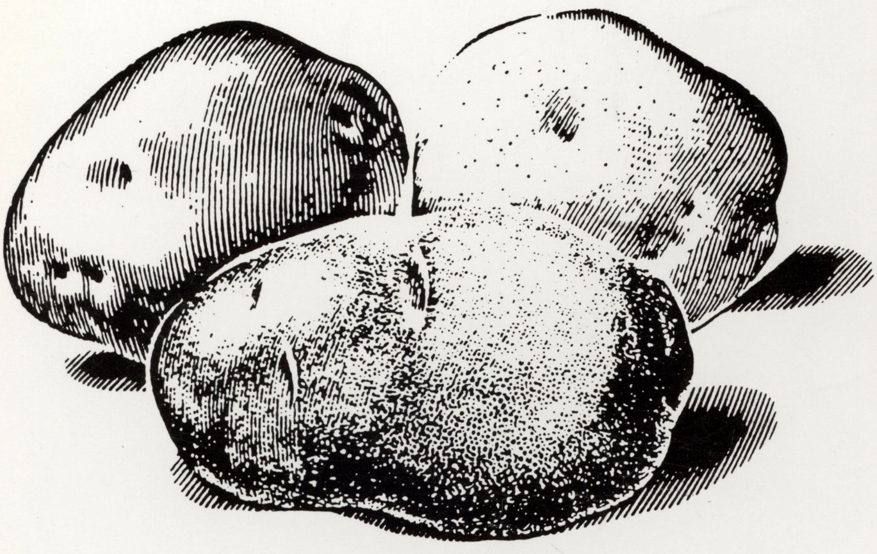
1995
MICHIGAN POTATO RESEARCH REPORT

VOLUME 27



Michigan State University
Agricultural Experiment Station

In Cooperation With

The Michigan Potato Industry Commission

February 13, 1996

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 1995 potato research projects.

This report includes research projects funded by the Michigan Potato Industry Commission as well as projects funded through the USDA Special Grant and other sources.

Providing research funding and direction to principal investigators at MSU is a function of the Michigan Potato Industry Commission's Research Committee.

Best wishes for a prosperous 1996 season,

The Michigan Potato Industry Commission

THE MICHIGAN POTATO INDUSTRY COMMISSION • 13109 SCHAVEY RD., STE. 7 • DEWITT, MI 48820 • (517) 669-8377

TABLE OF CONTENTS

1995 MSU POTATO RESEARCH REPORT

R.W. Chase, Coordinator

Introduction and Acknowledgements

The 1995 Potato Research Report contains reports of potato research projects conducted by MSU potato researchers at several different locations. The 1995 report is the 27th report which has been prepared annually since 1969. This volume includes research projects funded by the Special Federal Grant 92-34141-7158, the Michigan Potato Industry Commission 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 of 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 acknowledge the tremendous cooperation of individual producers who cooperate with 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.

Thanks go to Dick Crawford, for the day-to-day operations at the Research Farm; Chris Long, CSS Potato Technician and Dr. Kazimierz Jastrzebski, visiting scientist from Poland. Also, a special thanks to Jodie Schonfelder for the typing and preparation of this report and to MSUE Don Smucker, Montcalm CED for maintaining the weather records.

Weather

Weather during 1995 was very variable during the growing season. Average maximum temperatures were cooler in April and May, warmer in June, July and August and similar in September when compared with the 15 year average (Table 1). The greatest deviation occurred in the average minimum temperature and except for April and September, the temperatures were higher with the greatest deviation in August. In August, there were 15 days that the average minimum temperature did not go below 66F and in six of these days it did not go below 70F. This resulted in warm nights which lessens the potential for dry matter accumulation because of the increased respiration rate. In August, the average daily minimum temperature was 9° above the average. This did contribute to the lower than normal specific gravity values.

Rainfall data for the season was similar to the 15 year average (Table 2). In July it was 1.98 inches above the average and in September it was 2.84 inches below average and provided for excellent harvest weather.

