 pt (E,F,G,H,I)...........................	12.5 b	4.8 b	5.0 cd	3.6 bc	4.5 e	17.5 b	331 a
8 BAS510 70WDG 0.41 lb (A,B,C,D,E,F,G,H,I).......	5.0 cd	2.0 def	2.5 e	1.4 d	16.3 cd	4.5 ef	348 a
9 Headline 2SC 0.38 pt (A,B,C,D,E,F,G,H,I)............	4.3 d	1.6 f	8.3 bc	4.6 bc	3.3 e	4.3 f	344 a
10 Quadris 2SC 0.38 pt (A,B,C,D,E,F,G,H,I)..............	4.5 d	1.9 ef	7.5 bcd	4.4 bc	15.8 cd	8.8 cdef	357 a
11 Untreated..	22.5 a	8.9 a	16.3 a	9.0 a	31.3 a	35.0 a	322 a

[z] Days after planting (5 Jun).
[y] RAUDPC, relative area under the disease progress curve calculated from 30 DAP to 113 DAP.
[x] Late blight leaf area diseased, inoculum spread from inoculated plots within 10 m of trial plot, [*Phytophthora infestans* (US8, A2 mating type, mefenoxam-insensitive)].
[w] *Botrytis cinerea*, natural inoculum, percent leaf area diseased.
[v] Application dates: A= 23 Jun; B= 1 Jul; C= 8 Jul; D= 15 Jul; E= 22 Jul; F= 30 Jul; G= 7 Aug; H= 14 Aug; I= 21Aug.
[u] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Funding: Industry

POTATO (*Solanum tuberosum* L.'FL1879')
Late blight; *Phytophthora infestans*

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Evaluation of Headline, Ranman, EBDC and chlorothalonil-based programs for potato late blight control, 2002.

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 5 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 27 Jul. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 21 Aug (9 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. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 20 Jun), Basagran (2 pt/A on 20 Jun and 15 Jul) and Poast (1.5 pt/A on 28 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 Jun), Sevin 80S (1.25 lb/A on 1 and 28 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). Plots were rated visually for percentage foliar area affected by late blight on 27 Jul; 6, 12, 20, 27 Aug [6 days after final application (DAFA)] and 7 Sep (17 DAFA) 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, 27 Jul to 7 Sep, a period of 42 days. Vines were killed with Reglone 2EC (1 pt/A on 8 Sep). Plots (2 x 25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 7 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation.

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 7 Sep. From 50% emergence to harvest, 100 late blight disease severity values were accumulated (base 80% ambient relative humidity). Taking 31 days after inoculation (DAI) as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Programs 12 and 15 had significantly greater foliar late blight than programs with less than 1.75% foliar late blight. Taking 42 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. Program 12 had significantly greater foliar late blight than all other programs except 1 and 15. Programs 1 and 15 had significantly greater foliar than late blight programs with 5.0% foliar late blight. Programs 2, 5, 11 and 22 had significantly more foliar late blight than programs with less than 3.75% foliar late blight. All other programs were not significantly different from each other. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 37 DAI) compared to the untreated control. Application programs 12 had a significantly higher RAUDPC value than all other programs with values below 0.6. All other programs except program 15 had RAUDPC values < 1.19 and were not significantly different from each other. All programs had significantly greater US1 yield compared to the untreated control. There were no significant differences between programs with US1 yield from 245 to 278 cwt/A and programs with US1 yield from 229 to 260 cwt/A. All programs except program 19 had significantly greater total yield compared to the untreated control. There were no significant differences between programs with total yield from 292 to 333 cwt/A and programs from 316 to 358 cwt/A. Phytotoxicity was not noted in any of the treatments.

