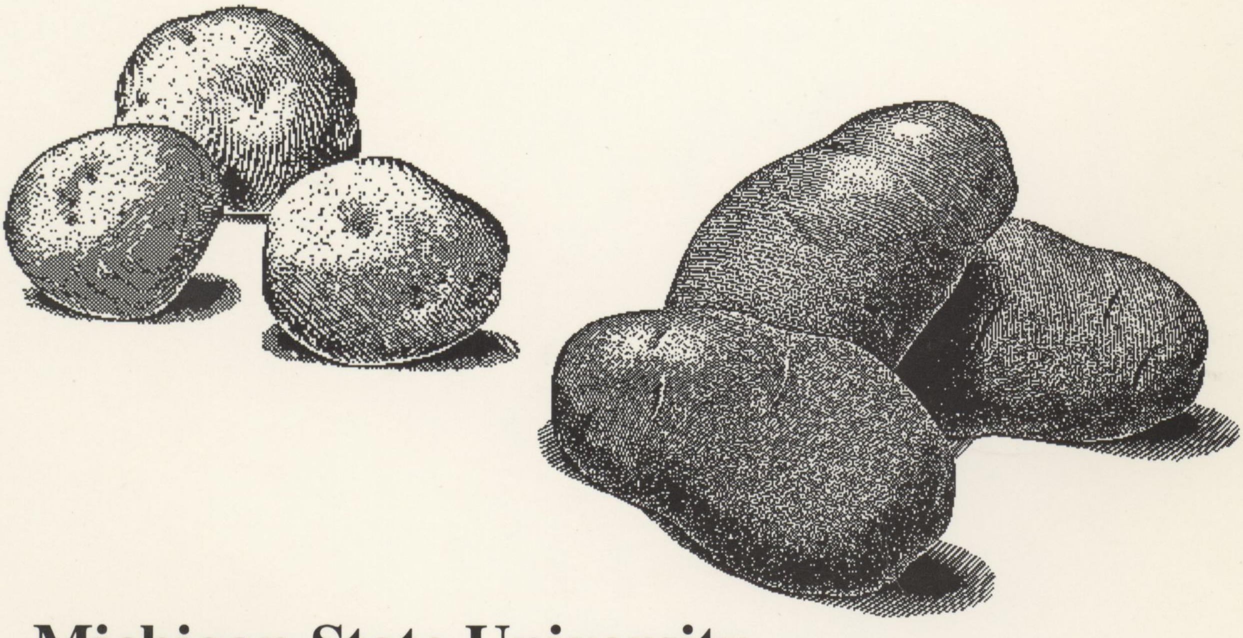
2000
MICHIGAN POTATO RESEARCH REPORT

VOLUME 32



Michigan State University
Agricultural Experiment Station

In Cooperation With
The Michigan Potato Industry Commission

THE MICHIGAN POTATO INDUSTRY COMMISSION

February 19, 2001

To All Michigan Potato Growers & Shippers:

The Michigan Potato Industry Commission, Michigan State University's Agricultural Experiment Station and Cooperative Extension Service are pleased to provide you with a copy of the results from the 2000 potato research projects.

This report includes research projects funded by the Michigan Potato Industry Commission, the USDA Special Grant and special allocations by the Commission. Additionally, the Commission expresses appreciation to suppliers of products for research purposes and special grants to the Commission and researchers.

Providing research funding and direction to principal investigators at MSU is a function of the Michigan Potato Industry Commission's Research Committee. The Commission is pleased to provide you with a copy of this report.

Best wishes for a prosperous 2001 season.

The Michigan Potato Industry Commission

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2000 MICHIGAN POTATO RESEARCH REPORT

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INTRODUCTION AND ACKNOWLEDGMENTS

The 2000 Potato Research Report contains reports of the many potato research projects conducted by MSU potato researchers at several locations. The 2000 report is the 32nd 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

On average, the weather during the 2000-growing season was cooler than 1999, but very close to the 15-year average (Table 1). There was one day that the temperature reached 90°F or above and eleven days in April that the temperature was below 32°F.

Rainfall for April through September was 28.46 inches which was nearly 8 inches above the 15 year average (Table 2). Rainfall recorded during the month of May was the highest in 15 years. Irrigation at MRF was applications 10 times averaging 0.55 inches for each application and was completed in early August.

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.
1986	60	36	70	46	77	50	82	59	77	51	72	50	73	49
1987	61	36	77	46	80	56	86	63	77	58	72	52	76	52
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	69	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	49
1995	51	31	66	45	81	57	82	60	82	65	70	45	72	50
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
15 Year Average	56	34	69	45	78	55	81	59	78	57	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
1986	2.24	4.22	3.20	2.36	2.10	18.60	32.72
1987	1.82	1.94	0.84	1.85	9.78	3.32	19.55
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	17.62
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
15 Year Average	2.97	3.12	3.52	3.21	4.55	4.03	21.40

GROWING DEGREE DAYS

Table 3 summarizes the cumulative, base 50°F growing degree days (GDD) for May through September. The total GDD for 2000 were 2,256, approximately 200 GDD less than 1999, but slightly higher then the 10-year average.

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

	Cumulative Monthly Totals				
Year	May	June	July	August	September
1991	452	1014	1632	2185	2491
1992	282	718	1210	1633	1956
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
10 Year Average	280	783	1374	1920	2244

*1991 and 1992 data calculated from Vestaburg weather station in Montcalm County (Dr. Jeff Andresen, Geography). 1993-2000 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 1998 and harvested summer of 1999. The rye stubble was disked and the plot area was fumigated that fall leaving the land bare during the winter of 1999. Potato early die was not a problem in 2000 due in part to fumigation.

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

	lbs/A			
pH	P_2O_5	K_2O	Ca	Mg
6.1	428	280	842	190

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

Application	Analysis	Rate	Nutrients ($N-P_2O_5-K_2O$)
Broadcast at plow down	0-0-60	200 lbs/A	0-0-120
At planting	16-22-0	18 gpa	32-44-0
At emergence	46-0-0	135 lbs/A	62-0-0
1^{st} Early side dress	46-0-0	200 lbs/A	92-0-0
2^{nd} Late side dress (late varieties)	46-0-0	200 lbs/A	92-0-0

HERBICIDES AND PEST CONTROL

Hilling was done in late May, followed by pre-emergence Dual and Sencor at 2 pints/A and .67 lbs/A, respectively.

Admire was applied at planting and Cygon was applied twice in the growing season. Fungicides used were Bravo ZN, Tatoo C and Polyram 80DF in 18 applications.

MICHIGAN STATE UNIVERSITY POTATO BREEDING PROGRAM 2000 STATUS 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 (at MSU and in grower fields), through conventional crosses we develop new genetic combinations in the breeding program, 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. In addition, our program utilizes genetic engineering as a tool to introduce new genes to improve varieties and advanced germplasm. We feel that these in-house capacities (both conventional and biotechnological) put us in a position to respond and focus upon the most promising directions and can effectively integrate the breeding of improved chip-processing and tablestock potatoes.

The breeding program is now initiating the naming and release of its first varieties. 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, extended cold storage) and cooking quality, bruise resistance, storability, along with shape, internal quality and appearance. 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.

PROCEDURE

I. Varietal Development

Each year, during the winter months, over 500 crosses are made between 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 being used as the breeding base for the program. Approximately 35,000 seedlings are grown annually for visual evaluation at the Montcalm and Lake City Research Farms as part of the first year selection process of this germplasm each fall. Then each selection is then evaluated for specific gravity and chip processing. These selections each represent a potential variety. This generation of new seedlings is the initial step to breed new varieties and this step is an on-going process in the MSU program. 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 out-of-state trials) over time and locations.

II. Germplasm enhancement

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. In general, diploid breeding utilizes haploids (half the chromosomes) from potato varieties, and diploid wild and cultivated tuber-bearing relatives of the potato. These represent a large source of valuable germplasm, which can broaden the genetic base of the cultivated potato and also provide specific desirable traits such as tuber dry matter content, cold chipping and dormancy, along with resistance to disease, insects, and virus. 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. The diploid breeding program germplasm base at MSU is a synthesis of six species: *S. tuberosum* (adaptation, tuber appearance), *S. phureja* (cold-chipping, specific gravity), *S. tarijense* and *S. berthaultii* (tuber appearance, insect resistance), *S. microdontum* (late blight resistance) and *S. chacoense* (specific gravity, low sugars, dormancy and leptine-based insect resistance).

III. Integration of Genetic Engineering with Potato Breeding

Genetic engineering offers 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 is set up to use *Agrobacterium*-mediated transformation to introduce genes into important potato cultivars. 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) gene 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. Using this gene (from Monsanto) we can manipulate the metabolism of the cultivated potato to limit the accumulation of reducing sugars during low temperature storage and to increase starch content. We also have begun working with the DES and prosystemin genes for LB and insect resistance, respectively. We are also investing our efforts in developing new vector constructs that 1) use alternate selectable markers and 2) give us the freedom to operate from an intellectual property rights perspective.

IV. Evaluation of Advanced Selections for Extended Storage

In 1999, the Michigan Potato Industry Commission constructed a demonstration storage facility to evaluate management systems to achieve extended storage of potatoes for chip processing. Our plan is to place our advanced selections in this facility each October to evaluate chip-processing under commercial-type conditions. Each winter we will be sampling monthly the tubers for their ability to chip-process from 42F or 50F storage.

RESULTS AND DISCUSSION

Breeding

For the 2000 field season over 400 crosses were planted and evaluated. Of those, 70% were crosses to select round whites. During the 2000 harvest, over 1000 selections were made from the 30,000 seedlings grown at the Lake City Experiment Station. Following harvest, specific gravity was measured on the larger tuber samples and chip-processing (from 42°F storage) will be tested January, 2001 directly out of storage. This storage period allows enough time for reducing sugars to accumulate in these selections. Atlantic (50°F chipper) and Snowden (45°F chipper) are chipped as check cultivars. When the 1999 single-hill selections were chipped directly out of 42°F storage, over 25% of the single-hill selections had acceptable chip color. These selections were evaluated as 8-hill selections in 2000. Of the 8-hill selections from 1999, 35% of the 200 clones chip-processed with acceptable color directly out of 42°F, while the 200 twenty-hill selections, 30% had acceptable chip color from 42°F storage. Twenty-seven of these clones were tested in the 2000 Preliminary Trial. In addition to chip processing qualities, some of these lines also show resistance to scab and/or late blight. In summary, the frequency of good chip-processors in the breeding program has increased over the previous years even with in spite the more stringent screening temperature (42 vs. 45°F storage).

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 (**Table 1**). We now have advanced into the crossing block these new MSU selections that have chip quality directly out of 42°F storage. Examination of pedigrees shows up to three different cold-chipping germplasm sources have been combined in these selections.

MSU Potato Breeding Chip-processing Results From the MPIC Demonstration Commercial Storage (January - June 2000)

In October 1999, tuber samples from select lines in the Montcalm Research Farm trials were placed in the bin designated to be cooled to 42°F. By January 6, 2000 the bin was cooled to 44.8F and the first samples were chip-processed at MSU. At this temperature some samples chip-processed well: Snowden, MSF099-3, MSF313-3, MSG227-2 and NY112. Meanwhile, Atlantic and a number of other lines chip-processed poorly. These lines that chip-processed poorly were placed in the 46°F bin (#2), while the other lines were maintained in the 42°F bin (#4). Each month, samples were pulled and chip-processed at MSU. **Table 2** shows the chip-processing results of the most promising lines in comparison to Snowden and Atlantic. The monthly chip-processing results clearly show the superiority of MSF099-3, MSG227-2, MSF313-3 and NY112 over Snowden. By May 5, 2000 Snowden went off-color while the other lines maintained acceptable chip color. MSE018-1 is not a cold-chipper, but in comparison to Atlantic, had good chip-color scores from the 46°F bin (#2). We are excited by the resulted obtained from the Demonstration Commercial Storage bins. MSF099-3, with intermediate scab resistance, shows great promise because of it excellent chip color and low defects over extended cold storage. MSG227-2 combines strong scab tolerance with acceptable chip quality and low defects. These lines and others will be retested in fall 2000.

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, high marketable yield and resistance to scab. From our efforts we have identified mostly round white lines, but we have a number of yellow-fleshed and russet selections that carry many of the characteristics mentioned above. We are also looking for a dual-purpose russet, round white and improved Yukon-type yellow-fleshed potatoes. Some of the tablestock lines were tested in on-farm trials in 2000, while others were tested under replicated conditions at MRF. Our current goals now are to 1) to continue to improve the frequency of scab resistant lines, 2) incorporate resistance to late blight along with marketable maturity and excellent tuber quality 3) select more russet lines, and 4) continue to introduce the *Bt-cry3A* gene into Yukon Gold, Norwis, Onaway, MSG274-3 (late blight resistant line) and MSE018-1. **Attachment 1** summarizes the most promising tablestock selections in the MSU potato breeding program.

In 1999, in addition to the grower-cooperator trials, we also initiated a large-scale field testing program (1 acre blocks per line on five farms) between the breeding program, the seed industry and the commercial growers called CHIPS2001 (**Attachment 2**). We have targeted four lines in 1999 (MSA091-1, MSNT-1, MSF099-3 and MSG274-3) and added two lines in year 2000 (MSG227-2 and MSE246-5) and considering MSH095-4 for 2001. We have also initiated a grower testing program for tablestock cultivars called Tablestock One-on-One (**Attachment 3**). In this program we work with specific growers to identify their agronomic and market needs and match up these needs with seed of advanced selections from the breeding program. Three growers participated in 1999, while over 12 participated in 2000. We also distributed a number of advanced selections to other states (California, North Carolina, Nebraska, Pennsylvania and Ontario) for agronomic evaluations. **Table 3** lists some of the potential lines for grower trials in year 2001.

Diploid Germplasm Enhancement

In 2000, about 10% of the populations evaluated as single hills were diploid. From this breeding cycle, we plan to screen the selections through the three-tier storage temperature evaluation for chip-processing. 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. In the fall, we made selections from 3,000 progeny that were segregating for leptine synthesis and day length adaptation and then evaluated processing quality of the selections and the leptine levels in the foliage (via HPLC analysis) during the winter. These selections are being cycled into the diploid crossing block for the winter 2001. Also added to the germplasm pool for crossing was a Verticillium resistant selection from *S. berthaultii*. This fall we were able to identify 10 selections that have chip-processing quality, late blight resistance and high tuber yields. These lines are also being added to the crossing block. This overall germplasm enhancement effort is the base from which long-term genetic improvement of the potato varieties in the MSU breeding program is generated.

Late Blight Breeding and Genetics

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.

We developed a diploid population with the objectives of mapping quantitative trait loci (QTL) conferring late blight (LB) resistance and verifying if the QTL for resistance was not associated with undesirable agronomic traits. The mapping population is a cross between *S. microdontum* (PI 595511) clone 5 and the MSA133-57 breeding clone. MSA133-57 is a cross between *S. phureja x (S. chacoense x S. tuberosum* dihaploid). A population of 110 clones that set tubers was multiplied in greenhouse and DNA isolated. This population was evaluated at the Muck Soil Research Farm in 1999 and 2000 for foliar late blight reaction using US8/A2 mating type of *P. infestans*. Disease severity was evaluated as the relative area under the disease progress curve. This population was also evaluated at Montcalm Research Farm for maturity, tuber number and size, yield, tuber appearance, specific gravity, and chip-color. A total of seven allozymes were polymorphic between the parents and they were scored in the total progeny. A total of 149 pairs of SSR primers, derived from the programs at SCRI and Virginia Tech, were screened using the parents and the bulks (resistant and susceptible to late blight). A total of 78 pairs of primers were polymorphic between the parents and they were used to genotype the whole progeny. We are currently working in the statistical analysis using MAPMAKER for linkage analysis and QTL CARTOGRAPHER for QTL analysis. At this time we can report that two pairs of primers were linked in coupling with late blight resistance, one of which maps to the chromosome II of the potato genome. This is the first report of a late blight resistance gene on chromosome II. Two other pairs of primers were linked in repulsion and both of them map to the chromosome VIII of the potato genome.

In addition, we are collaborating with the Scottish Crops Research Institute on this gene mapping project so that we can draw their expertise and experience in this area of research. During the summer 2000 a trip Scotland led to the AFLP marker analysis in the 4x population. We are also using SSR markers. The advantage of the specific SSRs we are using is that they were previously identified to be linked to late blight resistance genes in other potato lines.

Table 4 summarizes a group of selections in the breeding program that show late blight resistance based upon the early generation late blight trial at the Muck Soils Research Farm. We have been able to identify numerous selections that have resistance derived from different late blight resistance sources, potential chip-processing quality and genetic variation for vine maturity.

Genetic Engineering:

Development of Bt-cry3A-transgenic potato lines for host plant resistance to Colorado potato beetle

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. Field studies were conducted in the 2000 season to compare natural (glandular trichomes and high total glycoalkaloids), engineered (*Bt-cry3A*), and combined (glandular trichomes + *Bt-cry3A* and glycoalkaloids + *Bt-cry3A* transgenic potato lines) host plant resistance mechanisms of potato for control of Colorado potato beetle. Twelve different potato lines representing five different host plant resistance mechanisms were evaluated in a choice situation under Colorado potato beetle pressure at the Montcalm Research Farm in Entrican, Michigan and the Long Island Horticultural Research and Extension Center in Riverhead, New York (Fig. 1). Treatment plots were planted in the field between alternating rows of a susceptible guard in a randomized complete block design consisting of four replications of ten plants each. 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 high glycoalkaloid line, 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 high glycoalkaloid + *Bt-cry3A* transgenic line, which was significantly less than the *Bt-cry3A* transgenic line at the New York location. The glandular trichome line suffered less feeding than the susceptible control. Based on these results, the *Bt-cry3A* transgenic, glandular trichome, and high glycoalkaloid lines are effective tools that could be incorporated in a resistance management program for control of Colorado potato beetle.

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. In 1999 and 2000, we had an extensive field testing of our transgenic lines. **Table 5** summarizes the results from the field evaluations at Montcalm Research Farm. In general, the transgenic lines had agronomic and tuber characteristics of the non-transgenic parent line. We have made selections among the lines and will be advanced to further field trials in 2001.

Development of Bt-cry5-transgenic potato lines for host plant resistance to potato tuber moth in Egypt

Dave Douches traveled to Egypt to harvest field trials involving Bt-transgenic potato lines (at CIP and AGERI) (planted February 2000). The purpose of these trials was to obtain field data toward agronomic performance (CIP location) and resistance to potato tuber moth (PTM) damage to the foliage and tubers (CIP and AGERI) of these Bt-transgenic potato lines. These trials are now in their fourth year at AGERI and third year at CIP, and are under the supervision of Drs. Taymour El-Nasr and Magdy Madkour. In addition to the field trial harvest and evaluation, our other objective was to establish linkages with the Egyptian private and public sector (scientists and regular people) seed and commercial growers to disseminate information regarding the potential commercial use of Bt-transgenic potato lines. Based upon multi-year data in Egypt on potato tuber moth resistance and agronomic performance in Michigan, we have reduced our number of *Bt-cry5*-Spunta lines to three (G2, G3 and 6a-3). These lines have the strongest insect resistance and comparable agronomic performance to Spunta. We will continue to move toward commercialization of these lines in regions where potato tuber moth is found. The Altantic lines were dropped because of only moderate insect control. New Atlantic lines with greater tuber moth control have been developed.

Transformation and Evaluation of Potato Cultivars with the *glgC16* 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. Stark et al. (1992) transformed the potato cultivar 'Russet Burbank' with a *glgC-16* gene construct and found up to 35% more starch than control tubers. One purpose of this study is to examine the value of *glgC-16* to raise the dry matter content for potato tubers. In this study, we transformed 3 lines that differ in their dry matter content (MSE149-5Y: 1.066; Onaway: 1.072; Atlantic 1.084). They were then evaluated by checking for increased expression of the ADP glucose pyrophosphorylase enzyme using an ELISA test for changes in specific gravity, chip processing quality and storage stability of field grown tubers.

The tissue culture transplants of Atlantic, MSE149-5Y and their AGPase transgenics grew vigorously during the summer months. In contrast, the Onaway lines were less vigorous and senesced shortly after tuberization. The growth pattern for the Onaway lines was typical of the growth pattern observed for tissue culture transplants of the early maturing lines. The tuber appearance of the various AGPase-lines was similar to non-transgenic Onaway and the MSE149-5Y lines. The two Atlantic-AGPase lines suffered from severe growth cracks. These results were also observed on a sample of tuber-grown Atlantic-AGPase lines. These lines were also very susceptible to tuber rot before and shortly after harvest. None of the Onaway-AGPase lines had severe growth cracks, but 3 of the 19 MSE149-5Y lines showed the tuber growth crack phenotype.

Table 6 summarizes the tuber AGPase ELISA, specific gravity, and chip-processing data of the selected lines. The lines shown in **Table 6** have significantly higher tuber specific gravity than the check line. Four AGPase-transgenic lines were above the 1.080 specific gravity threshold. There does not seem to be a correlation between tuber specific gravity and AGPase-ELISA values. Also given in **Table 6** are the chip color scores (Snack Food Association scale) and defects from a chip sample processed shortly after harvest. We will conduct further chip processing on samples from 10°C and 4°C storage after 4 and 6-month storage. The lines described in **Table 6** will be tested in agronomic trials in 2001 and further chip- processing analysis following the 2001 harvest season.

Variety Releases:

Jacqueline Lee: A Tablestock Late Blight Resistant Variety with Marketable Maturity

Jacqueline Lee is a new potato variety (*Solanum tuberosum* L.) that has been developed at Michigan State University that is resistant to the US8 genotype of late blight (*Phytophthora infestans* Mont. de Bary). Jacqueline Lee was evaluated as seedling number MSG274-3. It is a selection from a cross made in 1994 between the late maturing, late blight resistant variety Tollocan and the early maturing variety Chaleur for the purpose of breeding late blight resistant cultivars with marketable maturity. Jacqueline Lee is named for the daughter of the breeder.

Jacqueline Lee is an oval/oblong tablestock selection with a high tuber set. The tubers have a bright skin, and a smooth, attractive appearance with a yellow flesh that is typical of many European cultivars. The primary strength of this selection is its strong foliar resistance to the US8 genotype of late blight (as determined by four years of field testing) combined with a vine maturity that is similar to Snowden. Other strengths of Jacqueline Lee are that the tubers have very low incidence of internal defects, excellent culinary quality and a long dormancy.

The seedling generation was grown in 1994, followed by two years of selection and seed multiplication at Lake City Experiment Station, Lake City, MI. Since 1997, it has been tested in replicated agronomic trials at the Montcalm Research Farm, Entrican, MI and in inoculated late blight trials at the Muck Soils Research Farm, Bath, MI. In 1999 it was entered into farm trials in Michigan as well as commercial seed production.

Liberator: A Round White Chip-processing Variety with Resistance to Scab

Liberator is a new round white chip-processing potato variety (*Solanum tuberosum* L.) that has been developed at Michigan State University that is resistant to scab (*Streptomyces scabies* Thaxter). Liberator was evaluated as seedling number MSA091-1. It is a selection from a cross made in 1988 between the moderately scab resistant breeding line MS702-80 and chip-processing variety Norchip for the purpose of breeding scab resistant chip-processing varieties. The name Liberator was chosen to acknowledge the resistance to scab in this round white chip-processing variety.

Liberator is a round white chip-processing variety with a medium set of bright-skinned tubers similar in appearance to Norchip. The tubers have a low level of internal defects. The primary strength of this variety is its strong resistance to scab combined with chip-processing quality. Another strength of Liberator is that the tubers have a level tolerance to fusarium dry rot similar to Snowden. Liberator was tested in the North Central Regional Trials and the National Snack Food Trials. Under irrigated conditions the yield and specific gravity are similar to Snowden and Atlantic with vine maturity similar to Snowden.

The seedling generation was grown in 1988, followed by two years of selection and seed multiplication at the Clarksville Horticultural Experiment Station, Clarksville, MI. Since 1992, seed increase was relocated to the Lake City Experiment Station. Since 1993, it 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 1997 it was entered into farm trials in Michigan and then in 1999 was placed into commercial seed production.

Attachment 1

MSU Tablestock Breeding Lines

<u>MSE192-8RUS</u>: A russet tablestock selection. The tubers are long with an attractive russet appearance like Russet Norkotah. In comparison to Russet Norkotah it has a bright white flesh, a good taste and expresses PVY symptoms. Its strengths are scab resistance, low incidence of internal defects, and bruise resistance. The vines have early-mid season maturity. We view this as a potential Russet Norkotah replacement.

<u>MSE202-3RUS</u>: A russet tablestock selection. The tubers are long with a lighter russet appearance. The tubers are smooth shaped and attractive with high yield potential. It has a full season maturity.

<u>MSB106-7</u>: A high yielding, long white type. Internal quality is excellent with a bright white flesh, however, specific gravity in only 1.070. It has performed well in Louisiana and Nebraska. We regard this as a niche variety.

<u>MSF313-3</u>: A high yielding selection with acceptable specific gravity for chip-processing. It has cold-chipping (45°F) potential. The tubers have an attractive appearance and have excellent internal quality. Scab resistance is above average. We regard this as a potential Onaway replacement.

<u>MSF373-8</u>: A very 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. This selection also has tablestock potential. We regard this as a potential Onaway/Ontario replacement.

<u>MSB107-1</u>: A high yielding selection that produces large tubers that have excellent internal characteritics. Scab tolerance is intermediate and maturity is medium-late. We regard this as a potential Onaway/Ontario replacement.

<u>MSE018-1</u>: A very high yield potential, high specific gravity, and 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. We regard this as a potential Katahdin replacement (baker).

<u>MSE221-1</u>: A high yielding selection with scab resistance and a moderately early vine maturity. Tubers are netted with an attractive appearance. The internal qualitites of the tubers are excellent. We regard this as a potential Superior replacement.

<u>MSE149-5Y</u>: A light yellow-fleshed selection with smooth, round tubers that have a bright appearance. Specific gravity is low but the selection has high yield potential. Internal qualities are excellent and the vine maturity is medium-early. We regard this as a potential Norwis replacement.

<u>MSG004-3</u> - a MSU tablestock selection. It has average yield potential and produces bright attractive tubers with good internal quality. It was in the on-farm trials for the first time in 2000.

<u>MSG274-3</u>: An oval/oblong table stock 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.

<u>Michigan Purple</u>: 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. We regard this as a novelty type.

Attachment 2

CHIPS2001

Time line:

1. Choose 3-4 lines; Start T.C. propagation	January, 1999
2. Transplant 1000 plants/line to GH	May 15, 1999
3. Transplant to field at Lake City (MSU)	June 15, 1999
4. Harvest tubers (10-20 cwt/line)	October, 1999
5. Plant field by Seed Grower (1/2 - 1 acre)	Spring, 2000
6. Harvest tubers (125-250 cwt)	Fall, 2000
7. Plant commercial fields (5 acres) & seed field (1 acre)	Spring, 2001
8. Harvest 300-500 cwt/line Send load to chip-processor Fill research storage bins Seed harvest for 2002	Fall, 2001
9. Chip-process storage samples	Winter, 2002

Candidate Chip Line	Priority	Pedigree	Comments
MSG274-3	1	Tollocan X Chaleur	Late blight resistant, dual table/chip
MSF099-3	1	Snowden X Chaleur	Cold-chipping, exc. internals & shape
MSNT-1	1	-	Scab resistant, exc. internals
MSA091-1	1	MS702-80 X Norchip	Scab resistant
MSG227-2	2	Prestile X MSC127-3	Cold-chipping, scab resistant, exc. shape
MSE246-5	2	E55-27 X W870	Cold-chipping, scab resistant
MSH095-4	3	MSE266-2 OP	Exc. chip color, mod. tolerance to scab

Attachment 3

Tablestock One-on-One

Michigan State University
Potato Breeding Program

The MSU potato breeding program has been generating advanced selections that have commercial potential. Many of these selections have been tested in MSU research trials and in grower-cooperator trials around the state. This year we initiated a program we call Tablestock One-on-One to cooperate with tablestock growers to evaluate specific selections on specific farms.

We want to work with individual growers to understand their agronomic needs, production constraints and market targets. In this way we can identify specific advanced selections that you can test on your farm. At this time, we can supply seed for testing at small levels (10 lbs. to 100 lbs.).

The goal of the on-farm testing is to compare our advanced selection to your current variety. Therefore, we want to compare the MSU line side-by-side with your currently-grown variety. Our suggestion is to plant the lines at a minimum of 3-4 row plots (depending on your planter). In this way the middle rows could be sampled for yield checks.

If you are interested in testing lines or learning more about the program, please contact Dr. Dave Douches, potato breeder, at Michigan State University. You can also check out the variety images on the MSU Potato Breeding and Genetics web site (www.msu.edu/user/douchesd).

Dr. Dave S. Douches
Associate Professor
Depart. of Crop and Soil Sciences
Michigan State University
East Lansing, MI 48824

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517-353-5174 FAX
douchesd@pilot.msu.edu

Table 1. **Promising Early Generation Cold-Chipping Selections from Michigan State University.**

Line	Specific Gravity*	OTF[1] Chip Score*	Storage (42F) Chip Score*	Late Blight* Field Resistance[2]	Pedigree Female	Pedigree Male
MSI058-4	1.084	1.5	2.0	MR	Brodick	F134-1
MSI111-A	1.086	1.5	1.0		E251-1	OP
MSJ042-3	1.095	1.5	2.0	R	Brodick	Zarevo
MSJ047-5	1.088	1.0	1.5		B076-2	S438
MSJ080-8	1.092	1.0	2.0		C148-A	S440
MSJ107-4	1.101	1.0	2.0	MR	E230-6	Zarevo
MSJ143-4	1.090	1.0	1.5		ND01496-1	S440
MSJ147-1	1.081	1.0	1.5		ND2417-6	S440
MSJ153-2Y	1.074	2.5	2.0		NY101	Penta
MSJ165-1	1.089	1.0	1.0		Prestile	S440
MSJ167-1	1.085	1.0	1.5		P84-13-12	E250-2
MSJ324-2R	1.077	2.0	2.0	MR	C084-A	Bertita
MSJ343-1	1.088	1.5	1.0	R	Brodick	F077-8
MSJ430-6Y	1.084	1.0	2.0		S438	Penta
MSJ438-2	1.093	2.5	2.0		Penta	Zarevo
MSJ457-2	1.091	1.0	2.0	R	E55-44	Tollocan
MSJ459-3	1.079	1.5	1.5	R	Lenape	Tollocan
MSJ482-1	1.098	1.5	1.5	MR	Zarevo	C127-3

*2000 data

[1] Chipped out of the field: Snack Food Association scale (1-5); 1.0 = excellent, 2.5 = not acceptable, 5.0 = poor.

[2] 2000 Late blight field disease trial results: R = resistant, MR = Moderately resistant.

Table 2. 1999-2000 MPIC Demonstration Storage Chip Results at the Montcalm Research Farm.

†Chip Scores: SFA Scale

	1999			Sample Dates:					
	DOH*		1999	1/6/00	2/3/00	3/2/00	4/6/00	5/5/00	6/8/00
POTATO LINE	CWT/A		DOH*	Storage Bin Temperature (°F)					
BIN#4	US#1	TOTAL	SPGR	44.8F	42.0F	46.0F	47.2F	50.6F	56.0F
MSF099-3	230	314	1.086	1.5	1.0	1.0	1.0	1.5	1.5
MSF313-3	318	370	1.077	1.0	1.5	2.5	2.0	2.0	2.0
MSG227-2	236	321	1.080	1.5	1.5	2.5	1.5	2.0	2.0
NY112	385	422	1.079	1.5	2.0	1.5	1.5	1.5	2.0
SNOWDEN	**247**	**314**	**1.080**	**1.5**	**2.0**	**1.5**	**1.5**	**3.0**	**3.0**
BIN#2				44.8F	46.0F	46.6F	47.2F	50.2F	56.0F
ATLANTIC	**324**	**374**	**1.090**	**2.0**	**2.5**	**2.5**	**1.5**	**3.0**	**2.5**
MSE018-1	386	449	1.089	2.0	2.0	1.0	1.0	2.0	1.5
$LSD_{0.05}$	46	42	0.002						

*DOH: Results from the Date of Harvest Round Whites Trial.

† Snack Food Association scale (1-5); 1.0 = excellent, 2.5 = not acceptable, 5.0 = poor.

†† Scab Disease Rating 1 - 5 (from MSU Scab Nursery): 1: Little or no disease present; 5: Severe susceptibility.

Table 3. Potential Lines for 2001 On-Farm Grower Trials.

Tablestock	Comments	Processing	Comments	
MSE018-1		MSA091-1	Scab R	SFA
MSE149-5Y	Scab MR	MSE018-1		
MSE192-8RUS	Scab R	MSF099-3		
MSE202-3RUS	Scab R	MSF313-3		
MSE221-1	Scab R	MSF373-8	Scab MR	
MSF313-3		MSG015-C	Scab R	
MSF373-8	Scab MR	MSG227-2	Scab R	SFA
MSG004-3		MSH031-5	Scab MR	
MSG274-3	LBR	MSH094-8		
MSH026-3RUS	Scab R	MSH095-4		
MSH031-5		MSH098-2		
Michigan Purple				
Wolverine				

Table 4. Late blight (LB) clone selections in 2000 based on LB reaction and maturity.

Line	2000 SPGR	2000 OTF[1] CHIP	1999 MAT	2000 LBFLD[2]	Female	Male
MSI152-A	1.071	2.5	-	R	Mainestay	B0718-3
MSJ042-3	1.095	1.5	-	R	Brodick	Zarevo
MSJ107-4	1.101	1.0	-	MR	E230-6	Zarevo
MSJ307-2	1.067	2.0	4	R	C148-1	B0718-3
MSJ317-1	1.072	2.0	4	MR	Prestile	B0718-3
MSJ319-1	1.086	2.0	3	R	B0718-3	W870
MSJ319-7	1.068	2.5	2	R	B0718-3	W870
MSJ334-1Y	1.080	2.0	-	MR	D040-4	Brador
MSJ343-1	1.088	1.5	-	R	Brodick	F077-8
MSJ453-4Y	1.085	1.0	4	R	A091-1	Tollocan
MSJ456-2Y	1.082	2.5	3	R	Tollocan	Conestoga
MSJ456-4Y	1.087	1.5	4	R	Conestoga	Tollocan
MSJ457-2	1.091	1.0	4	R	E55-44	Tollocan
MSJ458-2	1.077	1.0	3	R	Krantz	Tollocan
MSJ459-3	1.079	1.5	3	R	Lenape	Tollocan
MSJ459-4	1.072	2.0	3	R	Lenape	Tollocan
MSJ461-1	1.079	1.5	3	R	NY88	Tollocan
MSJ482-1	1.098	1.5	4	MR	Zarevo	C127-3
MSJ494-1	1.094	1.0	3	MR	Pike	Zarevo

[1] Chipped out of the field: Snack Food Association scale (1-5); 1.0 = excellent, 2.5 = not acceptable, 5.0 = poor.

[2] 2000 Late blight field disease trial results: R = resistant, MR = Moderately resistant.

Table 5. 2000 *Bt-cry3A* Transgenic Breeding Line Preliminary Trial at the Montcalm Research Farm.

	Weight			Tuber Quality[1]				Total	*Bt-cry3A* Concentration
CLONE	US#1	Total	SPGR	HH	VD	IBS	BC	Cut	(ng/ml)
E018-1	**558**	**608**	**1.088**	**0**	**0**	**0**	**1**	**20**	**NA[2]**
E08.02	536	567	1.091	1	0	0	0	20	41
E08.07	532	581	1.091	1	0	1	0	20	78
E08.10	530	603	1.095	3	0	0	0	20	76
L28.2	488	528	1.077	0	1	0	0	10	101
L28.13	484	526	1.081	0	0	0	0	20	138
L28.12	430	480	1.079	1	0	0	0	10	147
L28.11	409	454	1.077	0	0	0	0	10	143
L28.3	408	433	1.075	1	0	0	0	10	147
L28.5	379	441	1.079	0	0	0	0	20	60
L235-4	**356**	**402**	**1.075**	**0**	**0**	**0**	**0**	**20**	**-7**
Lemhi Russet	**509**	**571**	**1.084**	**10**	**0**	**1**	**0**	**20**	**NA**
LR8.3	476	543	1.079	4	0	0	0	20	72
NO8.2	563	597	1.070	3	0	3	3	20	173
NO8.6	534	589	1.070	0	0	0	1	20	110
Norwis	**506**	**535**	**1.063**	**5**	**0**	**0**	**4**	**20**	**NA**
NO8.8	482	525	1.067	0	0	0	1	20	125
NO8.1	467	508	1.067	2	0	3	0	20	106
NY123	**431**	**477**	**1.079**	**0**	**0**	**0**	**3**	**20**	
NY8.02	340	409	1.074	0	0	0	0	20	102
ON8.28	358	428	1.069	0	0	1	0	20	54
ON8.06	356	449	1.064	0	0	0	0	20	54
ON8.07	328	406	1.068	2	0	0	0	20	125
SP8.16	544	620	1.061	0	0	4	0	20	115
SP8.12	541	615	1.058	0	0	0	0	20	156
SP8.7	527	592	1.059	2	0	0	0	20	203
Spunta	**451**	**499**	**1.058**	**1**	**0**	**0**	**0**	**20**	**NA**
SP8.3	398	459	1.061	1	0	3	0	20	178
Yukon Gold	**494**	**525**	**1.080**	**6**	**0**	**2**	**2**	**20**	**NA**
YG8.13	404	437	1.061	6	0	1	2	20	147
YG8.19	379	416	1.077	7	0	1	2	20	146
YG8.3	375	422	1.077	5	0	0	1	20	149
YG8.6	373	411	1.078	6	0	1	1	20	95
YG8.1	367	406	1.075	6	0	0	2	20	42
YG8.4	367	404	1.074	16	0	0	0	20	152
YG8.12	293	336	1.078	5	0	0	0	20	144

[1]Tuber Quality: HH: Hollow Heart, VD: Vascular Discoloration, IBS: Internal Brown Spot, and BC: Brown Center.

[2]NA: Not Applicable

Table 6. AGPase Transgenic Potato Analysis of Chosen Lines[a] (Year 2000).

Line	ELISA (avg.)[d]	Tissue Culture Planting SPGR (avg.)	Tuber SPGR (avg.)	Chip Color[b]	Tuber Defects[c]
E149-5Y	0.149	1.066		3	
EAGP3	0.705	1.087		2	1HH
EAGP4	0.471	1.115		1	1HH
EAGP8	0.171	1.078		2	
EAGP9	0.843	1.074		3	2HH
EAGP15	0.155	1.078		2	
EAGP20	0.165	1.078		3	1HH
EAGP24	0.662	1.084		1	2HH
ONAWAY	0.169	1.074	1.071	4	
ONW AGP1	0.511	1.078	1.078	5	Very Small
ONW AGP2	0.493	1.079	1.081	5	3HH
ONW AGP3	1.211	1.083		4	1HH
$LSD_{0.05}$ =	0.104	0.006			

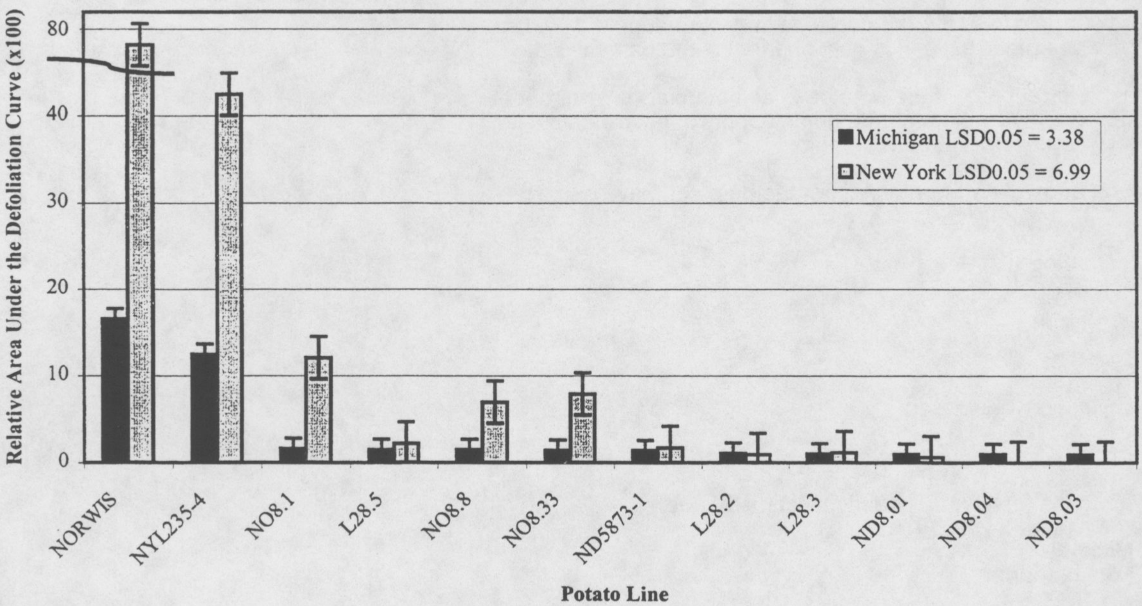
[a] These are selected lines based upon agronomic performance, tuber quality and AGPase ELISA expression.

[b] Chip color grading : 1-5 Snack Food Association scale; 1.0 = excellent, 2.5 = not acceptable, 5.0 = poor

[c] HH = Hollow heart

[d] ELISA DATA: Each sample was replicated three times per assay. Two of three assays were done with different tubers. An average of the three reps for each sample was taken for each assay.
The number represented here is an average of the three assays.

Figure 1. 2000 CPB Field Trial of Natural and Engineered HPR in Potato



From: "Hougan, Michael" <Michael.Hougan@sno.wednet.edu>
To: "'David Douches'" <douchesd@pilot.msu.edu>
Subject: RE: Potato search
Date: Tue, 9 Jan 2001 12:21:09 -0800

Dear David,

Thank you for your help in ID'ing the potatoes that were supplied by Jack DeKubber. With a name like his, it is no wonder why the name is Dutch.

He has asked me to research if the potatoe is commercialy grown. If not, is it worth following up on (he has a large home supply of seed), and if it is, who might we contact for more information.

Again, thank you and your students/staff for the help you have given us.

Michael Hougan
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Snohomish High School
1316 5th St.
Snohomish WA 98290
360.563.4123

michael.hougan@sno.wednet.edu

-----Original Message-----
From: David Douches [mailto:douchesd@pilot.msu.edu]
Sent: Tuesday, October 24, 2000 7:14 AM
To: Hougan, Michael
Subject: Re: Potato search

Dear Michael,

Yesterday we were able to run the fingerprinting analysis on the tuber sample you sent me. According to our fingerprint database, it matched the Dutch variety Bintje. This variety was released around the turn of the century and it is still a commonly grown cultivar in the Netherlands because the consumers enjoy it's cooking qualities. Any comments?

Sincerely,

Dave Douches

At 01:00 PM 9/13/2000 -0700, you wrote:
>David Douches,
>
>I am a High School instructor of horticultural science, and was approached
>by a member of our community with an interesting case.
>
>Jack DeKubber, a past administrator of our district, as grown a variety of
>potato that has been difficult to identify.
>
>He has taken it to the Washington State University Cooperative Extension
>field day, where "potato experts" had gathered with no luck.
>
>Andy Jensen and Rick Knowles, of WSU recommended that he contact you, for
>help in this matter. In turn, he has passed the torch to my advanced
>horticulture students to try and figure out the problem.
>
>History of this potato:
>
>Originally the potato entered the US on 1907from Zeeland Province,
Perneuzen
>South Holland (near Belgium). The potatoes have been grown both
>commercially and for home use for 3 genrations.
>
>How can we identify this potato? Any suggestions?
>

Funding Fed. Grant/MPIC

2000 POTATO VARIETY EVALUATIONS

D.S. Douches, R.W. Chase, J. Coombs, C. Long, K. Walters, R. Hammerschmidt, W. Kirk, and J. Greyerbiehl

Departments of Crop and Soil Sciences and Botany and Plant Pathology Michigan State University East Lansing, MI 48824

Each year we conduct a series of variety trials to assess advanced selection from the MSU 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), dormancy (at 50°F), as well as susceptibilities to late blight, common scab, Fusarium dry rot, Erwinia soft rot and blackspot bruising are determined.

Nine field experiments were conducted at the Montcalm Research Farm in Entrican, MI. They were planted in randomized complete block design 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). The other field experiments were the Long, North Central Regional, European, Adaptation and Preliminary 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, dormancy, 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.

Results

A. Round White Varieties: Chip-processors

There were 17 entries that were compared at two harvest dates. Atlantic, Snowden and Pike were used as checks. The plot yields were above average in the early harvest (104 days), however; only a moderate yield increase was observed for the second harvest date (140 days). Tuber specific gravity readings were above average. The results are presented in Tables 1 and 2. In the early harvest trial NY112, MSE018-1, MSF373-8, MSG227-2, Atlantic, MSH094-8 and MSH031-5 had the highest yields of the 17 entries. At the later harvest the same lines were again among the top yielding lines along with P83-11-5. MSF373-8, NY112 and MSE018-1 were also top yielding lines in the on-farm processing trials. MSA091-1 and MSG227-2 are two very promising selections that have scab resistance along with chip-processing ability. Chip-processing quality was high among all the entries in the out-of-the-field samples. Incidence of internal defects were low in 2000, but Atlantic was well above the other entries in the frequency of hollow heart at the early harvest. These results were surprising considering the percentage of oversize tubers in the trials.

Variety Characteristics

MSA091-1 - a MSU selection for chip-processing with strong scab resistance. Yield and specific gravity over the past four 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. It is also in the CHIPS2001 program. It is being named and released in 2001.

MSE018-1 - a MSU chip-processing selection with high yield potential. It was an outstanding yielder in the MSU and on-farm trials the past four years. Specific gravity is high and it has a good general appearance. Scab tolerance is intermediate and it has a reduced susceptibility to late blight. Chip-processing has been variable in the on-farm trials, but it chip-processed well out of the new MPIC demonstration storage (50°F) in spring 2000.

MSF099-3 – 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. This line is in the CHIPS2001 program.