Table 1. The 15 year summary of average maximum and minimum temperatures 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
1981	56	35	64	39	73	50	77	51	78	53	67	47	69	46
1982	53	28	72	46	70	44	80	53	76	48	66	44	70	44
1983	47	28	60	38	76	49	85	57	82	57	70	46	70	46
1984	54	34	60	39	77	54	78	53	83	55	69	45	70	47
1985	58	38	70	44	71	46	81	55	75	54	70	50	71	48
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
15-YR. AVG.	55	33	68	43	77	52	81	57	79	56	70	47	72	48

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
1981	4.19	3.52	3.44	1.23	3.48	3.82	19.68
1982	1.43	3.53	5.69	5.53	1.96	3.24	21.38
1983	3.47	4.46	1.19	2.44	2.21	5.34	19.11
1984	2.78	5.14	2.93	3.76	1.97	3.90	20.48
1985	3.63	1.94	2.78	2.58	4.72	3.30	18.95
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
15-YR. AVG.	2.96	2.97	3.13	3.27	4.22	4.22	20.76

Growing Degree Days

Table 3 summarizes the cumulative, base 50F, growing degree days (GDD) for May through September. These data show that the season started very cold with only 45% of the GDD recorded for May compared with the 452 GDD for May 1991, the unseasonably warm year. For the balance of the growing season, the GDD were higher than that of 1992, 1993 and 1994 but below that of 1991. The greatest increase occurred during August.

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

	Cumulative Monthly Totals				
	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

*1991 and 1992 data calculated from Vestaburg weather station in Montcalm County (Dr. Jeff Andresen, Geography). 1993, 1994 and 1995 data from the weather station at MSU Montcalm Research Farm (Don Smucker, Montcalm County Extension Director).

Previous Crops and Fertilizers

The general research plot area was planted to rye in 1994 and harvested for seed, disced and re-seeded to rye. The area was fall fumigated in 1994 using a field applicator. The following fertilizers were used in the general plot area:

Application	Analysis	Rate	Nutrients
Plowdown	0-0-60	200 lbs/A	0-0-120
In-furrow	20-10-10	300 lbs/A	60-30-30
Hilling - Round whites	45-0-0	165 lbs/A	75-0-0
- Long/Snowden	45-0-0	200 lbs/A	90-0-0
Fertigation - Round whites	28-0-0	15 gpa	45-0-0
- Long/Snowden	28-0-0	15 gpa (2X)	90-0-0

Soil Tests

Soil tests for the general plot area:

	lbs/A				
pH	P_2O_5	K_2O	Ca	Mg	Cation Exchange Capacity
5.8	465	160	436	107	2.9 me/100 g

Herbicides and Hilling

Hilling was done in late May, just prior to potato emergence, followed by a tank mix of metolachlor (Dual) at 2 lbs/A plus metribuzin (Sencor) at 2/3 lb/A.

Irrigation

Irrigation was initiated on June 17 and seven applications were made at 0.75 inches per application. There were three applications in June, two in July and one in each of August and September.

Insect and Disease Control

Admire was used in all plantings with excellent control of CPB. Additional foliar insecticides used were Asana + PBO, Neemix and Monitor. Fungicide applications were initiated on June 16 and continued on a 7-10 day schedule using Bravo, Dithane and Terranil.

Funding: Fed. Grant/MPIC

MICHIGAN STATE UNIVERSITY POTATO BREEDING PROGRAM
1995 STATUS REPORT

David S. Douches, K. Jastrzebski and Chris Long
Department of Crop and Soil Sciences

Cooperators: R.W. Chase, Ray Hammerschmidt, Ed Grafius
Jerry Cash and Willie Kirk

INTRODUCTION

The MSU program has a multi-faceted approach to variety development. We conduct variety trials of advanced selections, 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 expect to see directed improvement towards improved varieties. We are also using the European germplasm as a source of key traits. In addition, our program utilizes new biotechnologies such as genetic mapping and genetic engineering to improve varieties. 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 process.

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, Fusariun dry rot, soft rot, early die and virus resistance), chipping and cooking quality, storability, along with shape, internal quality and appearance.

PROCEDURE

I. Varietal Development

Each year, during the winter months, approximately 500 crosses are made between the most promising cultivars and advanced breeding lines. The parents are chosen on the basis of yield potential, chip or tablestock 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 30,000 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, 20-hill stages. The best selections are then tested in replicated 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 five species: S. tuberosum (adaptation, tuber appearance), S. phureja (cold-chipping, specific gravity), S. tarijense and berthaultii (tuber appearance, insect resistance) and S. chaconese (specific gravity, low sugars, dormancy).