Funding: Industry

	Treatment and rate/A	Foliar late blight (%) 31 DAI[z] 6 DAFA[y]	Foliar late blight (%) 42DAI 13 DAFA	RAUDPC[x] 0 - 42 DAI	Yield (cwt/A) US1	Yield (cwt/A) Total
1	Echo ZN 6SC 2.13 pt (A,B,C,D,E,F,G,H,I)[w]	2.62 bcd[v]	9.00 bc	1.19 bcd	275 a	357 a
2	Echo ZN 6SC 1.5 pt + Quadris 2.08SC 0.28 pt (A,C) Echo ZN 6SC 1.5 pt (B,D,E,H.I) Polyram 80WP 2.0 lb + Super Tin 80WP 0.23 lb (F,G)	1.60 cd	6.50 cd	0.81 bcd	278 a	354 a
3	Echo ZN 6SC 2.13 pt (A,B,D,F,H,I);Gem 50WP 0.19 lb (C,E,G)	1.75 cd	5.00 de	0.73 bcd	259 abcd	342 ab
4	Ranman 40SC 0.13 pt + Silwet I-77 6SC 0.1 pt (A,B,C,D,E,F,G,H,I)	1.75 cd	5.00 de	0.72 bcd	240 bcd	318 abc
5	Ranman 40SC 0.17 + Silwet I-77 6SC 0.1 pt (A,B,C,D,E,F,G,H,I)	3.25 bc	6.50 cd	1.11 bcd	246 abcd	316 abc
6	Ranman 40SC 0.13 pt + Silwet I-77 6SC 0.1 pt (A,B,D,F,H,I) BAS536F 18.7 WP 1.66 lb (C,E,G)	0.87 cd	4.50 de	0.53 cd	237 cd	323 abc
7	Ranman 40SC 0.17 pt + Silwet I-77 6SC 0.1 pt (A,B,D,F,H,I) BAS536F 18.7 WP 1.66 lb (C,E,G)	0.80 d	3.25 e	0.41 cd	276 a	344 ab
8	Ranman 40SC 0.13 pt + Silwet I-77 6SC 0.1 pt (A,D,G) Headline 2SC 0.77 pt (B.E.H) BAS550 50WP 0.4 lb + Polyram 80WP 2.0 lb (C,F,I)	0.77 d	2.50 e	0.34 cd	273 ab	337 ab
9	Ranman 40SC 0.13 pt (A,C,E,G,I); Headline 2SC 0.77 pt (B.D,F,H)	1.07 cd	3.75 e	0.49 cd	264 abc	335 ab
10	Headline 2SC 0.77 pt (A,C); Bravo WS 6SC 1.5 pt (B,H) Polyram 80WP 2.0 lb + Agri Tin 80WP 0.16 lb (D,E,F,G.I)	1.58 cd	4.75 de	0.73 bcd	269 ab	335 ab
11	Headline 2SC 0.77 pt (A,C); Bravo WS 6SC 1.5 pt (B,H) Polyram 80WP 2.0 lb + Acrobat 50WP 0.4 lb (D,E,F,G.I)	2.35 bcd	6.75 cd	0.97 bcd	237 cd	321 abc
12	Bravo WS 6SC 1.5 pt (A,C,E,G,I) Messenger 3WDG 0.38 lb (B.D,F,H)	4.25 b	13.00b	1.90 b	258 abcd	340 ab
13	Bravo WS 6SC 1.5 pt + Champ DP 4.6FL2.67 pt (A,B,C,D) Dithane RS 75DF 1.5 lb + Champ DP 4.6FL2.0 pt + Agri Tin 80WP 0.13 lb (E,F,G.I)	1.12 cd	3.00 e	0.45 cd	230 cd	306 bc
14	Bravo WS 6SC 1.5 pt + Champ DP 4.6FL2.67 pt (A,B,C,D) Dithane RS 75DF 1.5 lb + Champ DP 4.6FL2.0 pt + Phostrol 53.6SC 8.0 pt (E,F,G.I)	0.83 cd	2.00 e	0.31 cd	260 abcd	337 ab
15	Bravo WS 6SC 1.5 pt + Champ DP 4.6FL2.67 pt (A,B,C,D) Champ DP 4.6FL2.0 pt + Phostrol 53.6SC 8.0 pt (E,F,G.I)	4.25 b	9.00 bc	1.53 bc	237 cd	324 abc
16	Quadris 2.08SC 0.4 pt + Bravo WS SC 1.5 pt (A) Bravo WS 6SC 1.5 pt + Champ DP 4.6FL2.67 pt (B,D) Bravo WS 6SC 1.5 pt + Acrobat 50WP 0.4 lb (C,H) Dithane RS 75DF 1.5 lb + Champ DP 4.6FL2.0 pt + Agri Tin 80WP 0.16 lb + Phostrol 53.6SC 8.0 pt (E,F,G.I)	0.65 d	1.50 e	0.24 d	251 abcd	327 abc
17	Quadris 2.08SC 0.4 pt + Equus SC 1.5 pt (A); Equus SC 1.5 pt (B,D) Equus SC 1.5 pt + Acrobat 50WP 0.4 lb (C,H) Equus SC 1.5 pt + Kocide4.5FL 2.67 pt (E,F,G.I)	1.75 cd	5.25 cde	0.73 bcd	247 abcd	317 abc
18	Quadris 2.08SC 0.4 pt + Equus SC 1.5 pt (A,C,E); Equus SC 1.5 pt (B,D) Manzate 75WP 2.0 lb + Super Tin 80WP 0.16 lb (F,G,H,I)	0.70 d	2.00 e	0.29 cd	245 abcd	308 bc
19	Quadris 2.08SC 0.4 pt + Equus SC 1.5 pt (A,C,E) Equus SC 1.5 pt (B,D) Equus SC 1.5 pt + Super Tin 80WP 0.16 lb (F,G,H,I)	1.20 cd	4.75 de	0.60 cd	229 d	292 cd
20	Headline 2SC 0.77 pt + Polyram 80WP 2.0 lb (A,B,C) Ranman 40SC 0.13 pt + Polyram 80WP 2.0 lb (D,E,F,G) Polyram 80WP 2.0 lb + Agri Tin 80WP 0.16 lb (H,I)	1.20 cd	3.50 e	0.50 cd	241 bcd	309 bc
21	Headline 2SC 0.77 pt + Polyram 80WP 2.0 lb (A,B,C) Acrobat 50WP 0.4 lb + Polyram 80WP 2.0 lb (D,E,F,G) Polyram 80WP 2.0 lb + Agri Tin 80WP 0.16 lb (H,I)	1.25 cd	4.00 de	0.57 cd	273 ab	348 ab
22	Headline 2SC 0.77 pt + Polyram 80WP 2.0 lb (A,B,C) Curzate 60DF 0.2 lb + Polyram 80WP 2.0 lb (D,E,F,G) Polyram 80WP 2.0 lb + Agri Tin 80WP 0.16 lb (H,I)	1.50 cd	8.75 cd	0.99 bcd	234 cd	316 abc
23	Headline 2SC 0.77 pt + Polyram 80WP 2.0 lb (A,B,C) Previcur 6SC 1.2 pt + Polyram 80WP 2.0 lb (D,E,F,G) Polyram 80WP 2.0 lb + Agri Tin 80WP 0.16 lb (H,I)	0.92 cd	4.00 de	0.52 cd	264 ab	333 abc
24	Untreated	83.75a	100.0a	27.86a	182 e	263 d