MSF313-3 – a MSU tablestock and chip-processing selection. It has medium vine maturity, above average yield potential, however its yield was poor in 2000 and the specific gravity was intermediate. The tubers have few defects and the shape is smooth and round with a bright appearance. It will chip-process out of the field and from storage. In spring 2000 it was one of the best chip-processors in the 42°F MPIC demonstration storage.

MSF373-8 - a MSU tablestock and chip-processing selection. It has a large vine and a late maturity, but tends to size early. Tuber set is low which leads to a high percentage of large tubers. Specific gravity is intermediate and the tubers have medium-deep eyes. Cooking quality is good.

MSG227-2 – a MSU chip-processing selection with strong scab resistance. It has a specific gravity acceptable for chip-processing, excellent chip quality and cold-chipping potential. The tubers are smooth-shaped with a flattened round appearance that is attractive. This line is in CHIPS2002. In 2000 it was one of the best chip-processors in the 42°F MPIC demonstration storage. This line will be considered for release in 2002.

MSH094-8 - a MSU chip-processing selection. It has above average yield, high specific gravity and excellent chip quality. It will be entered in the on-farm trials for 2001.

MSNT-1 - a MSU chip-processing selection. It has average yield potential, excellent chip quality and strong resistance to scab. Yield was below average in the MSU trial. It has been in the SFA trials along with the on-farm trials. It performed well in Ontario trials in 1999. It is in the CHIPS2001 program.

NY112 – a Cornell University chip-processing selection. It has high yield potential and was the top yielding line in the 1998 SFA trials. The specific gravity is in the range of 1.080 or lower. Blackspot bruise has been observed in simulated bruise tests in the past two years, but the chip quality is high from out-of-the-field and from storage samples.

B. Round White Varieties: Tablestock

There were 10 entries that were compared at two harvest dates. Onaway and Superior were used as checks. The plot yields were high in the early harvest (104 days), and a yield increase was observed on some of the lines for the second harvest date (140 days). Tuber specific gravity readings were above average. The results are presented in Tables 3 and 4. In the early harvest trial MSG050-2, MSE221-1, Onaway and Superior were the top yielding lines. Internal quality was good except for some brown centers observed in Superior. In the later harvest MSE028-1, Onaway, MSE228-1 and MSE221-1 were the top yielding lines. Incidence of internal defects was only notable in Superior (brown center) and MSE028-1 (internal brown spot). The most promising selections are MSE221-1, which is a Superior-type selection with scab resistance, MSE149-5Y, which is an attractive, bright-skinned selection with good cooking quality; and MSG274-3, which has strong late blight resistance, attractive oval tubers and good cooking quality.

Variety Characteristics

MSG274-3 – a MSU tablestock selection. It has strong late blight resistance to US8, but susceptible to scab. The line has high yield potential and a very high tuber set that can lead to a high percentage of B-size tubers. The tubers are oval with an attractive smooth shape and a bright skin with excellent cooking quality. It is in the CHIPS2001 program and is being named and released in 2001.

MSE149-5Y – a MSU tablestock selection. It has high yield potential and produces attractive round tubers with a bright skin and light yellow flesh. It has been a top yielder in the on-farm trials. It chips out of 45°F cold storage, but has a low specific gravity. In the lab we have used this line for transformation with the starch gene to raise the specific gravity. These AGPase-transgenic lines were field-tested in 2000.

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. It was in the on-farm trials for the first time in 2000.

C. Long Varieties

Four varieties and eight breeding lines were tested in 2000. Russet Burbank and Russet Norkotah were grown as check varieties. The trial was dug at 140 days from planting and results are shown in Table 5. The yield of the lines ranged widely with Bannock Russet and MSE202-3RUS having high yields and Russet Norkotah and MSE192-8RUS with below average yields. The top two lines were also late maturing and had high levels of scab resistance. Internal defects were low except that MSE202-3RUS and AO87277-6 had greater amounts of hollow heart in the oversize tubers. The lines with the nicest russet type were A9014-2 and MSE192-8RUS. Russet Burbank was the only line to generate a undesirable amount of cull potatoes.

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. In 1999 it was the top yielder in Nebraska. 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 yields in on-farm trials have been disappointing, but performed well in some on-farm trials in 1999. 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 medium-late maturity and high yield potential. Its specific gravity is equivalent to Russet Burbank and the tubers are long with an attractive russet skin. Scab resistance is also high.

D. North Central Regional Trial

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. Nineteen breeding lines and seven varieties were tested in Michigan. The results are presented in Table 6. The yield was high and specific gravities of the lines were average in 2000. The range of yields was wide. As like 1999, the MSU selections MSE018-1 and MSB107-1 performed well. Other promising lines include chip-processor W1386, the red-skinned selection ND3574-5R, and the round white selection MSF373-8. The scab resistant chip-processing MSU line MSA091-1 performed comparable to Snowden. In general, the russet varieties and lines performed below average.

E. European/Yellow Trial

Fifteen varieties and advanced selections were tested in 2000. Yukon Gold and Saginaw Gold were used as checks. The results are summarized in Table 7. The yields were above average and varied considerably. The best yielding lines in 2000 were MSE048-2Y and Torridon, but internal defects and late vine maturity make these lines undesirable at the commercial level. Sinora was a strong overall performing line with excellent internal quality and chip-processing potential. Accord had excellent chip color but suffered from internal brown spot. Lady Claire had excellent chip color too, but has low yield potential. Michigan Purple is a new selection with an attractive purple skin and a white flesh with no defects. The yield is above average along with a mid-early vine maturity. MSI201-2PY is a novelty selection with blue skin and yellow flesh with a blue-pigmented pattern. Hollow heart was noted in the oversize tubers of MSG145-1Y and MSE048-2Y in both 2000 and 1999.

F. Adaptation Trial

Four varieties and 35 advanced breeding lines were evaluated in the Adaptation trial (Table 8). The trial was harvested after 139 days. The highest yielding lines were MSH333-3, MSI050-4, AF1437-1, MSB107-1, NY120 and MSH112-6, however MSI050-4 and NY120 suffered from internal defects. The best performing scab resistant lines are MSH112-6, MSF060-6 and MSH015-2. The best lines with chip-processing quality are MSH333-3, NDO1496-1, MSH106-2, MSH217-1, MSH360-1, MSH098-2 and MSH123-5. MSH123-5 also had strong resistance to scab, but it had a below average yield. The lines with the best overall tablestock performance are AF1437-1, MSB107-1, and MSE228-11. The best overall chip-processing lines are MSH112-6, MSH015-2, MSH095-4, MSH098-2, MSH360-1 and MSH370-3.

G. Preliminary Trial

The Preliminary trial, harvested at 134 days, is the first replicated trial for evaluating new advanced selections from the MSU potato breeding program. Sixty advanced selections and five check varieties were tested, but some were dropped from Table 9 because of poor tuber quality noted at harvest and grading. Twelve yellow-fleshed lines were tested and three of the lines, MSJ033-10Y, MSJ033-6Y and MSJ049-1Y showed strong resistance to scab. Five lines were included in the trial that had either moderate to strong late blight resistance of which MSJ343-1, MSJ307-2, and MSJ456-4 show the most overall promise. Lines with the best chip-processing quality are MSJ080-1, MSJ080-8, MSJ147-1, MSJ059-3, MSJ202-1, MSH018-5 and MSH356-A. Lines with the best potential for the round white tablestock market are MSI582-A, MSJ204-3 and MSJ166-1. MSJ472-4P is a blue-skinned line with white and blue flesh the chip-processes.

H. Potato Scab Evaluation

Each year a replicated field trial at the MSU Soils Farm is conducted to assess resistance to common and pitted scab. This year we modified the scale from a 1-5 to 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 10A categorizes many of the varieties and advanced selections tested in 2000 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. These three categories are good levels of scab tolerance. Susceptible lines have greater than 25% infection with pitted lesions. Scores of 4.0 or greater are found on lines with >50% infection and severe pitted lesions. The check varieties Russet Burbank, Superior, Onaway, Red Pontiac, Yukon Gold, Atlantic and Snowden can be used as references (bolded in Table 10). Table 10 indicates that we have been able to breed numerous lines for the chip-processing and tablestock markets. Most notable are the lines MSA091-1, MSG227-2, MSE202-3RUS and MSE221-1. Scab results are also found in the Trial Summaries (Tables 3-9). Table 10B summarizes the 1998-2000 scab trial results for the varieties and lines that have been tested at least two years in the past four years. These multi-year results give a more stable rating score for the clones tested in these trials.

H. Late Blight Trial

In 2000 a late blight trial was conducted at the Muck Soils Research Farm. Over 170 entries were evaluated in replicated plots. The field was inoculated late-July and ratings were taken during 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 blight trial. The results are summarized in Table 11. Lines with the least infection from multi-year testing were LBR8, A90586-1, NY121 (Q237-25), MSG274-3, B0767-2, B0692-4 and Torridon (a Scottish variety). The good agronomic and tuber qualities of MSG274-3 make this selection the strongest late blight resistant line a candidate for commercialization. In addition, many new MSU selections were in this top tier. Included in this group are MSJ459-4, MSJ457-2 and MSJ456-4, MSJ459-3 and MSJ453-4 which all are progeny of Tollocan; MSJ307-2, MSJ018-2, MSJ319-1, MSI152-A and MSJ319-7 which are progeny of B0718-3; and MSJ343-1 and MSI058-4 which are progeny of Brodick. We find these late blight resistant lines valuable because many of them also have marketable maturity. Tuber late blight resistance is being evaluated on all the selections with foliar late blight resistance.

I. Blackspot Susceptibility

Increased evaluations of advanced seedlings and new varieties for their susceptibility to blackspot bruising have been implemented in the variety evaluation program. Check samples of 25 tubers were collected (a composite of 4 reps) from each cultivar at the time of grading. A second 25 tuber sample was similarly collected, placed in 50°F storage overnight and then was placed in a hexagon plywood drum and tumbled 10 times to provide a simulated bruise. Both 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 Tables 12A and 12B. Table 12A summarizes the data for the samples receiving the simulated bruise and Table 12B, the check samples. 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 50F tubers is helping to standardize the bruise testing. However, these results become more meaningful when evaluated over 3 years that reflects different growing seasons and harvest conditions. The data indicates that bruise levels were average compared to other years. The most bruise resistant lines this year were MSH031-5, MSF313-3, MSE149-5Y, MSE221-1, MSH026-3RUS, MSE192-8RUS, ND3574-5R, Lady Claire, MSG145-1Y, MSH098-2, MSI178-8, MSJ049-1Y, MSJ472-4P and Superior.

J. 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 8 whole tubers post-harvest from each line in the variety trials. The tubers were held at 20°C for approximately three weeks and then scored for dry rot infection depth and width. These data for average lesion depth for the varieties and lines are ranked and summarized in Table 13. Infection levels within a clone can vary as seen by the multiple tests of the check varieties. Snowden, which has tolerance to fusarium, had infections from 4.9 - 9.6 mm in depth. Superior infections ranged from 16.1 - 16.8 mm, while Onaway infections were from 25.4 - 27.4 mm. No clones showed immunity to dry rot, however, some lines show tolerance at levels equivalent to Snowden. This year results also were surprising in that Superior and Russet Norkotah had much greater infection levels. Some key lines with identified tolerance are AO87277-6, P83-11-5 (similar to 1999), MSE192-8RUS, MSJ033-10Y, MSH356-A, MSG004-3, MSH031-5, MSE018-1, NY112, MSG227-2 and MSG274-3.

Table 1

ROUND WHITE CHIP POTATOES: EARLY HARVEST
MONTCALM RESEARCH FARM
AUGUST 14, 2000 (104 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		3-YR AV US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	MAT[4]	CWT/A
NY112	473	505	94	4	67	26	2	1.074	2.0	6	3	0	0	40	3.5	448
MSF373-8	466	503	92	2	52	40	5	1.075	1.5	6	0	0	0	40	3.3	-
MSE018-1	445	514	86	11	71	16	3	1.083	1.0	0	0	0	0	40	4.5	377
MSG227-2	422	465	91	9	81	10	0	1.083	1.0	6	0	0	0	40	3.4	306*
ATLANTIC	**412**	**462**	**89**	**8**	**75**	**14**	**3**	**1.084**	**1.0**	**17**	**0**	**1**	**0**	**40**	**3.0**	**343**
MSH094-8	403	435	93	6	71	21	1	1.082	1.0	1	0	0	0	40	3.3	-
MSH031-5	403	460	88	10	82	6	3	1.078	1.5	3	0	0	1	40	3.1	-
P83-11-5	375	464	81	13	75	6	7	1.086	1.0	5	0	2	0	40	2.9	275*
MSE230-6Y	368	482	76	23	76	0	1	1.087	1.0	0	0	0	0	40	3.6	-
MSA091-1	352	409	86	10	73	13	4	1.082	1.0	2	0	0	0	40	2.8	277
MSG015-C	350	408	86	13	77	9	2	1.075	1.5	0	0	0	0	40	2.8	-
MSF099-3	347	397	87	11	80	7	2	1.081	1.0	0	0	0	0	40	3.0	312
SNOWDEN	**315**	**363**	**87**	**12**	**80**	**7**	**2**	**1.084**	**1.0**	**1**	**1**	**0**	**0**	**40**	**2.5**	**264**
MSE246-5	305	376	81	15	79	2	4	1.090	1.0	1	0	0	0	40	2.8	250
MSNT-1	294	357	82	17	80	2	0	1.083	1.0	5	0	0	0	40	2.3	257
PIKE	**280**	**324**	**86**	**14**	**82**	**4**	**0**	**1.081**	**1.5**	**0**	**0**	**1**	**0**	**40**	**3.3**	**-**
MSF313-3	268	313	86	11	71	15	4	1.074	1.5	1	0	0	0	40	3.0	265*
MEAN	369	426						1.081								
$LSD_{0.05}$	53	53						0.004								

* Two-Year Avera

[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 Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

[4]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 2

ROUND WHITE CHIP POTATOES: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 25, 2000 (146 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]	CWT/A
MSE018-1	533	600	89	8	62	26	3	1.086	1.0	3	7	0	0	40	2.2	3.8	458
NY112	520	550	95	4	60	34	1	1.075	1.0	3	3	1	0	40	2.2	3.5	472
MSF373-8	517	550	94	2	37	57	4	1.076	1.5	9	0	0	0	40	2.1	3.3	-
MSH031-5	446	491	91	8	84	7	1	1.079	1.0	0	0	1	1	40	3.8	2.8	-
MSG227-2	439	484	91	8	72	18	1	1.080	1.0	7	0	2	0	40	0.8	3.3	338*
MSH094-8	429	472	91	8	73	18	1	1.079	1.0	2	0	2	1	40	2.0	2.3	-
P83-11-5	428	521	82	8	73	9	9	1.083	1.0	2	5	1	1	40	2.0	2.6	315*
MSE230-6	421	516	82	17	78	4	1	1.089	1.0	1	0	2	1	40	2.2	3.0	-
ATLANTIC	**418**	**481**	**87**	**7**	**59**	**27**	**6**	**1.086**	**1.0**	**8**	**0**	**2**	**1**	**40**	**3.3**	**3.0**	**381**
MSA091-1	405	471	86	9	69	17	5	1.081	1.0	0	5	2	2	40	0.5	3.3	296
MSG015-C	401	456	88	10	70	18	2	1.076	1.0	1	1	0	0	40	1.5	2.5	-
MSF099-3	385	435	88	9	71	17	3	1.083	1.0	4	1	0	1	40	2.0	2.5	333
SNOWDEN	**371**	**417**	**89**	**11**	**78**	**11**	**0**	**1.085**	**1.0**	**1**	**8**	**0**	**0**	**40**	**3.0**	**2.3**	**318**
PIKE	**335**	**370**	**90**	**9**	**76**	**14**	**1**	**1.087**	**1.5**	**0**	**1**	**0**	**0**	**40**	**1.8**	**3.1**	**-**
MSNT-1	318	371	86	13	82	4	1	1.082	1.5	3	0	0	0	40	1.8	2.0	260
MSE246-5	318	394	81	16	74	7	3	1.096	1.0	2	3	0	0	40	2.0	2.5	281
MSF313-3	311	376	83	11	63	20	6	1.075	1.5	2	0	1	2	40	1.8	3.0	315*
MEAN	411	468						1.082									
$LSD_{0.05}$	78	72						0.003									

* Two-Year Average

[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 Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 3

ROUND WHITE TABLESTOCK POTATOES: EARLY HARVEST
MONTCALM RESEARCH FARM
AUGUST 14, 2000 (104 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL		3-YR AV US#1
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	MAT[3]	CWT/A
MSG050-2	500	534	94	5	58	35	1	1.077	1	0	0	1	40	3.3	365*
MSE221-1	472	508	93	3	60	33	4	1.070	3	0	0	0	40	2.8	387
ONAWAY	**462**	**506**	**91**	**6**	**62**	**29**	**3**	**1.068**	**0**	**1**	**0**	**0**	**40**	**2.5**	**327**
SUPERIOR	**456**	**488**	**94**	**6**	**87**	**7**	**0**	**1.073**	**0**	**0**	**1**	**5**	**40**	**1.3**	**314***
MSE149-5Y	386	449	86	7	65	21	7	1.069	1	0	0	0	40	3.0	307
MSE028-1	368	405	91	8	80	11	2	1.074	1	0	0	0	40	4.8	-
MSE228-1	347	498	70	29	69	0	2	1.082	0	0	0	0	40	3.8	320
MSG141-3	342	413	83	16	80	3	1	1.088	1	0	0	0	40	2.8	-
MSG004-3	310	336	92	8	76	16	0	1.064	0	0	0	0	40	3.5	-
MSG274-3	251	430	58	41	57	1	1	1.078	0	0	0	0	40	3.5	170*
MEAN	389	457						1.074							
$LSD_{0.05}$	48	52						0.003							

* Two-Year Avera

[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]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 4

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

ROUND WHITE TABLESTOCK POTATOES: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 25, 2000 (146 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	SCAB[3]	MAT[4]	3-YR AVG US#1 CWT/A
MSE028-1	641	707	91	7	60	31	3	1.075	1	0	16	0	40	1.0	4.4	-
ONAWAY	**559**	**603**	**93**	**5**	**57**	**35**	**3**	**1.067**	**0**	**0**	**0**	**0**	**40**	**1.2**	**1.8**	**358**
MSE228-1	529	669	79	20	74	5	1	1.082	0	1	0	0	40	2.2	3.5	402
MSE221-1	527	569	93	3	58	34	4	1.069	0	0	2	0	40	1.3	1.5	395
MSG050-2	501	540	93	5	63	29	2	1.075	0	0	0	1	40	2.5	1.8	392*
MSE149-5Y	444	514	86	8	55	32	6	1.065	1	0	3	1	40	1.5	2.5	351
SUPERIOR	**435**	**473**	**92**	**7**	**87**	**5**	**1**	**1.071**	**2**	**0**	**0**	**10**	**40**	**1.5**	**1.0**	**331***
MSG141-3	431	493	87	12	78	10	1	1.087	0	0	1	0	40	2.5	2.0	-
MSG274-3	418	593	70	27	65	6	3	1.081	5	0	0	0	40	2.5	2.5	298*
MSG004-3	371	399	93	7	63	30	0	1.065	0	0	0	0	40	1.8	3.0	-
MEAN	486	556						1.074								
$LSD_{0.05}$	102	103						0.003								

* Two-Year Average

[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
(From MSU Scab Nursery)
0: No Infection
1: Low Infection <5%
3: Intermediate
5: Highly Susceptible

[4]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 5

MICHIGAN STATE UNIVERS
POTATO BREEDING and GENET

LONG WHITE and RUSSET TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 19, 2000 (140 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	SCAB[3]	MAT[4]	3-YR A US#1 CWT/
BANNOCK RUSSET	**555**	**602**	**92**	**6**	**40**	**53**	**2**	**1.077**	**4**	**0**	**0**	**0**	**40**	**0.3**	**4.3**	**-**
MSE202-3RUS	499	600	83	12	47	36	5	1.081	17	1	0	0	40	0.0	4.1	353*
A087277-6	467	538	87	12	62	25	1	1.083	14	0	0	0	40	2.8	2.8	-
A9045-7	466	511	91	7	45	47	2	1.080	2	0	0	0	40	2.2	2.8	-
A9014-2	445	514	87	13	68	19	1	1.080	3	1	1	0	40	1.0	3.3	-
GEM RUSSET	**392**	**506**	**77**	**21**	**61**	**16**	**2**	**1.080**	**6**	**0**	**0**	**0**	**40**	**1.5**	**3.5**	**-**
RUSSET BURBANK	**369**	**529**	**70**	**20**	**57**	**13**	**11**	**1.079**	**6**	**0**	**0**	**0**	**40**	**1.0**	**2.8**	**248**
A8893-1	369	480	77	18	56	21	5	1.072	8	1	0	0	40	0.5	3.3	-
MSB106-7	346	427	81	14	59	22	5	1.065	0	1	0	1	40	1.3	1.3	252
MSH026-3RUS	322	455	71	28	64	6	1	1.076	3	6	2	0	40	1.0	2.8	263*
RUSSET NORKOTAH	**293**	**439**	**67**	**33**	**60**	**6**	**1**	**1.071**	**2**	**0**	**0**	**0**	**40**	**1.8**	**1.0**	**200**
MSE192-8RUS	274	362	76	22	64	12	2	1.066	1	1	0	0	40	2.0	1.8	200
MEAN	423	516						1.077								
$LSD_{0.05}$	69	66						0.003								

* Two-Year Avera

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

[2]QUALITY
HH: Hollow Heart
BC: Brown Center
VD: Vascular Discoloration
IBS: Internal Brown Spot

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

[4]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 6

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 7, 2000 (128 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[3]	MAT[4]
MSE018-1	613	661	93	6	64	29	1	1.089	1.5	4	1	1	0	40	2.2	3.0
MSB107-1	554	590	94	5	66	28	2	1.076	1.0	0	1	0	0	40	2.5	3.5
RED PONTIAC	**554**	**622**	**89**	**8**	**73**	**16**	**3**	**1.064**	**4.0**	**18**	**0**	**1**	**0**	**40**	**-**	**3.0**
W1386	472	533	89	8	74	15	3	1.083	1.0	3	1	2	1	40	2.5	2.8
NORVALLEY	**454**	**538**	**84**	**12**	**72**	**12**	**4**	**1.077**	**1.0**	**2**	**1**	**3**	**0**	**40**	**-**	**2.3**
ND3574-5R	450	511	88	10	80	8	2	1.056	3.0	0	1	0	0	40	2.2	1.3
ATLANTIC	**445**	**489**	**91**	**7**	**73**	**18**	**2**	**1.088**	**1.5**	**17**	**0**	**2**	**2**	**40**	**3.3**	**2.8**
W1368	444	531	84	16	75	8	0	1.088	1.0	3	1	0	5	40	3.0	2.0
MSF373-8	430	444	97	3	50	47	1	1.078	1.5	3	0	0	0	40	2.2	3.5
W1431	425	458	93	7	82	11	0	1.086	1.0	3	0	1	0	40	2.5	2.5
DARK RED NORLAND	**425**	**476**	**89**	**8**	**82**	**7**	**3**	**1.062**	**3.0**	**0**	**0**	**1**	**1**	**40**	**3.0**	**1.0**
MN17989	410	460	89	7	61	28	4	1.070	3.5	8	0	1	1	30	-	2.6
V0056-1	388	457	85	10	74	11	5	1.076	1.5	26	0	0	2	40	2.0	1.0
MSA091-1	379	433	88	9	69	18	3	1.087	1.0	1	1	0	0	40	0.5	3.0
V0168-3	372	415	90	9	75	15	1	1.067	3.0	3	1	2	0	40	3.0	1.0
ND3196-1R	356	404	88	11	87	1	1	1.068	3.0	0	0	0	5	40	1.5	1.0
SNOWDEN	**354**	**421**	**84**	**10**	**63**	**21**	**6**	**1.081**	**1.0**	**3**	**4**	**0**	**0**	**40**	**3.0**	**2.0**
MN17993	333	415	80	13	66	15	6	1.065	2.5	0	1	0	0	30	-	1.3
MN18713	329	476	69	28	65	4	3	1.086	1.5	4	0	0	0	30	-	2.6
V0024-6	327	390	84	10	69	15	6	1.065	1.5	11	2	3	0	40	3.0	2.0
V0123-25	324	396	82	15	74	7	4	1.072	1.5	5	1	1	0	40	2.0	1.0
MN18365	308	388	79	17	78	2	4	1.059	3.0	0	0	1	1	30	-	1.6
ND4093-4RUS	307	419	73	24	65	8	3	1.071	2.5	9	0	0	1	40	-	1.5
W1355-1	288	423	68	32	67	1	0	1.085	1.0	0	1	1	0	40	3.0	2.3
RUSSET BURBANK	**274**	**444**	**62**	**22**	**57**	**5**	**17**	**1.078**	**1.5**	**4**	**0**	**0**	**0**	**40**	**1.0**	**2.8**
RUSSET NORKOTAH	**265**	**382**	**69**	**29**	**61**	**8**	**2**	**1.069**	**3.0**	**2**	**2**	**0**	**0**	**40**	**2.5**	**1.3**
MEAN	395	468						1.075								
$LSD_{0.05}$	72	71						0.003								

[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 Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 7

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

YELLOW FLESH and EUROPEAN TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 21, 2000 (142 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]
MSE048-2Y	684	713	96	4	63	33	1	1.081	-	19	1	1	0	40	2.2	4.1
TORRIDON	636	771	82	11	71	11	7	1.087	2.5	13	0	13	0	40	3.3	4.3
ACCORD	529	603	88	12	81	7	1	1.079	1.0	0	0	13	0	40	3.3	2.8
SINORA	517	598	86	12	76	10	1	1.079	1.5	0	0	0	0	40	3.0	1.8
MICHIGAN PURPLE	505	540	94	5	65	28	1	1.068	-	0	0	0	0	40	3.0	1.5
MSG147-3P	462	480	96	3	54	43	0	1.062	1.5	0	0	0	0	40	2.8	3.5
MSI201-2PY	449	588	76	22	68	8	2	1.075	-	2	0	0	1	40	3.2	3.3
YUKON GOLD	**416**	**432**	**96**	**3**	**62**	**34**	**1**	**1.080**	**1.5**	**4**	**0**	**1**	**1**	**40**	**2.0**	**1.0**
SAGINAW GOLD	**389**	**459**	**85**	**14**	**79**	**6**	**1**	**1.073**	**1.5**	**0**	**1**	**0**	**0**	**40**	**2.0**	**1.0**
MSF165-6RY	385	425	91	9	79	12	1	1.074	-	0	0	0	0	40	2.0	1.0
SW93107	320	499	64	31	62	2	5	1.073	-	0	0	0	0	40	1.5	4.0
MSG145-1Y	311	341	91	5	69	22	3	1.070	3.5	13	1	0	0	40	1.5	1.5
LADY CHRISTL	286	453	63	36	61	2	1	1.064	-	0	1	3	7	40	1.3	2.3
MSE040-6RY	268	375	71	26	70	1	3	1.071	-	0	0	0	0	35	3.0	2.0
LADY CLAIRE	246	405	61	39	61	0	0	1.080	1.0	0	1	0	0	40	1.3	1.8
MEAN	427	512						1.074								
$LSD_{0.05}$	103	100						0.003								

[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 Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

ADAPTATION TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 18, 2000 (139 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL		
LINE	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]
MSH333-3	573	613	93	3	53	40	4	1.075	1.0	0	0	2	0	40	4.5	2.5
MSI050-4	556	612	91	8	79	11	1	1.081	-	0	0	0	20	40	3.0	2.5
AF1437-1	537	569	94	5	80	14	1	1.061	1.5	2	0	3	0	40	-	2.3
MSB107-1	523	560	93	4	64	29	3	1.075	1.5	0	1	0	0	40	2.2	3.3
NY120	520	542	96	2	79	17	2	1.085	1.5	0	18	0	0	40	1.5	2.8
MSH112-6	502	566	89	10	76	13	1	1.089	1.5	1	2	0	0	40	1.7	2.3
MSE273-8	490	551	89	7	68	21	4	1.078	2.0	9	3	3	0	40	3.5	3.3
AF1775-2	473	514	92	4	57	35	4	1.079	2.0	19	1	0	0	40	3.0	3.0
AF1615-1	465	530	88	8	66	22	4	1.074	2.0	1	4	3	2	40	3.0	3.0
SUPERIOR	**464**	**492**	**94**	**5**	**87**	**7**	**1**	**1.070**	**2.0**	**1**	**2**	**2**	**4**	**40**	**1.5**	**1.0**
MSE228-11	462	597	77	22	74	3	1	1.082	2.0	0	1	1	0	40	3.0	3.0
MSI002-3	458	516	89	10	77	11	1	1.079	2.0	1	1	0	0	40	4.0	1.3
ONAWAY	**454**	**499**	**91**	**6**	**73**	**18**	**3**	**1.065**	**3.5**	**1**	**2**	**1**	**0**	**40**	**1.2**	**1.5**
ATLANTIC	**447**	**490**	**91**	**6**	**69**	**22**	**2**	**1.086**	**2.0**	**16**	**0**	**2**	**1**	**40**	**3.5**	**2.5**
ND01496-1	442	491	90	7	73	17	3	1.082	1.0	1	2	1	0	40	3.3	3.5
MSI037-4	436	479	91	8	74	17	1	1.085	1.5	2	2	0	2	40	3.0	3.0
MSF001-2	431	469	92	6	81	11	3	1.087	1.5	1	1	1	0	40	3.2	2.8
MSI085-10	430	488	88	9	77	11	3	1.085	1.5	1	7	0	0	40	4.0	3.8
MSF060-6	422	445	95	5	68	27	0	1.080	1.5	3	2	3	2	40	1.5	3.0
MSH015-2	419	469	89	5	70	20	6	1.090	1.5	0	2	3	0	40	1.0	2.5
B1865-2	414	454	91	7	66	25	2	1.067	2.0	1	0	3	0	40	2.8	4.0
MSB076-2	398	453	88	11	82	6	1	1.092	1.5	5	0	0	0	40	1.6	2.8
MSH095-4	387	432	90	9	70	20	2	1.086	1.5	2	3	2	0	40	2.5	3.0
MSH106-2	380	423	90	10	83	7	0	1.092	1.0	0	1	9	3	40	1.0	3.0
MSI055-5	371	440	84	14	80	4	2	1.079	1.5	0	0	8	3	40	4.0	2.0
SNOWDEN	**367**	**418**	**88**	**11**	**77**	**11**	**2**	**1.082**	**-**	**2**	**6**	**1**	**0**	**40**	**3.0**	**2.3**
MSH067-3	366	404	91	5	67	24	4	1.083	1.5	6	0	4	0	40	3.3	1.8
MSE080-4	363	399	91	8	70	21	1	1.073	2.0	1	3	0	0	40	2.0	2.0
MSG106-5	362	405	90	9	70	19	1	1.071	2.0	1	1	1	0	40	3.5	1.5
MSH217-1	362	438	83	14	71	12	4	1.085	1.0	1	0	5	0	40	3.3	3.3
MSH098-2	358	376	95	4	64	32	0	1.081	1.0	1	0	1	1	40	3.0	2.3
MSH360-1	355	391	91	9	73	18	0	1.086	1.0	2	0	1	0	40	3.0	3.0
MSH370-3	342	423	81	17	72	9	2	1.082	1.0	3	1	0	1	40	3.0	1.8
MSE030-4	327	393	83	16	66	17	0	1.075	1.5	0	0	0	0	40	2.2	2.5
MSI168-2	321	398	81	18	75	6	1	1.085	1.5	0	3	0	0	40	3.3	1.8
MSH123-5	312	365	85	11	66	20	4	1.084	1.0	0	8	1	0	40	1.0	5.0
AF1668-60	272	303	89	7	73	16	3	1.076	1.0	1	4	0	0	40	1.5	1.5
MSF382-2	264	295	90	9	84	6	1	1.066	2.0	0	0	0	0	40	1.0	1.3
MEAN	417	466						1.080								
$LSD_{0.05}$	71	68						0.003								

[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 Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 9

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

PRELIMINARY TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 13, 2000 (134 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						CHIP	TUBER QUALITY[2]				TOTAL			
LINE	US#1	OTAL	US#1	Bs	As	OV	PO	SP GR	SCORE[3]	HH	VD	IBS	BC	CUT	SCAB[4]	MAT[5]	PEDIGREE
MSJ080-1	624	683	91	8	66	25	1	1.074	1.0	3	0	0	0	20	3.2	2.5	C148-A X S440
MSJ033-10Y	586	664	88	11	74	14	1	1.072	-	0	4	3	0	20	1.0	3.0	A097-1Y X PENTA
MSI582-A	562	624	90	8	71	19	2	1.078	2.5	0	1	0	0	20	2.5	3.0	P88-13-4 X W877
MSI011-AY	532	622	86	12	80	6	3	1.079	1.5	0	2	0	0	20	2.0	3.0	ACKERSEGEN X ND01496-1
MSJ132-1Y	531	563	94	4	56	39	1	1.083	2.0	2	0	1	0	20	3.0	3.0	LENAPE X ZAREVO
MSJ107-4	530	578	92	7	76	16	2	1.097	1.5	6	1	0	0	20	-	3.5	E230-6 X ZAREVO
MSJ343-1	491	573	86	8	67	19	6	1.087	1.5	10	1	0	0	20	-	4.5	BRODICK X F077-8
ONAWAY	**476**	**536**	**89**	**7**	**71**	**18**	**4**	**1.069**	**-**	**0**	**1**	**0**	**0**	**20**	**1.2**	**1.5**	
MSJ080-8	472	533	88	10	83	5	1	1.087	1.0	1	0	0	0	20	2.5	2.5	C148-A X S440
MSJ153-2Y	464	496	93	5	54	40	1	1.073	-	4	0	3	1	20	2.0	4.0	NY101 (Y) X PENTA
MSJ163-7R	458	526	87	13	79	8	0	1.102	1.5	1	1	0	0	20	-	3.0	PIKE X ZAREVO
MSI170-4	440	490	90	7	68	22	3	1.086	1.5	1	3	0	0	20	3.0	3.3	NORVALLEY X E234-3
MSJ168-2Y	431	461	94	6	69	24	0	1.066	1.0	0	1	0	0	20	2.0	3.0	P84-13-12 X ND860-2
MSI058-22	427	476	90	10	82	8	0	1.085	1.0	9	0	0	0	20	4.0	2.0	BRODICK X F134-1
MSJ156-4Y	425	462	92	7	59	33	1	1.069	-	3	0	0	0	20	2.5	2.5	NY101 (Y) X YUKON GOLD
MSJ204-3	422	453	93	4	67	27	3	1.066	-	0	0	0	0	20	1.8	3.5	SUPERIOR X OP
MSJ060-2	420	445	94	5	70	24	1	1.082	1.5	4	0	0	0	20	3.0	1.5	B0766-3 X W877
MSJ049-1Y	417	467	89	10	72	17	1	1.080	-	0	0	2	0	20	1.8	1.0	B076-2 X YUKON GOLD
SUPERIOR	**416**	**447**	**93**	**6**	**86**	**7**	**1**	**1.073**	**-**	**1**	**0**	**1**	**2**	**20**	**1.5**	**1.0**	
MSJ177-5R	407	469	87	13	79	8	1	1.070	2.0	0	0	0	0	20	2.5	1.5	REDDALE X ZAREVO
MSJ307-2	407	453	90	5	57	33	6	1.065	-	0	1	0	0	20	1.8	3.5	B0718-3 X C148-1
ATLANTIC	**402**	**453**	**89**	**8**	**70**	**18**	**3**	**1.086**	**1.0**	**10**	**0**	**0**	**0**	**20**	**3.5**	**2.5**	
MSJ147-1	397	462	86	14	83	3	0	1.083	1.0	1	0	0	0	20	2.3	3.8	ND2417-6 X S440
MSJ166-1	388	436	89	9	74	15	2	1.077	-	0	1	1	0	20	2.8	2.0	PRESTILE X YUKON GOLD
MSJ438-2	387	480	81	16	71	10	3	1.104	-	3	0	0	0	20	-	4.0	PENTA X ZAREVO
MSJ456-4	387	453	85	14	75	11	0	1.085	2.0	4	0	0	0	20	-	3.0	TOLLOCAN X CONESTOGA
MSJ033-6Y	382	429	89	10	65	24	1	1.073	-	0	0	1	0	20	1.0	3.5	A097-1 X PENTA
MSJ170-4	378	465	81	18	78	3	1	1.089	1.5	2	0	0	0	20	2.8	2.5	P84-13-12 X S440
MSJ316-3	365	416	88	12	74	14	0	1.082	1.5	2	0	3	0	20	-	4.0	B0718-3 X PIKE
MSJ059-3	359	445	81	19	77	4	0	1.095	1.0	0	1	1	0	20	-	3.0	B0766-3 X S440
PIKE	**353**	**387**	**91**	**8**	**75**	**16**	**1**	**1.089**	**1.0**	**0**	**0**	**3**	**0**	**20**	**1.5**	**3.0**	
MSJ202-1	353	450	78	14	77	1	7	1.094	1.0	0	0	0	0	20	2.0	3.5	SPARTAN PEARL X ZAREVO
MSH018-5	350	465	75	23	75	1	2	1.093	1.0	0	0	0	0	20	3.0	2.5	BRODICK X MSC127-3
MSH380-3Y	348	393	89	11	74	15	1	1.086	1.0	6	0	0	1	20	3.3	2.5	GRETA X C127-3
MSH356-A	346	385	90	10	79	11	0	1.086	1.0	2	1	1	0	20	1.0	3.0	PIKE X C135-5
MSH222-58	342	413	83	13	74	9	4	1.068	1.5	1	0	0	0	20	3.5	1.5	MSA091-1 X HLG75-297
MSI201-2PY	341	544	63	36	61	2	2	1.081	-	0	0	1	0	20	3.2	3.0	ERNESTOLZ X E234-7
SNOWDEN	**340**	**405**	**84**	**15**	**76**	**8**	**1**	**1.082**	**1.0**	**0**	**0**	**0**	**0**	**20**	**3.0**	**2.5**	
MSJ112-5	336	377	89	11	82	7	0	1.086	1.0	0	0	0	0	20	2.0	2.0	E250-2 X S440
MSI137-CY	330	380	87	13	71	17	0	1.084	1.5	5	0	1	0	20	2.0	3.0	GRETA X F077-8
MSJ212-2	318	426	75	25	70	4	0	1.080	1.5	0	0	6	0	20	2.3	3.0	S438 X ZAREVO
MSJ452-4Y	317	483	66	23	61	5	11	1.094	-	0	4	0	0	20	4.0	3.0	STOBRAWA X YUKON GOLD
MSI026-A	313	393	80	19	78	1	1	1.081	1.0	0	0	0	0	20	-	3.0	B076-2 X C135-4
MSJ494-1	312	393	79	20	79	1	1	1.095	1.0	3	0	1	0	20	-	3.5	ZAREVO X PIKE
MSJ472-4P	303	417	73	27	68	5	1	1.088	1.0	3	0	0	1	20	2.5	3.0	ZAREVO X A199-1P
MSJ482-2	259	386	67	30	65	2	3	1.101	1.5	0	0	2	0	20	1.8	2.5	ZAREVO X C127-3
MEAN	405	473						1.083									
$LSD_{0.05}$	116	107						0.005									

[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 Assoc. Scale
(Out of the field)
Ratings: 1 - 5
1: Excellent
5: Poor

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

[5]MATURITY RATING
(taken August 14, 2000)
Ratings: 1 - 5
1: Early (vines completely dead)
5: Late (vigorous vine; some flowering)

Planted May 2, 2000

Table 10A

2000 SCAB DISEASE TRIAL
SCAB NURSERY, EAST LANSING, MI

LINE	RATING	LINE	RATING	LINE	RATING	LINE	RATING
MSE202-3RUS	0.0	MSB076-2	1.6	MSF373-8	2.1	AF1615-1	3.0
BANNOCK RUSSET	**0.3**	MSH112-6	1.7	A9045-7	2.2	AF1775-2	3.0
A8893-1	0.5	MSF313-3	1.8	MSB107-1	2.2	**DARK RED NORLAND**	**3.0**
MSA091-1	0.5	MSG004-3	1.8	MSE018-1	2.2	MICHIGAN PURPLE	3.0
MSG227-2	0.8	MSJ049-1Y	1.8	MSE030-4	2.2	MSE040-6RY	3.0
A9014-2	1.0	MSJ204-3	1.8	MSE048-2Y	2.2	MSE228-11	3.0
MSE028-1	1.0	MSJ307-2	1.8	MSE228-1	2.2	MSH018-5	3.0
MSF382-2	1.0	MSJ482-2	1.8	MSE230-6	2.2	MSH098-2	3.0
MSH015-2	1.0	MSNT-1	1.8	ND3574-5R	2.2	MSH360-1	3.0
MSH026-3RUS	1.0	MSE080-4	2.0	NY112	2.2	MSH370-3	3.0
MSH106-2	1.0	MSE192-8RUS	2.0	MSJ147-1	2.3	MSI037-4	3.0
MSH123-5	1.0	MSE246-5	2.0	MSJ212-2	2.3	MSI050-4	3.0
MSH356-A	1.0	MSF099-3	2.0	MSG050-2	2.5	MSI170-4	3.0
MSJ033-10Y	1.0	MSF165-6RY	2.0	MSG141-3	2.5	MSJ060-2	3.0
MSJ033-6Y	1.0	MSH094-8	2.0	MSG274-3	2.5	MSJ132-1Y	3.0
RUSSET BURBANK	**1.0**	MSI011-AY	2.0	MSH095-4	2.5	SINORA	3.0
ONAWAY	**1.2**	MSI137-CY	2.0	MSI582-A	2.5	**SNOWDEN**	**3.0**
LADY CHRISTL	1.3	MSJ112-5	2.0	MSJ080-8	2.5	V0024-6	3.0
LADY CLAIRE	1.3	MSJ153-2Y	2.0	MSJ156-4Y	2.5	V0168-3	3.0
MSB106-7	1.3	MSJ168-2Y	2.0	MSJ177-5R	2.5	W1355-1	3.0
MSE221-1	1.3	MSJ202-1	2.0	MSJ472-4P	2.5	W1368	3.0
AF1668-60	1.5	P83-11-5	2.0	**RUSSET NORKOTAH**	**2.5**	MSF001-2	3.2
GEM RUSSET	**1.5**	**SAGINAW GOLD**	**2.0**	W1386	2.5	MSI201-2PY	3.2
MSE149-5Y	1.5	V0056-1	2.0	W1431	2.5	MSJ080-1	3.2
MSF060-6	1.5	V0123-25	2.0	A087277-6	2.8	ACCORD	3.3
MSG015-C	1.5	**YUKON GOLD**	**2.0**	B1865-2	2.8	**ATLANTIC**	**3.3**
MSG145-1Y	1.5			MSG147-3P	2.8	MSH067-3	3.3
ND3196-1R	1.5			MSJ166-1	2.8	MSH217-1	3.3
NY120	1.5			MSJ170-4	2.8	MSH380-3Y	3.3
PIKE	**1.5**					MSI168-2	3.3
SUPERIOR	**1.5**					ND01496-1	3.3
SW93107	1.5					TORRIDON	3.3
						MSE273-8	3.5
						MSG106-5	3.5
						MSH222-58	3.5
						MSH031-5	3.8
						MSI002-3	4.0
						MSI055-5	4.0
						MSI058-22	4.0
						MSI085-10	4.0
						MSJ452-4Y	4.0
						MSH333-3	4.5

SCAB DISEASE RATING
(From MSU Scab Nursery)
0: No Infection
1: Low Infection <5%
3: Intermediate
5: Highly Susceptible

Table 10B

SCAB DISEASE TRIAL, THREE-YEAR SUMMARY
SCAB NURSERY, EAST LANSING, MI

LINE	1998 RATING[1]	1999 RATING[1]	2000 RATING[2]	LINE	1998 RATING[1]	1999 RATING[1]	2000 RATING[2]
ATLANTIC	**3.3**	**3.0**	**3.3**	MSG015-C	1.0	1.2	1.5
MICHIGAN PURPLE	-	3.0	3.0	MSG050-2	4.0	2.0	2.5
MSA091-1	1.5	1.0	0.5	MSG145-1Y	3.0	2.0	1.5
MSB076-2	1.2	1.5	1.6	MSG147-3P	3.0	2.5	2.8
MSB106-7	2.3	1.3	1.3	MSG227-2	1.0	1.1	0.8
MSB107-1	1.0	1.5	2.2	MSG274-3	3.3	3.5	2.5
MSE018-1	3.0	3.0	2.2	MSH031-5	2.0	2.0	3.8
MSE028-1	1.8	1.0	1.0	MSH067-3	2.7	1.8	3.3
MSE040-6RY	2.5	2.0	3.0	MSH098-2	1.3	2.5	3.0
MSE048-2Y	1.0	2.0	2.2	MSH106-2	1.0	1.0	1.0
MSE149-5Y	1.8	2.0	1.5	MSNT-1	1.8	1.5	1.8
MSE192-8RUS	1.0	1.2	2.0	NY112	1.8	1.5	2.2
MSE202-3RUS	1.0	1.2	0.0	**ONAWAY**	**1.5**	**1.2**	**1.2**
MSE221-1	1.5	1.2	1.3	P83-11-5	2.0	1.7	2.0
MSE228-1	2.8	3.0	2.2	**PIKE**	**1.0**	**-**	**1.5**
MSE228-11	3.2	3.0	3.0	**RED PONTIAC**	**3.3**	**3.8**	**-**
MSE230-6	2.3	1.5	2.2	**RUSSET BURBANK**	**1.0**	**1.0**	**1.0**
MSE246-5	1.0	2.0	2.0	**RUSSET NORKOTAH**	**2.0**	**2.0**	**2.5**
MSF001-2	4.0	3.5	3.2	**SAGINAW GOLD**	**2.0**	**1.3**	**2.0**
MSF099-3	3.7	2.7	2.0	**SNOWDEN**	**3.5**	**3.0**	**3.0**
MSF313-3	2.7	2.7	1.8	**SUPERIOR**	**1.2**	**1.0**	**1.5**
MSF373-8	2.3	1.7	2.1	W1355-1	3.0	2.8	3.0
MSG004-3	1.0	3.0	1.8	**YUKON GOLD**	**2.7**	**2.5**	**2.0**

[1]SCAB DISEASE RATING
1: Practically No Infection
2: Low Infection
3: Avg. Susceptibility (i.e. Atlantic)
4: High Susceptibility
5: Severe Susceptibility

[2]SCAB DISEASE RATING
0: No Infection
1: Low Infection <5%
3: Intermediate
5: Highly Susceptible

Table 11

MICHIGAN STATE UNIVERSITY
POTATO BREEDING and GENETICS

LATE BLIGHT VARIETY TRIAL
MUCK SOILS RESEARCH FARM

Inoculated July 26, 2000
Rating based on a 39-day evaluation period
RAUDPC Max = 1.000

LINE	RAUDPC[1] LSMEAN	LINE	RAUDPC LSMEAN
LBR8	0.003	Umatilla	0.176
MSG274-3	**0.007**	MSJ107-4	0.182
MSJ459-4	0.009	A12039-06	0.183
MSJ457-2	0.009	**Russet Burbank**	**0.186**
MSJ456-4	0.010	MSJ494-1	0.193
B0767-2	0.013	MSJ324-2	0.193
MSJ307-2	0.014	NY103	0.195
Q237-25	0.017	MSH123-5	0.199
Torridon	0.018	MSJ438-2	0.201
MSJ459-3	0.019	**Snowden[2]**	**0.234**
MSJ018-2	0.019	Bannock Russet	0.257
MSJ319-7	0.023	Ranger Russet	0.267
B0692-4	0.025	**Yukon Gold**	**0.278**
MSJ453-4	0.025	NorDonna	0.278
MSJ343-1	0.030	**Superior**	**0.278**
MSJ319-1	0.031	**Russet Norkotah**	**0.281**
A90586-1	0.032	**Russet Burbank**	**0.288**
B1865-2	0.033	**Atlantic**	**0.298**
MSI152-A	0.043	**Snowden**	**0.312**
MSJ458-2	0.044	**DR Norland**	**0.322**
MSJ456-2	0.045	**NorValley**	**0.323**
MSJ317-1	0.050	Lady Claire	0.332
MSJ464-1	0.068	Sinora	0.337
MSI058-4	0.086	**Atlantic**	**0.341**
LBR7	0.136	**Russet Norkotah**	**0.352**
MSJ468-1	0.144	Saginaw Gold	0.354
MSI050-4	0.151	Lady Christl	0.360
MSJ334-1Y	0.156	**Pike**	**0.365**
LBR1R2R3R4	0.157	Michigan Purple	0.408
ND02438-7R	0.170	**Onaway**	**0.428**
C086218-2	0.171	**Superior**	**0.442**
LBR5	0.171		
		$LSD_{0.05}$ =	0.0801

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

[2] 214 varieties and breeding lines were tested in all. For brevity purposes, only selected varieties and breeding lines with a RAUDPC value greater than 0.200 are listed.