We are also using other sources of germplasm to introgress disease resistance and tuber quality. Many European cultivars have high yield potential and resistance to various diseases such as scab, late blight and Erwinia soft rot. Some also have superior cooking qualities. These cultivars are being used in the crossing block each year. Dr. John Helgeson (USDA/ARS) has developed somatic fusion hybrids that have resistance to Erwinia soft rot, PLRV, Early Blight or Late Blight. We have those lines and have been crossing them to our best lines to initiate the adaptation of this germplasm source to Michigan.

III. Linking Genetic Markers with Potato Tuber Quality Traits

DNA (restriction fragment length polymorphisms or RFLPs) and protein markers (isozymes) have excellent prospects for the rapid development of new breeding methodologies that can take advantage of current molecular biology techniques. Analysis of RFLPs has recently become feasible in potato and provides a genetic map with sufficient resolution to indicate the numbers, types, and distributions of genes influencing quantitatively inherited traits (traits controlled by many genes). The most important traits in potato are quantitatively inherited. With a detailed genetic map we are developing and applying a new approach to breeding quantitatively inherited traits, (i.e. chip-processing ability, specific gravity and tuber dormancy) in potato, which is referred to as quantitative trait loci analysis or QTL analysis.

IV. Correlation of Chip-processing in Greenhouse and Field-grown Tubers

The initial field selection of single hills in the breeding program leaves a large percentage of genotypes behind. If chip-processing quality is of primary importance, we must devise a procedure to identify the superior chip-processors. We are testing whether the greenhouse-generated tubers would chip-process. If so, we can compare greenhouse chip color with field-grown chip color. This study was established for 1995.

V. Integration of Genetic Engineering with Potato Breeding

Our laboratory is set up to use Agrobacterium-mediated transformation to introduce genes into important potato cultivars. We presently have genes that confer resistance to PVY, PLRV, Colorado Potato Beetle and the Potato tuber moth. We also have the glgC16 gene or starch gene from Monsanto to influence starch and sugar levels in potato tubers. We have transgenic lines that express the PVYcp and Bt genes. Transformations with the starch gene are presently being conducted.

RESULTS AND DISCUSSION

One of our objectives is 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 which carry many of the characteristics mentioned above. Our goal now is to improve further on the level of scab resistance and begin to incorporate resistance to late blight.

Another one of the objectives is to develop potato varieties that will not accumulate reducing sugars in cold storage (40F). We commonly call these varieties "cold chippers". There is a question as to which temperature is most appropriate to screen for cold-chipping. We have chosen, as our initial screen, to chip-process directly out of 45F storage. We feel there is no long-term value in 2-4 week reconditioning out of 40F storage, and we do not want to reduce the number of selections too quickly in the breeding program. If we do select too hard and too soon, we may lose the opportunity to combine other important traits (i.e. yield, specific gravity, disease resistance, etc..) along with cold-chipping. As desirable cold-chipping genes accumulate in the breeding program, we will reduce the storage temperature for screening to 40F.

Some of the parents used in the crossing block over the past few years has included Snowden, ND860-2, MS702-80, Atlantic, S440, Lemhi Russet, E55-35, Chipeta, W877, etc. In addition, we have advanced into the crossing block new MSU selections that have enhanced chip quality directly out of 45F storage and other new 45F chippers from the US and Europe such as ND2417-6, ND01496-1, NDA2031-2 and Brodick. These clones constitute a diverse genetic base from which to combine good chipping quality with agronomic performance.

For the 1995 field season over 350 crosses have been planted. Of those six percent of the crosses were between long types, ninety percent between round whites, and four percent each were crosses to select red-skinned and yellow-flesh varieties. During the 1994 harvest, approximately 1600 selections were made from the 30,000 seedlings grown at the Montcalm Research Farm and Lake City Experiment Station. Following harvest, specific gravity was measured and chip-processing (from 45F storage) was tested January, 1995 directly out of storage. This storage period allowed enough time for reducing sugars to accumulate in these selections. Atlantic (unacceptable) and Snowden (excellent) were chipped as check cultivars. When chipped directly out of 45F storage, about 8.75% of the single-hill selections had acceptable chip color. These selections are being evaluated as 8-hill selections in 1995. Of the 8-hill selections from 1994, 21% of the 270 clones chip-processed with acceptable color directly out of 45F. From the 100 twenty-hill plots, 22% had acceptable chip color from 45F storage. Sixty-five of these clones were tested in the 2x23-hill and Adaptation trials in 1995 (Tables 1 and 2). Erwinia soft rot tests, scab trial results and blackspot bruise tests are found in Tables 3, 4 and 5, respectively.