[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. Maximum value of 100.
[W] Application dates: A= 23 Jun; B= 1 Jul; C= 8 Jul; D= 15 Jul; E= 22 Jul; F= 30 Jul; G= 7 Aug; H= 14 Aug; I= 21Aug.
[V] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Funding: Industry

POTATO (*Solanum tuberosum* L.'FL1879')
Late blight; *Phytophthora infestans*
Early blight; *Alternaria alternata*

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Evaluation of Tanos, Famoxate and Curzate programs for potato late blight and Alternaria spp. control, 2002.

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 5 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 27 Jul. All fungicides in this trial were applied on a 7-day interval from 23 Jun to 21 Aug (9 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. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 20 Jun), Basagran (2 pt/A on 20 Jun and 15 Jul) and Poast (1.5 pt/A on 28 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 Jun), Sevin 80S (1.25 lb/A on 1 and 28 Jul), Thiodan 3EC (2.33 pt/A on 1 and 21 Aug) and Pounce 3.2EC (8 oz/A on 28 Jul). Plots were rated visually for percentage foliar area affected by late blight on 27 Jul; 6, 12, 20, 27 Aug; 3 Sep [13 days after final application (DAFA)] and 7 Sep (17 DAFA) when there was 100% foliar infection in the untreated plots and for Alternaria spp. foliar blight on 7 Sep (17 DAFA). The relative area under the disease progress curve was calculated for each treatment from date of inoculation, 27 Jul to 7 Sep, a period of 42 days. Vines were killed with Reglone 2EC (1 pt/A on 8 Sep). Plots (2 x 25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Maximum and minimum air temperature (°F) were 92.1 and 64.4 (Jun), 92.5 and 72.5 (Jul), 88.7 and 68.6 (Aug) and 91.3 and 64.8. Maximum and minimum soil temperature (°F) were 82.0 and 70.8 (Jun), 84.6 and 74.2 (Jul), 84.3 and 74.2 (Aug) and 82.3 and 69.3 (to 7 Sep). Precipitation was 0.32" (Jun), 1.14" (Jul), 0.41" (Aug) and 0.0" (to 7 Sep). Plots were irrigated to supplement precipitation to about 1"/A/4 day period with overhead sprinkler irrigation.