Table 12A

2000 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									
MSH031-5	18	5					23	78	0.217
MSE230-6	18	5	1	1			25	72	0.400
MSF313-3	16	8		1			25	64	0.440
MSF373-8	13	11	1	1			26	50	0.615
P83-11-5	14	8	1	2			25	56	0.640
MSG227-2	10	13	2				25	40	0.680
MSF099-3	9	13	2	1			25	36	0.800
MSH094-8	8	11	5				24	33	0.875
NY112	8	7	6	2			23	35	1.087
ATLANTIC	9	5	5	3			22	41	1.091
SNOWDEN	6	11	7	1			25	24	1.120
MSA091-1	9	9	3	1	3		25	36	1.200
PIKE	6	9	7	3			25	24	1.280
MSE018-1	1	10	12	2			25	4	1.600
MSNT-1	3	7	8	4	2	1	25	12	1.920
MSG015-C		9	8	8	1		26	0	2.038
MSE246-5	2	5	7	4	4	2	24	8	2.375
ROUND WHITES: TABLE									
MSE149-5Y	16	7					23	70	0.304
MSE221-1	18	6	1				25	72	0.320
MSG141-3	14	9	1	1			25	56	0.560
MSE028-1	15	6	3	1			25	60	0.600
SUPERIOR	15	8	2		1		26	58	0.615
ONAWAY	15	6	5				26	58	0.615
MSE228-1	12	10	3				25	48	0.640
MSG050-2	11	12	4	1			28	39	0.821
MSG004-3	9	7	7	2			25	36	1.080
MSG274-3	3	10	10	2			25	12	1.440

* 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 31, 2000. The table is presented in descending 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									
MSH026-3RUS	15	9	1				25	60	0.440
MSE192-8RUS	15	7	3				25	60	0.520
BANNOCK RUSSET	14	7	2	2			25	56	0.680
RUSSET NORKOTAH	10	11	2	1			24	42	0.750
MSE202-3RUS	9	12	4				25	36	0.800
A087277-6	7	13	3	1			24	29	0.917
A9014-2	8	13	3		1		25	32	0.920
A8893-1	8	8	7	1			24	33	1.042
RUSSET BURBANK	8	8	6	3			25	32	1.160
GEM RUSSET	3	11	7	3			24	13	1.417
A9045-7	5	8	9	2	1		25	20	1.440
MSB106-7	5	5	8	4	2		24	21	1.708
NORTH CENTRAL REGIONAL TRIAL									
ND3574-5R	24	2	1				27	89	0.148
V0024-6	21	4	1				26	81	0.231
DR NORLAND	19	6					25	76	0.240
VO168-3	17	9					26	65	0.346
MN17993	16	3			1		20	80	0.350
RUSSET NORKOTAH	18	4	3				25	72	0.400
RED PONTIAC	15	8	1				24	63	0.417
NORVALLEY	11	12	1				24	46	0.583
MSF373-8	12	10	1	1			24	50	0.625
V0056-1	15	4	6				25	60	0.640
ND3196-1R	14	9	3	1			27	52	0.667
MN18365	9	6	2	1			18	50	0.722
RUSSETBURBANK	9	11	3	2			25	36	0.920
W1431	13	7	7			1	28	46	0.929
ND4093-4RUS	11	6	7	2			26	42	1.000
SNOWDEN	8	12	3	1		1	25	32	1.040
ATLANTIC	7	10	5	3			25	28	1.160
MSA091-1	4	15	5	1		1	26	15	1.269
VO123-25	8	8	7	2		1	26	31	1.269
MN17989	3	7	5	2	1		18	17	1.500
MSB107-1	5	10	4	3	3		25	20	1.560
W1368	4	9	5	3	2		23	17	1.565
MSE018-1	4	7	8	8	2		29	14	1.897
W1355-1	1	7	7	5	3		23	4	2.087
MN18713	2	3	7	2	3	1	18	11	2.222
W1386		1	3	4	1	4	13	0	3.308
YELLOW FLESH and EUROPEAN TRIAL									
MSG147-3P	20	2	1				23	87	0.174

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
LADY CLAIRE	19	6					25	76	0.240
MSG145-1Y	18	6					24	75	0.250
MSF165-6RY	20	5	1				26	77	0.269
MSE040-6RY	20	3	2				25	80	0.280
LADY CRYSTAL	16	6	1				23	70	0.348
YUKON GOLD	17	4	3				24	71	0.417
MSI201-2PY	14	10	1				25	56	0.480
SINORA	11	6	1	1			19	58	0.579
MICHIGAN PURPLE	9	12	4				25	36	0.800
SAGINAW GOLD	7	13	6	1			27	26	1.037
ACCORD	6	9	8	2			25	24	1.240
MSE048-2Y	5	10	8	2			25	20	1.280
TORRIDON	4	6	9	6	1		26	15	1.769
SW93107	2	11	5	4	3		25	8	1.800
ADAPTATION TRIAL									
MSH098-2	21	1					22	95	0.045
MSI178-8	22	3					25	88	0.120
AF1668-60	19	3					22	86	0.136
MSE228-11	21	3	1				25	84	0.200
SUPERIOR	20	4	1				25	80	0.240
MSI002-3	17	8					25	68	0.320
MSE080-4	19	4	2				25	76	0.320
MSI050-4	18	4			1		23	78	0.348
MSH015-2	17	5	2				24	71	0.375
MSH067-3	13	9	2				24	54	0.542
MSF382-2	16	4	5				25	64	0.560
MSH370-3	10	4	3				17	59	0.588
MSH217-1	12	7	3				22	55	0.591
MSI055-5	14	8	2	1			25	56	0.600
AF1437-1	14	5	3	1			23	61	0.609
MSH106-2	14	7	3	1			25	56	0.640
MSI037-7	13	7	3		1		24	54	0.708
MSH112-6	14	6	3	2			25	56	0.720
ND01496-1	11	9	2		1		23	48	0.739
ONAWAY	12	9	1	1	1		24	50	0.750
MSE030-4	12	8	4	1			25	48	0.760
AF1615-1	9	11	2	1			23	39	0.783
MSF001-2	9	11	4				24	38	0.792
MSI085-10	8	10	4				22	36	0.818
MSB076-2	10	8	5	1			24	42	0.875
MSH333-3	9	10	4	1			24	38	0.875
B1865-2	12	6	5	1		1	25	48	0.960
AF1775-2	11	6	4	2	1		24	46	1.000

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MSE273-8	12	6	3	3	1		25	48	1.000
NY120	6	13	3	2			24	25	1.042
MSH360-1	6	14	2	2	1		25	24	1.120
MSG106-5	8	8	7	2			25	32	1.120
MSH123-5	10	5	7	4			26	38	1.192
MSI168-2	8	8	5	4			25	32	1.200
ATLANTIC	8	8	4	2	2		24	33	1.250
SNOWDEN	6	7	11		1		25	24	1.320
MSB107-1	5	10	5	1	1	1	23	22	1.391
MSH095-4	5	8	5	3	3	1	25	20	1.760
MSF060-6	1	4	8	5	3	2	23	4	2.478
PRELIMINARY TRIAL									
MSJ168-2Y	20						20	100	0.000
MSJ049-1Y	10	5					15	67	0.333
MSJ156-4Y	12	5	3				20	60	0.550
SUPERIOR	13	4	2	1			20	65	0.550
MSJ472-4P	11	5	4				20	55	0.650
MSJ033-6Y	11	4	4	1			20	55	0.750
MSI201-2PY	5	14	1				20	25	0.800
MSJ170-4	9	6	2	2			19	47	0.842
MSJ153-2Y	3	4	3				10	30	1.000
MSJ204-3	9	6	3	1		1	20	45	1.000
MSJ316-3	5	10	3	2			20	25	1.100
MSJ154-16A	4	2	1	2			9	44	1.111
MSJ033-10Y	6	6	7	1			20	30	1.150
MSI587-A	9	5	2	3		1	20	45	1.150
MSJ080-1	6	6	5	1		1	19	32	1.263
MSH186-13Y	5	6	6	2			19	26	1.263
MSJ069-3	8	3	5	1	2		19	42	1.263
MSH222-58	5	5	9	1			20	25	1.300
MSJ307-2	7	3	6	5	1		22	32	1.545
MSJ112-5	7	2	5	5	1		20	35	1.550
ONAWAY	4	5	6	5			20	20	1.600
MSJ202-1	3	4	8	3			18	17	1.611
MSJ060-2	2	5	9	4			20	10	1.750
MSJ059-3	5	6	3	3	1	2	20	25	1.750
MSJ343-1	2	6	6	4	1		19	11	1.789
MSJ494-1	4	6	3	2	4		19	21	1.789
MSJ166-1	1	9	5	3	2		20	5	1.800
MSJ080-8	4	6	4	3	1	2	20	20	1.850
MSJ147-1	7	2	5	5	1	2	22	32	1.864
MSJ163-7R	1	7	5	5	1		19	5	1.895
MSH308-3Y	1	5	6	8			20	5	2.050

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MSJ132-1Y	4	2	7	2	2	2	19	21	2.105
ATLANTIC	2	4	7	4	2	1	20	10	2.150
MSJ212-2	1	5	6	6	2		20	5	2.150
MSJ482-2		5	8	6	1		20	0	2.150
MSJ107-4	2	3	7	3	1	2	18	11	2.222
MSI058-2	2	3	9	3		3	20	10	2.250
MSH018-5		4	9	4	3		20	0	2.300
MSI011-A		4	6	7	2		19	0	2.368
SNOWDEN	1	4	6	4	1	3	19	5	2.474
MSJ452-4Y	1	3	7	4	3	2	20	5	2.550
MSJ438-2	1	5	3	4	4	2	19	5	2.579
PIKE	2	2	4	8	1	3	20	10	2.650
MSI170-4	2	2	6	4	1	5	20	10	2.750
MSI137-CY	2	1	6	2	1	6	18	11	2.944
MSH356-A		2	3	6	3	3	17	0	3.118
MSI058-38	1	3	2	4	3	7	20	5	3.300
MSI026-A		4	2	4	2	7	19	0	3.316
MSJ456-4	1	1	4	2	3	8	19	5	3.526
MSI102-E			2	4	4	10	20	0	4.100
SNACK FOOD ASSOCIATION TRIAL									
NY112	21	3					24	88	0.125
FL1867	21	4					25	84	0.160
AF1668-60	21	4					25	84	0.160
SNOWDEN	23	6	1				30	77	0.267
W1431	20	6	3				29	69	0.414
B0766-3	16	9	1				26	62	0.423
ATLANTIC	16	9	1				26	62	0.423
MSA091-1	16	8		1			25	64	0.440
MSNT-1	16	7	1	1			25	64	0.480
MSE246-5	9	5	2				16	56	0.563
NY120	14	7	4				25	56	0.600
AF1775-2	12	10	3				25	48	0.640

Table 12B

2000 BLACKSPOT BRUISE SUSCEPTIBILITY TEST
CHECK 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									
MSNT-1	22	3					25	88	0.120
MSH094-8	21	4					25	84	0.160
P83-11-5	21	3	1				25	84	0.200
MSE230-6	18	5					23	78	0.217
MSF099-3	17	5					22	77	0.227
MSH031-5	17	5	1				23	74	0.304
MSF373-8	19	6	1				26	73	0.308
SNOWDEN	18	7	1				26	69	0.346
MSF313-3	17	6	2				25	68	0.400
MSA091-1	15	8	2				25	60	0.480
MSE246-5	14	7	4				25	56	0.600
MSG227-2	13	9	3				25	52	0.600
ATLANTIC	13	6	6				25	52	0.720
MSE018-1	9	13	3				25	36	0.760
NY112	11	9	4	1			25	44	0.800
PIKE	12	8	3	2	1		26	46	0.923
MSG015-C	4	8	7	6			25	16	1.600
ROUND WHITES: TABLE									
MSG141-3	22	2					24	92	0.083
SUPERIOR	22	3					25	88	0.120
MSE228-1	20	3					23	87	0.130
MSE221-1	19	6					25	76	0.240
MSE149-5Y	22	2	1	1			26	85	0.269
MSG004-3	17	7	1				25	68	0.360
ONAWAY	19	4	1	1			25	76	0.360
MSG274-3	16	7	1	1			25	64	0.480
MSE028-1	12	13					25	48	0.520
MSG050-2	15	5	4				24	63	0.542

** Tuber samples were collected at harvest, graded, and held until evaluation.
Samples were abrasive-peeled and scored on November 1, 2000.
The table is presented in descending 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									
A8893-1	27						27	100	0.000
GEM RUSSET	24						24	100	0.000
MSE192-8RUS	25						25	100	0.000
RUSSET NORKOTAH	25						25	100	0.000
A087277-6	27	1					28	96	0.036
MSE202-3RUS	24	1					25	96	0.040
RUSSET BURBANK	23	1					24	96	0.042
BANNOCK RUSSET	22	1					23	96	0.043
MSH026-3RUS	18	1					19	95	0.053
A9014-2	20	2					22	91	0.091
A9045-7	23	4					27	85	0.148
MSB106-7	15	7	3				25	60	0.520
NORTH CENTRAL REGIONAL TRIAL									
DR NORLAND	26						26	100	0.000
MN17993	20						20	100	0.000
MSA091-1	25						25	100	0.000
ND3574-5R	26						26	100	0.000
ND4093-4RUS	26						26	100	0.000
ND3196-1R	25						25	100	0.000
RUSSET NORKOTAH	25						25	100	0.000
V0056-1	24						24	100	0.000
W1431	25						25	100	0.000
V0024-6	25	1					26	96	0.038
NORVALLEY	24	1					25	96	0.040
RUSSETBURBANK	24	1					25	96	0.040
MN17989	19	1					20	95	0.050
MN18365	19	1					20	95	0.050
MSE018-1	24	2					26	92	0.077
W1355-1	24	2					26	92	0.077
SNOWDEN	23	2					25	92	0.080
MSF373-8	22	3					25	88	0.120
RED PONTIAC	22	3					25	88	0.120
W1386	17	3					20	85	0.150
V0168-3	20	5					25	80	0.200
ATLANTIC	21	3	2				26	81	0.269
MN18713	14	3	1				18	78	0.278
W1368	18	7					25	72	0.280
MSB107-1	21	4	2				27	78	0.296
V0123-25	17	4	4				25	68	0.480
YELLOW FLESH and EUROPEAN TRIAL									
LADY CLAIRE	25						25	100	0.000

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MSF165-6RY	25						25	100	0.000
MSG145-1Y	25						25	100	0.000
LADY CRYSTL	25	1					26	96	0.038
MSI201-2PY	25	1					26	96	0.038
SINORA	25	1					26	96	0.038
YUKON GOLD	24	1					25	96	0.040
ACCORD	23	1					24	96	0.042
MSG147-3P	23	1					24	96	0.042
SW93107	20	1					21	95	0.048
MICHIGAN PURPLE	24			1			25	96	0.120
MSE040-6RY	18	3					21	86	0.143
TORRIDON	19	4					23	83	0.174
MSE048-2Y	19	2	1				22	86	0.182
SAGINAW GOLD	19	5					24	79	0.208
ADAPTATION TRIAL									
MSE228-11	21						21	100	0.000
MSE273-8	22						22	100	0.000
MSH098-2	25						25	100	0.000
MSH106-2	25						25	100	0.000
MSI002-3	20						20	100	0.000
MSI055-5	20						20	100	0.000
MSI168-2	27						27	100	0.000
SUPERIOR	22						22	100	0.000
MSE030-4	24	1					25	96	0.040
B1865-2	23	1					24	96	0.042
MSH015-2	23	1					24	96	0.042
MSI037-7	23	1					24	96	0.042
MSH112-6	22	1					23	96	0.043
MSH370-3	22	1					23	96	0.043
AF1668-60	21	1					22	95	0.045
MSF001-2	19	1					20	95	0.050
MSI050-4	24	2					26	92	0.077
MSH217-1	23	2					25	92	0.080
MSB076-2	20	3					23	87	0.130
MSI178-8	18	3					21	86	0.143
SNOWDEN	22	4					26	85	0.154
AF1775-2	19	4					23	83	0.174
ONAWAY	22	3	1				26	85	0.192
MSH067-3	17	2	1				20	85	0.200
MSH333-3	20	5					25	80	0.200
ATLANTIC	22	4	1				27	81	0.222
MSE080-4	19	2		1			22	86	0.227
MSF382-2	20	4	1				25	80	0.240

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MSH123-5	19	6					25	76	0.240
ND01496-1	20	4	1				25	80	0.240
MSH095-4	18	5	1				24	75	0.292
MSI085-10	18	3	1	1			23	78	0.348
AF1615-1	17	7	1				25	68	0.360
MSG106-5	15	9					24	63	0.375
NY120	15	8	1				24	63	0.417
AF1437-1	12	6	2				20	60	0.500
MSH360-1	15	7	1		1	1	25	60	0.720
MSB107-1	9	11	4				24	38	0.792
MSF060-6	9	11	5				25	36	0.840
PRELIMINARY TRIAL									
MSI058-2	20						20	100	0.000
MSI137-CY	18						18	100	0.000
MSI201-2PY	17						17	100	0.000
MSJ112-5	19						19	100	0.000
MSJ154-16A	9						9	100	0.000
MSJ168-2Y	20						20	100	0.000
MSJ316-3	19						19	100	0.000
SUPERIOR	20						20	100	0.000
MSJ033-6Y	20	1					21	95	0.048
ATLANTIC	19	1					20	95	0.050
MSH308-3Y	19	1					20	95	0.050
MSI026-A	19	1					20	95	0.050
MSJ170-4	19	1					20	95	0.050
MSJ177-5R	19	1					20	95	0.050
MSJ080-8	18	1					19	95	0.053
MSJ156-4Y	18	1					19	95	0.053
SNOWDEN	18	1					19	95	0.053
MSJ147-1	17	1					18	94	0.056
MSJ307-2	17	1					18	94	0.056
MSJ049-1Y	16	1					17	94	0.059
MSJ163-7R	15	1					16	94	0.063
MSH186-13Y	18	2					20	90	0.100
MSJ153-2Y	9	1					10	90	0.100
MSJ202-1	18	2					20	90	0.100
MSJ107-4	17	2					19	89	0.105
MSJ212-2	17	2					19	89	0.105
ONAWAY	18	1	1				20	90	0.150
MSJ472-4P	16	3					19	84	0.158
MSJ482-2	16	3					19	84	0.158
MSJ059-3	14	3					17	82	0.176
MSJ204-3	18	2	1				21	86	0.190

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	PERCENT (%) BRUISE FREE	AVERAGE SPOTS/TUBER
MSJ494-1	17	4					21	81	0.190
MSJ069-3	16	4					20	80	0.200
MSJ166-1	16	4					20	80	0.200
MSI102-E	15	5					20	75	0.250
MSI058-38	16	3	1				20	80	0.250
MSJ080-1	16	3	1				20	80	0.250
PIKE	15	5					20	75	0.250
MSJ343-1	14	6					20	70	0.300
MSJ452-4Y	13	6					19	68	0.316
MSI587-A	16	4		1			21	76	0.333
MSH222-58	14	5	1				20	70	0.350
MSJ060-2	14	5	1				20	70	0.350
MSH018-5	15	4			1		20	75	0.400
MSI011-A	15	3	1	1			20	75	0.400
MSJ033-10Y	12	7	1				20	60	0.450
MSJ132-1Y	12	7	1				20	60	0.450
MSH356-A	13	4	3				20	65	0.500
MSJ438-2	11	8	1				20	55	0.500
MSJ456-4	15	3	1			1	20	75	0.500
MSI170-4	10	9	1				20	50	0.550
SNACK FOOD ASSOCIATION TRIAL									
AF1668-60	24	1					25	96	0.040
SNOWDEN	24		1				25	96	0.080
FL1867	23	3					26	88	0.115
AF1775-2	20	5					25	80	0.200
MSNT-1	20	5					25	80	0.200
MSE246-5	15	2	1				18	83	0.222
NY112	17	5					22	77	0.227
ATLANTIC	20	4	1				25	80	0.240
MSA091-1	19	7					26	73	0.269
W1431	18	6	1				25	72	0.320
B0766-3	18	5	2				25	72	0.360
NY120	16	10	2				28	57	0.500

2000 *FUSARIUM* DRY ROT TRIAL

Line	Average Lesion Depth	Line	Average Lesion Depth
A087277-6	2.5	**Yukon Gold**	15.9
MSI058-22	2.7	**Superior**	16.1
Snowden	4.9	MSI002-3	16.3
P83-11-5	5.1	MI Purple	16.4
MSJ494-1	5.5	MSJ156-4Y	16.7
MSH356-A	5.7	MSI026-A	16.8
MSI050-4	5.9	MSI137-CY	16.8
SpCry5-G3	5.9	MSJ472-4P	16.8
MSE192-8RUS	6.0	**Superior**	16.8
MSG106-5	6.4	MSJ080-1	17.0
MSJ033-10Y	7.7	W1431	17.1
MSJ168-2Y	7.7	MSF099-3	17.2
MSJ202-1	8.0	MSH222-58	17.3
L235-4	8.4	NY123	17.7
SpuntaG2	8.8	MSJ033-6Y	17.8
W1355-1	9.1	MSJ482-2	18.5
MSH106-2	9.3	MSI170-4	18.7
Snowden	9.6	MSJ107-4	20.6
MSG227-2	9.9	MSJ132-1Y	20.6
MSG004-3	10.0	MSE221-1	20.9
LadyClaire	10.0	Torridon	21.0
MSG274-3	10.2	MSF373-8	21.3
NY120	10.7	MSJ059-3	21.7
MSE018-1	10.8	Spunta	21.7
MSJ153-2Y	11.0	W1386	21.7
MSJ060-2	11.2	MSH333-3	21.8
MSA091-1	11.7	MSJ307-2	21.8
Accord	11.7	MSH098-2	22.2
ND3196-1R	11.8	**Russet Burbank**	22.4
MSH094-8	11.9	MSJ147-1	23.0
MSH018-5	12.0	SPCry5-6a-3	23.2
MSH026-3RUS	12.5	MSF452-4Y	23.5
MSJ163-7R	12.7	MSJ438-2	23.9
MSH031-5	12.8	MSF313-3	24.1
MSI037-7	12.8	**Russet Norkotah**	24.1
NY112	12.8	MSJ456-4	24.5
MSJ177-5R	13.5	MSJ316-3	24.7
L235-4.8	13.6	MSJ170-4	25.1
MSI201-2PY	13.7	Saginaw Gold	25.1
Gem Russet	14.0	**Onaway**	25.4
MSH095-4	14.3	MSJ112-5	26.4
Bannock Russet	14.6	**Onaway**	27.4
Atlantic	14.7	MSH123-5	27.5
MSI055-5	14.9	MSE230-6	27.7
MSI011-A	15.3	MSE202-3RUS	27.8
MSJ080-8	15.3	MSI582-A	28.6
MSJ204-3	15.6	MSJ166-1	28.7
Pike	15.6	ND3574-5R	29.4
MSJ343-1	15.9	MSJ049-1Y	32.1

$LSD_{0.05} = 10.5$

Funding: Federal Grant, MPIC and SFA

2000 On-Farm Potato Variety Trials

Dr. Dick Chase, Dr. Dave Douches, Don Smucker (Montcalm), Paul Marks (Monroe), David Glenn (Presque Isle) and Jim Isleib (Alger)

Introduction

On-farm potato variety trials were conducted on ten farms in 2000; six evaluating processing entries and 4 evaluating fresh market entries. The processing cooperators were Crooks Potato Farms (St. Joseph), L. Walther & Sons, Inc. (St. Joseph), W. J. Lennard & Sons, Inc. (Monroe), Kevin Denniston (Allegan) & Sandyland Farms (Montcalm). The SFA Chip Trial was at V & G Farms (Montcalm). Freshmarket trial cooperators were Horkey Bros. (Monroe), Tom Fedak (Bay), Cliff Wilk (Presque Isle) & Van Damme Farms (Alger). A fresh market trial located at Brian Wilhams Farm in Sanilac County was not harvested because of severe water damage.

Procedure

There were 10 entries in the Processing Trials which were compared with check varieties Atlantic & Snowden. At the Walther Farm, seed was planted in 3 replicated plots for two harvest dates of 107 & 133 days after planting.

Within the fresh market trials, there were 7 entries planted in the 3 locations of Presque Isle, Alger & Monroe Counties and compared with Onaway. The trial at the Fedak Farm consisted of round whites, long russets and yellow flesh entries so data is presented separately.

Results

A. Processing Trial Results

The overall average of the four locations of St. Joseph, Allegan, Monroe & Montcalm Counties are shown in Table 1. The data from the Walther Farm in St. Joseph County are shown separately in Table 2 (first harvest, 107 days) and Table 3 (second harvest, 133 days). The size parameters are different from the other 4 locations.

MSE018-1 (Gemchip x W877) Highest marketable yield, strong upright vine, late maturity, high specific gravity, minimal internal defects and intermediate scab susceptibility. At harvest, chip color 1.9 with mostly internal defects of color and stem end discoloration.

MSF373-8 (MS702-80 x WY88) High yield of large potatoes, medium-low S.G., intermediate scab, some HH and growth crack. At harvest, chip color 1.9 with some stem end discoloration and color defects.

NY112 (Atlantic x Q155-3) High yields of uniform size tubers, late maturity and medium S.G. Good scab tolerance, and some HH noted. At harvest, chip color 1.7 with some color and stem end discoloration.

Atlantic Check variety with some HH. Chip color at harvest 1.3 with HH and some color and stem end discoloration.

Snowden Check variety with HH, vascular discoloration and stem end discoloration. At harvest, chip color 1.1 with some color.

MSF313-3 (Spartan Pearl x NY88) Above average yield of uniform potatoes with medium to low S.G. and intermediate scab. At harvest, chip color very good 1.3 with vascular discoloration and slight color.

MSF099-3 (Snowden x Chaleur) Average yields, medium S.G., of oval to ablong tubers with intermediate scab tolerance. At harvest chip score 1.5 with stem end discoloration and vascular discoloration.

MSG227-2 (Prestile x MSG127-3) Average yields of scab resistant, attractive tubers with medium S.G. at harvest chip score 1.3 with some stem end discoloration and vascular discoloration.

MSE230-6 - to be deleted because of pointed ends.

MSH031-5 (MSB110-3 x MSC108-2) Below average yields of small size tubers with bright, smooth appearance. No internal defects noted. At harvest chipscore 1.6 of acceptable chip color but severe color of defect chips.

MSNT-1 (MS716-15 open pollinated) Medium maturity and below average yields of tubers with medium S.G. and good scab tolerance. At harvest, chip score 1.6 with internal defects of color and HH.

MSE246-5 - to be deleted because of low yield.

B. SFA Chip Trial

The Michigan location of the SFA Chip Trial was at V & G Farms in Stanton. Table 4 shows the yields, size distribution and specific gravity of the entries when compared with Atlantic and Snowden. Table 5 shows the chip quality evaluation from samples processed and scored by Jays Foods, LLC, Chicago.

C. Fresh Pack Variety Trials

Table 6 shows the overall average of 8 entries at three locations of Presque Isle, Alger and Monroe Counties.

MSF378-8 which was the second highest yields in the processing trial, was the highest yielder. It produces a high percentage of tubers over 3 1/4" and internal defects were very low.

MSG050-2 (Eramosa x L235-4) produced high yields of bright, round and flattened tubers. Tubers were well sized with slight vascular discoloration.

Onaway included as a check variety.

MSG274-3 (Tollocan x Chaleur) is a late maturing advanced seedling which has overal shaped potatoes with a light yellow flesh. It sets heavy and has a strong foliar resistance to US8 late blight. It is intermediate in scab susceptibility. Tuber size is generally small which relates to the heavy set.

MSE221-1 (Superior x Spartan Pearl) produced good yields, minimal internal defects and has very good scab tolerance. Could be a Superior replacement.

MSE228-1 (Russet Nugget x Spartan Pearl) Average yields of mid-size potatoes. Minimal internal defect primarily vascular discoloration. Intermediate scab susceptibility.

MSE149-5Y (Saginaw Gold x ND860-2) Below average yields of bright skin potatoes with a light yellow flesh and low internal defects. Tubers generally attractive and scab tolerance between Superior and Atlantic.

MSG141-3 (Spartan Peal x Zarevo) Below average yields mostly mid-size and higher percent of B size tubers. Tubers have a sparse eye distribution and scab tolerance between Superior and Atlantic. Will be deleted from further testing.

D. Fedak Farms Trial

Table 7 summarizes the data obtained from the various tuber types of fresh market potatoes.

MSG004-3 (Mainestay x MS702-80) Highest yielder of mid to large size tubers with no internal defects and a bright skin. Scab tolerance is intermediate and maturity is late.

Reba (NY87) High yields of bright tubers with good general appearance and no internal defects.

MSG050-2 (Eramosa x L235-4) Intermediate scab tolerance, good yields of flattened, round tubers and no internal defects noted. May have early die resistance.

__MSE202-3Rus__ (Frontier Russet x A8469-5) A long, medium russetted selection with good yields, size and a medium-high S.G. It has a high scab tolerance and minimal internal defects.

__MSB106-7__ (LaBelle x Temhi Russet) A blocky to long white type with average yields, very good scab tolerance and minimal internal defects.

__MSG145-1y__ (Steuben x Yukon Gold) Below average yields of potatoes with a strong yellow flesh color and attractive appearance. Scab tolerance is good and no internal defects noted.

__MSE192-8Rus__ (A8163 x Russet Norkotah) A long dark russet selection with very good scab tolerance. It has a bright white flesh and good color after cooking. S.G. is similar to Russet Norkotah. Yields were below average.

__MSE40-6Ry__ (Rose Gold x Fontenot) Yields were below average, no internal defects noted and a high percentage of B size tubers.

__MSE149-5y__ (Saginaw Gold x ND860-2) Below average yields and no internal defects noted. Data also noted in Table 6.

__MSG274-3__ (Tollocan x Chaleur) Low yields of markitable tubers with mostly mid to small size. Data also noted in Table 6.

Table 1. 2000 MSU Potato Processing Trial
Overall Average - Four Locations
(St. Joseph, Allegan, Monroe, Montcalm)

	Yield (cwt/A)		Percent Size Distribution							
Entry	No. 1	Total	No. 1	<2'	2-3 1/4"	>3 1/4"	Culls	S.G.	Int. Def.	Comments
E018-1	593	633	94	6	74	20	Tr	1.087	1/40BC 1/40HH	
F373-8	543	572	95	4	37	58	1	1.078	5/30HH	G.C., deep eye
NY112	537	562	96	4	66	30	0	1.083	4/40HH	
Atlantic	448	483	93	6	74	19	1	1.091	9/40HH	
Snowden	404	468	86	14	77	9	0	1.083	3/40HH 9/40VD 2/10SED	
F313-3	400	434	92	8	81	11	0	1.075	1/40IBS 1/40SED	scab
F099-3	397	426	93	7	80	13	0	1.084	1/20HH	pitted scab
G227-2	387	423	91	8	79	12	Tr	1.082	1/40IBS 1/40BC 1/40HH 1/40VD	V.G. type, uniform
E230-6	360	473	76	21	75	1	3	1.089	1/40HH 1/40IBS 1/40SED	pointed ends
H031-5	348	409	84	14	82	2	1	1.079	clean	bright, smooth
NT-1	302	358	83	16	81	2	1	1.085	2/40VD 2/40HH	
E246-5	292	343	85	15	79	6	0	1.098	7/40VD 1/40HH	small size

Table 2. 2000 MSU Potato Processing Trial
L. Walther & Sons, Inc.
Three Rivers, MI
FIRST HARVEST

	CWT/A		Percent of Total[1]							
	"A"		US#1		Small	Large	Tuber			
Entry	US#1	Total	"A"	"B"	"A"	"A"	Set	SPGR	HH[2]	SCAB[3]
MSF373-8	495	497	100	0	9	91	4.6	1.077	1	0
MSG227-2	493	530	93	7	51	42	8.3	1.080	0	0
NY112	446	471	95	5	37	58	6.6	1.075	0	0
ATLANTIC	424	452	94	6	50	43	7.2	1.089	0	0
MSH031-5	384	412	92	8	58	34	6.6	1.078	0	0
MSF313-3	381	415	92	8	56	36	6.6	1.076	0	0
SNOWDEN	373	415	90	10	74	16	6.5	1.082	0	1
MSE230-6	372	487	76	24	68	8	10.8	1.083	0	0
MSE018-1	361	398	91	9	57	34	6.8	1.078	0	0
MSF099-3	310	363	84	16	71	13	6.5	1.082	2	0
MSNT-1	299	341	87	13	64	23	6.7	1.083	3	0
MSE246-5	220	271	80	20	67	13	6.8	1.092	0	0
MEAN	380	421					7.0	1.081		
$LSD_{0.05}$	130	132					2.0	0.005		

[1]Percent of Total (Size)
US#1: 4 - 1.8 in
Large "A": 4 - 2.5 in
Small "A": 2.5 - 1.8 in
"B": < 1.8 in

[2]Hollow Heart Internal Defects
Number of tubers of 30 cut

[3]Scab Disease Rating
1 = occasional surface scab
2 = frequent surface scab
3 = a few pits
4 = frequent pits
5 = severe pitted scab

Planted May 22, 2000
Harvested September 6, 2000 (107 days)

Table 3. 2000 MSU Potato Processing Trial
L. Walther & Sons, Inc..
Three Rivers, MI
SECOND HARVEST

	CWT/A		Percent of Total[1]							
	"A"		US#1		Small	Large	Tuber			
Entry	US#1	Total	"A"	"B"	"A"	"A"	Set	SPGR	HH[2]	SCAB[3]
MSG227-2	512	540	95	5	56	38	7.6	1.079	0	0.0
SNOWDEN	495	519	95	5	57	39	7.2	1.083	0	1.0
NY112	478	491	97	3	28	69	5.9	1.076	6	0.0
MSF373-8	468	472	99	1	9	90	4.9	1.075	2	1.0
MSH031-5	442	471	93	7	59	34	6.8	1.080	0	1.3
ATLANTIC	424	447	95	5	42	53	5.7	1.090	6	1.3
MSE018-1	394	424	93	7	56	37	6.1	1.074	0	3.0
MSF313-3	363	400	91	9	59	32	6.2	1.076	0	1.7
MSF099-3	351	402	86	14	67	19	6.8	1.083	3	1.7
MSE230-6	327	458	71	29	65	5	10.0	1.082	0	1.3
MSNT-1	308	338	92	8	65	27	5.2	1.083	0	0.0
MSE246-5	167	200	83	17	69	14	3.7	1.089	2	1.0
MEAN	394	430					6.3	1.081		
$LSD_{0.05}$	107	109					1.5	0.005		

[1]Percent of Total (Size)
US#1: 4 - 1.8 in
Large "A": 4 - 2.5 in
Small "A": 2.5 - 1.8 in
"B": < 1.8 in

[2]Hollow Heart Internal Defects
Number of tubers of 30 cut

[3]Scab Disease Rating
1 = occasional surface scab
2 = frequent surface scab
3 = a few pits
4 = frequent pits
5 = severe pitted scab

Planted May 22, 2000
Topkill September 13, 2000
Harvested October 2, 2000 (133 days)

Table 4. Michigan
2000 SFA ChipTrial - V & G Farm

	Yield (cwt/A)		Percent Size Distribution							
Entry	No. 1	Total	No. 1	<2"	2-3 1/4"	>3 1/4"	Culls	S.G.	Percent Mature (Sept. 5)	Internal Defects[1)]
AF1775-2	463	520	89	2	78	11	2	1.080	20	1/30 HH
NY120	403	424	95	1	79	16	0	1.080	60	5/30 VD
B0766-.3	372	420	89	2	80	8	1	1.085	40	1/30 HH 1/30 IBS 1/30 BC
NY112	362	404	90	2	81	9	1	1.071	30	1/30 HH
ATLANTIC	327	377	87	2	76	11	2	1.076	40	2/30 HH
AF1668-60	323	352	92	1	73	18	1	1.071	70	4/30 HH 1/30 VD
W1431	301	335	90	2	76	14	1	1.073	20	1/30 VD
MSA091-1	286	352	81	3	68	13	4	1.071	20	1/30 VD
SNOWDEN	268	353	76	4	75	1	0	1.078	20	1/30 VD
MSNT-1	235	326	72	5	71	1	1	1.080	60	clean
Average	334	386	86					1.076		

[1)]Defect/No. Cut

HH = Hollow Heart

VD = Vascular Discoloration

IBS = Internal Brown Spot

BC = Brown Center

Planted: May 24, 2000

Harvested: October 17, 2000 (146 days)

Table 5. 2000 SFA Chip Quality Evaluation*
V & G Farms - Stanton, MI

Entry	Specific Gravity	Chip Color	Percent Internal Defects	Percent External Defects	Percent Total Defects	Percent Chip Moist
AF1775-2	1.080	60.2	9.3	1.2	10.5	1.12
NY120	1.080	61.5	0.8	13.6	13.6	1.08
NY112	1.071	61.4	0.0	15.0	15.0	1.03
B0766-3	1.085	61.4	6.1	0.0	6.1	0.96
ATLANTIC	1.076	62.7	2.4	16.2	18.6	1.03
SNOWDEN	1.078	61.8	3.0	12.8	15.8	1.12
AF1668-60	1.071	64.0	0.0	1.6	1.6	1.06
W1431	1.073	61.9	0.0	2.1	2.1	1.09
MSA091-1	1.071	61.0	3.6	9.0	12.6	1.07
MSNT-1	1.080	60.6	12.7	0.0	12.7	0.81
MSE246-5	1.084	60.0	29.0	4.0	33.0	1.06

*Samples harvested October 17, processed and scored by Jays Foods, LLC.

Chicago, Oct. 23, 2000.

Table 6. 2000 Fresh Pack Potato Variety Trials
Overall Average - Three Locations
(Presque Isle, Alger, Monroe)

	Yield (cwt/A)		Percent Size Distribution							
Entry	No. 1	Total	No. 1	<2'	2-3 1/4"	>3 1/4"	Culls	Int. Def.	S.G.	Comments
F373-8	600	617	97	3	37	60	TR	1/25IBS	1.075	
G050-2	507	544	93	7	59	33	0	3/25VD	1.075	Rd/flat
Onaway	442	483	89	7	65	23	5	5/25VD	1.071	
G274-3	429	552	78	21	62	15	1	0/15	1.078	sl. scab
E221-1	420	452	92	4	62	30	4	1/25BC 2/25VD	1.073	G.C.
E228-1	417	487	86	14	80	6	0	4/25VD	1.082	
E149-5Y	373	411	90	7	61	29	3	2/25VD	1.071	scab
G141-3	273	329	83	16	80	3	1	2/25BC 2/25VD	1.088	surface scab

Table 7. Potato Variety Freshpack Trial
Fedak Farms - Bay County

Entry	Yield (cwt/A) No. 1	Yield (cwt/A) Total	Percent Size Distribution No. 1	<2'	2-3 1/4"	>3 1/4"	Culls	S.G.	Internal Defects	% Maturity 8/26/00
G004-3	354	375	94	2	61	33	4	1.075	0/10	10
Reba	351	365	96	4	87	9	0	1.080	0/10	75
G050-2	330	377	88	11	80	8	1	1.081	0/10	80
E202-3 Rus	296	351	85	8	73	12	7	1.086	1/10 HH 1/10 sl. VD	90
B106-7	259	294	88	12	82	6	0	1.072	1/10	90
G145-1y	238	265	90	10	82	8	0	1.083	0/10	90
E192-8 Rus	222	251	88	12	68	20	0	1.075	0/10	90
E040-6Ry	222	276	80	20	75	5	0	1.077	0/8	45
E149-5y	217	263	83	11	78	5	7	1.072	0/10	90
G274-3	209	342	62	34	60	2	4	1.086	--	80
Average	270	316	85					1.078		

Planted: NA

Harvested: September 21, 2000

POTATO (*Solanum tuberosum* L.'Snowden')
Black scurf and stem canker; *Rhizoctonia solani*
Common scab; *Streptomyces scabies*

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EVALUATION OF SEED TREATMENTS AND IN FURROW APPLICATIONS OF FUNGICIDES FOR THE CONTROL OF STEM CANKER, BLACK SCURF AND COMMON SCAB ON POTATO, 2000: Potatoes infected with *Rhizoctonia solani* (black scurf), 2- 5% tuber surface area infected, were selected for the trials. Potatoes were planted into an area of the farm previously infected with *Streptomyces scabies* (common scab). Potato seed was prepared for planting by either cutting and treating with fungicidal seed treatments seven days prior to planting (7 dbp) or on the day of planting (0 dbp). 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 at a total rate of 0.02 pt product + H_2O/cwt onto the cut seed-tuber pieces in the Gustafson seed treater. Treatments were applied seven days prior to planting. In furrow applications of Blocker 4SC, Ridomil Gold 4EC and Mocap 70SC 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). Manzate 75WP was applied at 2.0 lb/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 38 dap. Insects were controlled with Admire 2F at 1.25 pt/A at planting, Sevin 80S at 1.25 lb/A 31 and 45 dap, Thiodan 3 EC at 2.33 pt/A 45 dap and Pounce 3.2EC at 8 oz/A 45 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=1) 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 50 days after planting (about 100% canopy closure), (max = 1). Severity of stolon canker was estimated as the percentage of stolons with greater than 5% girdling caused by *R. solani*, measured 50 days after planting (5 plants per sample were destructively harvested and total stolon number and number affected was counted). Vines were killed with Diquat 2EC (1 pt/A on 20 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded. Two sets of samples of 20 tubers per plot were harvested 14 days after dessication (approximately 97 dap). The tubers were evaluated 14 days after harvest. The two sets of tubers were washed and one set assessed for black scurf (*R. solani*)and the other for common scab (*S. scabies*) incidence (number of tubers with infection, percent incidence) and disease severity (average percent surface area infected of individual tubers from entire sample).

Emergence and canopy formation: Taking 29 days after planting (dap) as a key reference point, no seed treatment or fungicide applied in-furrow delayed emergence in comparison with the untreated control or any other treatment in terms of the final plant stand or the relative rate of emergence (RAUEPC). However, the final number of emerged plants was low for all treatments and considerable tuber rot had occurred. *Fusarium sambucinum* (dry rot pathogen) and *Erwinia carotovora* var *caratovora* (soft rot pathogen) were recovered from non-emergent plants. Canopy formation (RAUCDC) was not affected by any seed treatment or in-furrow application of any fungicide. The seed treatments and in-furrow applications of fungicides were not phytotoxic.

Stolon pruning/stem canker: all treatments significantly reduced the percentage of stolons with greater than 5% girdling in comparison with both untreated controls except all the Blocker 4SC-based treatments. There was a clear interaction between the high organic content soil and the efficacy of both the seed treatment and the in-furrow application of Blocker 4SC. Only L1036 0.75 lb/cwt was not significantly different from the untreated control cut 7 days before planting and the Blocker 4SC-based treatments.