We further tested these acceptable 8-hill and 20-hill selections for chip-processing directly out of 40F storage. Results showed that genetic variation exists among these selections for sugar accumulation. Acceptable chip color was observed directly out of 40F for a few selections in 1994, but retesting in 1995 showed greater sugar accumulation. In addition, the best lines have been incorporated into the 1995 crossing block.

The previous years chip data also feeds information back to the crossing program. When we examined the pedigrees of these selections, a number of parents were identified that contribute to cold-chipping out of 45F storage. These were ND860-2, ND2008-2, W877, S440, MS702-80, Snowden, E55-35, E55-44 and Lemhi Russet. For 1993 we continued to use these parents in the MSU crossing block to breed superior chip-processing potatoes. In addition, we have advanced selections from previous breeding cycles into the crossing block that have one or two of the parents in the pedigree. Hence, we are beginning to concentrate genes for cold-chipping while maintaining a broad genetic base.

In the diploid germplasm about 20 of the best lines with differing pedigrees formed the crossing block to generate new populations in 1995. From this material we expect to find improved diploid *Solanum* species parents to be used in crosses to select new varieties. These crosses will be planted to obtain tuber families for the 1996 growing season. We added to the germplasm enhancement program a number of genetic lines that are derivatives of cell (protoplast) fusions between *S. brevidens* (from Argentina) and the cultivated potato. These lines were developed by J. Helgeson at the University of Wisconsin and have been noted for their *Erwinia* soft rot, early blight and PLRV resistance. Through further crossing and evaluation we hope to incorporate these resistances into the breeding populations we have been selecting for chip-processing. These populations were in the field this season and selections were made. This germplasm enhancement (diploid and protoplast fusion) is the base from which long-term genetic improvement of the potato varieties in the MSU breeding program is generated.

The objective of gene mapping research is to identify genetic associations (or linkages) between genetic markers (isozymes, RAPDs and RFLPs) and genes controlling specific gravity, tuber dormancy and chip color in diploid potatoes. The identification of these genetic linkages will make it more efficient to breed in the traits from the diploid breeding program to the cultivated gene pool. Twenty-two linkages have been found between the mapped genetic markers and chromosome segments controlling specific gravity and tuber dormancy, while six linkages were identified for chip-processing. These linkages to chip color explain 50% of the genetic variation observed in the population. Linkage analysis indicates that these genes are distributed on at least six chromosomes.

We are currently testing the efficiency of making selection upon the genetic marker linked to these traits. We will be collecting data in 1995 and 1996 from field trials located at Montcalm Research Farm. Ultimately we hope to be able to breed in these valuable genes by tracking with these genetic markers from the diploid to cultivated (tetraploid) level.

We have a number transgenic lines which express the PVYcp and Bt genes. These will be field tested in 1996 in observation trials at MRF. We hope to have transgenics that carry the starch gene and PLRVcp by summer also. We hope that the starch gene may enhance our efforts to achieve cold-chipping potato cultivars.

Table 1

ADAPTATION TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 12, 1995
(117 DAYS)