Late blight developed slowly after inoculation then rapidly during Aug and untreated controls reached 100% foliar infection by 7 Sep. From 50% emergence to harvest, 100 late blight disease severity values were accumulated (base 80% ambient relative humidity). Taking 38 days after inoculation [(DAI), 13 DAFA] as a key reference point, all fungicide programs reduced the foliar late blight significantly compared to the untreated control. Programs 1, 4, 5 and 10 had significantly greater foliar late blight than programs with less than 4.5% foliar late blight. All other programs were not significantly different from each other. Taking 42 DAI (17 DAFA)as a key reference point, there was almost complete defoliation of the untreated control due to late blight and all fungicide programs had significantly less foliar late blight than the untreated control. Program 4 had significantly greater foliar late blight than all other programs with 30.0% or less foliar late blight and program 10 with programs with 20.0% or less foliar late blight. Programs 1, 5, 6 and 9 were not significantly different from each other but programs 1 and 5 had significantly greater foliar late blight than programs with 11.5% or less foliar late blight All other programs were not significantly different from each other. All fungicide programs significantly reduced the average amount of foliar late blight over the season (RAUDPC, 0 to 42 DAI) compared to the untreated control. Application programs 4 and 10 had significantly higher RAUDPC values than all other programs with values below or equal to 1.99. Programs 1 and 5 had significantly higher RAUDPC values than program 3. *Alternaria alternata* was present throughout the season and programs 8 and 9 had significantly more *A. alternata* lesions than any other programs. Programs 6 and 11 had the lowest amount of *A. alternata* blight, significantly less than programs 1, 3, 7, 8, 9 and 10 but were not significantly different from any other programs. There were no significant differences in yield between any treatments. Phytotoxicity was not noted in any of the treatments.

Funding: Industry

Treatment and rate/A	Foliar late blight (%) 38 DAI[z] 13 DAFA[b]	42 DAI 17 DAFA	RAUDPC[x]	Foliar *Alternaria alternata* (%) 17 DAFA	Yield (cwt/A) US1
1 KQ667 68.8WDG 1.0lb (A,C); Bravo WS 6SC 1.5pt (B) Curzate 60DF 0.21 lb + Bravo WS 6SC 1.0 pt (D,F,H) KQ667 68.8WDG 1.0lb + Curzate 60DF 0.21 lb (E,G,I)[w]	9.5 bc[v]	18.8 d	3.28 bc	31.3 bc	322 a
2 KQ667 68.8WDG 1.5lb (A,C); Bravo WS 6SC 1.5pt (B) Curzate 60DF 0.21 lb + Bravo WS 6SC 1.0 pt (D,F,H) KQ667 68.8WDG 1.5lb + Curzate 60DF 0.21 lb (E,G,I).........	3.5 d	8.3 e	1.25 cd	13.8 de	337 a
3 KQ667 68.8WDG 2.0lb (A,C); Bravo WS 6SC 1.5pt (B) Curzate 60DF 0.21 lb + Bravo WS 6SC 1.0 pt (D,F,H) KQ667 68.8WDG 2.0lb + Curzate 60DF 0.21 lb (E,G,I).........	2.8 d	7.5 e	1.03 d	25.0 bcd	310 a
4 KQ667 68.8WDG 1.5lb (A,C); Manzate 75WP 2.0 lb (B) Curzate 60DF 0.21 lb + Manzate 75WP 2.0 lb (D,F,H) KQ667 68.8WDG 1.5lb + Curzate 60DF 0.21 lb (E,G,I).........	12.5 b	38.8 b	4.89 b	12.5 de	332 a
5 KP481 50WDG 0.31 lb + Manzate 75WP 1.0 lb (A,C) Bravo WS 6SC 1.5pt (B) Curzate 60DF 0.21 lb + Bravo WS 6SC 1.0 pt (D,F,G,H,I) KP481 50WDG 0.5 lb + Manzate 75WP 1.0 lb + Curzate 60DF 0.21 lb (E)..	10.0 b	20.0 d	3.45 bc	17.5 cde	334 a
6 Quadris 2.08SC 0.78 pt (A,C); Bravo WS 6SC 0.75pt (B) Curzate 60DF 0.21 lb + Bravo WS 6SC 1.0 pt (D,F,G,H,I) Curzate 60DF 0.21 lb + Quadris 2.08SC 0.78 pt (E)..............	3.0 d	12.0 de	1.59 cd	8.8 e	344 a
7 Bravo WS 6SC 1.5 pt (A,B,C) Curzate 60DF 0.21 lb + Bravo WS 6SC 1.0 pt (D,E,F,G,H,I).	4.0 d	10.8 e	1.57 cd	37.5 b	330 a
8 Manzate 75WP 1.5 lb (A,B); Quadris 2.08SC 0.39 pt (C) Curzate 60DF 0.21 lb + Equus ZN 6SC 1.5 pt (D,E,F,G,H,I)..	4.5 d	11.5 e	1.59 cd	41.3 a	320 a
9 Manzate 75WP 1.5 lb (A,B); Quadris 2.08SC 0.39 pt (C) Equus ZN 6SC 1.5 pt + Super Tin 80WP 0.16 lb (D,E,F,G,H,I)………………………	5.0 cd	14.5 de	1.99 cd	55.0 a	367 a
10 Quadris 2.08SC 0.39 pt (A,C) Curzate 60DF 0.21 lb + Polyram 80DF 2.0 lb (B,D,E,F,G,H,I)………………………..	11.3 b	30.0 c	4.32 b	27.5 bcd	355 a
11 KQ667 68.8WDG 1.5lb (A,B,C) KQ667 68.8WDG 1.5lb + Curzate 60DF 0.21 lb (D,E,F,G,H,I)…………………………	2.5 d	10.3 e	1.28 cd	7.5 e	321 a
12 Untreated...	96.5 a	99.5 a	40.8 a	nd[u]	250 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. 0-42 DAI