Tuber black scurf: Maxim 48SC 0.005 pt/cwt + Alder Bark 0.5 lb/cwt (7 dbp), Maxim 48SC 0.005 pt/cwt + Fir Bark 0.5 lb/cwt (7dbp), Maxim 48SC 0.005 pt/cwt (0 dbp), Maxim 48SC 0.005 pt/cwt + Alder Bark 0.5 lb/cwt (0 dbp) and Tops MZ 0.75 lb/cwt (0 dbp) seed-piece treatments significantly reduced the incidence of black scurf affected tubers in comparison with both untreated controls. All other treatments were not significantly different from both untreated controls. Maxim 48SC 0.005 pt/cwt + Fir Bark 0.5 lb/cwt (7dbp) and Maxim 48SC 0.005 pt/cwt (0 dbp) seed-piece treatments significantly reduced the incidence of black scurf affected tubers in comparison with Mancozeb 0.5 lb/cwt (0 dbp) and *Trichoderma atroaviride* 0.5 lb/cwt (0 dbp) and all Blocker 4SC-based in-furrow applications. No other treatments were significantly different from each other in terms of incidence of black scurf on progeny tubers. All treatments significantly reduced the severity of black scurf on progeny tubers in comparison with treatments both untreated controls. The Blocker 4SC-based treatments appeared to have had some activity on soil-borne *R. solani* and may therefore have not been totally inactivated by the high organic matter content of the Muck soil. The severity of black scurf on the tubers was reduced to less than 3% by all other treatments.

Common scab: no treatments had any affect on common scab in terms of incidence or severity on progeny tubers with close to 100% incidence and 8 - 12% of the surface affected by common scab lesions on tubers in all treatments.

Yield: In general yields were low due to the lateness of planting the crop. In terms of US1 grade and total yield, all of the programs had similar yield and none were different from either of the untreated controls. None of the treatment programs were significantly different from each other.

Treatment and rate/cwt (seed treatment) rate/acre (in furrow)	Time of Seed Cutting dbp[1]	Emergence (RAUEPC)[2]		Plant number emerged (%; 29 dap)		Canopy development (RAUCPC)[3]		Percent stolons with greater than 5% girdling due to *R. solani*[4]		Incidence of black scurf on tubers (%)[5]		Severity of black scurf on tubers (%)[6]		Incidence of common scab on tubers (%)[7]		Severity of common scab on tubers (%)[8]		Yield cwt/A Marketable (US1)[9]		Yield cwt/A Total[10]	
Untreated	7	0.48	a[11]	92	a	0.31	a	70.2	ab	100.0	a	8.3	a	100	a	10.3	a	174	a	187	a
Untreated	0	0.44	a	85	a	0.32	a	76.6	a	100.0	a	8.3	a	100	a	9.3	a	172	a	184	a
Maxim 48SC 0.005 pt/cwt	7	0.47	a	83.5	a	0.31	a	39.4	c	90.0	abcd	2.6	def	100	a	9.6	a	205	a	215	a
Maxim 48SC 0.005 pt/cwt + Alder bark 0.5 lbs/cwt	7	0.43	a	87	a	0.31	a	29.7	c	81.3	bcd	1.1	f	100	a	9.8	a	179	a	198	a
Maxim 48SC 0.005 pt/cwt + Fir Bark 0.5 lbs/cwt	7	0.48	a	89	a	0.32	a	35.9	c	72.5	d	1.0	f	100	a	10.7	a	179	a	204	a
Maxim 48SC 0.005 pt/cwt	0	0.49	a	91	a	0.32	a	32.3	c	76.3	d	1.1	f	100	a	10.2	a	184	a	204	a
Maxim 48SC 0.005 pt/cwt + Alder bark 0.5 lbs/cwt	0	0.47	a	89.5	a	0.34	a	27.0	c	82.5	bcd	1.6	ef	100	a	9.8	a	160	a	184	a
Maxim 48SC 0.005 pt/cwt + Fir Bark 0.5 lbs/cwt	0	0.45	a	87	a	0.31	a	31.6	c	83.8	abcd	1.5	f	99	a	8.6	a	173	a	185	a
Maxim 0.5D 0.5 lb/cwt	0	0.44	a	85	a	0.29	a	34.7	c	82.5	abcd	1.3	f	100	a	9.7	a	195	a	211	a
Mancozeb 0.5 lb/cwt	0	0.47	a	81	a	0.32	a	35.0	c	95.0	ab	1.8	ef	99	a	10.7	a	219	a	229	a
Mancozeb + Auxigro 0.5 lb/cwt	0	0.47	a	86	a	0.29	a	29.8	c	88.8	abcd	2.1	ef	100	a	9.0	a	240	a	255	a
Tops MZ 0.5 lb/cwt	0	0.45	a	88.5	a	0.33	a	36.1	c	85.0	abcd	1.7	ef	100	a	10.8	a	183	a	200	a
Tops MZ 0.75 lb/cwt	0	0.48	a	86.5	a	0.31	a	41.0	c	76.3	cd	1.1	f	98	a	9.7	a	174	a	186	a
Evolve 0.5 lb/cwt	0	0.48	a	92	a	0.30	a	33.8	c	82.5	abcd	1.4	f	99	a	10.6	a	226	a	238	a
L1037-Al 0.75 lb/cwt	0	0.48	a	84.5	a	0.32	a	30.8	c	83.8	abcd	1.6	ef	99	a	9.5	a	150	a	167	a
L1036 0.75 lb/cwt	0	0.48	a	88	a	0.30	a	42.0	bc	91.3	abc	2.1	ef	100	a	9.6	a	205	a	220	a
Trichoderma[12] 0.5 lb/cwt	0	0.45	a	86.5	a	0.30	a	36.0	c	95.0	ab	2.1	ef	100	a	10.2	a	207	a	220	a
Untreated Blocker 4SC 7.0 pt/A	0	0.46	a	84.5	a	0.30	a	69.4	ab	97.5	ab	2.8	cdef	100	a	9.8	a	178	a	195	a
Untreated Blocker 4SC 10.0 pt/A	0	0.47	a	85.5	a	0.32	a	69.0	ab	100.0	a	4.0	bcde	99	a	9.3	a	168	a	183	a
Maxim 0.5D 0.5 lb/cwt Blocker 4SC 7.0 pt/A	0	0.47	a	87	a	0.32	a	70.6	ab	100.0	a	5.4	b	100	a	8.7	a	157	a	173	a

Treatment and rate/cwt (seed treatment) rate/acre (in furrow)	Time of Seed Cutting dbp[1]	Emergence (RAUEPC)[2]		Plant number emerged		Canopy development (RAUCPC)[3]		Percent stolons with greater than 5% girdling due to *R. solani*[4]		Incidence of black scurf on tubers (%)[5]		Severity of black scurf on tubers (%)[6]		Incidence of common scab on tubers (%)[7]		Severity of common scab on tubers (%)[8]		Yield cwt/A			
																		Marketable (US1)[9]		Total[10]	
Maxim 0.5D 0.5 lb/cwt Blocker 4SC 10.0 pt/A[13]	0	0.45	a	84	a	0.32	a	71.4	ab	100.0	a	4.6	bcd	100	a	9.9	a	191	a	208	a
Maxim 0.5D 0.5 lb/cwt Blocker 4SC 10 pt/A + Ridomil Gold 4EC 0.4 pt/A	0	0.47	a	87	a	0.31	a	68.5	ab	100.0	a	5.7	b	100	a	11.3	a	194	a	213	a
Untreated Blocker 4SC 10 pt/A + Mocap 70EC 6 pt/A	0	0.48	a	84.5	a	0.31	a	70.6	ab	100.0	a	4.8	bcd	100	a	10.5	a	168	a	184	a
Untreated Mocap 70EC 6 pt/A	0	0.48	a	87.5	a	0.31	a	73.2	ab	100.0	a	5.1	bc	100	a	10.4	a	145	a	164	a
sem P = 0.05		0.019		2.50		0.015		4.27		3.42		0.45		0.65		0.76		20.7		20.85	

[1] Timing of seed cutting measured as days before planting.
[2] RAUEPC, relative area under the plant emergence progress curve calculated from the day of planting to full emergence at 29 days after planting (dap); (max = 1).
[3] RAUCPC, relative area under the canopy development curve calculated from day of planting to key reference point taken as 50 dap (about 100% canopy closure), (max = 1).
[5] Percent incidence of tubers with sclerotia of *R. solani* from sample of 20 tubers per replicate.
[4] Percentage of stolons with greater than 5% girdling caused by R. solani, 5 plants per sample taken at 50 dap.
[6] Average percent surface area covered by sclerotia of *R. solani* on tubers from sample of 20 tubers per replicate as a measure of disease severity.
[7] Percent incidence of tubers with lesions of common scab *(Streptomyces scabies)* from sample of 20 tubers per replicate.
[8] Average percent surface area covered by lesions of common scab *(S. scabies)* on tubers from sample of 20 tubers per replicate as a measure of disease severity.
[9] Marketable yield, tubers greater than 2.5" in any plane (US1 grade).
[10] Total yield, combined total of US1 grade and tubers less than 2.5" in any plane.
[11] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).
[12] *Trichoderma atroaviride* biocontrol agent applied as a seed treatment mixed in Talc.
[13] Blocker applied as an in furrow application in 5 gal water/A.

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

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EVALUATION OF QUADRIS AND CHLOROTHALONIL-MIXED PROGRAMS, BAS 500 0F-BASED MIXED PROGRAMS, FLINT-BASED MIXED PROGRAMS, IKF-916 400 SC2,CHAMP-BASED PRODUCTS IN MIXED PROGRAMS, PENNCOZEB-BASED PRODUCTS IN MIXED PROGRAMS, CHAMP-BASED PRODUCTS IN MIXED PROGRAMS AND REZIST-BASED PROGRAMS FOR POTATO LATE BLIGHT CONTROL, 2000: Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 15 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. The center and outside guard double rows were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* US8 biotype (insensitive to metalaxyl, A2 mating type) at 10^4 spores/fl oz on 23 Jul. Fungicides were applied weekly (unless otherwise stated) from 25 Jun to 13 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 23, Jul; 22, 27 Aug and 6 and 15 Sep 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, 23 Jul to 15 Sep, a period of 48 days. Vines were killed with Diquat 2EC (1 pt/A on 16 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded.

Late blight developed slowly after inoculation then rapidly during Aug, and untreated controls reached 85 - 95% foliar infection by 15 Sep. Over the period from 50% emergence to harvest, 109 late blight disease severity values were accumulated. The bulk of these DSV were accumulated between inoculation and desiccation.

Final foliar late blight: Taking 36 days after inoculation (dai) as a key reference point, all fungicide programs with seven-day application intervals reduced the level of late blight foliar infection significantly compared to the untreated control. The double application program of Rezist 100SC + Stabilizer 100SC (1.0 pt + 2.0 pt), Flint 50WDG 0.25 lb + Bravo WS 6SC 1.5 pt (alternated) and Champ DP 4.6FL + Dithane NT 75DF (2.67 pt + 2.0 lb) programs. All other programs were not significantly different from each other. No programs had greater than 20% foliar late blight 36 dai.

The amount of foliar late blight increased in all programs. Taking 48 dai as a key reference point when there was complete defoliation of the untreated controls, all fungicide programs with seven-day application intervals reduced the level of late blight foliar infection significantly compared to the untreated control except the double application program of Rezist 100SC + Stabilizer 100SC (1.0 pt/A + 2.0 pt/A). Many programs had > 50% foliar late blight 48 dai, these included Flint 50WDG 0.25 lb + Bravo WS 6SC 1.5 pt (alternated), Champ DP 4.6FL + Dithane NT 75DF (2.67 pt + 2.0 lb), Champ DP 4.6FL + Dithane NT 75DF (2.67 pt + 2.0 lb) alternated with Champ DP 4.6FL + Dithane NT 75DF + PrincePhos 3SC (2.67 pt + 2.0 lb + 1.6 pt) b/A), Bravo WS 6SC + PrincePhos 3SC 1.6 pt (14 day interval application interval, 1.5 + 1.6 pt/A). These programs were not significantly different from programs or treatments with about 30 - 50% foliar infection. Programs and treatments that had ≤ 20% foliar infection 48 dai included IKF-916 400SC2 either with the increasing ramped program (starting at 0.9 pt/A and increasing through 0.13 to 0.17 pt/A) or at an application rate of 0.17 pt/A, Quadris 2SC 0.97 pt/A alternated with Bravo WS 6SC 1.5 pt/A and the BAS 500 0F 2.09SC + Penetrator Plus 25SC + Bravo Ultrex 82.5 WDG program [0.38 pt (increased to 0.77 pt) + 1pt + 1.36 lb] program. IKF-916 400SC2 showed a clear dose response and outstanding foliar late blight control either with the increasing ramped program (starting at 0.9 pt/A and increasing through 0.13 to 0.17 pt/A) or at an application rate of 0.17 pt/A. Programs and treatments with less than about 40% foliar infection were not significantly different from each other.

RAUDPC: the average amount of foliar late blight over the season from 0 to 48 dai was significantly reduced by all fungicide programs with seven-day application intervals compared to the untreated control. The lowest RAUDPC values (≤ 5 and NSD from each other) were recorded in IKF-916 400SC2 either with the increasing ramped program (starting at 0.9 pt/A and increasing through 0.13 to 0.17 pt/A) or at application rates of 0.09, 0.13 and 0.17 pt/A, IKF-916 400SC20.17 pt/A alternated with Bravo WS 6SC 1.5 pt/A, Quadris 2SC 0.97 or 0.8 pt/A alternated with Bravo WS 6SC 1.5 pt/A programs, Bravo WS 6SC 1.5 pt/A, Flint 50WDG 0.25 lb + Dithane NT 75DF (0.25 + 2.0 lb/A) alternated with Bravo WS 6SC 1.0 pt program, CGA27902/MZ 70WDG 2.5 lb/A alternated with Bravo WS 6SC 1.0 pt program, Bravo WS 6SC + Champ DP 4.6FL (1.5 + 2.67 pt/A) alternated with Dithane NT 75DF + Agritin 80WP (2.0 + 0.13 lb/A) program, Bravo WS 6SC (1.5 pt/A) alternated with Penncozeb 75DF (2.0 lb/A) program, Bravo WS 6SC (1.0 pt/A) and Bravo WS 6SC + Rezist + Stabilizer (1.0 pt + 1.0 + 2 pt/A) mixed program and the BAS 500 0F 2.09SC + Penetrator Plus 25SC ± Bravo Ultrex 82.5 WDG program [0.38 pt (increased to 0.77 pt) + 1pt + 1.36 lb] programs.

Yield: In general yields were low due to late planting, extremely high late blight pressure and early desiccation of the plots resulting in a high proportion of tubers less than 2.5" width in any plane. Yield was not well correlated with late blight susceptibility although the untreated plots had numerically the lowest total yield and marketable yield in comparison with other treatments and were comparable to the double application program of Rezist 100SC + Stabilizer 100SC (1.0 pt/A + 2.0 pt/A), Bravo WS 6SC (1.0 pt/A) and Bravo WS 6SC + Rezist + Stabilizer (1.0 pt + 1.0 + 2 pt/A) mixed program and the Bravo WS 6SC + Prince Phos 3SC 1.6 pt (14 day interval application interval, 1.5 + 1.6 pt/A), program.

Phytotoxicity was not noted in any of the treatments.

Treatment and rate/acre	foliar disease (%)				RAUDPC[2] max = 100 0 - 48 dai		Yield (cwt/acre)			
	36 dai[1]		48 dai				US1		Total	
Quadris 2SC 0.8 pt (A,C,E,G) Bravo WS 6SC 1.5 pt (B,D,F,H)	5.9	a	40.0	a-h	4.54	a-e	133	bcd	263	cd
Quadris 2SC 0.97 pt (A,C,E,G) Bravo WS 6SC 1.5 pt (B,D,F,H)	4.0	a	20.0	a-e	2.52	a-c	147	bc	303	abcd
Bravo WS 6SC 1.5 pt (A,B,C,D,E,F,G,H)	2.0	a	26.3	a-f	2.72	a-c	158	b	302	abcd
Manzate 75DF 2.0 lb (A,B,C,D,E,F,G,H)	9.3	ab	46.3	e-h	5.93	c-e	145	bc	295	abcd
IKF-916 400 SC2 0.09 pt (A,B,C,D,E,F,G,H)	3.5	a	45.0	e-h	4.70	a-e	149	b	289	abcd
IKF-916 400 SC2 0.13 pt (A,B,C,D,E,F,G,H)	3.0	a	23.8	a-f	2.69	a-c	118	bcdef	238	d
IKF-916 400 SC2 0.17 pt (A,B,C,D,E,F,G,H)	2.1	a	13.8	a	1.58	a	119	bcdef	256	cd
IKF-916 400 SC2 0.09 pt (A,B,C) IKF-916 400 SC2 0.13 pt (D,E) IKF-916 400 SC2 0.17 pt (F,G,H)	0.8	a	13.8	a	1.40	a	137	bcd	264	bcd
Bravo WS 6SC 1.5 pt (A,C,E,G) IKF-916 400 SC2 0.17 pt (B,D,F,H)	6.0	a	45.0	e-h	4.97	a-e	129	bcde	256	cd
Bravo WS 6SC 1.5 pt (A,B,G,H) IKF-916 400 SC2 0.17 pt (C,D,E,F)	7.3	a	33.8	a-g	4.59	a-e	137	bc	273	bcd
Flint 50WDG 0.25lb (A,C,E,G) Bravo WS 6SC 1.5 pt (B,D,F,H)	11.3	ab	50.0	g-h	6.54	de	121	bcdef	265	bcd
Flint 50WDG 0.25lb + (A,C,E,G) Dithane NT 75DF2.0lb Bravo WS 6SC 1.0 pt (B,D,F,H)	2.5	a	38.8	a-g	3.81	a-d	159	b	340	abc
CGA27902/MZ 70WDG2.5 lb (A,C,E,G) Bravo WS 6SC 1.0 pt (B,D,F,H)	3.3	a	41.3	b-h	4.25	a-e	159	b	311	abcd
Bravo WS SC 1.5 pt + (A,C,E,G) Champ DP4.6FL 2.67pt Dithane NT 75DF2.0lb + (B,D,F,H) AgriTin 80WP 0.13lb	2.9	a	18.8	a-d	2.26	ab	135	bcd	313	abcd
Champ DP4.6FL 2.67pt + (A,B,C,D,E,F,G,H) Dithane NT 75DF2.0lb	10.0	ab	66.3	g-i	7.62	e	215	a	348	abc
Champ DP4.6FL 2.67pt +(A,C,E,G) Dithane NT 75DF2.0lb Champ DP4.6FL 2.67pt +(B,D,F,H) Dithane NT 75DF2.0lb + Prince Phos 3SC 1.6 pt	5.3	a	57.5	g-i	6.04	c-e	232	a	380	a
Bravo WS 6SC 1.5 pt + (A,C,E,G) Prince Phos 3SC 1.6 pt	5.5	a	59.5	g-i	6.43	de	89	def	236	d
Quadris 2SC 0.4 pt + (A,C,E,G) Penncozeb 75DF2.0lb Penncozeb 75DF2.0lb (B,D,F,H)	7.8	ab	47.5	e-h	5.53	b-e	237	a	364	ab
Bravo WS 6SC 1.5 pt (A,C,E,G) Penncozeb 75DF2.0lb (B,D,F,H)	2.3	a	22.5	a-f	2.47	a-c	151	b	303	abcd

Treatment and rate/acre	foliar disease (%)				RAUDPC[2] max = 100 0 - 48 dai		Yield (cwt/acre)			
	36 dai[1]		48 dai				US1		Total	
BAS 500 0F 2.09 EC 0.38 pt + (A,B,C) Penetrator Plus 25 SC 1.0 pt BAS 500 0F 2.09 EC 0.77 pt + (D,E,F,G,H) Penetrator Plus 25 SC 1.0 pt	7.3	a	37.5	a-g	4.59	a-e	128	bcde	268	bcd
BAS 500 0F 2.09 EC 0.38 pt + (A,B,C) Penetrator Plus 25 SC 1.0 pt + Bravo Ultrex 82.5 WDG 1.36 lb BAS 500 0F 2.09 EC 0.77 pt + (D,E,F,G,H) Penetrator Plus 25 SC 1.0 pt + Bravo Ultrex 82.5 WDG 1.36 lb	4.0	a	16.3	ab	2.17	ab	133	bcd	290	abcd
Rezist 100 SC 1.0 pt + (C,E) Stabilizer 100 SC 2.0 pt	18.8	b	80.0	ij	11.7	f	98	cdef	221	d
Bravo WS 6SC 1.0 pt (A,B,D,F,G,H) Rezist 100 SC 1.0 pt + (C,E) Stabilizer 100 SC 2.0 pt + Bravo WS 6 SC 1.0 pt	4.4	a	32.5	a-g	3.63	a-d	71	f	219	d
Untreated	90.0	c	98.0	j	28.0	g	82	ef	262	cd

[1] Days after inoculation with *Phytophthora infestans*, US8, A2.
[2] RAUDPC, relative area under the disease progress curve calculated from the day of inoculation to the last evaluation of late blight.
[3] 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= 21 Aug; J = 16 Sep.
[4] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

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

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EVALUATION OF CHLOROTHALONIL-BASED PRODUCTS, MANCOZEB AND MANEB-BASED PRODUCTS IN MIXED PROGRAMS, MANCOZEB + AUXIGRO, GAVEL-BASED PROGRAMS FOR POTATO LATE BLIGHT CONTROL, 2000: Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 15 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. The center and outside guard double rows were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* US8 biotype (insensitive to metalaxyl, A2 mating type) at 10^4 spores/fl oz on 23 Jul. Fungicides were applied weekly (unless otherwise stated) from 25 Jun to 13 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 23, Jul; 22, 27 Aug and 6 and 15 Sep 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, 23 Jul to 15 Sep, a period of 48 days. Vines were killed with Diquat 2EC (1 pt/A on 16 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded.

Late blight developed slowly after inoculation then rapidly during Aug, and untreated controls reached 85 - 95% foliar infection by 15 Sep. Over the period from 50% emergence to harvest, 109 late blight disease severity values were accumulated. The bulk of these DSV were accumulated between inoculation and desiccation.

Final foliar late blight: Taking 36 days after inoculation (dai) as a key reference point, all fungicide programs with seven-day application intervals reduced the level of late blight foliar infection significantly compared to the untreated control . The chlorothalonil-based programs Equus 82.5DF (1.4 lb/A), Bravo WS 6SC (1.5 pt/A), Equus 6SC + Kocide 2000DF (1.5 pt/A + 2.25 lb/A), and the Dithane RS 75DF (2.0 lb/A) + Echo ZN 6SC (2.13 pt/A) mixed programs all had less than 5% foliar blight was significantly less than the Manex II 4SC + Auxigro WP (3.0 pt/A + 0.6 lb/A), Manex II (3.0 pt/A), Manzate 75WP (2.0 lb/A), Manex II 3.0 pt/A + Auxigro WP 0.06lb/A or 0.19 or 0.31 lb/A mixed programs and the Gavel 75WDG (.0 lb/A)+ Quadris 2SC (0.4 pt/A) mixed program. Programs with greater than 20% foliar late blight 36 dai, included Manex II (3.0 pt/A), Manex II 3.0 pt/A + Auxigro WP 0.06lb/A or 0.19 or 0.31 lb/A mixed programs and the Gavel 75WDG (2.0 lb/A)+ Quadris 2SC (0.4 pt/A) mixed program.

The amount of foliar late blight increased in all programs. Taking 48 dai as a key reference point when there was complete defoliation of the untreated controls, all fungicide programs with seven-day application intervals reduced the level of late blight foliar infection significantly compared to the untreated control except Manex II 4SC + Auxigro WP (3.0 pt/A + 0.6 lb/A), Manex II (3.0 pt/A), Equus 6SC (1.5 pt/A)/Manzate + Supertin 2.0 + 0.16 lb/A/Diquat + Supertin 80WP (1.0 pt + 0.23 lb)/ Kocide 4.5FL 2.67 (pt/A) mixed program. Although many programs had significantly less foliar late blight than the untreated control, no programs had less than 50% foliar late blight. The Equus 6SC + Kocide 2000DF (1.5 pt/A + 2.25 lb/A) had least foliar infection but not significantly less than Equus 6SC (1.5 pt/A), Equus 82.5DF (1.4 lb/A), Bravo WS 6SC (1.5 pt/A), Bravo Ultrex 82.5WDG (1.36 lb/A), Echo ZN 6SC (2.13 pt/A), Echo 75WDG (1.5 lb/A) programs, or the Dithane RS 75DF (2.0 lb/A) + Echo ZN 6SC (2.13 pt/A), and the Gavel 75WDG (2.0 lb/A) + Dithane RS 75DF (2.0 lb/A) mixed programs.

RAUDPC: the average amount of foliar late blight over the season from 0 to 48 dai was significantly reduced by all fungicide programs with seven-day application intervals compared to the untreated control. The lowest RAUDPC values were seen in Equus 6SC + Kocide 2000DF (1.5 pt/A + 2.25 lb/A), Equus 6SC (1.5 pt/A), Equus 82.5DF (1.4 lb/A), Bravo WS 6SC (1.5 pt/A), Bravo Ultrex 82.5WDG (1.36 lb/A), Echo ZN 6SC (2.13 pt/A), Echo 75WDG (1.5 lb/A) programs, or the Dithane RS 75DF (2.0 lb/A) + Echo ZN 6SC (2.13 pt/A), and the Gavel 75WDG (2.0 lb/A) + Dithane RS 75DF (2.0 lb/A) mixed programs which were all below RAUDPC = 10 (arbitrarily considered to be the acceptable amount of foliar late blight under highly conducive conditions. Although not significantly different from some treatments with RAUDPC < 10, the Manex II 4SC + Auxigro WP (3.0 pt/A + 0.6 lb/A), Manex II (3.0 pt/A), Equus 6SC (1.5 pt/A)/Manzate + Supertin 2.0 + 0.16 lb/A/Diquat + Supertin 80WP (1.0 pt + 0.23 lb)/ Kocide 4.5FL 2.67 (pt/A) mixed program, Gavel 75WDG (2.0 lb/A)+ Quadris 2SC (0.4 pt/A) mixed program all had RAUDPC values > 10.

Yield: In general yields were low due to late planting, extremely high late blight pressure and early desiccation of the plots resulting in a high proportion of tubers less than 2.5" width in any plane. Yield was not well correlated with late blight susceptibility although the untreated plots had numerically the lowest total yield and marketable yield in comparison with other treatments. The Manex II 4SC + Auxigro WP (3.0 pt/A + 0.6 lb/A) had a significantly higher yield of marketable tubers than many programs that had lower RAUDPC values e.g. Equus 82.5DF (1.4 lb/A), Bravo WS 6SC (1.5 pt/A), Equus 6SC + Kocide 2000DF

(1.5 pt/A + 2.25 lb/A) programs. The Gavel 75WDG (2.0 lb/A) + Dithane RS 75DF (2.0 lb/A) mixed programs had the highest total yield and was significantly different from Equus 82.5DF (1.4 lb/A), Bravo WS 6SC (1.5 pt/A) and Equus 6SC + Kocide 2000DF (1.5 pt/A + 2.25 lb/A) programs.

Phytotoxicity was not noted in any of the treatments.

Treatment and rate/acre	foliar disease (%)				RAUDPC[2] max = 100 0 - 48 dai		Yield (cwt/acre)			
	36 dai[1]		48 dai				US1		Total	
Equus 6SC 1.5 pt (A,B,C,D,E,F,G,H)	11.3	a - f	72.5	a-f	9.14	a-e	136	bcd	291	bc
Equus 82.5DF 1.4 lb (A,B,C,D,E,F,G,H)	3.5	a	71.3	a-e	7.50	ab	182	abc	361	abc
Bravo WS 6SC 1.5 pt (A,B,C,D,E,F,G,H)	4.0	a	66.3	ab	7.08	ab	112	cd	293	bc
Bravo Ultrex 82.5 WDG 1.36 lb (A,B,C,D,E,F,G,H)	12.5	a - g	67.5	a-c	8.75	a-d	138	bcd	299	abc
Manex II 4SC 3.0 pt + (A,B,C,D,E,F,G,H) Auxigro WP 0.06 lb	18.3	b - h	86.3	b-g	12.1	c-h	242	a	395	ab
Manex II 4SC 3.0 pt (A,B,C,D,E,F,G,H)	21.3	e - h	89.5	c-g	12.8	c-h	221	ab	385	ab
Equus 6SC 1.5 pt (A,B,C,D,E) Manzate 75 WP 2.0 lb + (F,G,H) Supertin 80WP 0.16 lb Supertin 80 WP 0.23 lb + (I) Diquat 36.4 EC 1.0 pt Kocide 4.5FL 2.67 pt (J)	12.5	a - g	87.5	b-g	11.3	b-g	153	abcd	324	abc
Equus 6SC 1.5 pt + (A,B,C,D,E,F,G,H) Kocide 2000DF 2.25 lb	3.0	a	57.5	a	6.20	a	143	bcd	297	bc
Manzate 75WP 2.0 lb (A,B,C,D,E,F,G,H)	23.8	g - i	93.5	fg	14.2	gh	163	abcd	361	abc
Manex II 4SC 3.0 pt + (A,B,D,F,G,H) Auxigro WP 0.06 lb Manex II 4SC 3.0 pt + (C,E) Auxigro WP 0.19 lb	27.5	h - i	87.5	b-g	13.7	f-h	194	abc	387	ab
Manex II 4SC 3.0 pt +(A,B,D,F,G,H) Auxigro WP 0.06 lb Manex II 4SC 3.0 pt +(C,E) Auxigro WP 0.31 lb	20.0	c - h	91.0	e-g	13.0	d-h	194	abc	364	abc
Echo ZN 6SC 2.13 pt (A,B,C,D,E,F,G,H)	8.3	a - d	77.5	a-g	9.48	a-f	140	bcd	300	abc
Echo ZN 6SC 2.13 pt (A,B,C,D,E,F) Dithane RS 75DF 2.0 lb (G,H)	8.3	a - d	70.0	a-d	8.54	a-d	140	bcd	326	abc
Dithane RS 75DF 2.0 lb (A,B) Echo ZN 6SC 2.13 pt (C,D,E,F,G,H)	4.3	a	67.5	a-c	7.40	ab	184	abc	349	abc
Echo 75 WDG 1.5 lb (A,B,C,D,E,F,G,H)	7.8	a - c	77.5	a-g	9.02	a-e	125	bcd	315	abc
Gavel 75WDG 2.0 lb (A,B,C,D,E,F) Dithane RS 75DF 1.2 lb (G,H)	9.5	a - e	72.3	a-f	8.7	a-d	219	ab	442	a
Gavel 75WDG 2.0 lb (A,B,D,F,G,H) Quadris 2SC 0.4 pt (C,E)	20.3	d - h	85.0	b-g	12.4	c-h	172	abcd	344	abc
Bravo WS 6SC 1.5 pt (A,B,D,F,G,H) Quadris 2SC 0.4 pt (C,E)	6.8	a - b	61.3	a	7.2	ab	167	abcd	342	abc
Untreated	95.8	k	99.0	g	33.1	j	82	d	226	c

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

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

[3] 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= 21 Aug; J = 16 Sep.

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

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

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EVALUATION OF POLYRAM-BASED PROGRAMS ALTERNATED WITH CURZATE, SUPERTIN AND QUADRIS MIXED PROGRAMS, BRAVO AND ACROBAT 50WP MIXED PROGRAMS, MANCOZEB AND CHLOROTHALONIL-BASED PROGRAMS, TATTOO C ALTERNATED WITH BRAVO AND QUADRIS MIXED PROGRAMS, REASON, WALABI AND SCALA MIXED PROGRAMS, KQ 667 68.75 WDG DOSE RATE PROGRAMS, KP 481 50DF AND MANZATE PROGRAMS AND CHLOROTHALONIL, CURZATE AND QUADRIS MIXED PROGRAMS FOR POTATO LATE BLIGHT CONTROL, 2000: Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 15 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. The center and outside guard double rows were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* US8 biotype (insensitive to metalaxyl, A2 mating type) at 10^4 spores/fl oz on 23 Jul. Fungicides were applied weekly (unless otherwise stated) from 25 Jun to 13 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 23, Jul; 22, 27 Aug and 6 and 15 Sep 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, 23 Jul to 15 Sep, a period of 48 days. Vines were killed with Diquat 2EC (1 pt/A on 16 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded.

Late blight developed slowly after inoculation then rapidly during Aug, and untreated controls reached 85 - 95% foliar infection by 15 Sep. Over the period from 50% emergence to harvest, 109 late blight disease severity values were accumulated. The bulk of these DSV were accumulated between inoculation and desiccation.

Final foliar late blight: Taking 36 days after inoculation (dai) as a key reference point, all fungicide programs with seven-day application intervals reduced the level of late blight foliar infection significantly compared to the untreated control The Reason 4.17SC 0.53 pt/A had significantly greater foliar late blight than any other program. KQ 667 68.75 showed a clear positive dose response in efficacy in terms of foliar late blight from 0.76 - 2.01 lb/A however these programs did not have significantly different levels of foliar late blight than other program in the trial. All other programs had less than about 15% foliar late blight at this stage and were not significantly different from each other.

The amount of foliar late blight increased in all programs. Taking 48 dai as a key reference point when there was complete defoliation of the untreated control plots, and few fungicide programs with seven-day application intervals reduced the level of late blight foliar infection significantly compared to the untreated control except the Quadris 2SC 0.4 and 0.8 pt/Polyram 80DF+ Supertin 80WP (2.0 + 0.16 lb)/Bravo WS 6SC 1.5 pt mixed program, Bravo WS 6SC 1.5 pt/Acrobat 50WP + Polyram 80DF (0.31 + 1.88 lb) mixed program, Polyram 80DF + Supertin 80WP (1.88 + 0.16 lb), Tattoo C 6.25SC + Bravo WS 6SC (1.3 + 0.75 pt), Bravo WS 6SC (0.75 and 1.5 pt) ramp program, and the Bravo WS 6SC(1.5 pt)/ Curzate 60WP + Equus 6SC (0.21 lb + 1.5 pt)/Quadris 2SC (0.8 pt) mixed program which all had less than about 70% foliar late blight. All other programs had greater than about 70% foliar late blight at this stage and were not significantly different from each other except Tattoo C 6.25SC + Bravo WS 6SC (1.3 + 0.75 pt) which had significantly less foliar late blight than programs with about greater than 80% foliar infection.

RAUDPC: the average amount of foliar late blight over the season from 0 to 48 dai was significantly reduced by all fungicide programs with seven-day application intervals compared to the untreated control. The lowest RAUDPC values (about 5 - 10; <10 arbitrarily considered acceptable late blight control) were seen in Tattoo C 6.25SC + Bravo WS 6SC (1.3 + 0.75 pt), Quadris 2SC 0.4 and 0.8 pt/Polyram 80DF 2.0 lb mixed program, Quadris 2SC 0.4 and 0.8 pt/Polyram 80DF+ Supertin 80WP (2.0 + 0.16 lb)/Bravo WS 6SC 1.5 pt mixed program, Bravo WS 6SC 1.5 pt/Acrobat 50WP + Polyram 80DF (0.31 + 1.88 lb) mixed program, Polyram 80DF + Supertin 80WP (1.88 + 0.16 lb), Bravo WS 6SC 1.5 pt/ Polyram 80DF + Supertin 80WP (1.88 + 0.16 lb) program, Tattoo C 6.25SC 1.3 pt/Quadris 2SC 0.8 pt/Tattoo C 6.25SC 2.3 pt mixed program, Walabi 4.4SC 1.7 pt, Bravo WS 6SC 0.75 pt/ Bravo WS 6SC + Scala 40SC (0.75 + 0.63 pt) mixed program, Manzate 75WP (1.0 + 2.0 lb) ramp program, Bravo WS 6SC (0.75 and 1.5 pt) ramp program, KQ 667 68.75WDG (1.0 to 2.01 lb) programs, KP481 50DF (0.5 lb and 0.62 lb)/Manzate 75DF 2.0 lb mixed programs, and both Bravo WS 6SC(1.5 pt)/ Curzate 60WP + Equus 6SC (0.21 lb + 1.5 pt)/Quadris 2SC (0.8 pt) mixed programs. Some programs had RAUDPC values greater than 10 but not significantly different from programs with RAUDPC < 10. Programs with RAUDPC values significantly greater than those program with RAUDPC values < 10 included Reason 4.17SC + Bond (0.35 pt and 0. 53 pt + 0.25 pt).

Yield: In general yields were low due to late planting, extremely high late blight pressure and early desiccation of the plots resulting in a high proportion of tubers less than 2.5" width in any plane. Yield was not well correlated with late blight susceptibility ($r^2 = 0.09$, no significant relation at $p = 0.05$) although the untreated plots had numerically the lowest total yield and marketable yield in comparison with other treatments. KQ 667 68.75WDG (1.0 to 2.01 lb) had significantly higher yield of marketable tubers than many programs and were greater than 200 cwt/A. Although many programs were not significantly different from the KQ 667 68.75WDG programs these higher yields were noteworthy.

Phytotoxicity was not noted in any of the treatments.

Treatment and rate/acre	Final foliar disease (%)				RAUDPC[2] max = 100 0 - 32 dai		Yield (cwt/acre)			
	36 dai[1]		48 dai				US1		Total	
Quadris 2SC 0.4 pt (A) Polyram 80DF 2.0 lb (B,D,E,F,G,H,I) Quadris 2SC 0.8 pt (C)	7.5	ab	75.0	abcd	8.6	abc	152	bcd	316	abcd
Quadris 2SC 0.4 pt (A) Polyram 80DF 2.0 lb + (B,D,E,F,G,H,I) Curzate 60DF 0.21 lb Quadris 2SC 0.8 pt (C)	13.8	ab	81.3	bcd	10.4	bcd	152	bcd	309	abcd
Quadris 2SC 0.4 pt (A) Polyram 80DF 2.0 lb + (B,D,E,F,G) Supertin 80WP 0.16 lb Quadris 2SC 0.8 pt (C) Bravo WS 6SC 1.5 pt (H,I)	8.3	ab	67.5	abc	8.0	ab	163	bcd	333	abcd
Bravo WS 6SC 1.5 pt (A,BE,F,H,I) Acrobat 50WP 0.31 lb + (C,D,G) Polyram 80DF 1.88 lb	9.3	ab	56.3	ab	7.1	ab	149	bcd	317	abcd
Polyram 80DF 1.88 lb + (A,B,C,D,E,F,G,H,I) Supertin 80WP 0.16 lb	8.3	ab	65.0	abc	7.7	ab	129	d	302	abcd
Bravo WS 6SC 1.5 pt (A,BE,F,H) Supertin 80WP 0.16 lb + (C,D,G,I) Polyram 80DF 1.88 lb	9.5	ab	70.0	abcd	8.5	abc	159	bcd	340	abcd
Tattoo C 6.25SC 1.3 pt + (A,B,C,D,E,F,G,H,I) Bravo WS 6SC 0.75 pt	5.8	ab	47.8	a	5.7	a	141	cd	284	bcd
Tattoo C 6.25SC 1.3 pt (A,B,D,E) Quadris 2SC 0.8 pt (C,F) Tattoo C 6.25SC 2.3 pt (G,H,I)	6.3	ab	71.3	abcd	7.9	ab	126	d	268	cd
Reason 4.17SC 0.35 pt + (A,B,C,D,E,F,G,H,I) Bond 8.33SC 0.25 pt	15.8	b	92.3	bcd	11.9	cd	153	bcd	297	abcd
Reason 4.17SC 0.53 pt + (A,B,C,D,E,F,G,H,I) Bond 8.33SC 0.25 pt	29.5	c	85.0	bcd	14.1	d	138	cd	270	bcd
Walabi 4.4 SC 1.7 pt (A,B,C,D,E,F,G,H,I)	10.8	ab	80.0	bcd	9.7	bc	136	cd	281	bcd
Bravo WS 6SC 0.75 pt (A,B,C) Bravo WS 6SC 0.75 pt + (D,E,F,G,H,I) Scala 40SC 0.63 pt	9.0	ab	76.3	bcd	9.0	abc	134	cd	328	abcd
Manzate 75DF 1.0 lb (A,B,C) Manzate 75DF 2.0 lb (D,E,F,G,H,I)	6.8	ab	78.8	bcd	8.7	abc	195	abcd	383	abc
Bravo WS 6SC 0.75 pt (A,B,C) Bravo WS 6SC 1.5 pt (D,E,F,G,H,I)	5.3	ab	62.5	abc	6.9	ab	133	cd	281	bcd
KQ 667 68.75 WDG 0.76 lb (A,B,C,D,E,F,G,H,I)	13.5	ab	78.8	bcd	10.1	bc	167	bcd	356	abc
KQ 667 68.75 WDG 1.0 lb (A,B,C,D,E,F,G,H,I)	6.5	ab	83.8	bcd	9.3	abc	210	abc	386	abc
KQ 667 68.75 WDG 1.5 lb (A,B,C,D,E,F,G,H,I)	8.3	ab	71.3	abcd	8.4	abc	228	ab	401	ab
KQ 667 68.75 WDG 2.01 lb (A,B,C,D,E,F,G,H,I)	3.3	a	68.8	abcd	7.1	ab	260	a	427	a
KP481 50DF 0.5 lb (A,C,E,G,I) Manzate 75DF 2.0 lb (B,D,F,H)	9.5	ab	76.3	abcd	9.1	abc	157	bcd	346	abcd

Treatment and rate/acre	Final foliar disease (%) 36 dai[1]		48 dai		RAUDPC[2] max = 100 0 - 32 dai		Yield (cwt/acre) US1		Total	
KP481 50DF 0.62 lb (A,C,E,G,I) Manzate 75DF 2.0 lb (B,D,F,H)	9.5	ab	75.0	abcd	9.1	abc	193	abcd	315	abcd
Quadris 2SC 0.8 pt (A,C,E,G,I) Bravo WS 6SC 1.5 pt (B,D,F,H)	11.8	ab	83.8	bcd	10.2	bc	162	bcd	302	abcd
Bravo WS 6SC 1.5 pt (A,B) Curzate 60DF 0.21 lb + (C,E,G) Equus 6SC 1.5 pt Quadris 2SC 0.8 pt (D,F,H,I)	9.5	ab	57.5	ab	7.3	ab	162	bcd	311	abcd
Bravo WS 6SC 1.5 pt (A) Curzate 60DF 0.21 lb + (B,C,E,F,H,I) Equus 6SC 1.5 pt Quadris 2SC 0.8 pt (D,G)	10.8	ab	70.0	abcd	8.7	abc	146	cd	324	abcd
untreated	91.3	d	98.8	d	29.8	e	116	d	219	d
sem p = 0.05	4.34		5.65		0.71		16.3		24.9	

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

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

[3] 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= 21 Aug.

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

Quadris 2SC 0.4 pt (A) Polyram 80DF 2.0 lb (B,D,E,F,G,H) Quadris 2SC 0.8 pt (C)	7 day app 1 7 day app 3 7 day apps 2,4 - 8
Quadris 2SC 0.4 pt (A) Polyram 80DF 2.0 lb + (B,D,E,F,G,H) Curzate 60DF 0.21 lb Quadris 2SC 0.8 pt (C)	7 day app 1 7 day app 3 7 day apps 2,4 - 8
Quadris 2SC 0.4 pt (A) Polyram 80DF 2.0 lb + (B,D,E,F,G) Supertin 80WP 0.16 lb Quadris 2SC 0.8 pt (C) Bravo WS 6SC 1.5 pt (H)	7 day app 1 7 day app 3 7 day apps 2,4 - 7 7 day app 8
Bravo WS 6SC 1.5 pt (A,BE,F,H) Acrobat 50WP 0.31 lb + (C,D,G) Polyram 80DF 1.88 lb	7 day app 1 - 2, 5 - 6, 8 7 day apps 3,4 and 7
Polyram 80DF 1.88 lb + (A,B,C,D,E,F,G,H) Supertin 80WP 0.16 lb	7 day
Bravo WS 6SC 1.5 pt (A,BE,F,H) Supertin 80WP 0.16 lb + (C,D,G) Polyram 80DF 1.88 lb	7 day app 1 - 2, 5 - 6, 8 7 day apps 3,4 and 7
Tattoo C 6.25SC 1.3 pt + (A,B,C,D,E,F,G,H) Bravo WS 6SC 0.75 pt	7 day
Tattoo C 6.25SC 1.3 pt (A,B,D,E) Quadris 2SC 0.8 pt (C,F) Tattoo C 6.25SC 2.3 pt (G,H)	7 day app 1 - 2, 4 - 5 app 3 and 6 7 day app 7 and 8
Reason 4.17SC 0.35 pt + (A,B,C,D,E,F,G,H) Bond 8.33SC 0.25 pt	7 day
Reason 4.17SC 0.53 pt + (A,B,C,D,E,F,G,H) Bond 8.33SC 0.25 pt	7 day
Walabi 4.4 SC 1.7 pt (A,B,C,D,E,F,G,H)	7 day
Bravo WS 6SC 0.75 pt (A,B,C) Bravo WS 6SC 0.75 pt + (D,E,F,G,H) Scala 40SC 0.63 pt	7 day apps 1 - 3 7 day 4 - end
Manzate 75DF 1.0 lb (A,B,C) Manzate 75DF 2.0 lb (D,E,F,G,H)	7 day apps 1 - 3 7 day 4 - end
Bravo WS 6SC 0.75 pt (A,B,C) Bravo WS 6SC 1.5 pt (D,E,F,G,H)	7 day apps 1 - 3 7 day 4 - end
KQ 667 68.75 WDG 0.76 lb (A,B,C,D,E,F,G,H)	7 day
KQ 667 68.75 WDG 1.0 lb (A,B,C,D,E,F,G,H)	7 day
KQ 667 68.75 WDG 1.5 lb (A,B,C,D,E,F,G,H)	7 day
KQ 667 68.75 WDG 2.01 lb (A,B,C,D,E,F,G,H)	7 day
KP481 50DF 0.5 lb (A,C,E,G) Manzate 75DF 2.0 lb (B,D,F,H)	7 day alternate 7 day alternate
KP481 50DF 0.62 lb (A,C,E,G) Manzate 75DF 2.0 lb (B,D,F,H)	7 day alternate 7 day alternate

Quadris 2SC 0.8 pt (A,C,E,G)	7 day alternate
Bravo WS 6SC 1.5 pt (B,D,F,H)	7 day alternate
Bravo WS 6SC 1.5 pt (A,B)	7 day apps 1 - 2
Curzate 60DF 0.21 lb + (C,E,G)	7 day apps 3,5,7,9
Equus 6SC 1.5 pt	
Quadris 2SC 0.8 pt (D,F,H)	7 day apps 4,6,8
Bravo WS 6SC 1.5 pt (A)	7 day apps 1
Curzate 60DF 0.21 lb + (B,C,E,F,H)	7 day apps 2,3,5,6,8,9
Equus 6SC 1.5 pt	
Quadris 2SC 0.8 pt (D,G)	7 day apps 4,7
untreated	

POTATO (*Solanum tuberosum* L.'Snowden')
Pink rot; Phytophthora erythrospetica
Pythium leak; *Pythium ultimum*

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EVALUATION OF AT-PLANTING IN-FURROW SOIL APPLICATIONS OF RIDOMIL 4EC, ULTRA FLOURISH 2EC AND PHOSPHONIC ACID PROGRAMS FOR POTATO PINK ROT AND PYTHIUM LEAK CONTROL, 2000: Soil inoculated with *Pythium ultimum* and *Phytophthora erythrospetica* was prepared at the Michigan State University Botany Farm, East Lansing, MI on 15 May. Inoculum was prepared for this experiment by soaking 1 lb of sweet corn in 2 pint water in 2 l flasks and adding mefenoxam-sensitive isolates of *P. ultimum* and *P. erythrospetica* to the sterile growing medium. Three colonies of each pathogen were prepared. The colonies were grown for 28 days and formed lush mycelia and were rich in oospores. The corn/mycelial/sporangium homogenate was mixed in 12.25 lb sand and broadcast over the trial plot (0.5 A) at a rate of 25 lb/A. Potatoes (cut seed) were planted at the Michigan State University Botany Farm, East Lansing, MI on 15 May into four-row by 50-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 at planting and soil moisture was monitored with tensiometers. Water was applied as needed with sprinklers to maintain soil moisture at a minimum of 80% filed 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 fungicides were applied weekly from 15 Jun to 3 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 28May) and Poast (1.5 pt/A on 17 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 15 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. Canopy senescence was rated in terms of green color on 14 Jul when some plants started to senesce. Plots were rated relative to the most green plot. At harvest, tuber samples of about 20 lb/plot (ca. 80 tubers) were weighed and tubers cut into 2 pieces and exposed to air at 60 - 70°F. The cut surfaces of the pieces were then assessed for symptoms indicative of Pink rot or Pythium leak (tuber discoloration). Symptomatic tubers were tested with Phytophthora and Pythium specific ELISA assays. Tubers with symptoms that correlated with symptoms that tested positive by immuno-diagnosis were rated as positive and infected with either Pink rot or Pythium or both. The weight of infected cut tubers was expressed as a percentage of the total sample weight and as a percentage of the untreated control. The pathogens causing the tuber infections were re-isolated from the infected tubers and sensitivity to mefenoxam established using the amended plate assay of Deahl et al., (1995).Vines were killed with Diquat 2EC (1 pt/A on 02 Sep). Plots (50-ft row) were harvested on 15 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).