	CWT/A		PERCENT OF TOTAL[1]							TUBER QUALITY[2]				TOTAL
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SFA	HH	VD	1BS	BC	CUT
E221-1	475	524	91	4	57	3	6	1.060	--	5	0	0	0	40
P88-9-8	458	552	83	12	68	15	5	1.068	3.5	3	0	2	0	40
AF1470-17	455	558	81	9	65	16	10	1.054	--	7	0	0	26	40
E230-6	423	526	80	15	79	1	4	1.082	1.5	0	0	1	0	11
SUPERIOR	416	451	92	6	85	7	2	1.064	--	1	0	0	0	17
ATLANTIC	407	441	92	5	82	11	3	1.079	1.5	21	0	1	1	33
E009-01	398	470	85	11	72	12	4	1.068	--	0	1	0	0	25
MSB110-3	384	469	82	15	75	6	3	1.080	1.5	4	0	1	0	20
E011-07	377	409	92	6	85	8	2	1.078	1.0	9	0	0	3	23
C148-A	376	424	89	9	77	11	3	1.073	1.0	9	1	0	0	26
E066-04	366	483	76	13	62	13	11	1.070	--	0	2	0	0	34
E048-01Y	356	419	85	11	81	4	4	1.075	2.0	0	0	1	0	14
E228-1	352	419	84	12	75	9	4	1.077	--	0	1	0	0	28
M28-3	350	379	92	4	57	36	4	1.063	1.0	2	0	2	3	30
E239-5	348	403	86	10	74	12	3	1.076	--	23	0	0	3	30
E084-5	348	413	84	10	70	14	5	1.069	1.5	14	0	0	0	24
E033-01RD	346	382	91	7	82	9	2	1.059	--	2	0	0	6	30
E074-02	344	389	88	10	77	11	2	1.074	2.0	6	0	1	0	28
E056-02	340	412	83	13	68	14	4	1.074	--	8	5	0	0	29
E247-2	338	474	71	22	64	8	7	1.074	1.0	0	1	2	0	28
E263-10	338	363	93	6	77	16	1	1.066	1.0	0	1	0	0	32
E263-3	335	427	79	18	78	1	4	1.071	2.0	2	0	0	0	3
E011-11	332	374	89	6	76	13	5	1.067	--	2	3	0	1	28
M39-4	329	371	89	8	77	11	3	1.077	1.0	14	0	3	0	28
M14-6	324	348	93	4	44	49	3	1.071	1.5	3	1	3	1	30
E265-1	321	403	80	14	73	6	6	1.080	1.5	0	0	2	0	20
E080-4	316	371	85	8	63	22	7	1.067	--	2	0	1	0	38
E011-25	310	367	84	13	83	1	3	1.069	1.0	0	0	0	0	4
E290-1Y	303	346	88	9	7	14	4	1.070	2.0	8	0	1	4	32
P88-13-4	299	422	71	26	67	4	3	1.077	1.5	0	0	0	0	12
E010-13	296	351	84	12	77	7	3	1.076	2.0	6	0	8	1	18
E246-5	293	377	78	19	77	1	3	1.090	1.5	0	0	0	0	3
E271-1	288	370	78	10	50	28	12	1.074	--	9	0	1	1	40
M19-4	285	326	87	6	63	24	6	1.064	1.5	2	3	12	0	36
E011-14	279	314	89	5	58	31	6	1.069	2.0	8	2	8	2	38
M14-1	271	318	85	10	76	9	5	1.069	1.5	1	0	1	2	20
E004-05	264	349	76	23	75	1	1	1.081	1.0	1	0	0	0	2
E228-9	262	303	87	10	70	17	4	1.068	--	0	0	0	0	29
E192-8	255	340	75	21	64	12	4	1.064	--	4	0	0	1	24
E215-12	254	351	72	24	72	0	4	1.070	1.0	0	0	0	0	0
E002-04	241	300	80	14	79	1	5	1.067	1.0	1	0	0	0	3
E290-6Y	233	319	73	15	69	4	12	1.070	2.0	1	0	2	2	8

E218-29	221	299	74	17	69	5	9	1.074	1.5	0	0	0	0	11
E220-14	211	263	80	16	77	3	4	1.077	1.0	2	0	0	0	6
MSB095-2	208	287	73	24	71	2	4	1.079	2.0	0	0	1	1	4
E250-2	202	261	77	19	74	4	4	1.079	2.0	3	0	0	0	7
C122-A	198	272	73	25	71	2	2	1.071	2.5	1	1	0	0	4
C100-B	177	220	80	13	67	14	7	1.067	1.5	7	0	1	1	21
E234-3	144	180	80	16	76	4	5	1.068	1.5	0	0	0	2	7
PEMBINA CH	134	241	55	33	55	0	11	1.059	1.0	0	0	0	0	1
$LSD_{0.05}$	84	83						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

PLANTED MAY 15, 1995

Table 2

MSU BREEDING LINE EVALUATION
MONTCALM RESEARCH FARM
SEPTEMBER 20, 1995
(127 DAYS)