[w] Application dates: A= 23 Jun; B= 1 Jul; C= 8 Jul; D= 15 Jul; E= 22 Jul; F= 30 Jul; G= 7 Aug; H= 14 Aug; I= 21Aug.

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

[u] No data as vines were defoliated by late blight.

Funding: MPIC

Summary Report for the 2001-2002 Dr. B. F. (Burt) Cargill Potato Demonstration Storage

Brian Sackett, Chris Long, Dick Crawford, Todd Forbush (Techmark, Inc.), Steve Crooks, Greg Perkins, Tim Young, Jason Walther, Don Smucker (Montcalm CED) Troy Sackett, Randy Styma and Paul Main

Introduction

This is a summary report of the 2001-2002 Dr. B.F. (Burt) Cargill Potato Demonstration Storage Annual Report Volume 1. This report is design to provide a short summary of the 2001-2002 storage committee activities. To obtain a copy of the full 2001-2002 Demonstration Storage Report please contact the Michigan Potato Industry Commission office (517-669-8377) or Chris Long at Michigan State University. The full report will be provided to you free of charge.

Summary and Highlights

The 2001-2002 storage season marked a time for expansion of the objectives for the Storage and Handling Committee. Previously, the committee's objective was to evaluate the storage protocols and storage management practices of commercial potato varieties utilized by Michigan growers. In the 2001-2002 storage season, the committee broadened their objectives by utilizing the storage performance of novel potato lines, from national breeding programs, as a selection criteria to evaluate the adaptability of new lines to the Michigan potato industry. Currently the Storage and Handling Committee's objectives are twofold: 1.) to develop and evaluate storage techniques and provide storage recommendation for commercially available varieties and 2.) to evaluate promising new breeding material for its benefit to the Michigan potato industry through storage profile development.

In order to effectively evaluate multiple breeding lines at one time, Bin #1 was converted to a box bin storage. Bin #1 can hold 20, 10 cwt. boxes which gives the committee the flexibility to develop storage profiles on 20 varieties at any one time. From the results from the box bin, three lines were selected to be grown in the bulk bins for the 2002-2003 storage season. Those lines are B0766-3, Liberator (MSA091-1) and W1201. The results of these storage profiles are described in the full report.

This storage season marked the first time a variety developed at Michigan State University has reached a level for commercial processing. 550 cwt. of the breeding line MSF099-3 was processed at UTZ quality Foods on April 4, 2002. This line was stored in bulk bin #2. Overall, the variety performed well in storage in spite of some field frost prior to bin loading. As a result of its satisfactory performance, MSF099-3 was selected to be stored in a bulk bin in the 2002-2003 storage season. Bins #3 and #4 contained FL1879. Both bins performed very well into April with excellent chip quality.