Emergence and canopy formation: 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. However, the final number of emerged plants was low for all treatments was low and considerable tuber rot had occurred. *Fusarium sambucinum* (dry rot pathogen) and *Erwinia carotovora* var *caratovora* (soft rot pathogen) were recovered from non-emergent plants. Canopy formation (RAUCDC) was not affected by any in-furrow application of any fungicide. Canopy senescence in terms of green color on 14 Jul was not significantly different between any treatment. The in-furrow applications of fungicides were not phytotoxic.

Yield: In general yields were low due to early vine senescence. None of the programs were significantly different from each other or from the untreated control.

Tuber-disease at harvest: extremely high soil moisture levels at the end of the season encouraged the development of both Pythium leak and Pink rot in tubers. No treatments reduced the percentage of tubers with Pythium or Pink rot symptoms to below 60% and although some treatments were better than others, no treatment could be said to have adequately controlled tuber infection. The Ultra Flourish 2EC 0.2 pt + Prince Phos 13SC 1.2 pt applied in furrow had a significantly lower proportion of tubers affected by Pythium and/or Pink rot in comparison with the untreated control plots, Ridomil Gold 4EC 0.15 pt impregnated onto dry or into liquid fertilizer and Ridomil Gold 4EC 0.15 pt applied in furrow at planting.

Treatment and rate/acre	Emergence % final[1]		Emergence RAUEPC[2]		Canopy development RAUCDC[3]		Canopy green-ness[4]		Yield cwt/A[5]		Tuber disease at harvest[6] %		Tuber disease at harvest[6] % of untreated control	
Bravo WS 6SC 1.5 pt 9 (C-J)[7]	75.2	a[8]	0.33	a	0.34	a	81.7	a	259	a	71.6	ab	84.8	abcd
Ultra Flourish 2EC 0.2 pt (A) Bravo WS 6SC 1.5 pt (C-J)	69.2	a	0.32	a	0.32	a	90.0	a	387	a	70.8	ab	83.9	abcd
Ultra Flourish 2EC 0.2 pt + (A) Prince Phos 13SC 1.2 pt Bravo WS 6SC 1.5 pt (C-J)	71.2	a	0.34	a	0.32	a	80.0	a	331	a	57.6	a	68.3	a
Ultra Flourish 2EC 0.2 pt + (A) Prince Phos 13SC 1.2 pt Bravo WS 6SC 1.5 pt (C,E,G,I,J) Prince Phos 13SC 1.6 pt Bravo WS 6SC 1.5 pt (D,F,H)	70.4	a	0.33	a	0.32	a	80.0	a	232	a	61.4	ab	72.8	ab
Ridomil Gold 4EC 0.1 pt + (A) Platinum 2SC 0.1 pt Bravo WS 6SC 1.5 pt (C-J)	75.0	a	0.36	a	0.33	a	75.0	a	250	a	65.0	ab	77.0	abc
Ridomil Gold 4EC 0.1 pt (A) Bravo WS 6SC 1.5 pt (C-J)	67.8	a	0.33	a	0.32	a	81.3	a	339	a	69.1	ab	81.9	cd
Ridomil Gold 4EC 0.15 pt (A) Bravo WS 6SC 1.5 pt (C-J)	70.0	a	0.32	a	0.32	a	71.3	a	208	a	80.0	b	94.9	cd
Ridomil Gold 4EC 0.15 pt (B) Bravo WS 6SC 1.5 pt (C-J)	73.0	a	0.36	a	0.30	a	91.3	a	367	a	76.9	b	91.2	bcd
Ridomil Gold 4EC 0.15 pt (B) Bravo WS 6SC 1.5 pt (C-J)	80.0	a	0.37	a	0.33	a	90.0	a	366	a	84.0	b	99.7	d
Untreated	75.7	a	0.36	a	0.33	a	89.6	a	321	a	84.3	b	100	d
sem p = 0.05	4.06		0.02		0.01		6.57		52.9		3.56		4.22	

[1] Percent emergence calculated as percent of maximum possible emergence in 2 x 50' rows.
[2] Relative rate of emergence calculated as Relative Area Under the Emergence Progress Curve from planting until 95% emergence [35 days after planting (dap)] in untreated control (max = 1).
[3] Relative rate of canopy formation calculated as Relative Area Under the Canopy development Curve from planting until 100% canopy cover (64 dap) in untreated control (max = 1).
[4] Canopy green-ness measured as percent of greenest plot in each replicate.
[5] Total marketable yield (cwt/A) estimated from 2 x 50ft row, tubers >2.5" width in any plane.
[6] A sample of about 20 lb/plot (ca. 80 tubers) was weighed and cut into 2 pieces and exposed to air at 60 - 70°F, the cut surfaces of the pieces were then assessed for symptoms indicative of Pink rot or Pythium leak (tuber discoloration). Symptomatic tubers were tested with Phytophthora and Pythium specific ELISA assays. Tubers with symptoms that correlated with symptoms that tested positive by immuno-diagnosis were rated as positive and infected with either Pink rot or Pythium or both. The weight of infected cut tubers was expressed as a percentage of the total sample weight and as a percentage of the untreated control.
[7] Application dates: A= 15 May; B= 15 May impregnated onto dry or into liquid fertilizer; C-J foliar applications; C= 8 Jul; D= 15 Jul; E= 22 Jul; F= 30 Jul; G= 7 Aug; H= 14 Aug; I= 21 Aug.
[8] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

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

Late blight; *Phytophthora infestans*
Stem canker; *Rhizoctonia solani*
Black scurf
White mold; *Sclerotinia sclerotiorum*

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EVALUATION OF AT-PLANTING IN-FURROW SOIL APPLICATIONS AND IMMEDIATE POST-EMERGENCE BANDED FOLIAR APPLICATIONS OF QUADRIS 2SC IN COMBINATION WITH SEED TREATMENTS FOR POTATO BLACK SCURF AND LATE BLIGHT CONTROL, 2000: Potatoes (cv. Snowden), infected with *Rhizoctonia solani* (black scurf), 2 - 3% tuber surface area infected, were selected for the trials. Seed were hand-planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 5 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 Gustaffson revolving drum seed treater and mixed for two minutes to ensure even spread of the fungicide The plots were hand-planted into closed potato beds in early Jun into two rows by 25 ft plots (34 in. row spacing). Each treatment was replicated four times. Treatments were applied seven days prior to planting. 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). 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 fungicides were applied weekly from 26 Jun to 3 Aug (6 applications) with an ATV rear-mounted R&D spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row. The plots were not directly inoculated with *P. infestans*, however they were less than 50 ft from plots which were inoculated with a zoospore suspension of *Phytophthora infestans* US8 biotype (insensitive to metalaxyl, A2 mating type) at 10^4 spores/fl oz (3.4 fl oz/25-ft row) on 28 Jul. Weeds were controlled by hilling and with Dual 8E (2 pt/A on 7 Jun) and Poast (1.5 pt/A on 17 Jul). Insects were controlled with Admire 2F (20 fl oz/A at planting on 5 Jun) and Sevin 80S (1.25 lb on 1 and 17 Jul). The early season applications of fungicides for *R. solani* control were applied 10 days after 50% emergence in 25 gal H_2O/A (19 Jun). Fungicides continued on a seven-day interval after the initial foliar/soil application, total of 8 applications. 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 (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). Emergence was rated as the number of plants breaking the soil surface or fully emerged 25 days after planting. The rate of emergence was estimated as the area under the plant emergence curve (max=1) from the day of planting until 25 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 50 days after planting (about 100% canopy closure), (max = 1). A subjective evaluation of canopy green-ness was done after plants had been treated with two foliar applications of Quadris 2SC on the 28 Jul by comparing the green color of plots in comparison with the most intense green treatment which was given a score of 100. Severity of stolon canker was estimated as the percentage of stolons with greater than 5% girdling caused by *R. solani*, measured 50 days after planting (5 plants per sample were destructively harvested and total stolon number and number affected was counted). Two separate samples of 100 tubers per plot were harvested 14 days after dessication (approximately 135 dap). One sample was evaluated for late blight (*P. infestans*)-induced rots on the day of harvest. Presence of *P. infestans* was confirmed by isolation of the pathogen from infected tubers. The second sample was stored in the dark at 45°F for 60 days. Tubers were washed and assessed for black scurf (*R. solani*) incidence (number of tubers with infection, percent incidence, *R. solani*) and disease severity (average percent surface area infected of entire sample, *R. solani* only) were estimated. Plots were rated visually for percentage foliar area affected by late blight on 23, Jul; 22, 27 Aug and 6 and 15 Sep when there was 100% foliar infection in the untreated plots. The relative area under the disease progress curve (RAUDPC, max = 100) was calculated for each treatment from date of inoculation, 28 Jul to 15 Sep, a period of 48 days. White mold, *Sclerotinia sclerotiorum* was evaluated as the estimated percent stem surface area that was or had been colonized by white mold mycelium and included the area that was infected with bacterial stem blight. The effect of late blight stem infection may have confounded this evaluation particularly in untreated plots and should be taken into consideration when interpreting these results. Vines were killed with Diquat 2EC (1 pt/A on 16 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded.

Emergence and canopy formation: Taking 25 days after planting (dap) as a key reference point, no fungicide applied in-furrow significantly reduced the number of emerged plants in comparison with the untreated control. The Tops MZ seed treatment followed by Bravo WS 6SC 1.5 pt/A program significantly reduced the number of emerged plants in comparison with the untreated control but not from other treatments. All treatments significantly delayed emergence in comparison with the untreated control but none were different from each other. Non-emerged plants were consistently affected by seed piece decay caused by *Fusarium sambucinum* (dry rot pathogen) and *Erwinia carotovora var caratovora* (soft rot pathogen) which were recovered from non-emergent plants. Delayed emergence was apparently due to stems developing from axillary buds on the tuber and may have been indirectly delayed due to an effect of seed piece decay on dominant sprouts. Canopy formation (RAUCDC) was not affected by application of any seed treatment, in-furrow or early soil/foliar application of any fungicide. Programs with Quadris 2SC applied to the canopy were significantly greener than those with Bravo WS 6SC applied alone or the untreated control.

Yield: In general yields were low due to the lateness of planting the crop which was clear given the proportion of US1:Total yield. In terms of US1 grade and total yield, all of the programs had significantly greater yield than the untreated control except the Maxim MZ seed treatment and Bravo WS 6SC foliar application program. None of the treatment programs were significantly different from each other. The reduction in yield in the untreated control was due primarily to the combined infection with both white mold and late blight.

Stolon pruning/stem canker: all treatments significantly reduced the percentage of stolons with greater than 5% girdling in comparison with the untreated control. The effect of the seed treatments was numerically (but not significantly) enhanced by the in-furrow and early soil/foliar applications of Quadris 2SC.

Tuber black scurf: all treatments significantly reduced the incidence of black scurf affected tubers in comparison with the untreated control. The in-furrow and early soil/foliar applications of Quadris 2SC significantly reduced the incidence of infected tubers in comparison with treatments that received only seed treatment fungicide applications. There appeared to be a synergistic trend to reduce the incidence of tuber infection between the combination of seed treatment fungicide application, in-furrow and early soil/foliar applications of Quadris 2SC, however this effect was not significant. All treatments significantly reduced the severity of black scurf on tubers in comparison with the untreated control however there were no significant differences between treatments.

Stem white mold: all treatments significantly reduced the percentage infection of stems with white mold in comparison with the untreated control. The most effective treatments were those with a foliar component of Quadris 2SC (0.8 pt/A) which had significantly lower white mold infection than treatments with a foliar program of Bravo WS 6SC (1.5 pt/A) only. The effect of the timing of initiation of Quadris 2SC within the program was not significantly different. Also, the absence or presence of the in-furrow or early soil/foliar application of Quadris 2SC had no effect on severity of white mold. The effect of late blight stem infection may have confounded this evaluation particularly in untreated plots and should be taken into consideration when interpreting these results.

Foliar late blight: taking 33 days after inoculation of the neighboring potato plots as a key reference point, all treatments significantly reduced the percentage foliar infection of late blight in comparison with the untreated control which had about 50% foliar infection. The amount of foliar late blight increased in all programs. Taking 48 days after inoculation of the neighboring potato plots as a key reference point, all treatments significantly reduced the percentage foliar infection of late blight in comparison with the untreated control.

RAUDPC: the average amount of foliar late blight over the season from 0 to 48 dai was significantly reduced by all fungicide programs with seven-day application intervals compared to the untreated control. There were no significant differences between fungicide programs.

All programs worked well however, the final application was applied only 11 days after inoculation and had programs continued during the epidemic they would probably have kept late blight at lower final levels. The final evaluation was made 37 days after the final application and it may be fair to comment that levels of late blight were kept under control up to 22 days after the final application.

Tuber late blight: although there was a higher percentage of rotted tubers in the samples collected from the untreated controls there were no significant differences between any treatments with respect to late blight initiated tuber rot. *P. infestans* was isolated from a sample of infected tubers confirming that the rots were probably initialed by late blight tuber infection.

Treatment and rate/acre	Emergence % final[1]		Emergence RAUEPC[2]		Canopy development RAUCDC[3]		Canopy green-ness[4]		Yield cwt/A[5] US 1		Yield cwt/A[5] Total	
Maxim MZ 0.5D 0.5 lb/cwt[6] (A)[7].................. Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft(C) Bravo WS 6SC 1.5 pt (D - I)	88	ab[8]	0.358	b	0.301	a	82.5	b	235	a	404	a
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Quadris 2SC 0.575 fl oz/1000rowft (B) Bravo WS 6SC 1.5 pt (D - I)	90	ab	0.38	b	0.295	a	82.5	b	213	a	389	a
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Quadris 2SC 0.767 fl oz/1000rowft (C) Bravo WS 6SC 1.5 pt (D - I)	84	ab	0.347	b	0.313	a	77.5	b	243	a	376	a
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft (C) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	87	ab	0.346	b	0.31	a	100	a	226	a	409	a
Tops MZ 0.75 lb/cwt (A)............................ Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft (C) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	88	ab	0.356	b	0.317	a	100	a	218	a	370	a
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft (C) Bravo WS 6SC 1.5 pt (D,F,H) Quadris 2SC 0.8 pt (E,G,I)	85	ab	0.362	b	0.282	a	97.5	a	218	a	436	a
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Quadris 2SC 0.767 fl oz/1000rowft (C) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	87	ab	0.35	b	0.307	a	100	a	217	a	376	a
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	85	ab	0.352	b	0.317	a	97.5	a	203	a	368	a
Tops MZ 0.75 lb/cwt (A)............................ Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	85	ab	0.382	b	0.314	a	95	ab	211	a	375	a
Untreated	95	a	0.451	a	0.343	a	85	b	130	b	255	b
Maxim MZ 0.5D 0.5 lb/cwt (A).................... Bravo WS 6SC 1.5 pt (D - I)	88	ab	0.358	b	0.316	a	77.5	b	179	ab	337	ab
Tops MZ 0.75 lb/cwt (A)............................ Bravo WS 6SC 1.5 pt (D - I)	80	b	0.335	b	0.304	a	77.5	b	209	a	369	a
sem p = 0.05	2.5		0.0128		0.0167		2.31		14.3		22.0	

[1] Percent emergence calculated as percent of maximum possible emergence in 2 x 20' rows.
[2] Relative rate of emergence calculated as Relative Area Under the Emergence Progress Curve from planting until 95% emergence [25 days after planting (dap)] in untreated control (max = 1).
[3] Relative rate of canopy formation calculated as Relative Area Under the Canopy development Curve from planting until 100% canopy cover (64 dap) in untreated control (max = 1).
[4] Canopy green-ness measured as percent of greenest plot in each replicate.
[5] Total and marketable yield (cwt/A), tubers >2.5" width in any plane, estimated from 2 x 20ft rows.
[6] Seed treatment, applied 7 days before planting to cut seed.
[7] Application dates: A= 1 Jun; B= 1 Jun applied as in-furrow application in 5 gal H_2O/A; C = 26 Jun, early soil/foliar application; D foliar applications = 3 Jul; E= 10 Jul; F= 17 Jul; G= 24 Jul; H= 1 Aug; I= 8 Aug.
[8] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Treatment and rate/acre	Stolon blinding[1]	*R. solani* Incidence on tubers (%)[2]	*R. solani* Average (%) surface area infected[3]	Stem white mold[4] 10 dbd[5]	Foliar late blight % 33 dai[6]	Foliar late blight % 48 dai final	Foliar late blight RAUDPC[7] 0 - 48 dai	Tuber rot at harvest[8]
Maxim MZ 0.5D 0.5 lb/cwt[9] (A)[10] Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft(C) Bravo WS 6SC 1.5 pt (D - I)[11]	3.5 b[11]	29.5 d	0.75 b	47.5 bc	3.3 b	32.5 b	5.05 b	11.3 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Quadris 2SC 0.575 fl oz/1000rowft (B) Bravo WS 6SC 1.5 pt (D - I)	2.8 b	30.0 cd	0.58 b	40 cd	4.5 b	38.8 b	6.1 b	7.5 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Quadris 2SC 0.767 fl oz/1000rowft (C) Bravo WS 6SC 1.5 pt (D - I)	2.0 b	28.8 d	0.63 b	41.3 bc	4.0 b	33.8 b	5.34 b	8.3 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft (C) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	3.5 b	34.3 cd	0.50 b	5.0 e	3.3 b	42.5 b	6.37 b	11.0 a
Tops MZ 0.75 lb/cwt (A) Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft (C) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	3.5 b	28.8 d	0.40 b	5.0 e	4.5 b	50.0 b	7.67 b	6.8 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Quadris 2SC 0.575 fl oz/1000rowft (B) Quadris 2SC 0.767 fl oz/1000rowft (C) Bravo WS 6SC 1.5 pt (D,F,H) Quadris 2SC 0.8 pt (E,G,I)	5.0 b	15.5 d	0.50 b	4.5 e	5.0 b	40.0 b	6.42 b	6.3 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Quadris 2SC 0.767 fl oz/1000rowft (C) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	3.5 b	19.8 d	0.50 b	2.5 e	5.0 b	28.8 b	4.99 b	5.8 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	10.3 b	21.0 d	0.83 b	6.25 de	4.0 b	41.3 b	6.51 b	6.0 a
Tops MZ 0.75 lb/cwt (A) Quadris 2SC 0.8 pt (D,F,H) Bravo WS 6SC 1.5 pt (E,G,I)	8.3 b	24.3 d	1.13 b	5.0 e	5.8 b	50.0 b	7.74 b	6.5 a
Untreated	41.3 a	85.0 a	5.75 a	86.25 a	51.3 a	98.3 a	24.2 a	15.0 a
Maxim MZ 0.5D 0.5 lb/cwt (A) Bravo WS 6SC 1.5 pt (D - I)	11.3 b	61.0 b	1.50 b	47.5 bc	4.0 b	48.8 b	7.41 b	8.5 a
Tops MZ 0.75 lb/cwt (A) Bravo WS 6SC 1.5 pt (D - I)	14.3 b	51.5 bc	1.75 b	57.5 b	5.0 b	50.0 b	7.83 b	7.8 a
sem p = 0.05	2.66	4.37	0.286	3.395	0.95	4.34	0.629	2.9

[1] Stolon blinding, percentage of stolons with greater than 5% girdling caused by *R. solani*, measured 50 days after planting.
[2] Percent tubers with presence of black scurf sclerotia 60 days after harvest (dah) (sample size = 100 tubers per plot)
[3] Black scurf severity (average percent surface area infected of entire sample) 60 dah.
[4] White mold, *S. sclerotiorum* estimated percent stem surface area colonized by white mold mycelium.
[5] Days before desiccation.
[6] Days after inoculation with *Phytophthora infestans*, US8, A2.
[7] RAUDPC, relative area under the disease progress curve calculated from day of inoculation to last evaluation of late blight (max = 100).
[8] Percent tubers with rot initiated by late blight at harvest (sample size = 100 tubers per plot)
[9-11] As [6-8] in previous table.

2000 Potato Nematology Research Report

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The 2000 Michigan State University Potato Nematology Research Program consisted of the following five projects:

- Potato line evaluation for resistance/tolerance to the Potato Early-Die Disease.
- Long-term potato farming systems research.
- Precision agriculture technology research.
- Bionematicide research.
- Development of a potato nematode management publication.

PED Resistance/Tolerance

Potato line/cultivar evaluation for resistance /tolerance to PED was started in 1997 as part of the USDA project. The research is conducted on two ranges at the Montcalm Potato Research Farm dedicated to this initiative. One range is used annually for the line/cultivar evaluations and the other is used to increase population densities of root-lesion nematodes, root-knot nematodes and *Verticillium dahliae*. One half of the PED nursery range is planted to potato and the other to hairy vetch. Replicated fumigation and control plots are established annually prior to planting the resistance/tolerance trial.

Twenty-five lines/cultivars were included in the 2000 trial (Table 1.). Six were evaluated in three of the four years. Five were evaluated for two years and eleven were in their first year of assessment. F349-1RY was resistant (absence of PED symptoms and no root-lesion nematode reproduction) to PED in 1998 and 2000. This is the only line/cultivar currently classified in the resistance category. F349-1RY will be evaluated again in 2001.

E228-1 exhibited tolerance (absence of PED symptoms) to PED in 1998, 1999 and 2000 (Table 1). Nine additional lines exhibited tolerance to PED in 2000. Three of these lines, F018-1, F313-3 and F373-3 will be in their third year of assessment in 2001. Both Atlantic and Snowden were susceptible to PED in all three years they were evaluated. Seven of the lines evaluated were classified in this category. Three of them will be evaluated for the third time in 2001.

E149-5Y was identified as highly susceptible to PED in 1998, 1999 and 2000 Table 1). Four additional lines also appear to be highly susceptible.

General observations on the twenty-five lines/cultivars evaluated for PED resistance/tolerance in 2000 are presented in Table 2. Progress was made in 2000 on the development of a tissue culture procedure for assessment of the tolerance/resistance of potato lines/cultivars to PED. The MSU Potato Nematode Resistance/Tolerance Website was updated and maintained throughout 2000.

Long-Term Potato Farming Systems Trial

2000 was the 10th and final year of the Long-Term Potato Farming Systems Trial at the Montcalm Potato Research Farm. The project was initiated in 1991 to evaluate various rotation crops for PED management. The research evolved into a broader farming systems project. It consisted of 10 systems, each replicated 8 times on a sandy site with a severe PED index (Table 3). In 2000, the entire site was planted to potato, and three nematicide treatments were incorporated into the trial. Potato following two years of alfalfa was used as the yield standard, except in the first year of the trial (1st-year potatoes only) and the second year (potatoes following one year of alfalfa). In all but five of the 44 yield observations, potatoes following two years of alfalfa had the highest tuber yields (Table 4). This was assigned a yield index of 1.00 and all other yields are relative on a scale of 0.00 to 1.00. The five cases were the yields exceeded that of the potatoes following two years of alfalfa were considered as over-yielding and assigned a relative value >1.00. In 1996, potatoes following oil seed radish and buckwheat over-yielded, and 1997 over-yielding was after oats following a nematode suppressive covercrop mixture in 1995. 2000 treatment with metham at 37.5 gal/acre and Telone II at 12 gal/acre also over-yielded the alfalfa rotation.

The 2000 tuber yields ranged from 121.4 cwt/acre (continuous conventional potatoes) to 348.0 cwt/acre (2nd-year potatoes following soil fumigation with metham) (Table 5). The 2000 spring root-lesion nematode population densities recovered from covercrop roots were highest following conventional corn-rye and wheat-clover systems and lowest following alfalfa, potato and buckwheat systems (Table 6). The highest northern root-knot nematode population densities were associated with alfalfa roots.

Soil chemical characteristics varied among the farming systems (Table 7). Soil pH ranged from 6.47 (continuous conventional potatoes) to 7.34 (2nd-year potatoes following fumigation with metham). Cation exchange capacity ranged from 3.00 (following second-year conventional corn) to 4.15 (following two years of conventional alfalfa). Potassium ranged from 84.3 (2nd-year potatoes following soil fumigation with metham) to 184.4 (following two years of alfalfa). Phosphorus ranged from 163.6 (conventional wheat rotation) to 221.6 (2nd-year organic potatoes in a buckwheat rotation). Magnesium ranged from 51.2 (following two year years of conventional corn) to 122 (conventional wheat rotation).

Differences in nematode community structure among the farming systems was reported in the 1999 and 1998 annual reports. It appears that nematode community analysis may be one of, if not the best procedure for soil quality analysis. Numerous other soil biological factors were measured, including active and total bacterial biomass, active and total fungal biomass, protozoa and annelids. The highest active bacterial biomass was associated with both the highest and the lowest tuber yields (Table 8).

Significant progress was made during the past 10 years on understanding soil quality in relation to PED. It appears that PED is a result of overall poor soil quality and future soil management procedures designed to enhance soil quality will significantly reduce or alleviate PED risk. It can also be stated that it is not possible to profitably raise potatoes on the Long-Term Potato Farming System Trial site with current conventional or organic production practices in the absence of nematicides. It should be possible, however, to enhance the quality of the soil at this site in a manner that will result in profitable potato production in the absence of nematicides. To do this, the site must be taken out of potato production for an extended period of time. It is known that a three-year potato rotation is not adequate for the necessary improvement of the soil quality at this site. It is not known how long the process with take. It is my recommendation that this site be dedicated to a 12-year soil quality enhancement project (four treatments, potatoes every 3, 4, 6 and 12 years with four replications in a Latin Square design.

Precision Agriculture Technology

The technologies of precision agriculture were used to map the soil physical and chemical characteristics of a 62.1 acre potato field at Andersen Brothers Potato Farm in Montcalm County. A one-acre grid system was used. Nematode and *Verticillum* samples were taken from the same grid, analyzed and a the MSU PED Risk Index (Table 9) used to map the field for PED (Figure 1). A PED-precision agriculture evaluation experiment was conducted at this site in 2000. The PED index was modified for its scale of 0-5 to a scale of 1-3. Five replications of each of 0, 37.5 and 75 gal/acre of metham were applied in 16 row by 200 ft plots in no, medium and high risk sites selected at random throughout the field. This type of experimental design is not possible without the technologies of precision agriculture. The tuber yields ranged from a low of 276.2 cwt/acre where there was to high-severe PED risk and no metham applied where there was a no-low PED risk and no metham applied (Table 10). The results of this experiment indicated that the current PED Risk Index is excellent. The technologies of precision agriculture allowed for the index to be tested for the first time under a field-scale experimental design. Previous research was done on a small field plot basis.

Additional research will be needed to determine the best way to use the technologies of precision agriculture for enhancing profit, reducing risk to PED and preventing unnecessary use of nematicides in potato production. The potential of the technology, however, appears to be outstanding for soil-based biological, chemical and physical issues. Data from the research were used to calculate eight nematicide use/profit enhancement scernarios (Table 10). Metham usage ranged from 0.00 to 4,657.5 gallons ($19,361.21 applied) for the field and tuber yield from 393.8 cwt to 430.6 cwt/acre, respectively. Profit was maximized ($149.89/acre increase in profit compared to no PED management) when 2,328.8 gallons of metham were used to treat the entire 62.1 acres. It is not possible, however, to simultaneously maximize or minimize two dependent variables, and in this case metham was used on approximately 20.5 acres where it was not needed. When only the 41.7 acres with a medium to severe PED risk were treated with 37.5 gal/acre of metham, there was a $111.59/acre increase in profit and a 765 gallon reduction in metham use. Using the power of the technologies of precision agriculture to treat 16.1 acres with 75 gal/acre of metham, 25.6 acres with 37.5 gal/acre and leaving 20.5 acres untreated, net profit was increased $112.28/acre.

Two issues associated with the economics of precision agriculture technology were identified. These related to the current cost of custom application of metham and the cost of sampling and nematode-*Verticillium* analysis on a 1.0-acre grid basis. If the application cost for the fumigation is based on treated acres instead of an entire field, the economics improves significantly (Table 11). The question of sampling relates to how much of the $40.00 precision agriculture technology fee should be charged to PED and how much should be discounted to other factors such as soil nutrients and pH.
A 55.3 acre field at Anderson Brothers Potato Farm has been selected and mapped in relation to soil physical and chemical characteristics and PED risk to repeat the experiment in 2001. It is likely that metham at 37.5 gal/acre and oxamyl (Vydate) will be used for PED management instead of two rates of metham.

For the next few years, the MSU Bird Laboratory will be making the technologies of precision agriculture a major component of its research program. Projects currently exist for potato, soybeans and carrots. Sugar beets will be included in 2001.

Bionematicides

The bionematicide Diterra (an inactivated fungal product) was evaluated for PED management in two experiments in 2000 at the Montcalm Potato Research Farm. No significant tuber yeild increases or decreases in root-lesion nematode population densities were observed.

Potato Nematode Management Publication

As requested by the MPIC, development of a Michigan potato nematode management publication is under development. It is anticipated that the website version of this document will be completed before the end of March 2001.

Table 1. Summary of 2000 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research.

Possible Resistance

F349-1RY (98, 00)

Tolerant

E228-1 (98, 99, 00)

Probable Tolerance

B107-1 (98 inconclusive, 99 susceptible, 00 tolerant)
E028-1 (00)
E273-8 (00)
F018-1 (99, 00)
F060-6 (00)
F313-3 (98 susceptible, 00 tolerant)
F373-3 (98, 00)
H031-5 (00)
MI Purple (00)

Susceptible

Atlantic (97, 99, 00)
Snowden (97, 99, 00)

Probable Susceptibility

B106-7 (00)
E202-E Rus (00)
E212-1 (00)
F099-3 (99, 00)
G050-2 (99 possible resistance, 00)
G124-85 (00)
G274-3 (99, 00)

Highly Susceptible

E-149-5Y (98, 99, 00)

Probable High Susceptibility

E048-2Y (98 possible tol., 99, 00)
G004-3 (00)
G227-2 (00)
P81-11-5 (00)

Table 1. Summary of 2000 Michigan State University Potato Early-Die Nematode Tolerance-Resistance Research.

Possible Resistance

F349-1RY (98, 00)

Tolerant

E228-1 (98, 99, 00)

Probable Tolerance

B107-1 (98 inconclusive, 99 susceptible, 00 tolerant)
E028-1 (00)
E273-8 (00)
F018-1 (99, 00)
F060-6 (00)
F313-3 (98 susceptible, 00 tolerant)
F373-3 (98, 00)
H031-5 (00)
MI Purple (00)

Susceptible

Atlantic (97, 99, 00)
Snowden (97, 99, 00)

Probable Susceptibility

B106-7 (00)
E202-E Rus (00)
E212-1 (00)
F099-3 (99, 00)
G050-2 (99 possible resistance, 00)
G124-85 (00)
G274-3 (99, 00)

Highly Susceptible

E-149-5Y (98, 99, 00)

Probable High Susceptibility

E048-2Y (98 possible tol., 99, 00)
G004-3 (00)
G227-2 (00)
P81-11-5 (00)

Table 2. Michigan State University 2000 Potato Early-Die Nematode Tolerance-Resistance Research Notes.

Possible Resistance
- F349-1RY (98, 00) Lowest root-lesion nematode reproduction in trial. Extremely high scab susceptibility.

Tolerant
- E228-1 (98, 99, 00) Second lowest root-lesion nematode reproduction in trial.

Probable Tolerance
- B107-1 (98 inconclusive, 99 susceptible, 00 tolerant)
- E028-1 (00) Scab tolerant.
- E273-8 (00) Root-knot nematode host.
- F018-1 (99, 00)
- F060-6 (00) Scab tolerant.
- F313-3 (98 susceptible, 00 tolerant) Scab susceptible.
- F373-3 (98, 00) Root knot nematode host.
- H031-5 (00) Scab susceptible.
- MI Purple (00) Scab susceptible

Susceptible
- Atlantic (97, 99, 00) Very good root-lesion nematode host
- Snowden (97, 99, 00) Very good root-lesion nematode host

Probable Susceptibility
- B106-7 (00) Root knot nematode host. Scab tolerant.
- E202-E Rus (00) Root knot nematode host. Scab tolerant.
- E221-1 (00) Excellent root knot nematode host.
- F099-3 (99, 00) Scab susceptible.
- G050-2 (99 possible resistance, 00) Excellent root-lesion nema host, RK host.
- G124-85 (00)
- G274-3 (99, 00) Scab susceptible.

Highly Susceptible
- E-149-5Y (98, 99, 00) Scab tolerant.

Probable High Susceptibility
- E048-2Y (98 possible tol., 99, 00)
- G004-3 (00) Excellent root-lesion nematode host. RK host. Scab tolerant.
- G227-2 (00) Scab tolerant.
- P81-11-5 (00) Excellent root knot nematode host. Scab susceptible.

Table 3. Description of the crops and soil nutrition programs used in a 10-Year Farming System - Nematode Management Research Project (1991-2000) at the Montcalm Potato Research Farm in Entrican, Michigan.

Farming System	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato[1]
2	Alfalfa[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Hairy vetch[1]	Potato Rye[1]	Buckwheat Rye[1]	Potato Clover[1]	Wheat Clover[1]	Potato[1]
3	Oats Rye[1]	Alfalfa[1]	Potato[1]	Potato[1]	Nematode mix[1]	Oats[1]	Potato Rye[3]	Potato Clover[3]	Potato Rye[3]	Potato + DiTerra[3,4]
4	Oats Rye[1]	Alfalfa[1]	Alfalfa[1]	Potato Rye[1]	Alfalfa[1]	Alfalfa[1]	Potato Rye[1]	Alfalfa[1]	Alfalfa[1]	Potato[1]
5	Oats Rye[1]	Potato Rye[1]	Potato Rye[1]	Potato Rye[1]	Annual rye grass[1]	Oats/Red Clover[1]	Potato Rye[1]	Wheat Clover[1]	Potato	Potato + DiTerra[1]
6	Oats Rye[1]	Soybean Rye[1]	Alfalfa[1]	Alfalfa[1]	Potato Rye[2]	Alfalfa[1]	Alfalfa[3]	Potato Alfalfa[1]	Alfalfa[1]	Potato + Telone II[1,5]
7	Oats Rye[1]	Soybean Rye[1]	Light red kidney beans, Rye[1]	Alfalfa[1]	Alfalfa[1]	Potato Rye[1]	Alfalfa[3]	Alfalfa[1]	Potato Alfalfa[1]	Potato + Metham[1,6]
8	Oats Rye[1]	Soybean Rye[1]	Light red kidney beans, Rye[1]	Green pea[1]	Oil seed radish[1]	Potato Rye[1]	Oil seed radish Rye[3]	Corn Clover[1]	Corn	Potato[1]
9	Oats Rye[1]	Soybean Rye[1]	Light red kidney beans, Rye[1]	Green pea[1]	Potato Rye[2]	Oil seed radish[1]	Potato Rye[1]	Buckwheat Clover[3]	Potato Clover[3]	Potato + DiTerra[3]
10	Oats Rye[1]	Soybean Rye[1]	Light red kidney beans, Rye[1]	Green pea[1]	Buckwheat[2]	Potato Rye[1]	Buckwheat Rye[3]	Potato Clover[3]	Buckwhe at Clover[3]	Potato[3]

[1]Conventional soil nutrition program.
[2]30 T/A cow manure compost.
[3]Alternative soil nutrition program.
[4]Diterra = Bionematicide
[5]Telone II at 12 gal/A
[6]Metham at 37.5 gal/A

Farming System Descriptions (1991-1999):
- Continuous Potato (No. 1 and No. 3)
- Potato-Wheat-Rye Rotation (No. 2, No. 5, and No. 8)
- 2-year Alfalfa-Potato (No. 4, No. 6, No. 7)
- Buckwheat-Potato (No. 9 and No. 10)
- Entire experiment planted to potato in 2000

January 3, 2001

Table 4. 1991-2000 relative potato tuber yields associated with a Ten-Year Farming System/Nematode Management Research Project at the Michigan State University Montcalm Potato Research Farm in Entrican, Michigan.

Crop									Relative Yield, U.S. No. 1 Potato Tubers[1]									
1991	1992	1993	1994	1995	1996	1997	1998	1999	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Potato[2]	Potato[2]	Potato[2]	Potato[2]	Potato[2]	Potato[2]	Potato[2]	Potato[2]	Potato[2]	**1.00**	0.69	0.34	0.29	0.79	0.87	0.45	0.61	0.33	0.58
Alfalfa[2]	Potato[2]	Potato[2]	Potato[2]	Hairy vetch[2]	Potato[2]	Buck-wheat[3]	Potato[2]	Wheat[2]	---	**1.00**	0.54	0.34	---	0.95	---	0.77	---	0.59[6]
Alfalfa[2]	Alfalfa[2]	Potato[2]	Potato[2]	Nematode tri-mix[2]	Oats[2]	Potato[4]	Potato[4]	Potato[4]	---	---	**1.00**	0.57	---	---	**1.05**	0.33	0.56	0.73
Oats[2]	Alfalfa[2]	Alfalfa[2]	Potato[2]	Alfalfa[2]	Alfalfa[2]	Potato[2]	Alfalfa[2]	Alfalfa[2]	---	---	---	**1.00**	---	---	**1.00**	---	---	**1.00**
Oats[2]	Potato[2]	Potato[2]	Potato[2]	Annual rye grass[2]	Oats/Red clover[2]	Potato[2]	Wheat[2]	Potato[2]	---	0.97	0.53	0.32	---	---	0.88	---	0.74	0.61[6]
Oats[2]	Soybean[2]	Alfalfa[2]	Alfalfa[2]	Potato[2]	Alfalfa[3]	Alfalfa[4]	Potato[2]	Alfalfa[2]	---	---	---	---	**1.00**	---	---	**1.00**	---	1.12[7]
Oats[2]	Soybean[2]	Light red kidney beans[2]	Alfalfa[2]	Alfalfa[2]	Potato[2]	Alfalfa[4]	Alfalfa[2]	Potato[2]	---	---	---	---	---	**1.00**	---	---	**1.00**	**1.65[8]**
Oats[2]	Soybean[2]	Light red kidney beans[2]	Green peas[2]	Oil seed radish[3]	Potato[2]	Oil seed radish[4]	Corn[2]	Corn[2]	---	---	---	---	---	**1.14**	---	---	---	0.71
Oats[2]	Soybean[2]	Light red kidney beans[2]	Green peas[2]	Potato[3]	Oil seed radish[3]	Potato[2]	Buck-wheat[4]	Potato[4]	---	---	---	---	0.93	---	0.97	---	0.56	0.66[6]
Oats[2]	Soybean[2]	Light red kidney beans[2]	Green peas[2]	Buck-wheat[3]	Potato[2]	Buck-wheat[4]	Potato[4]	Buck-wheat[4]	---	---	---	---	---	**1.35**	---	0.86	---	0.77

[1]Relative yields calculated by assigning a yield of 1.0 to the standard farming system (2 years of alfalfa followed by one year of potato) and dividing the U.S. No. 1 tuber yields for each farming system by the U.S. No. 1 tuber yield for the standard. The two exceptions were in 1991 and 1992, where the U.S. No. 1 tuber yields for the only potato system and the potato system following a single year of alfalfa were used as the standard, and in 1996 and 1997 when situations of over-yielding existed.
[2]Conventional potato production soil nutrition program.
[3]Application of 30 T/A of cow manure compost.
[4]Alternative potato production soil nutrition program.
[5]Entire reearch plot planted to potato in 2000.
[6]Diterra (bionematicide) treatment in 2000.
[7]Telone II applied at 12 gal/A.
[8]Metham applied at 37.5 gal/A.

Table 5. 2000 tuber yields from the 10th year of the Montcalm Potato Research Farm Potato Farming system Trial .

Farming System	Tuber weight (cwt/acre)			
	A	B	J	Total
7. 2nd-Year Potato + Metham (conventional)[1]	295.8d	42.7a	9.4b	348.0d
6. 1-Year Alfalfa + Telone II (conventional)	179.3c	49.0abc	7.7b	235.9c
4. 2-Year Alfalfa Rotation (conventional)	134.4bc	47.9ab	8.3b	210.8bc
10. Buckwheat Rotation (organic)	95.5ab	63.4bcd	0.0a	162.0ab
3. 4th-Year Potato + Diterra (organic)	83.2ab	66.5d	0.2a	153.2ab
8. 2-Year Corn (conventional)	84.1ab	62.2bcd	0.0a	150.5ab
9. 2nd –Year Potato + Diterra (organic)[2]	74.1ab	64.2cd	0.0a	140.1ab
5. Wheat Rotation + Diterra (conventional)	60.5a	66.2d	0.0a	128.1a
2. Wheat Rotation (conventional)	53.9a	69.6d	0.0a	125.4a
1. 10th-Year Potato (conventional)	51.1a	67.9d	0.0a	121.4a

[1]Alfalfa in 1994, 1995, 1997 and 1998.
[2]Buckwheat in 1998.

Table 6. Montcalm Potato Farming System Trial 10th-Year Nematode Data.

Farming System (Cover Crop)	Tuber weight (cwt/acre)	Nemas/1.0g root (3/30/00)	
		Root-Lesion	Root-Knot
7. 2nd-Year Potato + Metham (conventional)[1] Rye	348.0d	32.5a	35.6b
6. 1-Year Alfalfa + Telone II (conventional) Alfa	235.9c	146.9bc	1930.6b
4. 2-Year Alfalfa Rotation (conventional) Alfa	210.8bc	35.9a	1789.4a
10. Buckwheat Rotation (organic) Rye	162.0ab	96.3ab	1.3a
3. 4th-Year Potato + Diterra (organic) Clo	153.2ab	213.8c	6.3a
8. 2-Year Corn (conventional) Rye	150.5ab	243.1cd	10.6a
9. 2nd –Year Potato + Diterra (organic)[2] Rye	140.1ab	100.6ab	0.6a
5. Wheat Rotation + Diterra (conventional) Rye	128.1a	18.8a	23.1a
2. Wheat Rotation (conventional) Rye	125.4a	273.1d	0.0a
1. 10th-Year Potato (conventional) Rye	121.4a	65.6ab	0.0a

[1]Alfalfa in 1994, 1995, 1997 and 1998.
[2]Buckwheat in 1998.

Table 7. Montcalm Potato Farming System Trial 10th-Year Soil Characteristics.

Farming System	Tuber yield (cwt/acre)	pH	CEC	Ca	K	P	Mg
7. 2nd-Year Potato + Metham (conventional)[1]	348.0d	7.34d	3.98abc	631c	84.3a	174.9a	71.8ab
6. 1-Year Alfalfa + Telone II (conventional)	235.9c	7.10cd	3.47abc	450ab	128.1ab	187.6ab	105.7cd
4. 2-Year Alfalfa Rotation (conventional)	210.8bc	7.13cd	4.15c	538bc	184.4b	155.6a	117.9d
10. Buckwheat Rotation (organic)	162.0ab	7.21cd	3.98abc	563bc	104.3a	188.9ab	106.4cd
3. 4th-Year Potato + Diterra (organic)	153.2ab	7.00bcd	3.69abc	525bc	102.5a	182ab	93.6bc
8. 2-Year Corn (conventional)	150.5ab	6.55b	3.00a	431a	113.1a	163.8a	51.2a
9. 2nd –Year Potato + Diterra (organic)[2]	140.1ab	7.09cd	4.10bc	544bc	121.9a	221.6b	108.6cd
5. Wheat Rotation + Diterra (conventional)	128.1a	6.84bc	3.17abc	386a	81.3a	169.7a	122d
2. Wheat Rotation (conventional)	125.4a	6.56b	3.09abc	375a	108.3a	163.6a	110.5cd
1. 10th-Year Potato (conventional)	121.4a	6.47a	3.05 ab	563bc	92.6a	194.6ab	105.5cd

[1]Alfalfa in 1997 and 1998.
[2]Buckwheat in 1998

Table 8. Montcalm Potato Farming System Trial 10th-Year Soil Biology Data.