	CWT/A		PERCENT OF TOTAL[1]							TUBER QUALITY[2]				TOTAL
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SFA	HH	VD	IBS	BC	CUT
E228-1	587	656	89	8	71	19	2	1.060	--	0	0	1	0	10
E041-1	584	659	89	9	78	10	2	1.073	--	0	0	0	0	18
E222-5Y	573	683	84	12	79	5	4	1.074	--	3	0	0	0	15
E018-1	515	585	88	9	75	13	3	1.084	3.0	0	0	0	0	20
E048-2Y	505	546	92	6	79	13	2	1.069	--	1	0	0	0	13
E220-3	494	540	92	8	83	9	1	1.069	--	1	0	4	1	20
E149-5Y	484	576	84	12	77	7	4	1.062	1.5	1	0	0	0	18
E222-18	470	602	78	11	73	5	11	1.061	--	0	0	13	1	13
E030-4	467	530	88	10	79	9	2	1.067	--	0	0	0	0	11
E226-4Y	442	528	84	11	73	11	5	1.058	--	0	0	0	3	20
E276-5	434	548	79	6	55	24	15	1.074	--	0	0	1	0	20
E009-4	431	505	85	8	76	9	7	1.062	--	0	2	0	1	18
E028-1	428	505	85	12	84	1	3	1.059	--	0	0	0	0	1
E213-2	421	493	85	13	83	3	2	1.066	--	2	0	4	0	5
P88-15-1	415	506	82	6	48	34	12	1.061	--	0	1	7	6	20
E229-3Y	415	535	78	18	75	2	5	1.060	--	2	0	4	0	2
E012-01	415	449	92	4	68	24	3	1.061	--	0	0	0	0	20
SUPERIOR	407	443	92	7	85	7	2	1.063	--	0	0	3	0	11
E226-5	405	467	87	11	75	11	3	1.063	--	0	0	0	0	8
E006-14	395	436	91	7	73	18	2	1.065	2.0	5	0	0	0	12
E026-5	395	441	90	6	67	22	4	1.068	2.0	3	0	1	0	20
E037-4Y	388	472	82	15	79	3	3	1.073	--	0	0	1	0	6
E228-3	388	448	87	11	84	2	2	1.071	--	0	0	0	0	4
E028-4	387	427	91	6	76	15	3	1.055	--	1	0	1	0	13
LEMHI RUSS	382	534	72	24	62	9	4	1.075	--	1	1	2	0	17
E228-5	376	468	80	13	69	11	7	1.069	--	0	0	3	0	20
E040-6RY	367	483	76	22	72	4	2	1.062	--	0	0	0	0	7
E012-2	361	407	89	8	82	7	3	1.059	--	0	0	0	0	10
E011-31	351	412	85	12	78	7	3	1.064	--	0	0	1	0	12
ATLANTIC	348	386	90	6	72	18	4	1.075	1.5	11	0	8	0	17
SNOWDEN	345	428	81	14	72	8	6	1.068	1.5	0	0	4	0	16
E021-4	344	406	85	14	79	6	1	1.065	--	0	0	0	0	10
E218-15	340	418	81	16	78	4	3	1.066	1.5	0	0	0	0	7
E218-25	340	442	77	16	72	5	7	1.065	1.5	0	0	0	0	8
E011-10	331	374	89	7	81	7	4	1.076	--	2	0	0	2	11
E229-16Y	328	411	80	12	67	13	8	1.054	--	2	0	1	0	20
E273-8	324	378	86	10	67	19	4	1.067	2.0	1	0	0	0	16
E239-3	318	441	72	20	69	3	8	1.068	--	0	0	0	0	5
E230-13	317	358	89	7	70	18	5	1.060	--	0	0	0	0	18
E006-3	315	385	82	16	79	3	2	1.070	1.0	0	2	0	1	6
C010-20Y	307	359	86	7	75	11	7	1.058	1.5	0	0	5	1	15
E001-28	264	308	86	10	79	7	5	1.063	2.0	2	0	5	0	8