Farming System	Tuber weight (cwt/acre)	Active bact.	Total bact.	Active fungal	Total fungal
7. 2nd-Year Potato + Metham (conventional)[1]	348.0d	12.1	157	3.3	42
6. 1-Year Alfalfa + Telone II (conventional)	235.9c	9.9	170	4.2	63
4. 2-Year Alfalfa Rotation (conventional)	210.8bc	15.6	146	6.7	55
10. Buckwheat Rotation (organic)	162.0ab	9.0	169	4.4	40
3. 4th-Year Potato + Diterra (organic)	153.2ab	14.8	172	6.3	54
8. 2-Year Corn (conventional)	150.5ab	9.4	157	5.3	51
9. 2nd –Year Potato + Diterra (organic)[2]	140.1ab	11.5	160	7.0	38
5. Wheat Rotation + Diterra (conventional)	128.1a	17.6	162	6.2	52
2. Wheat Rotation (conventional)	125.4a	17.5	172	9.2	40
1. 10th-Year Potato (conventional)	121.4a	18.9	177	8.3	45

[1]Alfalfa in 1994, 1995, 1997 and 1998.
[2]Buckwheat in 1998.

Table 9. Michigan State Universtiy Potato Early-Die Risk Index.

PED RISK MATRIX

NEMA RISK	VERT RISK 0	1	2	3	4	5
0	0	1	2	3	4	5
1	1	1	2	3	4	5
2	1	1	3	4	5	5
3	2	3	4	4	5	5
4	3	4	5	5	5	5
5	4	5	5	5	5	5

Root Lesion Nema Risk	MSU	ABC
0 None Detected	0	
1 Low	1-24	
2 Low-Moderate	25-74	
3 Moderate-High	75-149	
4 High	150-299	
5 Severe	300+	

Vert DP Risk	MSU	ABC
0	0	
1	1-2	
2	3-4	
3	5-7	
4	8-15	
5	16+	

Vert Wet Seiving	MSU	ABC
0	0	
1	1-15	
2	16-35	
3	36-60	
4	61-100	
5	101+	

Table 10. Potential role of the technologies of precision agriculture in management of the Potato Early-Die Disease Complex in Michigan Potato Production (Based on 2000 field data from a 62.1 acre commercial site).

PED Risk Index	Treatment	Total Yield	Std Dev.
1. (none-low)	Control	413.9 cwt/acre	60
20.5 acres	Vapam (37.5 gpa)	439.3 cwt/acre	33
	Vapam (75.0 gpa)	447.8 cwt/acre	27
2. (medium)	Control	375.0 cwt/acre	49
25.6 acres	Vapam (37.5 gpa/a)	440.1 cwt/acre	64
	Vapam (75.0 gpa)	422.0 cwt/acre	63
3. (high-extreme)	Control	276.2 cwt/acre	29
16.1 acres	Vapam (37.5 gpa)	395.7 cwt/acre	34
	Vapam (75.0 gpa)	419.7 cwt/acre)	40

Table 11. Nematicide use, tuber yield and profit enhancement associated with eight PED management schemes.

Treatment	Metham (gpa)	Yield	+Profit/acre
1. No nematicide (62.1 acres)[1]	0.00 (0.00)	362.8	----
2. No nematicide (46 acres)[2] Metham 37.5 (16.1 gal)	603.5 (9.7)	393.8	$31.09
3. No nematicide (46 acres)[2] Metham 75 (16.1 acres)	1,207.5 (19.4)	400.0	$28.73
4. No nematicide (20.5 acres)[2] Metham 37.5 (41.7 acres)	**1,563.8 (25.2)**	**420.6**	**$111.59**
5. No nematicide (20.5 acres)[2] Metham 37.5 (25.6 acres) Metham 75 (16.1 acres)	2,110.5 (34.0)	426.9	$112.28
6.. Metham 37.5 (62.1 acres)[3]	2,328.8 (37.5)	429.0	$149.89
7. No. nematicide (20.5 acres)[2] Metham 75 (41.7 acres)	3,127.5 (50.4)	419.4	$54.88
8. Metham 75 (62.1 acres)[3]	4,657.5 (75.0)	430.6	$27.23

[1]Base Revenue = $5.00/cwt

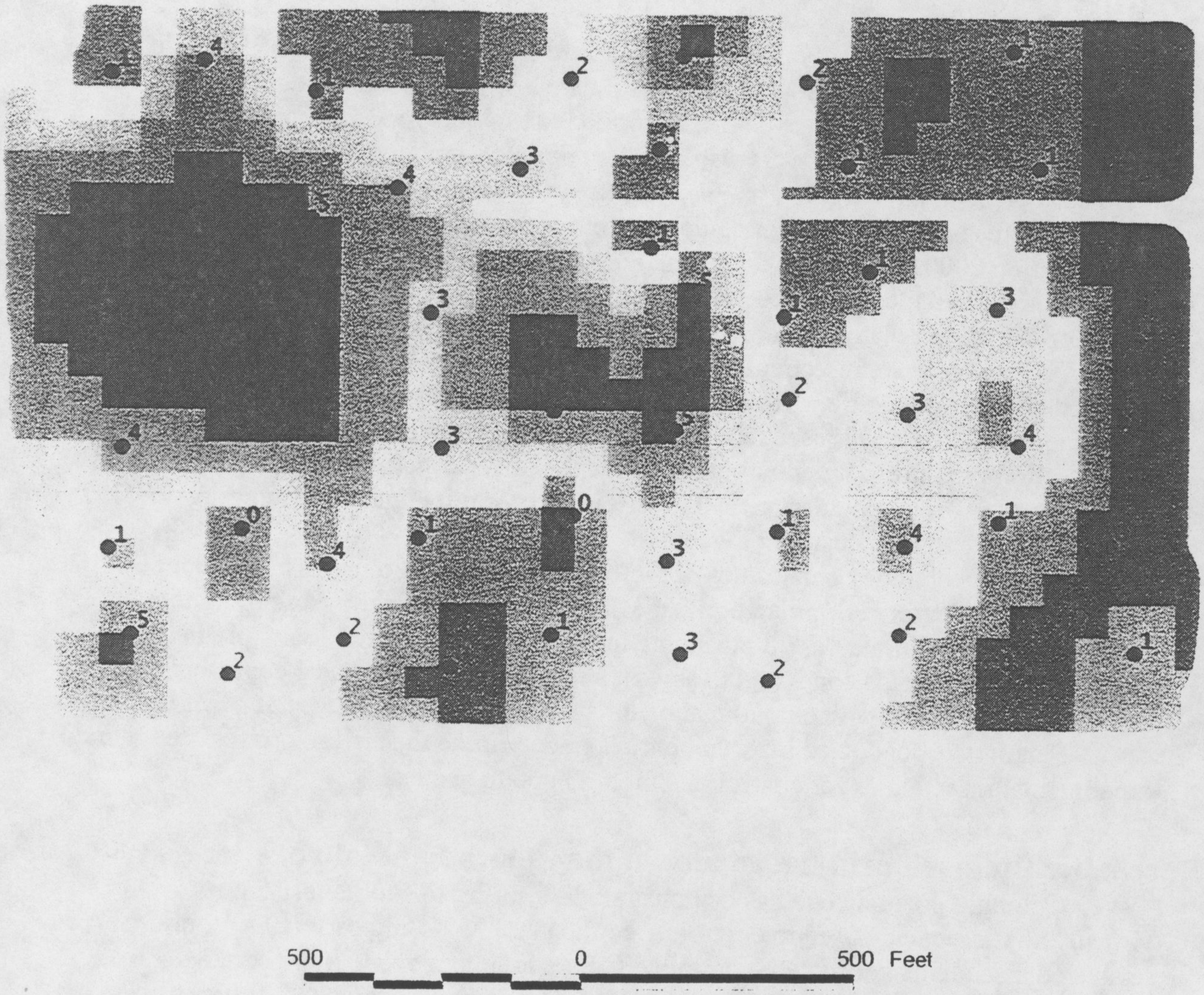
[2]$40.00/acre precision agriculture technology cost, $3.50/gal metham and $50/field acres application fee.

[3]$160/field sampling fee, $3.50 gal metham and 50$/field acres application fee.

Table 12. Profitability of two nematicide application fee schedules.

Treatment	+ Profit (Current custom application)	+Profit (Treated acres only)
1. No nematicide (62.1 acres)	----	-----
2. No nematicide (46 acres) Metham 37.5 (16.1 gal)	$31.09	$68.13
3. No nematicide (46 acres) Metham 75 (16.1 acres)	$28.73	$66.31
4. No nematicide (20.5 acres) Metham 37.5 (41.7 acres)	**$111.59**	**$128.33**
5. No nematicide (20.5 acres) Metham 37.5 (25.6 acres) Metham 75 (16.1 acres)	$112.28	$129.03
6.. Metham 37.5 (62.1 acres)	$149.89	$149.89
7. No. nematicide (20.5 acres) Metham 75 (41.7 acres)	$54.88	$71.63
8. Metham 75 (62.1 acres)	$27.23	$27.23

Potato Early-Die Risk Index.



Date: Dec 1, 1999
Field Name: AB26
Farm Name: AB-Vestaberg Farm
Client Name: Andersen Bros
Field Boundary Start Location
Latitude: 43.43488631
Longitude: -84.87582916
No. of Observations: 60
Minimum PEDRisk: 0
Maximum PEDRisk: 5
Average PEDRisk: 2

● 1999 ST Points
Clipped - PEDRisk Surface
0-NoneDetected (7.0ac.)
1-Low (13.5ac.)
2-Low-Moderate (14.2ac.)
3-Moderate-High (11.4ac.)
4-High (9.3ac.)
5-Severe (6.8ac.)

Insect Management in Potatoes

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Summary:

The 2000 growing season was characterized by cool, wet weather. Colorado potato beetle populations in most of Michigan were low to moderate. Admire ® and Provado® (imidacloprid, Bayer Corp.) continued to provide good control of Colorado potato beetle and aphids. Growers also had the option of applying imidacloprid as a liquid seed piece treatment (Genesis FL) because of a Michigan SLN registration. Fulfill (Novartis Corp) was registered for aphid control for the first time this year.

During 2000, our research focused once again on Colorado potato beetle. We investigated insecticide resistance, biological control and screened new insecticides for control of Colorado potato beetle.

Objectives of the insecticide resistance work included: 1) Surveying Colorado potato beetle field populations for resistance to Admire®, thiamethoxam, (Novartis Corp) and previously-used insecticides, 2) Determining how fast resistance increases with selection pressure, 3) Evaluating the influence of synergists on Admire toxicity in Colorado potato beetle populations with resistance to Admire, and 4) Examining how low levels of Admire resistance affect the length of control.

We also continued our studies of biological control of Colorado potato beetle. We evaluated the effect of imidacloprid use on biological control by examining the interaction between imidacloprid poisoning in Colorado potato beetles and predation by ground beetles. We also continued to assess the potential for biological control of Colorado potato beetle with entomopathogenic nematodes and *Beauvaria bassiana*.

Finally, we conducted insecticide trials to determine the efficacy of registered and experimental insecticides for control of Colorado potato beetles.

Admire (imidacloprid) resistance in the Colorado potato beetle

Colorado potato beetle has demonstrated its ability to evolve resistance to virtually any insecticide used to control it. In the late 1980's and early 1990's, no registered insecticide adequately controlled Colorado potato beetle in most of Michigan. In 1995, the neonicotinyl insecticide imidacloprid (Admire®, Provado®, Bayer Corp.) was registered and became the primary means to control insecticide-resistant Colorado potato beetles in Michigan and other areas of the U.S. Because imidacloprid is so widely used, concerns have arisen over potential imidacloprid resistance in Colorado potato beetle.

Survey of Admire (imidacloprid) and thiamethoxam resistance in field populations of Colorado potato beetle.

Since 1995, we have tested Colorado potato beetle populations collected from fields in Michigan and other areas of the United States to detect incipient resistance. In 1998 we also began testing these same populations for resistance to thiamethoxam, a neonicitinoid insecticide under development by Novartis Corp. We were especially interested in detecting any cross resistance between imidacloprid and thiamethoxam.

Insecticides used included imidacloprid (97.7%, technical grade) provided by Bayer (Kansas City, MO) and thiamethoxam (98.9%, technical grade) provided by Novartis (Greensboro, NC).

Colorado potato beetle populations were collected from three different Michigan counties (Arenac, Bay, and Houghton Counties). Novartis representatives and other cooperators collected one population each from: Washburn, ME; Becker, MN; Livingston, NY; Hermiston, OR; Painter, VA; Plainfield, WI; Moses Lake, WA; and Pasco, WA. Three populations maintained in the laboratory without selection were also screened. One was a susceptible strain collected in 1999 from Houghton County in the Upper Peninsula of Michigan (Hughes). The second strain was collected in 1998 from the MSU Potato Research Farm near Entrican, MI (Montcalm Farm). The third was a highly resistant strain collected in 1999 from Long Island, NY (Janesport).

Colorado potato beetle adults were either stored at room temperature (25±1 C) and fed foliage daily or, for long term storage, were kept in a controlled environment chamber (11±1 C) and fed weekly. Before each bioassay potato beetles were combined and randomly assigned to treatments. 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 stored at 25±1° 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 plus an acetone-only control. Based on the results of these screens, a range of five concentrations of each insecticide was selected for each population to be assayed. Each bioassay was replicated up to three times. In each replicate, 12-18 beetles were treated with each concentration (4-6 beetles per dish and 3 dishes per concentration).

The responses of the beetles were assessed 7 and 10 days after treatment. A beetle was classified as dead if its abdomen was shrunken, it did not move when the legs or tarsi were pinched, and its elytra were darkened. Dead beetles were removed from dishes. 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 by probit analyses using SAS® System v6.12.

LD_{50} values for imidacloprid, 7 days after treatment, ranged from 0.012 µg/beetle (Houghton) to 0.060 µg/beetle (Bay) for Michigan populations (Table 1). The LD_{50} values for out-of-state populations ranged from 0.011 µg/beetle (Pasco, WA) to 0.063 µg/beetle (Minnesota). These values are consistent with the levels of resistance to other insecticides generally found in populations in these regions, and are similar to the values obtained in 1998 and 1999.

Table 1. LD_{50} values (μg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with imidacloprid at 7 and 10 days after treatment.

	7 days post-treatment		10 days post-treatment	
strain	LD_{50}	95% fiducial limits	LD_{50}	95% fiducial limits
Michigan populations				
Arenac	0.050	0.034-0.069	0.044	0.030-0.061
Bay	0.060	0.040-0.080	0.061	0.038-0.082
Houghton	0.012	0.004-0.018	0.011	0.002-0.020
Out-of-state populations				
Maine	0.026	0.020-0.032	0.029	0.022-0.035
Minnesota	0.063	0.025-0.108	0.050	0.025-0.079
New York	0.041	0.032-0.050	0.039	0.029-0.050
Oregon	0.037	0.029-0.046	0.037	0.029-0.045
Virginia	0.054	0.033-0.079	0.057	0.034-0.085
Moses Lk.,WA	0.015	0.004-0.030	0.025	0.015-0.036
Pasco, WA	0.011	0.004-0.018	0.013	0.006-0.020
Wisconsin	0.044	0.028-0.063	0.063	0.050-0.076
laboratory populations				
Hughes	0.021	*	0.026	*
Montcalm farm	0.029	*	0.038	*
Janesport	0.612	0.139-2.175	0.699	0.253-2.601

The LD_{50} values for thiamethoxam 7 days after treatment, ranged from 0.011 μg/beetle (Houghton) to 0.065 μg/beetle (Bay) for Michigan populations (Table 2). The LD_{50} values for out-of-state populations ranged from 0.022 μg/beetle (Pasco, WA) to 0.058 μg/beetle (Virginia and Wisconsin) . The general resistance level, as measured by LD_{50} values, was not significantly different from those obtained in 1998 and 1999.

Again, the relative susceptibility to imidacloprid (as measured by LD_{50}) in Colorado potato beetle populations was significantly correlated with the relative susceptibility to thiamethoxam. (as measured by LD_{50}).

Resistance to previously-used insecticides in Colorado potato beetle populations in Michigan

Between 1990 and 1995, Colorado potato beetles in Michigan were poorly controlled by a variety of carbamate, organophosphate and pyrethroid insecticides because of resistance. Since the registration of Admire, the use of these insecticides has decreased dramatically. In 1999 and 2000 we tested Michigan populations to see if the level of resistance to these previously-used insecticides has decreased.

Colorado potato beetle populations were collected in the field from five Michigan counties including Arenac (Au Gres, MI), Bay (Bay City, MI), Clinton (Bath, MI), Houghton (Calumet, MI), and Montcalm (Entrican, MI). These populations were tested for insecticide resistance using petri dish resistance test kits (Bishop and Grafius 1991). Each test kit included separate tests for assessing resistance to Asana (esfenvalerate), Asana with PBO(piperonyl butoxide), Imidan (phosmet), Thiodan (endosulfan), and Furadan (carbofuran). Ten to 20 beetles each were placed in each dish. Response was assessed 24 hrs later. Colorado potato beetle populations were classified as susceptible if more than 70% of the population was affected by the insecticide, and resistant if less than 30% of the population was affected by the insecticide.

Table 2. LD_{50} values (µg/beetle) and 95% fiducial limits for Colorado potato beetle populations treated with thiamethoxam at 7 and 10 days after treatment.

	7 days post-treatment		10 days post-treatment	
strain	LD_{50}	95% fiducial limits	LD_{50}	95% fiducial limits
Michigan populations				
Arenac	0.035	0.008-0.062	0.024	0.001-0.056
Bay	0.065	0.046-0.084	0.052	0.037-0.071
Houghton	0.011	0.004-0.017	0.008	0.001-0.015
out-of-state populations				
Maine	0.045	0.030-0.055	0.043	0.028-0.052
Minnesota	0.050	0.034-0.071	0.041	0.030-0.052
New York	0.048	0.035-0.060	0.047	0.035-0.057
Oregon	0.045	0.036-0.055	0.043	0.031-0.053
Virginia	0.058	0.037-0.075	0.060	0.012-0.084
Moses Lk.,WA	0.042	0.025-0.065	0.032	0.018-0.049
Pasco, WA	0.022	0.012-0.032	0.018	0.009-0.027
Wisconsin	0.058	0.036-0.077	0.060	0.046-0.074
laboratory populations				
Hughes	0.023	0.018-0.029	0.020	0.014-0.027
Montcalm farm	0.050	0.039-0.062	0.050	0.040-0.060
Janesport	0.179	0.114-0.278	0.181	0.122-0.264

The population collected from Houghton County was the most susceptible of those tested. (Table 3). This was not surprising since it was collected from an organic farm in the Upper Peninsula of Michigan. The Houghton County population was not resistant to any of the insecticides and was susceptible to all but Asana. The Clinton County population was collected at the MSU Muck Soils Research Farm and had not been exposed to usual amounts of insecticide. This population (referred to as "Ingham County" in Table 3) was susceptible to Imidan, Thiodan, and Furadan and was only resistant to Asana.

Over the past several years, the levels of resistance to a number of previously-used insecticides, including Furadan, Thiodan, and Imidan have decreased in many Colorado potato beetle populations. This is not necessarily surprising, since these insecticides have not been widely used for several years. However, there are still plenty of resistant potato beetles in most populations, and resuming use of these insecticides would rapidly lead to high resistance levels.

Table 3. Percent of potato beetles poisoned or dead after 24 h in resistance test kit.						
	Percent of Colorado Potato Beetles					
strain	**control**	**Imidan**	**Furadan**	**Thiodan**	**Asana+PBO**	**Asana**
Arenac	0.0	52.5	55.0	77.5	7.5	5.0
Bay Co.	5.0	55.0	60.0	75.0	not tested	
Houghton Co.	3.3	93.3	100.0	100.0	51.7	41.7
Ingham Co.	7.5	95.0	70.0	97.5	25.0	32.5
Montcalm Co.	3.3	48.3	50.0	65.0	25.0	18.3

Speed of resistance development to Admire in Colorado potato beetle.

For several years we have investigated how quickly resistance to Admire increases when Colorado potato beetles are selected in the laboratory. Two laboratory strains of Colorado potato beetles selected each generation with Admire were established in 1998. The "Evans" strain was established from a population collected in Montcalm County, MI in 1997. Two generations were reared in the laboratory without selection. Beginning with the third generation, Colorado potato beetles were treated with Admire each generation, either as adults or larvae. For each selection, doses of Admire were used that resulted in 50% to 80% mortality. This strain has been selected for 12 consecutive generations. The original LD_{50} was 0.11µg /beetles. After 6 generations of selection it increased to 0.21µg/beetle. On 12 Jun, 2000 after 11 generations of selection, it was 1.93 µg/beetle.

The "NY-selected" strain was established from an Admire-resistant population collected on Long Island, NY in 1997. Colorado potato beetles were treated with a dose of Admire that resulted in 50% to 90% mortality each generation. The NY-selected strain has been selected for 8 consecutive generations.

In 2000 we established two new laboratory selected strains of Colorado potato beetles. These strains are being selected with thiamethoxam. The S-sel strain was established from the Hughes strain. The R-sel strain was established from Janesport strain. Two generations of each strain have been selected with thiamethoxam in the laboratory.

The effect of piperonyl butoxide (PBO) on Admire toxicity

Studies in 1998 and 1999 have shown that PBO increases toxicity of Admire in resistant Colorado potato beetle. PBO works by blocking detoxification enzymes (MFO's) and increased MFO's is one mechanism involved in Admire resistance (Zhao et al. 2000). We tested whether PBO could be used in the field to increase control of Colorado potato beetle by Admire.

Potatoes were planted in the greenhouse on 28 Apr. Admire at field rate rate (1.3 fl oz per 1,000 row feet) was applied to seed pieces at planting. An equal number of potatoes treated with water alone were planted as controls. Plants were maintained in the greenhouse with standard care.

Three laboratory strains of Colorado potato beetle with differing levels of resistance were used for all studies. These were a susceptible strain (Hughes) originally collected from the upper peninsula of Michigan, a strain of intermediate resistance

(Montcalm) originally collected from the MSU potato research farm, and a highly resistant strain (Janesport) originally collected from Long Island, NY.

Beetles were treated with the synergist piperonyl butoxide (98%, technical grade) provided by Chem Service (West Chester, PA) before being fed foliage.

After treatment, five treated (or untreated) potato beetles were placed in 6 oz. wax paper cups and were provided with either a treated or untreated greenhouse-grown potato leaf. Leaf stems were inserted in a vial of water. Colorado potato beetle responses were assessed at 3, 5, 7, 10, and 14 days after setup. Potato foliage was replaced at the same time. The responses of the beetles to feeding on treated foliage were assessed according to the same criteria as used in the topical treatment bioassays described above. Defoliation was assessed by recording the weights of the leaf pieces, excluding the weight of the vial and water, before and after they were fed on by the beetles.

This study was replicated two times.

The addition of PBO to Colorado potato beetles that fed on untreated and Admire-treated potato foliage increased poisoning in all strains (Table 4). The increase in poisoning in PBO-treated potato beetles (vs untreated potato beetles) that were fed Admire-treated foliage was similar to the increase in poisoning due to PBO-treatment in beetles that were fed untreated foliage in the Hughes and the Montcalm strains. However, the increase in poisoning in PBO-treated Janesport beetles (vs untreated beetles) that were fed Admire-treated foliage exceeded the increased poisoning due to PBO for Janesport beetles feeding on untreated foliage. The addition of pipernyl butoxide synergized the efficacy of Admire in these highly resistant potato beetles.

Table 4. Percent of Colorado potato beetles poisoned or dead after being treated with piperonyl butoxide before feeding upon Admire-treated foliage. Hughes = susceptible strain, Montcalm = intermediate strain, Janesport = resistant strain.

		Percent CPB Poisoned or Dead		
		Hughes	Montcalm	Janesport
Plants	CPB	4 weeks after planting		
UNTREATED	Untreated	10.0%	0.0%	5.0%
	PBO	32.5%	10.0%	37.5%
ADMIRE	Untreated	92.5%	80.0%	30.0%
	PBO	100.0%	87.5%	87.5%
		7 weeks after planting		
UNTREATED	Untreated	15.0%	5.0%	0.0%
	PBO	37.5%	25.0%	15.0%
ADMIRE	Untreated	70.0%	62.5%	37.5%
	PBO	85.0%	80.0%	80.0%

Length of control of imidacloprid-treated foliage

Field-collected populations of Colorado potato beetle vary in their susceptibility to Admire (as measured by LD 50's). When Admire is applied at planting, the concentration of Admire in the plant is initially high enough to control even resistant beetles. As the plant grows, this concentration drops. Eventually this concentration drops low enough that the more resistant potato beetles are able to survive, even though susceptible potato beetles are still killed.

This earlier survival of Colorado potato beetles with low levels of Admire-resistance may be important during cooler than normal seasons where emergence from overwintering is attenuated. However, control strategies that maximize the effectiveness of imidacloprid, such as use of a synergist, could mitigate this early season survival.

Our objective was to test the influence of Admire concentration in the plant.(as measured by length of time after planting) on poisoning in Colorado potato beetles that differ in their susceptibility to Admire.

Potted potatoes were planted in the greenhouse on 28 Apr. Admire at field rate rate (1.3 fl oz per 1,000 row feet) was applied to seed pieces at planting. An equal number of potatoes treated with water alone were planted as controls. Plants were maintained in the greenhouse with standard care.

Potatoes were planted at the MSU potato research farm in Montcalm County. (6 rows, 100 ft each) on 11 Jul and at the MSU muck soils research farm in Clinton County (17 rows, 50 ft each) on 12 Jul. Half of the rows in each plot were treated with Admire (1.3 fl oz per 1,000 row feet) applied at planting and half were left untreated.

Three laboratory strains of Colorado potato beetle with differing levels of resistance were used for all studies. These were a susceptible strain (Hughes) originally collected from the Upper Peninsula of Michigan. A strain with intermediate resistance levels (Montcalm) was originally collected from the MSU potato research farm. A highly resistant strain (Janesport) was originally collected from Long Island, NY.

For tests using greenhouse foliage, five Colorado potato beetles each were placed in a 16 oz wax paper cup and were provided with either a treated or untreated leaf piece whose stem was inserted in a vial of water. The response of potato beetles was assessed at 3, 5, 7, and 10 days after setup and potato foliage was changed at the same time. The responses of the beetles to feeding on treated foliage were assessed according to the criteria used for the topical treatment bioassays described above. Defoliation was assessed by recording the weights of the leaf pieces, excluding the weight of the vial and water, before and after they were fed on by the beetles.

Three cups of each beetle strain and treatment were included in each run of the experiment. Two replications of this experiment were conducted: the first on 30 May (4 weeks after planting) and the second on 16 Jun (7 weeks after planting).

The field-treated foliage experiment was conducted using the methods described above except that potato beetles were placed in petri dishes, rather than wax cups. Three replications were conducted with potato foliage grown at the Montcalm Potato Research Farm, the first on 22 Aug, 7 weeks after planting, the second on 11 Sep, 10 weeks after planting, and the third on 30 Sep, 12 weeks after planting. Because of high control mortality, this last replication was discontinued after potato beetles fed for 5 days.

Two replications were conducted with potato foliage grown at the Muck Farm; the first began on 29 Aug, 8 weeks after planting, and the second began on 15 Sep, 10 weeks after planting.

After 7 days of feeding on Admire-treated, 4-week old, greenhouse-grown foliage, similar proportions of susceptible (Hughes) and intermediate (Montcalm) potato beetles were poisoned and dead (Figure 1). The percent of poisoned potato beetles was lower in the resistant (Janesport) strain. Seven weeks after planting the level of Admire in greenhouse-grown foliage had decreased and so that the proportion of poisoned potato beetles in the intermediate strain (Montcalm) was less than that of the susceptible strain (Hughes), but still more than that of the resistant strain (Janesport).

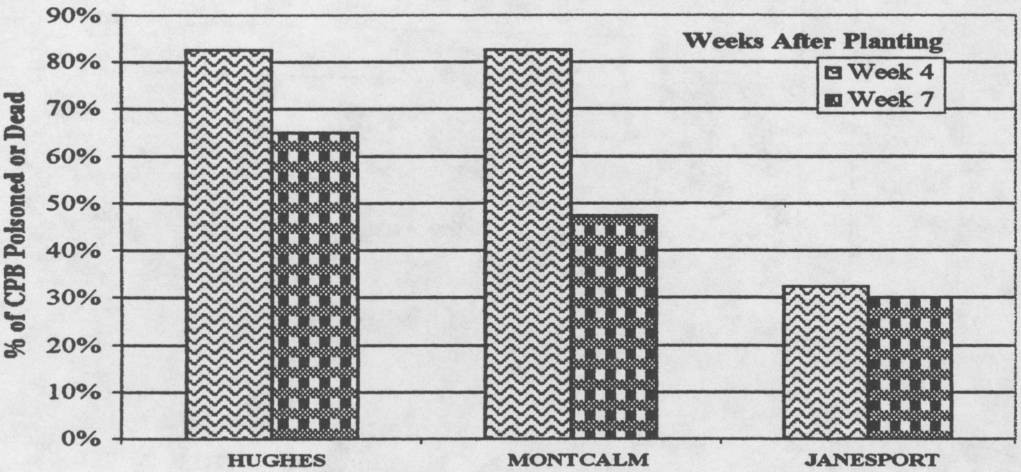

Figure 1. Percent of Colorado potato beetles poisoned and dead after feeding for 7 days on Admire-treated foliage from Greenhouse at 4 and 10 weeks after planting. Hughes = susceptible strain, Montcalm = intermediate strain, Janesport = resistant strain.

After 5 days of feeding on 7-week old, Admire-treated foliage grown at the MSU Montcalm Potato Research Farm, the proportion of poisoned and dead Colorado potato beetles was highest for the susceptible (Hughes) strain and lowest for the resistant (Janesport) strain (Figure 2). By 10 weeks after planting, the concentration of Admire in the potato foliage had decreased such that the proportion of poisoned and dead beetles was similar for the intermediate and resistant strains, and was less than thethe susceptible strain strain. By 12 weeks after planting, the percentage of poisoned and dead potato beetles was similar for all three strains.

After 5 days of feeding on 8-week old, Admire-treated foliage from the MSU Muck Farm, the proportion of poisoned and dead Colorado potato beetles was similar for all three strains. By 10 weeks after planting the concentration of Admire in the plants had decreased so that the percentage of poisoned beetles was highest in the susceptible (Hughes) strain and was lowers and similar for the intermediate (Montcalm) and resistant (Janesport) strains.

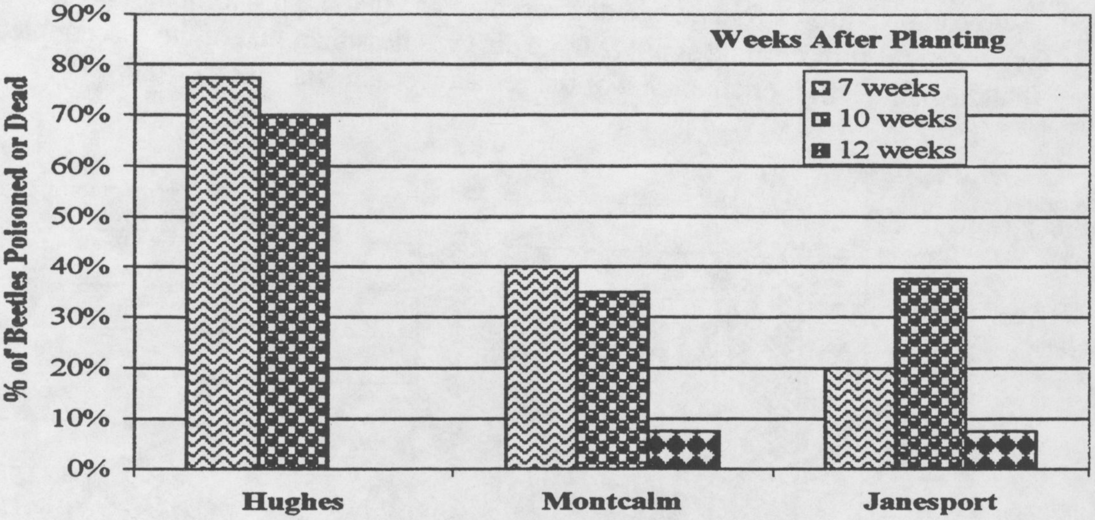

Figure 2. Percent of Colorado potato beetles poisoned and dead after feeding for 5 days on Admire-treated foliage from the MSU Montcalm Potato Research Farm at 7, 10 and 12 weeks after planting. (Hughes = susceptible strain, Montcalm = intermediate strain, Janesport = resistant strain).

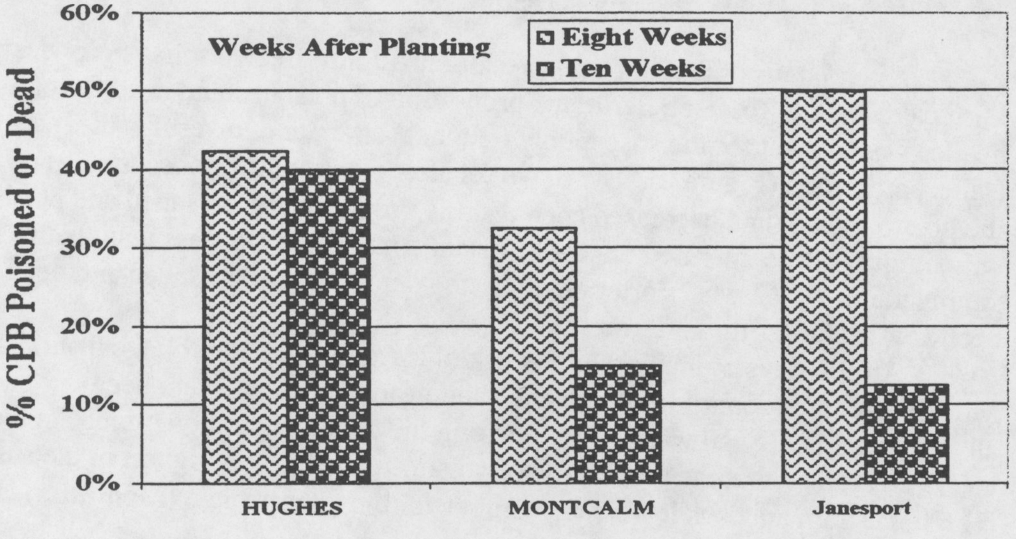

Figure 3. Percent of Colorado potato beetles poisoned and dead after feeding on Admire-treated foliage from the MSU Muck Farm at 8 and 10 weeks after planting (Hughes = susceptible strain, Montcalm = intermediate strain, Janesport = resistant strain).

Biological control of Colorado potato beetle

Admire poisoning in Colorado potato beetle and predation in the field.

Colorado potato beetles feeding on Admire-treated plants often initially succumb and fall off the plant. They may eventually recover from poisoning after several days of poisoning symptoms.. During the past 2 years, we tested if these poisoned beetles would be vulnerable to predation in the field.

In 1999, Colorado potato beetles from a laboratory strain (UP) were treated in the laboratory with 0.2 μg of Admire applied to the first abdominal sternite. In 2000, another laboratory strain (Hughes) that was treated with 0.08 μg of Admire was used. Other methods were similar in both years (except as noted below).

Two hours after treatment, five potato beetles each that were showing symptoms of poisoning were placed in the bottom of 20, 100 x 15 mm plastic petri dishes lined with filter paper. Ten of the dishes were covered with the top of the petri dish. The other 10 were each placed inside a nylon "knee-high" stocking that was stretched over the petri dish and tied with a knot.

Predation was assessed in potato fields at the MSU Muck Soils Research Farm, Clinton County, MI. Pairs of petri dishes (one covered with the petri dish top, one covered with the nylon stocking) were placed at 10 different locations within the field. After dishes were placed in the field, the plastic tops were removed to allow predators access to the potato beetles.

Dishes were examined daily for 3 days after being placed in the field. Remaining beetles were counted and were classified as "walking", "poisoned" or "dead" using the criteria described above.

This experiment was replicated three times over four weeks in 1999 and replicated three times over three weeks in 2000.

All beetles remaining in the open dish were poisoned or dead. Beetles missing from the open dish were presumed to have either recovered and walked away or been taken by predators. We assume the percent of "walking" beetles was the same in open and covered dishes. Therefore, any difference in the number of beetles in the open dish and the number of poisoned and dead beetles in the covered dish was assumed to be due to predation.

Table 5. Number of Colorado potato beetles remaining in petri dishes (open and covered with nylon stocking) 3 days after being placed in the field in 1999.

Date	Open	Covered	
	Poisoned & Dead	Walking	Poisoned & Dead
July 27, 1999	36	0	45
	80%	0%	100%
August 9, 1999	40	4	46
	80%	8%	92%
August 16, 1999	40	0	45
	88.9%	0%	100%
Mean	38.7	1.3	45.3
	83%	2.7%	97.3%

In all weeks during 1999 and in most weeks during 2000, the number of poisoned and dead potato beetles found after 3 days in covered dishes exceeded the number of potato beetles found in the open dish (Tables 5 and 6). On the last week in 2000, all of the potato beetles were still found in both open and covered dishes.

In 1999, an average of 6.6 potato beetles was missing and presumably preyed upon in the open dishes after 3 days. In 2000, an average of 2.3 beetles was missing after 3 days. This indicates that predators are consuming poisoned beetles

These results imply that beetles poisoned by Admire may be preyed upon. If left untouched, those beetles may have recovered. Predation of poisoned potato beetles provides an alternative mortality source, and may delay the development of Admire-resistance. Alternatively, the consumption of Admire-poisoned potato beetles may impact predators.

Table 6. Number of Colorado potato beetles remaining in petri dishes (open and covered with nylon stocking) 3 days after being placed in the field in 2000.

Date	**Open**	**Covered**	
	Poisoned & Dead	Walking	Poisoned & Dead
July 25, 2000	40 93%	0 0%	42 97.7%
August 1, 2000	36 72%	9 18%	41 82%
August 8, 2000	50 100%	0 0%	50 100%
Mean	42 88.3%	3.3 6%	44.3 93.2%

Effects of Admire-poisoning in Colorado potato beetles on predatory ground beetles (Carabidae)

In 1998, ground beetles that fed on poisoned Colorado potato beetles exhibited symptoms of Admire poisoning (extended legs, shaky legs and antennae, and uncoordinated movement). We expanded the trials in 1999, but the results were inconclusive; one test resulted in no symptoms in any ground beetles and the other with some symptomatic ground beetles.

In 2000, we used pitfall traps to collect ground beetles from our research plots at the MSU Muck Research Farm, Bath, MI and the MSU Montcalm Research Farm, Entrican, MI. Traps were checked regularly from 13 Jul to 30 Aug, and any *Pterostichus melanarus* ground beetles that were found were transported to the lab. Beetles were placed in plastic food containers (up to three beetles/container) with some soil and crushed dog food. Containers were checked and fed daily.

On 7 Sep, six ground beetles were placed in small petri dishes filled with soil and randomly given either an untreated Colorado potato beetle or a Colorado potato beetle that had been poisoned by a topical application of 0.1 µl imidacloprid. Colorado potato beetles were treated 2 h prior to placement with the ground beetles; this allowed us to use visibly poisoned beetles. Petri dishes were inspected daily for 10 days, and any poisoning or mortality of either Colorado potato beetles or ground beetles was recorded, as was evidence of predation.

Only one ground beetle attacked and consumed its Colorado potato beetle, and it was one of the untreated Colorado potato beetles. All but one ground beetle (paired with an untreated Colorado potato beetle) survived the trial. No signs of poisoning were noted this year, and only one test was conducted due to our difficulty in obtaining enough predatory ground beetles.

Biological control of CPB by entomopathogenic nematodes and *Beauveria bassiana*

During spring of 2000, laboratory tests were performed on the survival and pathogenicity of the entomopathogenic nematode *Heterorhabditis marelatus* (Liu and Berry), on four soil types (clay loam, muck, sandy loam, and sand) and four moisture levels (4.7, 40.5, 60.2, and 100.9%). Nematode survival was significantly higher in sandy loam compared with clay loam, higher in sand compared with clay loam, and highest at moisture levels 60%-100%. Host (*Galleria mellonella*) mortality due to *H. marelatus* was significantly higher in sandy soils and 60-100% moisture. Results of the study indicate that moisture levels above 60% and sandy soils are best for nematode survival and pathogenicity. These conditions are compatible with typical potato production in Michigan.

A field study testing the pathogenicity of *H. marelatus* on Colorado potato beetle at different doses was conducted at the Montcalm Research Farm during the 2000 growing season. Small potato plots were treated with known numbers of nematodes (0, 375, 750, or 1,200 nematodes/m^2). Results show significantly higher potato beetle numbers and greater potato defoliation (Figures 4 and 5, respectively) in untreated plots compared with nematode treated plots.

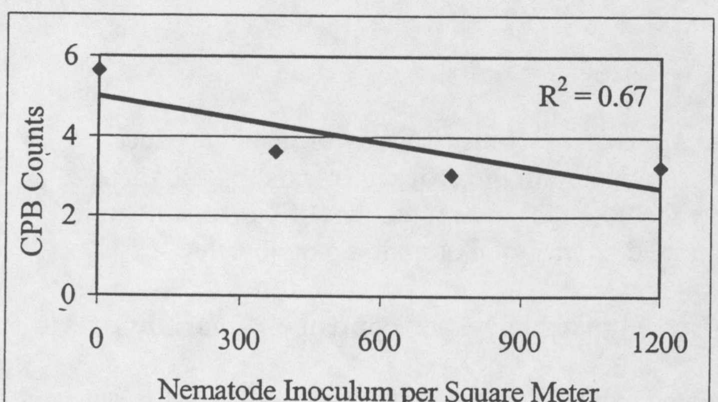

Fig. 4. Average CPB numbers vs. Nematode Dose. CPB was counted begining1 week after nematode application and continued for 5 weeks. Results shown in the graph are average CPB numbers for each treatment.

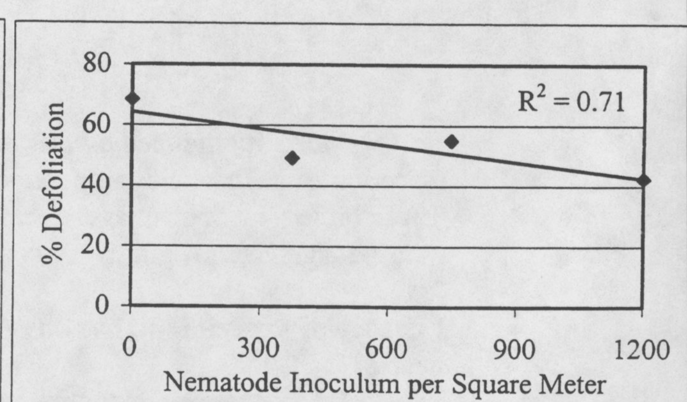

Fig. 5. % Potato defoliation by CPB vs. Nematode dose. Near the end of the field season high defoliation was noticed in control plots. Results are average % potato defoliation for each treatment.

A study to examine the best time for nematode application for optimal Colorado potato beetle control was conducted at the MSU Horticulture Farm. Twelve field cages each containing nine potato plants were established and 45 newly hatched potato beetle larvae were placed on plants in each cage. Nematodes were applied to the soil when fourth instar Colorado potato beetle were first present, at peak fourth, or at peak pupation; three cages were left untreated. The number of emerged adults was recorded. Significantly fewer numbers of Colorado potato beetle adults emerged in nematode-treated cages than in untreated cages (Figure 6).

Leaf bioassays were performed by placing potato leaves in a petri dish, adding five second instars to the leaves, and applying *Beauveria bassiana* with a hand held spray bottle. The experiment was conducted with five bioassays per rate and replicated three times using 0, 0.35, 0.53, and 0.7 ml *B. bassiana* per 500 ml of water. Results show significantly higher CPB mortality between 0 and 0.35 ml, 0.35 and 0.7 ml, and 0.53 and 0.7 ml *B. bassiana* per 500 ml of water (Figure 7).

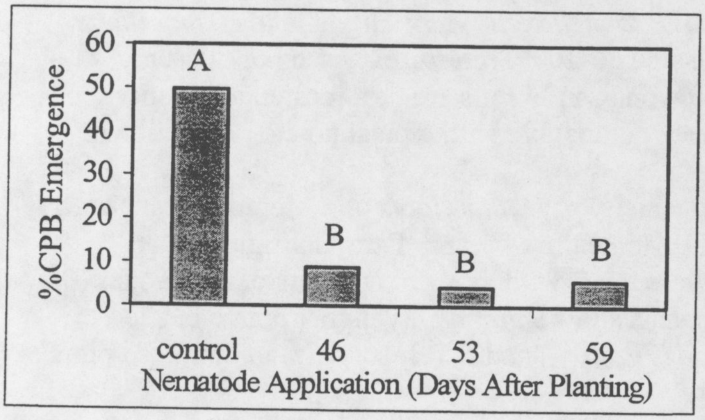

Fig. 6. The effect of nematode application timing on adult CPB emergence. All nematode treatments effectively controlled CPB.

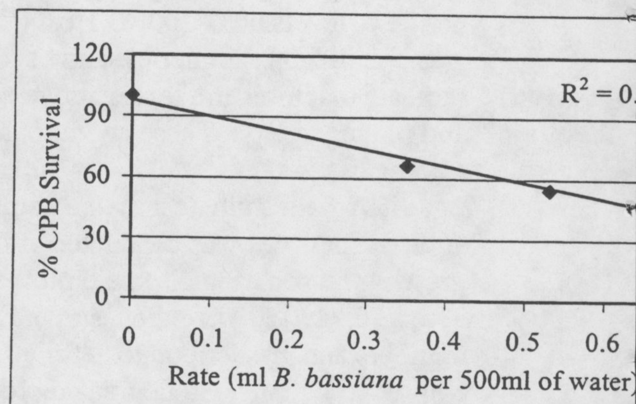

Fig. 7. Infection of CPB by *Beauveria bassian* As the rate of *B. bassiana* was increased, fewe CPB survived.

Mortality induced by *H. marelatus* and *B. bassiana* may ultimately reduce insecticide use in Michigan potatoes and maintain the efficacy of existing products. These biological control agents have the potential to become part of current integrated pest management programs for continued control of Colorado potato beetle.

Efficacy of experimental and registered insecticides for control of Colorado potato beetle

Fourteen insecticide treatments (Table 7) were tested at the MSU Potato Research Farm, Entrican, MI for control of Colorado potato beetle. 'Snowden' potatoes were planted 12 inches apart with a 34-inch row spacing on 16 May. Treatments were replicated four times in a RCB design. Plots were 50 ft long and three rows wide. Seven treatments were applied at planting. Admire, EXP-1, EXP-2, and Platinum were applied to seed pieces as infurrow-sprays using a single nozzle hand held boom (30 gpa, 35 psi). The Maxim+Adage and both Gaucho treatments were pre-mixed dusts applied to seed pieces (in a plastic tub) before they were planted. Foliar treatments were first applied at approximately 80% Colorado potato beetle hatch on 20 Jun. Subsequent first-generation sprays were applied on 27 Jun, 5 Jul, and 11 Jul. Avaunt was the only treatment applied on every spray date. Avaunt+PBO was applied on 20 Jun, 27 Jun, and 5 Jul (a measuring error resulted in the application of only 10% the desired amount of PBO on the later date). The remaining treatments were applied on two spray dates: Avaunt+Spintor and Spintor on 20 Jun and 27 Jun, Actara (low rate) and Provado on 20 Jun and 5 Jul, and Actara (high rate) on 20 Jun and 11 Jul. Post-spray counts were made two days after each application and consisted of complete counts of Colorado potato beetle adults and larvae (small and large) on five plants from the middle row of each plot. Defoliation ratings were taken on 7 Jul and 20 Jul. A maintenance spray of Agrimek was applied to all treatments on 22 Jul to control second generation Colorado potato beetle. On 5 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 and significance was found at the 0.05 level with Fisher's Protected LSD.

There were significant differences in the seasonal means of small larvae and large larvae among treatments and check plots (Table 7). All treatments resulted in significantly fewer large larvae than the check on all sampling dates. The Avaunt treatment resulted in significantly more large larvae than the other treatments on 29 Jun, 7 Jul, and 13 Jul. There was no significant difference among treatments in overall yield (Table 2). The highest yields were harvested from plots treated with Gaucho (12 oz/Acre), Platinum, and Maxim+Adage, respectively. Compared with the check, defoliation ratings were significantly lower for all treatments except Avaunt on 7 Jul. On 20 Jul, defloiation ratings from seven treatments were not significantly different from the check, and Admire and Maxim+Adage had the lowest defoliation ratings.

Table 7. Seasonal mean number of Colorado potato beetle egg masses, small larvae, large larvae, and adults per plant.

		Seasonal mean of 1[st]-generation CPB/plant			
Treatment/formulation	Rate	Egg Masses	Small Larvae	Large Larvae	Adults
Actara 25WG	1.5 oz/acre	0.2	0.5abc	0.1a	0.0
Actara 25WG	3.0 oz/acre	0.2	1.7 cd	0.1a	0.1
Admire 2F[a]	16.0 fl oz/acre	0.3	0.3ab	0.0a	0.1
Avaunt 30WG	0.09 lb AI/acre	0.3	4.5 e	1.1 b	0.2
Avaunt 30WG+	0.065 lb AI/acre	0.1	1.5 bc	0.1a	0.1
PBO-8	0.25 lb AI/acre				
Avaunt 30WG+	0.065 lb AI/acre	0.2	0.2ab	0.0a	0.1
Spintor 2SC	0.043 lb AI/acre				
EXP-1[a]		0.2	0.2ab	0.2a	0.1
EXP-2[a]		0.1	0.5abc	0.1a	0.2
TOPS-MZ-Gaucho[b]	8 oz/acre	0.1	0.4abc	0.2a	0.1
TOPS-MZ-Gaucho[b]	12 oz/acre	0.0	0.4abc	0.1a	0.1
Maxim 0.5DS+Adage(1:2.4 prepack)[b]	8 oz/cwt	0.0	0.0a	0.0a	0.1
Platinum 2SC[a]	127 g AI/ha	0.1	0.0a	0.0a	0.1
Provado 1.6F	3.75 oz/acre	0.1	0.1ab	0.1a	0.1
Spintor 2SC	4.5 oz/acre	0.1	0.5abc	0.1a	0.1
Untreated check		0.2	4.2 de	3.5 c	0.3

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

[a] treatment applied in furrow at planting

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

Table 8. Mean yield (weight/50 row ft) harvested and defoliation ratings taken on two sampling dates.

Treatment/formulation	Rate	Yield (lb/50 row ft)			Defoliation rating[c]	
		Size A	Size B	Total	7 Jul	20 Jul
Actara 25WG	1.5 oz/acre	108.1 bcd	3.9	111.9 bcd	1.3abc	1.8 cd
Actara 25WG	3.0 oz/acre	98.6ab	3.5	102.1ab	1.5 c	1.7 bcd
Admire 2F[a]	16.0 fl oz/acre	100.2abc	3.9	104.0abc	1.0a	1.1a
Avaunt 30WG	0.09 lb AI/acre	99.0ab	2.7	101.7ab	2.0 d	2.0 d
Avaunt 30WG + PBO-8	0.065 lb AI/acre 0.25 lb AI/acre	88.0a	3.5	91.5a	1.5 c	1.7 bcd
Avaunt 30WG + Spintor 2SC	0.065 lb AI/acre 0.043 lb AI/acre	103.0abcd	3.5	106.5abcd	1.2ab	1.7 bcd
EXP-1[a]		101.1abc	3.1	103.9abc	1.3 bc	1.7 bcd
EXP-2[a]		94.2ab	2.8	97.0ab	1.0a	1.2a
TOPS-MZ-Gaucho[b]	8 oz/acre	112.7 bcd	4.2	116.8 bcd	1.2abc	1.8 cd
TOPS-MZ-Gaucho[b]	12 oz/acre	121.0 d	3.6	124.6 d	1.3abc	1.5abc
Maxim 0.5DS + Adage (1:2.4 prepack)[b]	8.0 oz/cwt	119.1 cd	4.0	123.0 cd	1.0a	1.2a
Platinum 2SC[a]	127 g AI/ha	119.1 cd	4.5	123.6 cd	1.1ab	1.3ab
Provado 1.6F	3.75 fl oz/acre	98.3ab	4.1	102.4ab	1.3 bc	1.2a
Spintor 2SC	4.5 fl oz/acre	106.1abcd	3.1	109.2abcd	1.3 bc	1.5abc
Untreated check		97.7ab	3.4	101.1ab	2.1 d	2.0 d

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.

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

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EVALUATION OF FUNGICIDE APPLICATION METHODS A) PROPTEC AND HYDRAULIC SPRAYERS COMPARISON OF DITHANE AND GAVEL B) PIVOT APPLICATION OF MANZATE, BRAVO AND ACROBAT MZ FOR POTATO LATE BLIGHT CONTROL, 2000:

A) Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 15 Jun into 50-ft x 200 -ft blocks (34-in row spacing). Each block was split into four sections for disease and yield analysis. Plots were irrigated as needed with sprinklers and were hilled immediately before sprays began. These plots were not directly inoculated. However, adjacent plots were inoculated (3.4 fl oz/25-ft row) with a zoospore suspension of *Phytophthora infestans* US8 biotype (insensitive to metalaxyl, A2 mating type) at 10^4 spores/fl oz on 23 Jul. Fungicides, Gavel 75WP or Dithane 75WP were applied weekly from 25 Jun to 13 Aug (9 applications) with a conventional hydraulic spray boom delivering 25 gal/A (80 p.s.i.) and using three XR11003VS nozzles per row or a Proptec rotary atomizer sprayer delivering 5 gal/A from metering orifices. Proptec atomizers were positioned to cover two rows per nozzle (68 inches) and were operated approximately 60 inches above the canopy with the atomizers directed down and back 30 degrees from vertical. Ground speed was 3.4 mph. The plot design was not a true randomization and results should therefore be interpreted with caution.

B) Potatoes (cut seed) were planted at the Michigan State University Muck Soils Experimental Station, Bath, MI on 15 Jun into 16 blocks 50-ft x 50-ft (34-in row spacing). Groups of four blocks were planted around a center pivot water source. Four fungicide treatments were assigned at random to each of the four blocks, Manzate 75DF, Bravo WS 6SC, Acrobat MZ 69WP or untreated. The fungicides were applied weekly through a central pivot from 25 Jun to 13 Aug (9 applications). The central pivot was set up with nozzles sized to deliver 650 gal H_2O/A. Plots were separated by a 20-ft unplanted buffer zone. At approximately 11 weeks after planting, a point-source inoculation was made by placing into each of the plots a mature, potted potato plant (cv. Snowden) with approximately 50% foliar infection of potato late blight. The inoculum source plants were inoculated in controlled environments with *P. infestans* 10 days prior to positioning in the plots [MI95-7 (US8 biotype, A2 mating type, metalaxyl-resistant)].

General: 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 23, Jul; 22, 27 Aug and 6 and 15 Sep 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, 23 Jul to 15 Sep, a period of 48 days. Vines were killed with Diquat 2EC (1 pt/A on 16 Sep). Plots (25-ft row) were harvested on 5 Oct and individual treatments were weighed and graded.

General: Late blight initially developed slowly after adjacent plots were inoculated then rapidly during Aug. and untreated controls reached 85 - 95% foliar infection by 15 Sep. Over the period from 50% emergence to harvest, 109 late blight disease severity values were accumulated. The bulk of these DSV were accumulated between inoculation and desiccation. In general yields were low due to late planting.

A) All treatments had significantly less foliar late blight than the untreated control 46 days after inoculation (DAI) of adjacent plots. Proptec applied Gavel 75WP 2.0 lb./A and Dithane RS 75DF 2.0 lb./A had significantly lower foliar late blight than either product applied by hydraulic sprayer 46 DAI. Averaged over the period from inoculation of adjacent plots to 100% defoliation of untreated controls (RAUDPC) all treatments had significantly less foliar late blight than the untreated control and were not significantly different from each other.

Yield: Proptec applied Gavel 75WP 2.0 lb./A and Dithane RS 75DF 2.0 lb./A had significantly higher marketable yield (US1 grade) than either product applied by hydraulic sprayer and the untreated control. Hydraulic applied Gavel 75WP 2.0 lb./A and Dithane RS 75DF 2.0 lb./A were not significantly different form the untreated control in terms of marketable yield (US1 grade). In terms of total yield, there was a high proportion of tubers below 2.5" diameter in any plane due to late planting. Proptec applied Gavel 75WP 2.0 lb./A had significantly greater total yield than hydraulic applied Gavel 75WP 2.0 lb./A and Dithane RS 75DF and the untreated control but was not significantly different from the Proptec applied Dithane RS 75DF 2.0 lb./A. Proptec applied Dithane RS 75DF 2.0 lb./A was not significantly different in terms of total yield from hydraulic applied Dithane RS 75DF 2.0 lb./A or the untreated control but had significantly higher total yield than hydraulic applied Gavel 75WP 2.0 lb./A.

B) All treatments applied through the central pivot irrigation system had significantly less foliar late blight than the untreated control 46 days after inoculation (DAI) of adjacent plots. Acrobat MZ 69WP 2.25 lb./A and Manzate 2.0 lb./A had significantly less foliar late blight than Bravo WS 6SC 1.5 pt/A. In terms of the RAUDPC, all treatments had significantly less foliar late blight than the untreated control but were not significantly different from each other.

Yield: Manzate 2.0 lb./A had significantly higher marketable yield (US1 grade) than the untreated control but was not significantly different from the other treatments. In terms of total yield there no significant differences between any treatments.

A) Hydraulic and Proptec sprayer evaluation trial.

Treatment and rate/acre	foliar disease (%) 46 dai[1]		RAUDPC[2] max = 100 0 - 48 dai		Yield (cwt./acre) US1		Total	
Hydraulic applied Dithane RS 75DF 2.0 lb[3]	14.3	b	1.6	b	111.4	b	293.8	bc
Proptec applied Dithane RS 75DF 2.0 lb.	5.8	c	0.8	b	179.6	a	367.3	ab
Hydraulic applied Gavel 75WDG 2.0 lb.	12.3	b	1.4	b	108.3	b	279.3	c
Proptec applied Gavel 75WDG 2.0 lb.	6.5	c	0.8	b	210.3	a	394.5	a
Untreated	98.0	a	20.2	a	95.5	b	296.0	bc
sem p = 0.05	1.1		0.2		12.3		17.95	

[1] Days after inoculation with *Phytophthora infestans*, US8, A2.
[2] RAUDPC, relative area under the disease progress curves calculated from the day of inoculation to the last evaluation of late blight.
[3] Application dates: 23 Jun; 1 Jul; 8 Jul; 15 Jul; 22 Jul; 30 Jul; 7 Aug; 14 Aug; 21 Aug.
[4] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

B) Pivot fungicide application trial.

Treatment and rate/acre	foliar disease (%) 46 dai[1]		RAUDPC[2] max = 100 0 - 48 dai		Yield (cwt./acre) US1		Total	
Acrobat MZ 69WP 2.25 lb[3]	12.0	c	1.3	b	157	ab	330	a
Bravo WS 6SC 1.5 pt	16.3	b	1.7	b	177	ab	352	a
Manzate 75DF 2.0 lb	10.8	c	1.2	b	205	a	388	a
Untreated	98.0	a	20.2	a	66	b	243	a
sem p = 0.05	0.96		0.21		28.4		31.6	

[1] Days after inoculation with *Phytophthora infestans*, US8, A2.
[2] RAUDPC, relative area under the disease progress curves calculated from the day of inoculation to the last evaluation of late blight.
[3] Application dates: 22 Jun; 2 Jul; 9 Jul; 16 Jul; 23 Jul; 31 Jul; 8 Aug; 15Aug; 22 Aug.
[4] Values followed by the same letter are not significantly different at P = 0.05 (Tukey Multiple Comparison).

Combining Varietal Resistance with Managed Fungicide Applications for the Control of Potato Late Blight.

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INTRODUCTION

Late blight of potato, caused by *Phytophthora infestans*, is a major worldwide threat to the production of high quality potatoes. Unchecked, *P. infestans* can rapidly defoliate plants in the field and can infect potato tubers when spores are washed into the soil. Although fungicides have reduced the potential impact of late blight the efficacy and availability of commonly used fungicides has been threatened. The appearance of a more aggressive strain of *P. infestans* (US8) in the United States and the resistance of this pathogen to metalaxyl left potato growers without a fungicide that could effectively control late blight after infection occurred. This problem is compounded by the demand to reduce chemical input in agricultural systems and the potential loss of commonly used protectant fungicides such as chlorothalonil. In addition, the cost of protecting potato crops in the US against late blight is estimated at $155 million annually. Crop production economics would suggest that more effective methods of disease control are necessary.

There are several potential methods for reducing fungicide application in potato crop management including the use of fungicides with less active ingredient, reduced application rates, increased application intervals and a combination of any of these strategies. The use of late blight resistant potato varieties may allow for acceptable control of late blight with reduced input of protective fungicides. Although there are currently no late blight resistant potato varieties that meet commercial standards in the United States, controlled environment and field trials at Michigan State University have identified some foreign varieties and advanced breeding lines (ABL) that are less susceptible to *P. infestans* in the absence of fungicides. Therefore in 1997-2000, experiments were set up to evaluate the efficacy of crop protection programs against potato late blight utilizing a) reduced amounts of commercially available fungicide and with reduced amounts of novel fungicides that have less active ingredient (VxF trial) and b) with reduced amounts of commercially available fungicide at reduced application frequency (Timing trial).

MATERIALS AND METHODS

Residual Contact Fungicides

The fungicides chlorothalonil 6SC (commercial standard) and fluazinam 5SC (novel, low active ingredient compound) were used the VxF trial whereas only chlorothalonil was used in the timing trial. Recommended application rates to achieve late blight control with chlorothalonil were 0.87 kg ai^{-1} ha^{-1} $application^{-1}$ and 9.2 kg ai^{-1} ha^{-1} $season^{-1}$ (US recommendations, Zeneca 1999) and recommendations for fluazinam were 0.15 kg ai^{-1} ha^{-1} $application^{-1}$ and 1.5 kg ai^{-1} ha^{-1} $season^{-1}$(European recommendations, Zeneca 1999). Fungicide application rates used in field experiments were 0, 33, 67 and 100% of manufacturers' maximum recommended application rate (MRAR) for both chemicals. Fungicide applications started when plants were 15 cm tall, (about 7 days after 95% emergence) and at least two applications were made before canopy closure. Fungicides were applied until untreated plots of susceptible controls reached 100% infection. In the timing trial, the same application rates were used but applied at intervals of 5, 10 and 15 days. Untreated plots of each variety were included in both trials.

Potato Germplasm

The potato varieties/ABL used each year varied but always included late blight susceptible controls (commercial varieties) and varieties/ABL reported to have reduced susceptibility to late blight. The VxF trial included the varieties/ABL: Atlantic, Snowden, Matilda and Zarevo (1997), MSG141-3, MSG007-1, Snowden, MSE230-6, MSG297-4, Atlantic, MSE018-1, FL1533, MSA091-1, Picasso, MSC103-2, Matilda, MSE246-5, FL1625, MSG274-3, Lily, Zarevo (1998), Snowden, Atlantic, MSE081-1, MSE246-5, MSA091-1, FL1833, FL1625, FL1533, MSG274-3 (1999), MSE018-1, FL1930, Snowden, MSG050-2, MSF373-8, MSG124-8P, FL1625, MSG274-3 (2000). The timing trial included the variety Snowden (susceptible) and the ABL MSG274-3 (resistant).

Experimental Design, Agronomic Practices, Pathogen

Potato tubers were planted at the Michigan State University Muck Soils Research Station, Bath, MI on June 1, 1997, May 25, 1998, May 30, 1999 and June 9, 2000. The VxF trial was evaluated in all 4 years and was set up in two-row by 8 m plots. The timing trial was evaluated in 1999 and 2000 and was set up in two-row by 3.5 m plots. Both trials were planted at 0.9 m row spacing and were replicated four times in a randomized complete block design. The two-row beds were separated by a 1.6 m blank row. Cut and whole seed pieces (75-150g) of selected varieties and ABL were used.

When relative humidity (RH) fell below 80%, a mist irrigation system was turned on to maintain RH at >95% within the plant canopy. 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, 58 - 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. The dates of application were similar for all years.

All plots were inoculated at the same time with a zoospore suspension (100 ml 8 m row^{-1}, 10^3 conidia ml^{-1}) of *P. infestans* (US8 genotype, insensitive to metalaxyl, A2 mating type). Inoculation was done on July 23, 25, 23 and 26 (1997-2000 respectively).

Disease Evanluation and Data Analysis

As soon as late blight lesions were detected (about 7 days after inoculation, DAI), each plot was visually rated at 3-5 day intervals for percent leaf and stem (foliar) area affected by late blight. Evaluations continued until untreated plots of susceptible varieties reached 100% infection (32, 33, 36 and 39 DAI in 1997-2000 respectively). This was taken as a key reference point for calculation of relative area under the disease progress curve (RAUDPC). The area under the disease progress curve (AUDPC) was calculated by adding the area under the linear progression of disease between each successive estimation of disease from inoculation to the key reference point (noted above for each year). The RAUDPC is calculated by dividing the measured AUDPC by the maximum AUDPC (100 x duration of epidemic). The RAUDPC was expressed with a maximum value of 100. Data were analyzed by two-way analysis of variance and an LSD $_{p=0.05}$ was calculated for the V x F trial. For the timing trial, data from individual years were analyzed by factorial analysis of variance with SAS proc glm and data combined for 1999 and 2000 were analyzed by factorial analysis of variance with SAS proc mixed where years were considered as fixed effects An arbitrary scale of resistance to late blight was determined related to RAUDPC: 0 - 5, resistant; 5 - 10, moderately resistant; 10 - 20, moderately susceptible; >20, susceptible.

Microclimate Measurement

Microclimate within the potato canopy was monitored with temperature and humidity sensors from 50% emergence to 100% canopy senescence. The Wallin late blight prediction model (Wallin, 1953) was developed in the Eastern US under conditions similar to those in Michigan and was adapted to local conditions (Baker et al., 2000). Late blight disease severity values (DSV) were estimated from the Wallin late blight prediction model and accumulated from inoculation to final evaluation. RAUDPC values for Snowden (susceptible) and MSG274-3 (resistant) treated with 0.0 MRAR were plotted against yearly DSV values to determine if RAUDPC varied with DSV.

RESULTS

Microclimate conditions

Late blight developed rapidly during August (1997-2000) and untreated controls in susceptible varieties reached 95% foliar infection 32, 33, 36 and 39 DAI (1997-2000). Accumulated DSV from inoculation to 100% haulm death were 68, 55, 78 and 109 (1997-2000), which indicated that in all years environmental conditions were conducive to late blight development (DSV > 18) (Wallin, 1953). However, conditions were less conducive in 1998 than in 1997 and 1999. In addition, despite highly conducive conditions in 2000 (DSV = 109) late blight was very slow to develop and 95% infection of untreated susceptible controls occurred at 39 DAI. When RAUDPC values for untreated (0.0 MRAR) Snowden (susceptible variety) and MSG274-3 (resistant advanced breeding line) were plotted against yearly DSV values RAUDPC generally increased as DSV increased with the exception of 2000 (Figure 1). In addition, the arbitrary classification of both varieties varied from year to year. Snowden ranged from moderately susceptible (RAUDPC 10 - 19.9 in 2000) to susceptible (RAUDPC > 20 in 1997, 1998, 1999) and classification of MSG274-3 ranged from moderately resistant (RAUDPC 5 - 9.9 in 1999) to resistant (RAUDPC < 5 in 1998 and 2000).

1997 V x F Trial (Figure 2)

All four varieties tested (Atlantic, Snowden, Matilda and Zarevo) were susceptible to late blight (RAUDPC >20 for untreated controls) despite reported late blight resistance in Zarevo and Matilda. In all varieties, all fungicide programs (chlorothalonil and fluazinam, 33 -100% MRAR) applied every seven days reduced the level of foliar late blight significantly compared to untreated controls. Chlorothalonil applied at 66 and 100% MRAR reduced RAUDPC to <5 in Atlantic and Snowden. When applied at 33% MRAR, chlorothalonil reduced RAUDPC to 5 - 10 in Snowden and Atlantic and to <5 in Matilda and Zarevo. All rates of fluazinam used (33-100%) reduced RAUDPC to <5 in all four varieties.

1998 V x F Trial (Figure 3)

Varieties and ABL were significantly different in response to late blight and were classified and ranked based on mean RAUDPC of untreated plots. The most susceptible (RAUDPC>20) were Atlantic, Snowden, MSE230-6, MSG007-1, MSG297-1 and MSG141-3 (Figure 3A; Figure 3B); moderately susceptible (RAUDPC 10-19.9) were MSE018-1, MSC103-2, Picasso, Matilda and MS246-5 (Figure 3C; Figure 3D); resistant (RAUDPC 0 - 4.99) were Lily, Zarevo and MSG274-3 (Figure 3E; Figure 3F). No varieties or ABL were moderately resistant to late blight (RAUDPC 5-9.9).

Fungicide application rates of 33-100% MRAR of both chlorothalonil and fluazinam significantly decreased RAUDPC in susceptible and moderately susceptible varieties/ABL in comparison to untreated controls. At 100% MRAR of both fungicides the RAUDPC was <5 in all varieties and ABL except MSE018-1 (RAUDPC 5-9.9). Application of either fungicide at any rate (33 to 100% MRAR) did not significantly reduce RAUDPC in resistant varieties/ABL in comparison to the untreated controls.

1999 V x F Trial (Figure 4)

All varieties/ABL tested were susceptible to late blight (RAUDPC >20) except for MSG274-3 which was moderately resistant (RAUDPC 5-9.9). Chlorothalonil and fluazinam at all rates (33-100% MRAR) applied at 7 day intervals to MSE018-1 and MSA091-1 reduced late blight foliar infection significantly compared to the most susceptible treatment (Snowden, 0.0 MRAR). Chlorothalonil applied at 33% MRAR did not significantly reduced RAUDPC in Atlantic, Snowden or MSE246-5 compared to the susceptible variety Snowden treated with 0.0 MRAR. Chlorothalonil applied at 33% MRAR failed to reduce the RAUDPC to <20 in any variety or ABL except MSE018-2. Chlorothalonil applied at 66% MRAR significantly reduced the RAUDPC to about 20 in Atlantic, Snowden, MSE246-5 and MSA091-1. Application of 100% MRAR chlorothalonil did not reduce RAUDPC significantly in comparison with application at 66% MRAR in MSE018-1, Snowden, and MSA091-1 (RAUDPC 10-19.9), whereas the RAUDPC of Atlantic and MSE246-5 were reduced to 5-9.9. Fluazinam applied at 66% MRAR reduced RAUDPC to between 10 and 19.9 in all varieties/ABL. At 100% MRAR, fluazinam reduced RAUDPC to 5-9.9 in Snowden, MSA091-1, MSE246-5, and MSE018-1. Application of chlorothalonil and fluazinam at any rate (33 - 100% MRAR) did not significantly reduce RAUDPC in MSG274-3 compared to 0.0 MRAR although the application of 66 and 100% of both fungicides reduced the RAUDPC to <5.

2000 V x F Trial (Figure 5)

Varieties and ABL were significantly different in response to late blight ranging in RAUDPC from 0.1 (MSG274-3) to 22.8 (MSE018-1). At all application rates, chlorothalonil reduced RAUDPC to <5 on all varieties /ABL except for FL1930 and MSG124-8P at 33% MRAR. Fluazinam applied at 33% MRAR reduced RAUDPC to <5 in only one variety (FL1625) whereas, at 66 and 100% MRAR this chemical reduced RAUDPC to <5 in all varieties/ABL except MSE018-1. No application rate of either chemical significantly reduced the RAUDPC for MSG274-3.

1999 Timing Trial

In 1999, Snowden was susceptible to late blight (RAUDPC >20) and MSG274-3 was resistant (RAUDPC <5) (Figure 6A). When analyzed across cultivars, all treatments significantly reduced RAUDPC compared to untreated controls. At a 5 day spray interval 66 and 100% MRAR (RAUDPC 3.1 and 2.6) were not significantly different, at a 10 day spray interval 33 and 66% MRAR (RAUDPC 15.5 and 12.0) were significantly different from 100% MRAR (RAUDPC 8.8) and at a 15 day spray interval 66 and 100% MRAR were not significantly different (RAUDPC 16.7 and 13.3). In Snowden, all treatments were significantly different from the untreated control however, no treatment reduced RAUDPC to <5. All application rates at a 5 day interval reduced RAUDPC to the moderately resistant range (5-9.9), one treatment (100% MRAR, 10 day interval) reduced RAUDPC to the moderately susceptible range (10 - 19.9) and all other treatments resulted in RAUDPC values in the susceptible range (>20). In MSG274-3 all treatments significantly reduced the RAUDPC value compared to the untreated control except 33% MRAR at a 15 day interval. However, the RAUDPC values for all treatments and for the control were <5. All treatments reduced the RAUDPC to <1 except 33 and 66% MRAR at a 15 day interval.

2000 Timing Trial

In 2000, Snowden was again susceptible to late blight but due to a slower disease progression the RAUDPC value was 16.7 as compared to a RAUDPC value >20 in 1999 (Figure 6B). Analyzed across cultivars, application rates within each spray interval were not significantly different. In general application rates at 5 day intervals were the most effective (RAUDPC < 5), application rates at 10 day intervals reduced RAUDPC to 5.2 to 6.6, and application rates at 15 day intervals reduced RAUDPC to 3.0 to 5.2. In Snowden, 66 and 100% MRAR at a 5 day interval reduced RAUDPC to <5. Treatments that reduced RAUDPC to 5 - 9.9 included 33% MRAR (5 day interval) and 33 and 100% (15 day interval). All other treatments resulted in RAUDPC values in the 10 - 19.9 range. All treatments lowered RAUDPC significantly compared to the untreated control except 33 and 66% MRAR at a 10 day spray interval. In MSG274-3 no treatment was significantly different from the untreated control.

When data were analyzed across years, no treatment was significantly different from the untreated control for the advanced breeding line MSG274-3. In the cultivar Snowden, all treatments were significantly different from the untreated control. However, only 66 and 100% MRAR at the 5 day spray interval reduced the RAUDPC to <5 (Figure 1B). One treatment (33% MRAR at a 5 day interval) lowered the RAUDPC into the moderately resistant category (5 - 9.9). Four treatments had RAUDPC values in the moderately susceptible range (10 - 19.9) including 66 and 100% MRAR at a 10 day interval as well as 33 and 100% MRAR at the 15 day spray interval. All other treatments resulted in RAUDPC values >20.

DISCUSSION

The results of these studies clearly demonstrate that control of late blight can be accomplished through the use of managed fungicide application programs in combination with host plant resistance. However, in 1999 when environmental conditions were more favorable for the development of late blight lower application rates (33 and 66% MRAR) provided unsatisfactory control. In the V x F trials, under conditions moderately conducive to late blight development, reduced amounts of both chlorothalonil and fluazinam were effective at all application rates tested on all varieties/ABL in comparison with the untreated controls. In some varieties/ABL, 33% of the full application rate was sufficient to achieve acceptable control, whereas other varieties/ABL required 67% to control late blight. No further reduction in disease was measured by application of the full, recommended rate of either fungicide in any variety or ABL. The least susceptible varieties/ABL did not respond to applications rates greater than 33% of the full, recommended rate of either fungicide.

In the timing trials, application of fungicides at 10 and 15 day intervals gave unsatisfactory control of late blight at all rates of chlorothalonil tested in susceptible varieties. In the resistant ABL MSG274-3 no treatment was significantly different from the untreated control indicating that the lowest application rate with the longest spray interval could be used to control late blight in a resistant cultivar. Similarity in efficacy against late blight between chlorothalonil and the novel fungicide fluazinam in the V x F trials suggests that fluazinam will also be ineffective at reduced application rates beyond a 5 day application interval in susceptible cultivars.

The opportunity for reduction of fungicide applications by managing the rate and timing of application of traditional fungicides and novel fungicides with lower amounts of active ingredient in varieties less susceptible to late blight is clear. More critical dose response studies are required for new chemicals to establish effective rates of application for control of late blight. The efficacy of reduced rates of novel 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 rate fungicide applications.

As new varieties with enhanced late blight resistance are developed and released it will be important to provide growers with recommendations for the most effective and efficient chemical control of late blight in these new varieties. Therefore, a canopy microclimate dependent model, specific for different categories of varietal susceptibility to late blight, needs to be developed to advise and guide growers which rate, fungicide and frequency of application is required to provide adequate protection against late blight. It would be tempting to use the arbitrary scale of resistance based on RAUDPC values in model development. However, because the RAUDPC value for a variety is dependent on the yearly DSV value it would be difficult to accurately classify variety resistance based on RAUDPC values. Therefore, new varieties will need to be carefully screened in the manner describe in this study in order to develop accurate models for fungicide application.

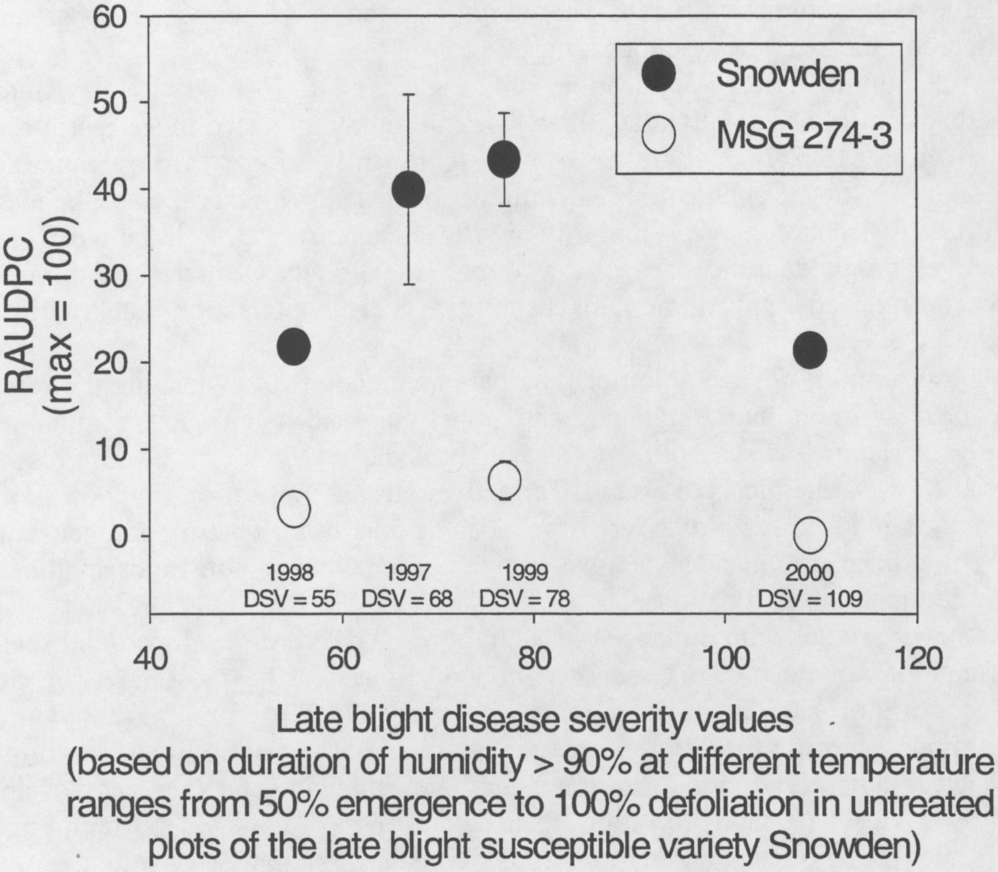


Figure 1. Relative area under the disease progress curve (max=100) in Snowden and MSG274-3 inoculated with *P. infestans* (US8, A2) as a function of late blight disease severity value (DSV) over a period of four years (1997 – 2000). Plants were not protected with any fungicide applications. The bars are standard errors of the estimated mean (n = 4 all years).

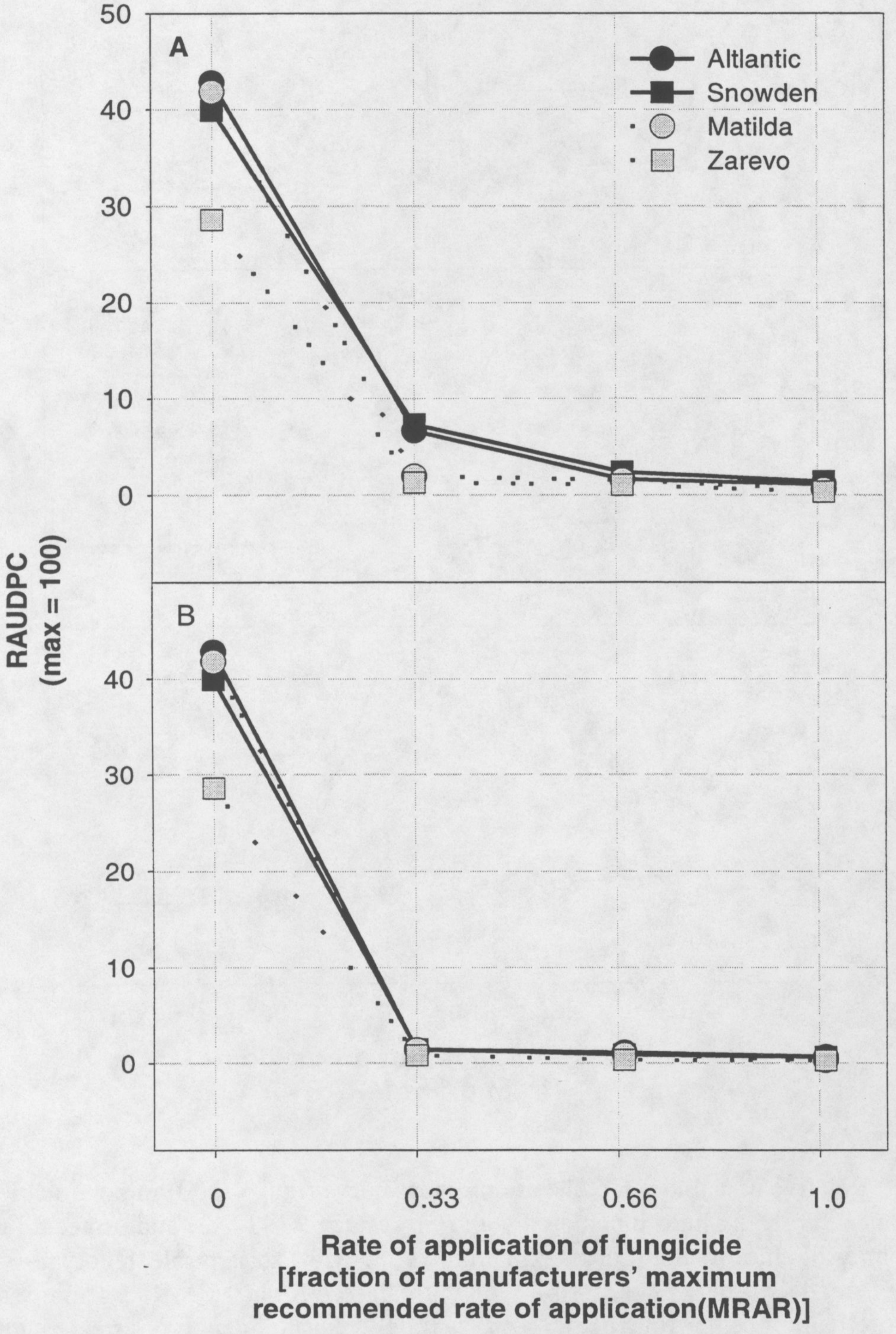


Figure 2. Relative area under the disease progress curve (max=100) in potato cultivars and advanced breeding lines inoculated with *P. infestans* (US8, A2) and protected with reduced rates of chlorothalonil (A) or fluazinam (B) in 1997. $LSD_{0.05} = 4.15$ for both fungicides and cultivar comparisons. DSV = 68 from 50% emergence to desiccation.

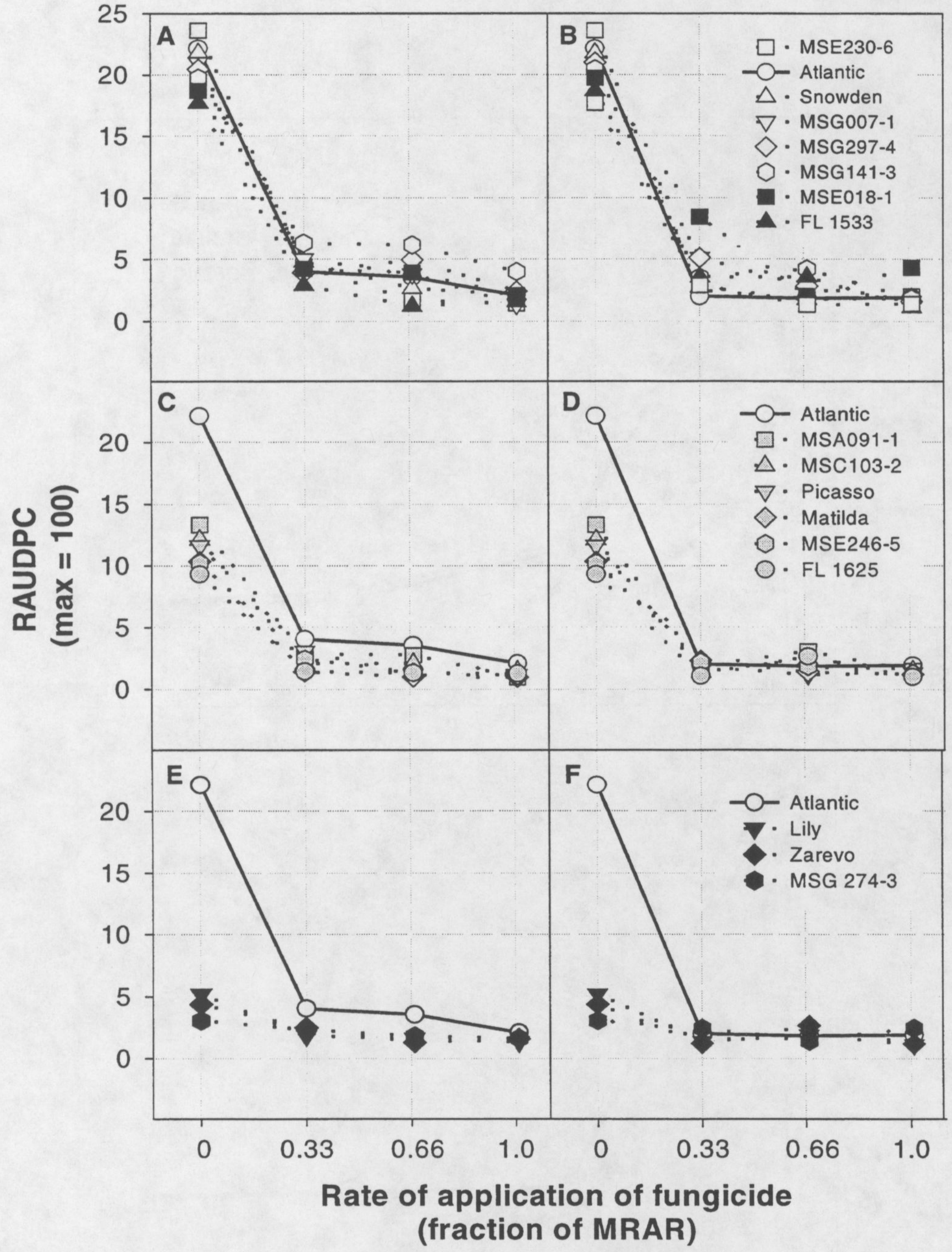


Figure 3. Relative area under the disease progress curve (max = 100) in potato cultivars and advanced breeding lines inoculated with *P. infestans* (US8, A2) and protected with reduced rates of chlorothalonil or fluazinam in 1998. Most susceptible genotypes were sorted in legend by order of susceptibility in untreated control (0.0 MRAR) and treated with chlorothalonil (A) or fluazinam (B); moderately resistant genotypes treated with chlorothalonil (C) or fluazinam (D); most resistant genotypes treated with chlorothalonil (E) or fluazinam (F). $LSD_{0.05} = 2.75$ for both fungicides and cultivar comparisons. DSV = 55 from 50% emergence to desiccation.

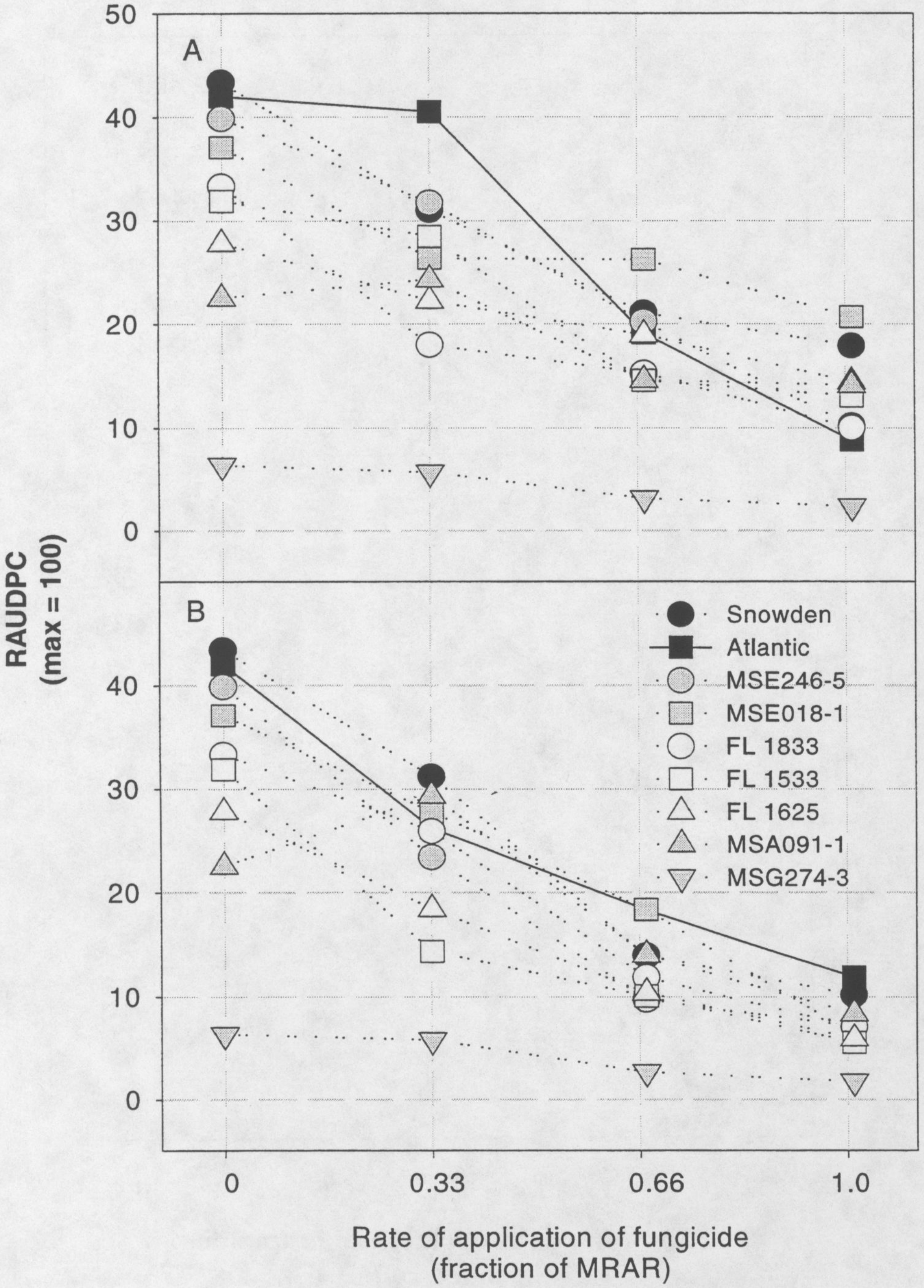


Figure 4. Relative area under the disease progress curve (max = 100) in potato cultivars and advanced breeding lines inoculated with *P. infestans* (US8, A2) and protected with reduced rates of chlorothalonil (A) or fluazinam (B) in 1999. Cultivars and advanced breeding lines were sorted in the legend in order of susceptibility of untreated control (0.0 MRAR).). $LSD_{0.05}$ = 4.35 for both fungicides and genotype comparisons. DSV = 78 from 50% emergence to desiccation.

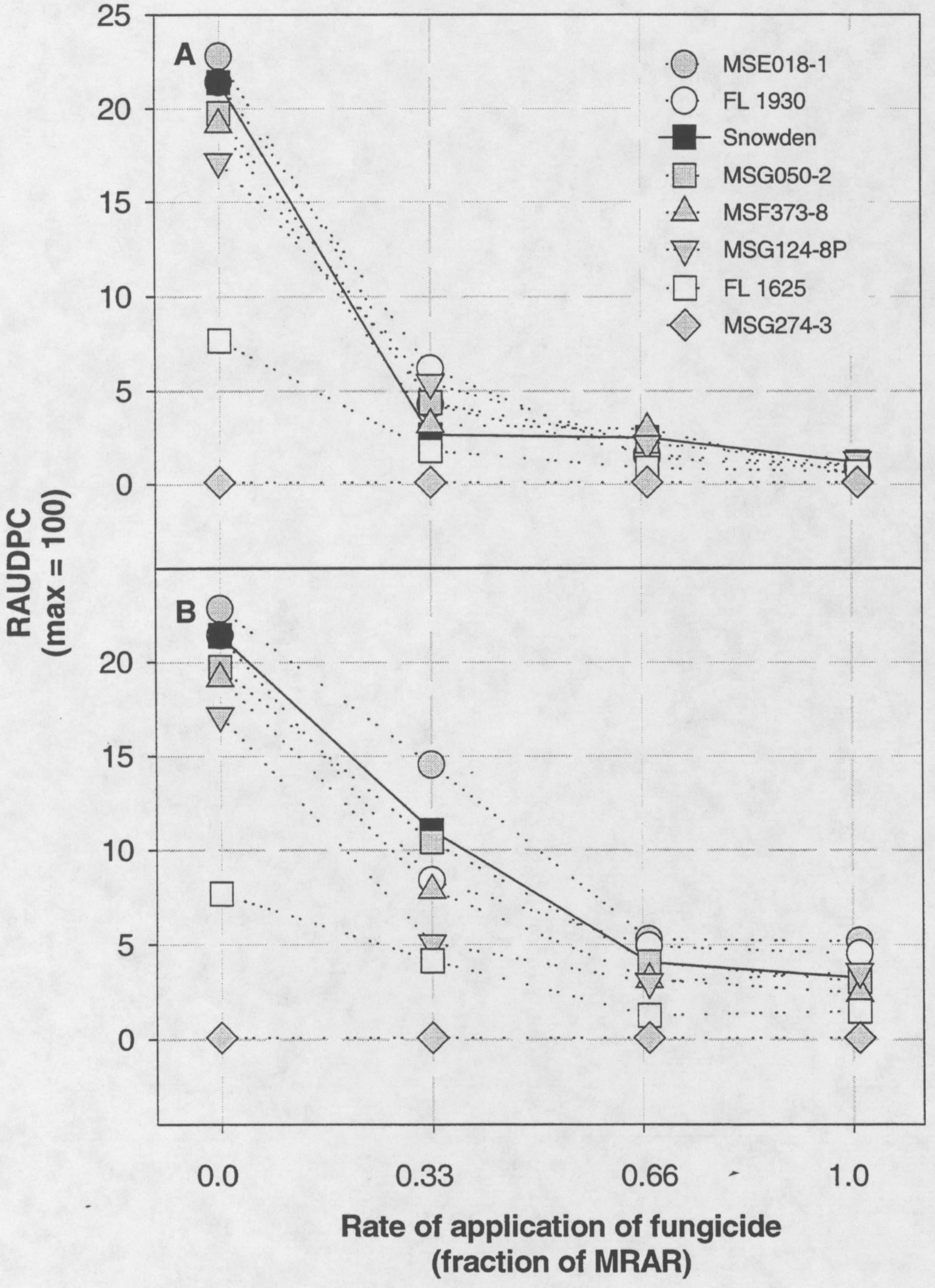


Figure 5. Relative area under the disease progress curve (max = 100) in potato cultivars and advanced breeding lines inoculated with *P. infestans* (US8, A2) and protected with reduced rates chlorothalonil (A) or fluazinam (B) in 2000. Cultivars and advanced breeding lines were sorted in the legend in order of susceptibility of untreated control (0.0 MRAR). $LSD_{0.05} = 4.22$ for both fungicides and genotype comparisons DSV = 109 form 50% emergence to desiccation.

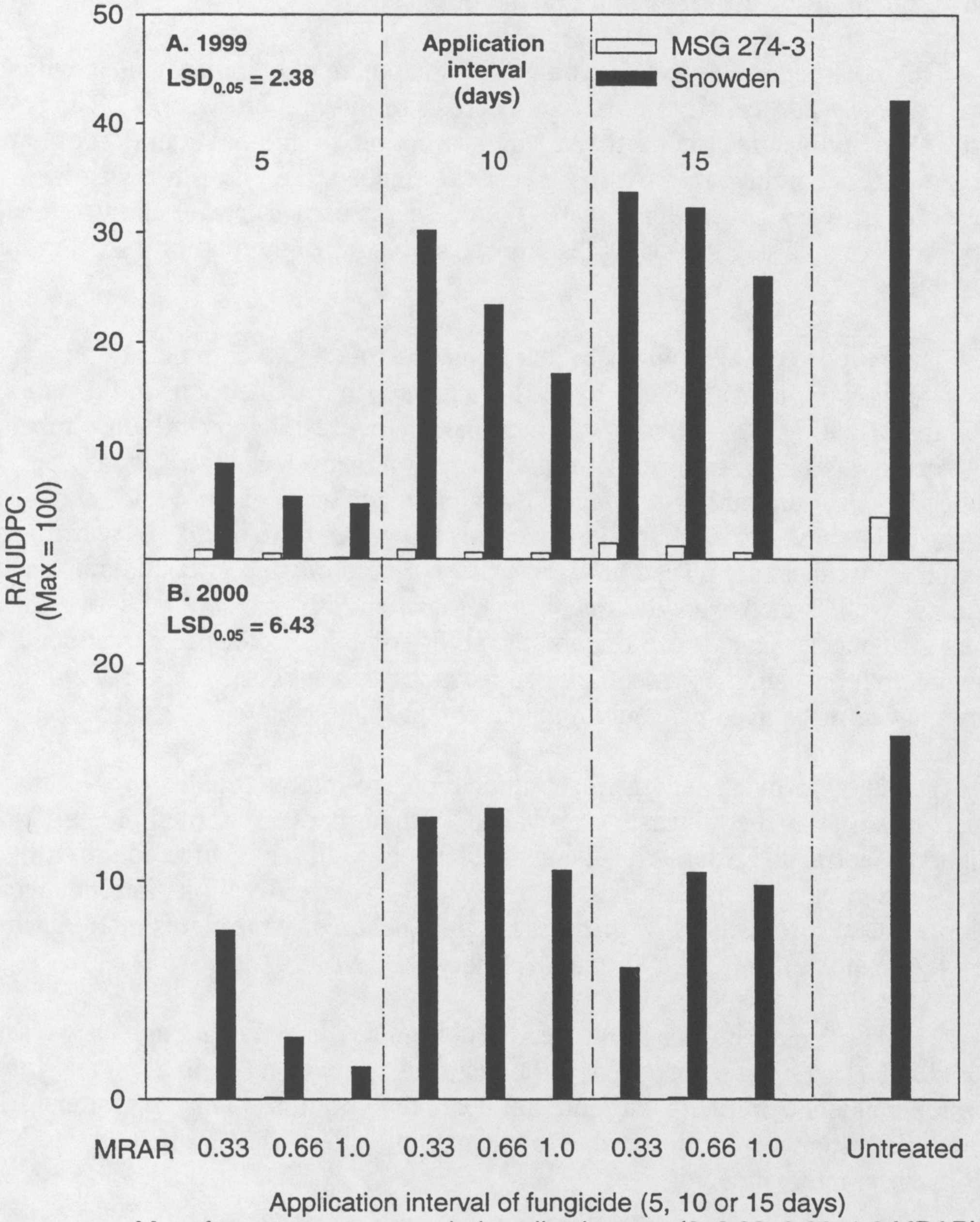


Figure 1A - B. Relative area under the disease progress curve (max=100) in the late blight susceptible commercial cultivar Snowden and the advanced breeding line MSG 274-3 inoculated with *P. infestans* (US8, A2) and protected with reduced rates of chlorothalonil applied at 5, 10 or 15 day intervals in 1999 (A) or 2000 (B). Application intervals (5, 10 and 15 days) were separated by the dashed lines. $LSD_{0.05}$ = 2.38 (1999) and 6.43 (2000) for both application timing and cultivar comparisons. Late blight DSV = 78 (1999) and 108 (2000) from 50% emergence to desiccation. Note change in RAUDPC scale between years. In MSG 274-3, late blight infection was too low show up on Figure 1B, but ranged from RAUDPC = 0.01(1.0 MRAR of chlorothalonil, 5 day interval) - 0.05 (0.66 MRAR of chlorothalonil, 15 day interval and untreated control).

TACKLING INTERNAL NECROSIS

Sieglinde Snapp, Richard Chase and Phil Throop

The most persistent quality problem for the potato chip industry in Michigan is internal necrosis (also called internal heat necrosis or internal brown spot). The potato varieties Pike and Atlantic, in particular, are susceptible to internal quality problems. Yet, potato producers continue to grow these varieties. Indeed, the Pike variety is the primary defense chip growers have against scab. If our research shows growers how to ameliorate quality problems in Pike, then we will improve scab control by making Pike a more viable option.

The purpose of this study is to determine the role of calcium nutrition in ameliorating tuber quality defects. In 2001 we are expanding the focus of this work to include investigating how different calcium management strategies influence tuber storage quality. We hypothesize that sugar formation from carbohydrates may be influenced by calcium nutrition, where low calcium enhances glucose and sucrose production. The severity of internal brown spot fluctuates from season to season, and even after Pike tubers are placed in storage there are reports that internal defects can decrease as well as increase with time. Taken together with research indicating that calcium influences sugar formation, and the ability of calcium fertilizer treatments to reduce internal problems under some circumstances, this suggests that tuber storage quality may be influenced by calcium management.

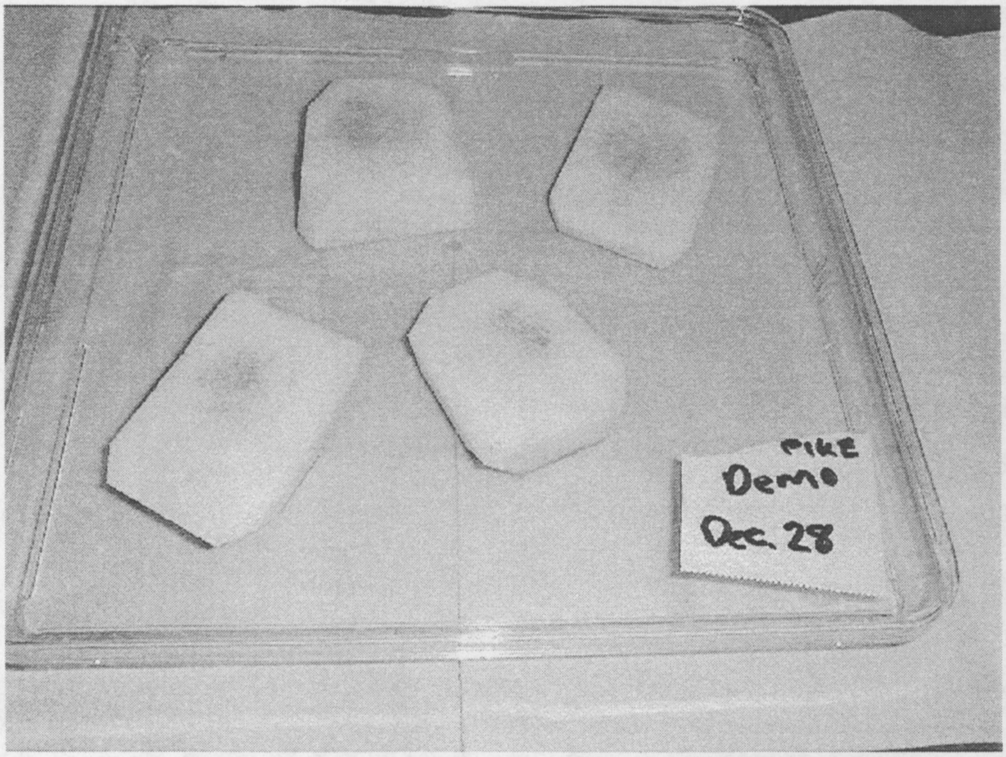
The 2000 growing season was not conducive to internal quality problems. Consistent rainfall and cool weather prevailed, with higher than normal precipitation throughout Central and Southern Michigan. This may well have buffered growth conditions, allowing even tuber bulking. Even growth generally limits internal necrosis development, so fortunately few growers had internal quality problems in 2000 (informal survey by Snapp at Dec 13, 2000 Potato Variety Day, MSU).

The low incidence of internal necrosis posed a research challenge, as we sampled Pike and Atlantic (~200 tubers/field) varieties on six grower fields in 2000 and found only three incidence of tubers with internal necrosis symptoms. This was an insufficient severity of internal necrosis to be able to evaluate the effect of calcium nutrition in relationship to internal necrosis.

We decided instead to evaluate how calcium nutrition influenced storage quality in Pike. We have tubers that vary in calcium pulp levels from 0.024 to 0.54%, and we have stored them at the 48 degree (target temperature) Pike demonstration storage bin at Montcalm Research Farm. We are monitoring glucose and sucrose, defects and chip color over time (four sample of 25 tubers evaluated each month, one sample each from four levels of calcium nutrition sites – i.e., different fields). This information will be not be complete until the end of the extended storage experiment, and results will be reported next year.

In 2000, we also initiated developing a Pike Internal Quality Laboratory Assay to investigate reported flucuations in severity of darkening and internal problems with time. We are evaluating if an external calcium treatment applied during storage can limit the development of internal necrosis. This experiment is in progress (see Figure 1 below). Results will be reported next year.

In 2001, we will conduct a research trial on calcium nutrition at Montcalm Research Farm and at the Crop and Soil Sciences Department MSU campus. This trial will investigate the effect of 'spoon feeding' calcium – split applications with different calcium fertilizers to optimize calcium nutrition - on Pike tuber quality. High rates and multiple, split applications of calcium from different fertilizer sources will be compared to a one-time calcium treatment of gypsum, and a high-calcium poultry compost calcium source. Internal necrosis and bruising will be monitored, and we will investigate if calcium nutrition influences extended storage of tubers. We will determine, for Michigan conditions, if higher calcium levels improve chip quality of stored Pikes by limiting carbohydrate transformation to sugars. This has not been previously tested in Michigan.



POTATO STORAGE EXPERIMENTS

Objective: investigate management strategies, technologies and varieties to help Michigan growers increase the marketability and reduce the risk during extended season storage of Michigan grown chip potatoes.

Chip Potato Extended Season Storage

- Varieties - cold chipping for minimal low temperature response (long-term)
- Storage Control - temperature, humidity, oxygen, pressure bruise
- Storage Management - temperature control relative to potato needs and weather conditions

Methods

The Michigan potato industry, through the Michigan Potato Industry Commission, purchased land adjacent to the Montcalm potato research farm in the spring of 1999 and constructed on that land an experimental storage building containing six research bins. The bins are 10' x' 12' by 18' high, holding an estimated 500 cwt. of potatoes. Each bin has an independent air control and management system. Refrigeration was installed in each bin in late-May 1999.

The building was finished in the fall of 1999 and filled with Snowden variety potatoes. There were two separate comparison protocols used in determining filling and storage management.

The first protocol compared Snowden potatoes with three different planting dates (early, normal, late). Potatoes were grown by the same producer and harvested in three different dates. The three bins in this protocol were :

- **Bin 1:** potatoes planted June 5 and harvested October 18; desired holding temperature 46°F; comparison with bins 5 and 6 for different planting dates
- **Bin 5:** potatoes planted May 15 and harvested September 25; desired holding temperature 46°F; comparison with bins 1 and 6 for different planting dates
- **Bin 6:** potatoes planted May 4 and harvested September 18; desired holding temperature 46°F; comparison with bins 5 and 6 for different planting dates

The second protocol compared Snowden potatoes harvested from the same field and stored at three different temperatures (warm, normal, cool). The three bins in this protocol were:

- **Bin 2:** potatoes planted May 23 and harvested October 5; desired holding temperature 46°F; comparison with bins 3 and 4 for different storage temperatures
- **Bin 3:** potatoes planted May 23 and harvested October 5; desired holding temperature 38°F; comparison with bins 2 and 4 for different storage temperatures
- **Bin 4:** potatoes planted May 23 and harvested October 5; desired holding temperature 42°F; comparison with bins 2 and 3 for different storage temperatures

While the bins were being filled, mesh bags were filled with potatoes and weighed. The bags were buried in the pile as filling progressed, using four bags in each of three levels (bottom, middle, top). In addition, each field truck delivering potatoes was weighed before and after unloading in order to determine the total initial weight of potatoes in each bin.

The bins were actively managed by the storage & handling committee relative to the bi-weekly tuber samples from each bin. Sprout inhibitor was applied to all bins on December 29, 1999.

When the bins were emptied, the buried sample bags were reweighed to determine weight loss and were evaluated for pressure bruise. The potatoes were graded, with total weights before and after grading determined.

Utz Quality Foods (Hanover, PA) agreed to be the processor cooperator. The bi-weekly chip samples results, plus digital pictures of the resulting chips were supplied to Utz representatives during the winter and spring months. Marketing decisions were make by the Storage and Handling committee, in consultation with the MPIC office and Utz representatives.

Results: Planting Date Protocol

Bin 1 (late planted) was the last bin to ship, being processed in early-June (data for shipping and quality analysis are presented in Table 1). By late April, bins 5 and 6 (normal and early planting respectively) were beginning to show signs of sugar accumulation (see Figure 1 for a graph of the bi-weekly sample analysis data). Bin 5 was shipped successfully in late April. Reconditioning was attempted on Bin 6, but the sugars continued increasing. The potatoes were sent to a dehydration plant in late May.

Table 1. Shipping dates and quality analysis of three-planting date comparison bins for the 1999-2000 storage season.

	Bin 1 late	**Bin 5 normal**	**Bin 6 early**
Planting Date	Early June	Mid May	Late April
Harvest Date	10/18/99	9/25/99	9/18/99
Shipping Date	6/6/00	4/25/00	5/31/00
Weight Loss			
• bags, %	4.7	5.9	8.4
• before grade, %	6.3	7.3	11.6
• after grade, %	14.0	16.4	dehy
Plant Chip Quality			
• internal, %	7	13	21
• external, %	2	total	total
Pressure Bruise			
• top, %	6	20	10
• middle, %	42	8	36
• bottom, %	49	19	58

Results: Storage Temperature Protocol

All three of the storage temperature comparison bins were shipped approximately the same time in mid-May (data for shipping and quality analysis are presented in Table 2). The early warm temperatures of the spring meant that even Bin 3 (low storage temperature) was not at the desired temperature for very long. The sugar concentrations were similar for all three bins, with some sucrose increase noticeable shortly after Bins 3 and 4 reached the desired storage temperature (see Figure 2 for a graph of the bi-weekly sample analysis data).

Table 2. Shipping dates and quality analysis of three storage temperature comparison bins for the 1999-2000 storage season.

Storage Temperature	Bin 3 40 F	Bin 4 43 F	Bin 2 46 F
Planting Date	5/23/99	5/23/99	5/23/99
Harvest Date	10/5/99	10/5/99	10/5/99
Shipping Date	5/11/00	5/15/00	5/16/00
Weight Loss			
• bags, %	4.4	4.6	4.8
• before grade, %	5.7	8.0	6.9
• after grade, %	16.0	18.7	19.2
Plant Chip Quality			
• internal, %	2	2	2
• external, %	1	2	2
Agtron	63.7	60.4	59.3
Pressure Bruise			
• top, %	2	5	6
• middle, %	12	32	20
• bottom, %	34	45	50

Conclusions

- The Michigan potato industry has a new tool for improving storage management
- Refrigeration management will be important for June delivery

Figure 1. Bi-weekly sample analysis data for three planting date comparison bins for the 1999-2000 storage season.

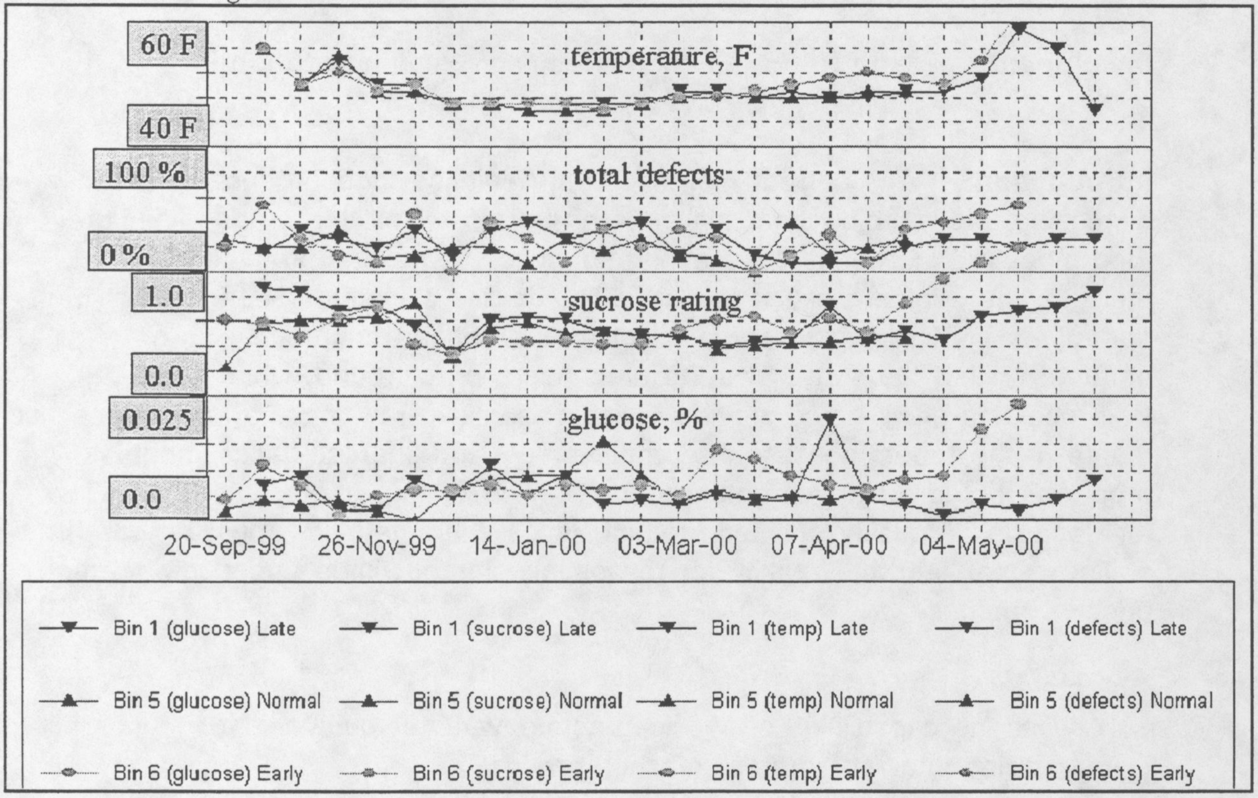
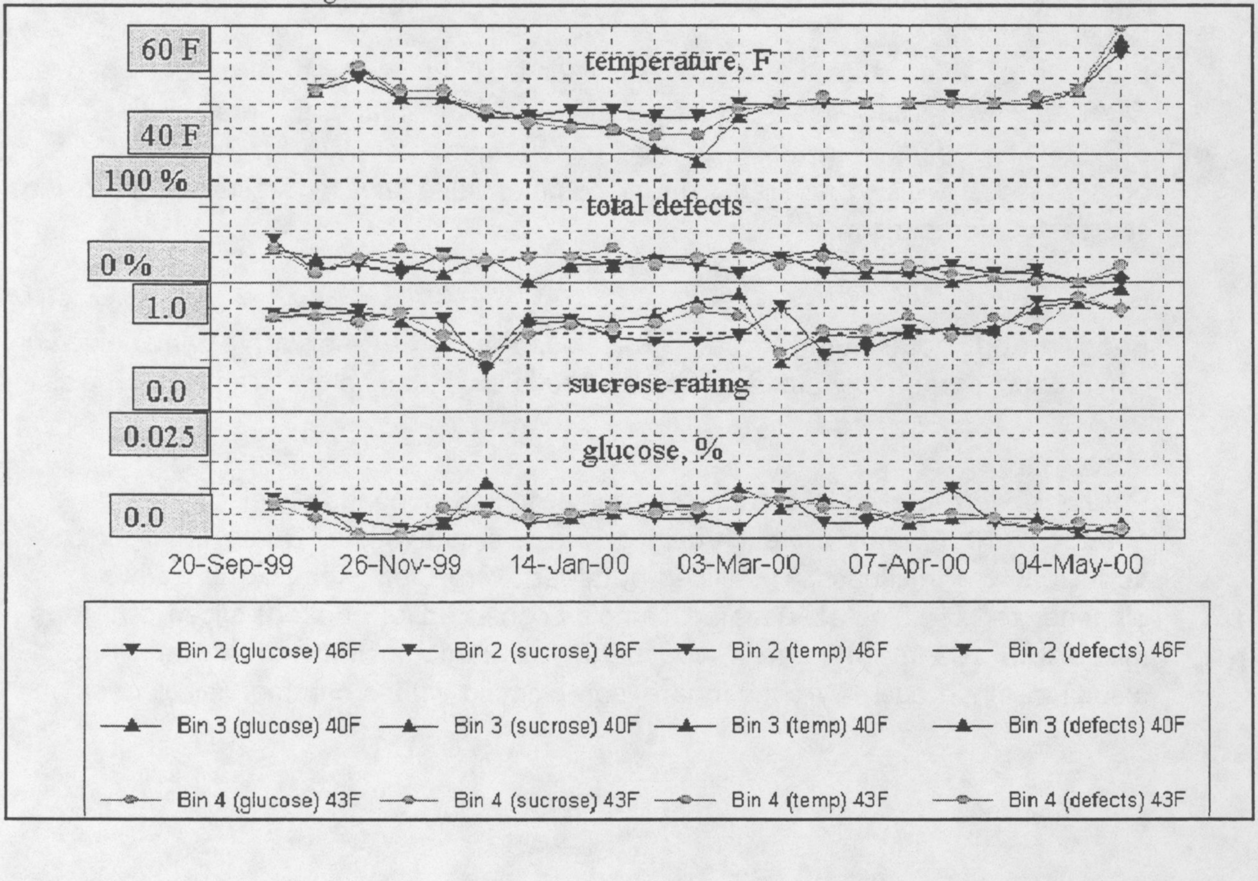


Figure 2. Bi-weekly sample analysis data for three storage temperature comparison bins for the 1999-2000 storage season.



Title: Evaluation of Michigan potato varieties and development of processing procedures for use in refrigerated, mashed potatoes.

Investigator: Jerry N. Cash, Food Science and Human Nutrition Department, Michigan State University

Introduction: The current market for convenience food products is steadily increasing and is rapidly becoming one of the most lucrative areas within the food industry. Refrigerated, mashed potatoes are gaining prominence in this fast growing segment of the industry. The decline of commercial french frying operations in Michigan, which has reduced the options for processing of potatoes within the state, plus the preponderance of round, white sort outs from chipping stock could provide a viable source of raw material for the mashed market if the tubers possess the proper processing characteristics for this product. In addition to the internal composition of the tubers, which will allow for good, initial quality mashed product, these characteristics must include the ability to maintain that quality for reasonable storage times under refrigeration prior to purchase

Objectives:

1) Assess the capabilities of Michigan potato varieties/cultivars for processing into refrigerated, mashed product.
2) Determine peeling, holding and treatment paramenters necessary to insure quality in finished product.

Materials and methods

Potato Samples

Samples of five white cultivars (G277-2, MSG 227-2, Atlantic, Snowden and Pike) and two yellow flesh (G 274-3, MSG 274-3) cultivars were obtained from the MSU breeding program and were tested immediately after harvest. Mashed potatoes were also prepared from a commercial cultivar obtained from a local source for comparison.

Reagents

Food grade potassium sorbate was used as a preservative and disodium dihydrogen pyrophosphate was used for retaining color in the treated samples.

Processing

Potatoes were peeled in an abrasive peeler for 45 seconds. Peeled, raw potatoes (1000 gram for each cultivar) were sliced with a Qualheim slicer to about 0.5 cm thickness. The sliced potatoes were then steamed in a Dixie blancher for 15 minutes. Treated samples consisted of cooked, sliced potatoes mixed with 165 ml whole milk, 40g butter, 0.1% potassium sorbate and 0.05% disodium dihydrogen pyrophosphate and blended with a commercial blender on low speed. The control samples were prepared by the same process but without adding potassium sorbate or disodium dihydrogen pyrophosphate. Treated and control samples were placed in storage at 5 °C for color and sensory evaluation.

Color Analysis

CDM color of triplicate samples was measured with a Hunter color difference meter (D25 DP-9000 system, Hunter Associates Laboratory, Reston, VA). This system is based on the Hunter "*L*", "*a*" and "*b*" coordinates. The *L* represents lightness, from white (L = 100) to black (L = 0) and "*a*" and "*b*" indicate hue and chroma, measuring from $+a$ (redness to $-a$ (greenness) and $+b$ (yellowness) to $-b$ (blueness). About 50 gram of sample (for each cultivar) were placed in a standard optical cell for the measurement after standardization with a white tile (L_L = 85.06; a_L = 82.93; b_L = 100.31). The samples were measured before and after microwave heating (45 seconds) at 7 day intervals for one month.

Sensory evaluation

Sensory color was evaluated by trained panelists at 7 days intervals for 28 days.

Experiment Design

The experiment was arranged as a cultivar × treatment × storage time factorial design with three replications. The color data for white fleshed (G277-2, MSG 227-2, Atlantic, Snowden, Pike and Commercial) and yellow fleshed (G 274-3, MSG 274-3) mashed potatoes were analyzed separately using ANOVA techniques. Significant means were analyzed using the Least Significant Difference test and software was Statistical Analysis System (SAS, 1982).

Results and Discussion

Analysis of variance for the effects of cultivar, treatment and storage time on *L* values of mashes from both white and yellow fleshed cultivars, unheated, are shown in Table 1a and 1b, respectively. Analysis of variance indicated significance in the sample color ($p < 0.05$) due main effects and interactions between cultivar, treatment and storage time.

Effect of cultivar

Tables 2a and 2b show the *L* values of control and treated samples from the different white and yellow fleshed cultivars, respectively. The *L* values of Atlantic and MSG 277-2, determined without heating, were in the same range (Table 2a) for both control and treated samples except for the 14-days storage. The commercial sample gave the lowest *L* values (ie. darkest color) for all storage times, while Pike and Snowden samples gave the highest values (lightest color) at different storage times for both control and treated samples when determined without heating.

For the yellow fleshed potatoes (Table 2b), G274-3 and MSG 274-3 gave *L* values in the same range except for control samples of MSG 274-3, measured at 7 and 14-days, which gave higher values than G274-3 at corresponding storage times. All these samples were measured without microwave heating.

These data indicate that *L* values were significantly different for different cultivars when determined without heating. The commercial sample gave the darkest mashes while Pike and Snowden gave the whitest mashes for the white fleshed potatoes. The yellow fleshed cultivars, G274-3 and MSG274-3 gave values that were not significantly different.

Effect of treatment

In most cases, treated samples had higher *L* values and better color (Table 2a and 2b) than the untreated controls, due to the action of disodium dihydrogen pyrophosphate, which served as a color-retaining agent.

Effect of storage time

In general, *L* values of unheated samples (Table 2a and 2b) increased as storage time increased except for the commercial mashed potatoes. Even though significant differences were observed, all the samples maintained acceptable color for at least 14 days storage. All the samples began to exhibit darker color by 21 days of storage and mold growth was evident on some samples. By 28 days of storage almost all the samples had mold growth. A higher concentraton of potassium sorbate might have prevented this mold occurrence.

Table 1a **Analysis of Variance of *L* values of mashed potatoes from white fleshed cultivars, 2000 (WITHOUT HEATING)**

Source	DF	Mean Square
Cultivar	5	95.46*
Treatment	1	3.89*
Time	2	5.55*
Cultivar *Treatment	5	2.56*
Treatment*Time	2	0.33*
Cultivar *Time	10	3.07*
Cultivar* Treatment* Time	10	0.55*

* significant at $p < 0.05$

Table 1b **Analysis of Variance of *L* values of mashed potatoes from yellow fleshed Cultivars, 2000 (WITHOUT HEATING)**

Source	DF	Mean Square
Cultivar	1	1.07*
Treatment	1	12.25*
Time	2	3.07*
Cultivar * Treatment	1	0.87
Treatment*Time	2	2.08*
Cultivar *Time	2	0.91*
Cultivar *Treatment* Time	2	0.78*

* significant at $p < 0.05$

Table 2a **Effect of cultivar, treatment and storage (5 °C) on *L* values of mashed potatoes from white fleshed cultivars, 2000 (WITHOUT HEATING)**

	0 days		7 days		14 days	
Cultivar	Control	Treated	Control	Treated	Control	Treated
Commerical	69.4 [a]	69.4 [a]	67.2 [a]	67.2 [a]	68.2 [a]	68.2 [a]
G277-2	70.9 [b]	70.4 [b]	71.2 [b]	72.4 [b**]	71.3 [b]	72.3 [b**]
Atlantic	71.9 [c]	73.0 [c**]	71.8 [c]	73.1 [c**]	73.5 [c]	75.8 [c**]
MSG277-2	71.8 [c]	73.2 [c**]	71.8 [c]	73.0 [c**]	73.0 [d]	73.0 [d]
Pike	74.4 [d]	73.9 [d**]	74.4 [d]	74.1 [d]	74.9 [e]	74.3 [e**]
Snowden	74.1 [d]	74.2 [d]	74.1 [d]	74.2 [d]	74.9 [e]	74.4 [e**]

[a] **Means in a column not followed by the same letter differ ($p<0.05$)**
** **significant difference between mean of the treatment and control**

Table 2b **Effect of cultivar, treatment and storage (5 °C) on *L* values of mashed potatoes from yellow fleshed cultivars, 2000 (WITHOUT HEATING)**

	0 days		7 days		14 days	
Cultivar	Control	Treated	Control	Treated	Control	Treated
G274-3	70.2 [a]	72.3 [a**]	72.3 [a]	72.6 [a]	72.6 [a]	72.8 [a]
MSG274-3	70.3 [a]	72.3 [a**]	71.3 [b]	72.5 [a**]	71.1 [b]	72.8 [a]

[a] **Means in a column not followed by the same letter differ ($p<0.05$)**
** **significant difference between mean of the treatment and control**

Table 3a Analysis of Variance of *L* values of mashed potatoes from white fleshed Cultivars, 2000 (AFTER MICROWAVE HEATING for 45 seconds)

Source	DF	Mean Square
Cultivar	5	122.85*
Treatment	1	0.40*
Time	2	22.71*
Cultivar *Treatment	5	5.34*
Treatment *Time	2	1.53*
Cultivar *Time	10	3.77*
Cultivar *Treatment*Time	10	5.08*

* significant at $p< 0.05$

Table 3b Analysis of Variance of *L* values of mashed potatoes from yellow fleshed Cultivars, 2000 (AFTER MICROWAVE HEATING for 45 seconds)

Source	DF	Mean Square
Cultivar	1	22.40*
Treatment	1	1.44*
Time	2	26.49*
Cultivar *Treatment	1	0.49*
Treatment *Time	2	5.28*
Cultivar* Time	2	18.49*
Cultivar *Treatment*Time	2	3.67*

* significant at $p< 0.05$

Table 4a Effect of cultivar, treatment and storage (5 °C) on *L* values of mashed potatoes from white fleshed cultivars, 2000 (AFTER MICROWAVE HEATING for 45 seconds)

	0 days		7 days		14 days	
Cultivar	Control	Treated	Control	Treated	Control	Treated
Commerical	66.5^{a}	66.5^{a}	64.3^{a}	64.3^{a}	64.2^{a}	64.2^{a}
G277-2	68.4^{b}	70.0^{b**}	67.8^{b}	67.6^{b}	67.7^{b}	67.9^{b}
Atlantic	71.2^{c}	71.0^{c}	70.8^{c}	70.8^{c}	66.2^{c}	68.8^{c**}
MSG277-2	71.0^{c}	71.5^{c**}	70.9^{c}	71.0^{c}	67.4^{d}	66.7^{d**}
Pike	71.5^{d}	$71.7^{d.}$	71.8^{d}	71.6^{d}	70.7^{e}	71.3^{e}
Snowden	71.7^{d}	72.8^{e**}	71.7^{d}	72.9^{e**}	71.3^{f}	72.6^{f**}

[a] Means in a column not followed by the same letter differ ($p<0.05$)

**** significant different between mean of the treatment and control**

Table 4b Effect of cultivar, treatment and storage (5 °C) on *L* values of mashed potatoes from yellow fleshed cultivars, 2000 (AFTER MICROWAVE HEATING for 45 seconds)

	0 days		7 days		14 days	
Cultivar	Control	Treated	Control	Treated	Control	Treated
G274-3	69.1^{a}	$70.3^{a\ **}$	68.7^{a}	66.5^{a**}	68.7^{a}	67.8^{a**}
MSG274-3	71.2^{b}	$72.1^{b\ **}$	71.1^{b}	71.9^{b**}	68.3^{a}	$66.1^{b\ **}$

[a] Means in a column not followed by the same letter differ ($p<0.05$)

**** significant different between mean of the treatment and control**

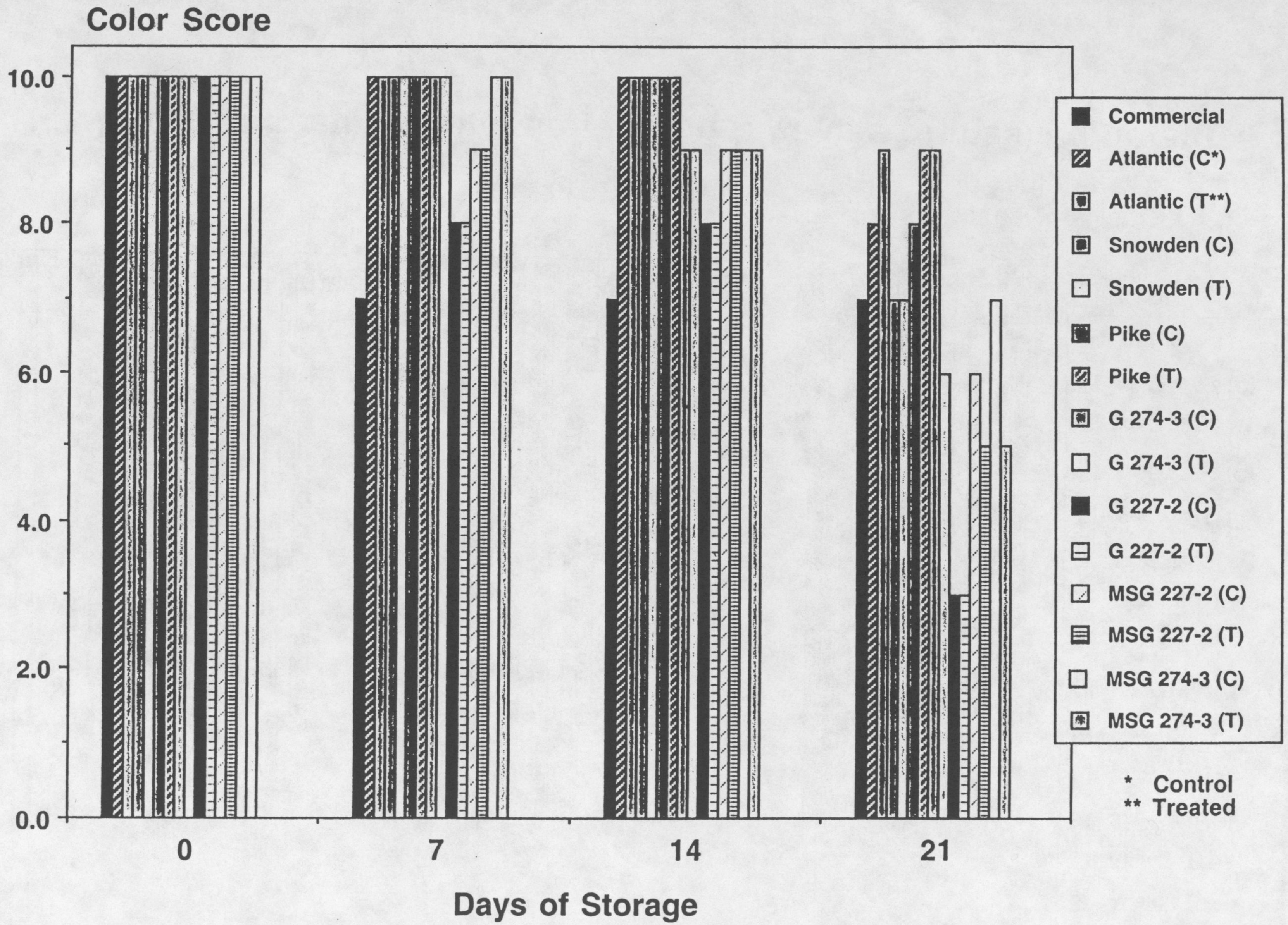


FIG 1. Effect of treatment and storage on sensory color scores of mashed potatoes

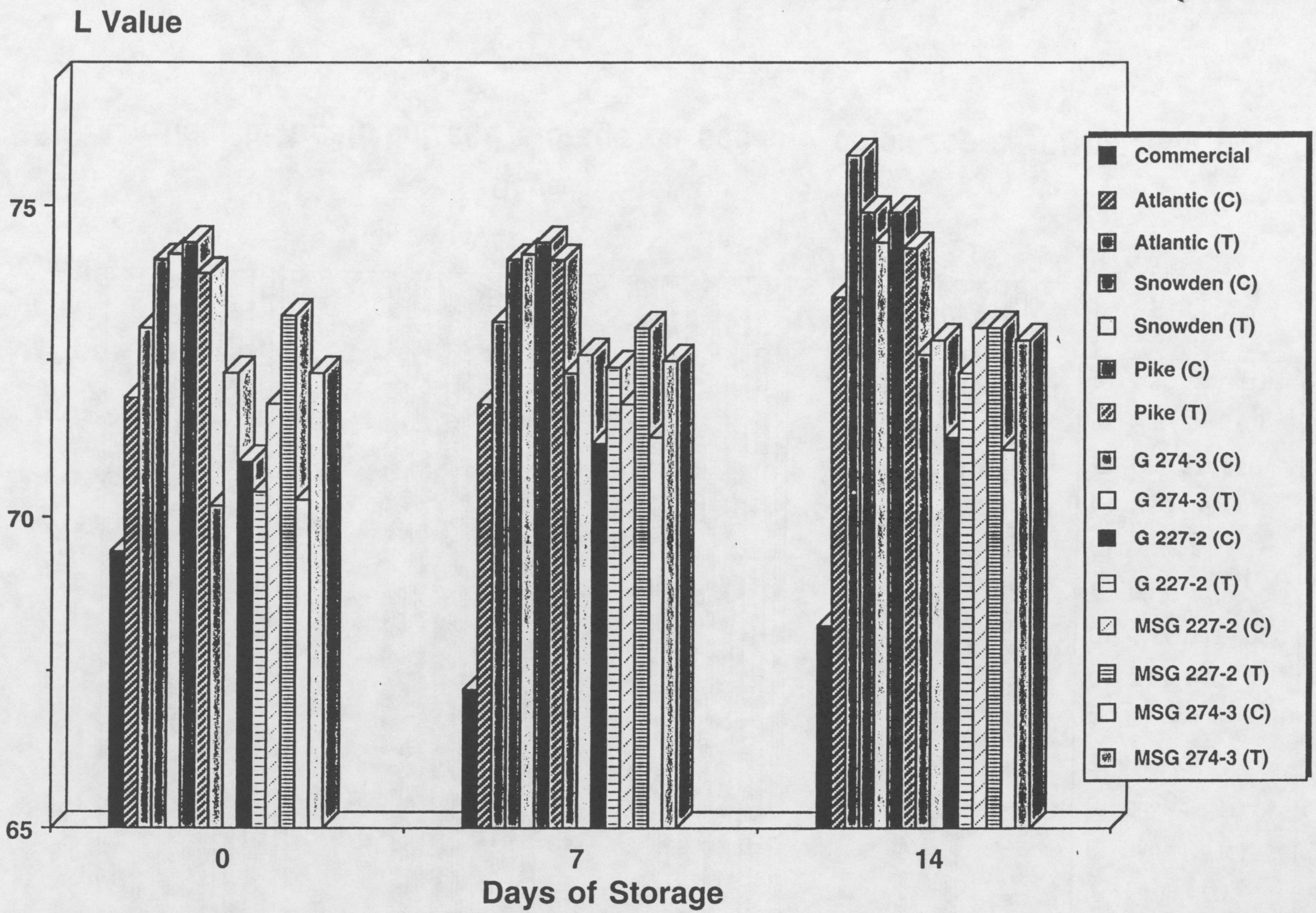


FIG 2. Effect of treatment and storage on L Values of mashed potatoes