E015-2	263	297	88	8	73	15	4	1.067	--	0	0	0	2	14
E234-7	262	312	84	13	74	10	3	1.071	--	0	0	2	0	14
E246-1	260	309	84	11	78	6	5	1.070	1.5	0	0	0	3	10
E230-3	255	331	77	17	77	0	6	1.068	2.0	0	0	0	0	0
E218-19	251	349	72	15	67	5	13	1.062	--	1	0	0	1	6
E013-1	243	333	73	22	72	1	5	1.061	--	0	0	0	0	2
E304-4Y	241	482	50	33	50	0	17	1.057	--	0	0	0	0	0
E228-8	237	307	77	13	74	3	10	1.061	--	0	0	0	0	4
E218-30	202	262	77	17	68	9	6	1.069	--	0	0	0	0	9
C127-A	201	253	80	14	77	2	6	1.055	--	0	0	0	0	2
E001-27	185	340	55	41	55	0	5	1.075	--	0	0	0	0	0
C113-A	169	208	81	13	59	23	6	1.069	--	1	0	7	0	18
E007-8	90	189	47	53	47	0	0	1.085	--	0	0	0	0	0
$LSD_{0.05}$	113	116						0.006						

[1]SIZE

B - < 2"
A - 2-3.25"
OV - > 3.25"
PO - PICKOUTS

[2]QUALITY

HH - HOLLOW HEART
BC - BROWN CENTER
VD - VASCULAR DISCOLORATION
IBS - INTERNAL BROWN SPOT

PLANTED MAY 15, 1995

Table 3 1995 TUBER DISEASE EVALUATIONS

		ERWINIA		FUSARIUM DRY ROT				ERWINIA		FUSARIUM DRY ROT	
LINE	TRIAL	Test1	Test2	Ave.#	Severity	LINE	TRIAL	Test1	Test2	Ave.#	Severity
ATLANTIC	2X23	3		0	9	AF1470-17	AD	5		0.5	8
C010-20Y	2X23		1.5			ATLANTIC	AD	4		0	8.5
C113-A	2X23	3		3	5	C100-B	AD	4		1	7
C127-A	2X23	3		1	4.5	C122-A	AD	3		1.5	5.5
E001-28	2X23		2			C148-A	AD	3		0	8
E006-14	2X23	2				E002-04	AD	4		0	9
E009-4	2X23	5		5	2	E004-5	AD	2		2.5	3.5
E011-10	2X23		4			E009-01	AD	3		0	6.5
E011-31	2X23		2			E010-13	AD	3		0	8
E012-1	2X23	3		0	7.5	E011-07	AD	5		1	6
E012-2	2X23		1			E011-11	AD	4		0	8
E013-1	2X23	2		1.5	6	E011-14	AD	2		1.5	7
E015-2	2X23	3		5	1.5	E011-25	AD	4		2	2
E018-1	2X23	2		8.5	1	E033-01RD	AD	2		0	6
E021-4	2X23	1	2	2.5	4	E048-01Y	AD	4		0	8
E028-1	2X23	2.5		6	2	E056-2	AD	1	3	2	4
E028-4	2X23	4		4	2	E066-4	AD	2		4.5	4.5
E030-4	2X23	2		3	2	E074-02	AD	2		1	5.5
E037-4Y	2X23	2		5	2.3	E080-4	AD	4		2	2
E040-6RY	2X23	1	2	6	1.5	E084-5	AD	2		0.5	8
E041-1	2X23	1	1	5.5	2	E192-8	AD	3		3.5	2
E048-2Y	2X23	3		0.5	4	E215-12	AD	5		0	7.5
E149-5Y	2X23		4			E218-29	AD	3		4.5	2
E213-2	2X23	4		3.5	3	E220-14	AD	4		0.5	5
E218-15	2X23	4		4.5	3	E221-1	AD	5		0.5	5
E218-19	2X23	2	3	7	1.5	E228-09	AD	4		0.5	6
E218-25	2X23	1	1	5	3.5	E228-11	AD	1	3	0	9
E218-30	2X23	1	3	3.5	4	E230-6	AD	1	2	4.5	3
E220-3	2X23	3		3.5	3.5	E234-3	AD	2		0	8
E222-18	2X23	4		0	3	E239-5	AD	2		0	9
E222-5Y	2X23	1	4	4.5	1.5	E246-5	AD	1	3	0	8
E226-4Y	2X23	5		5	3.5	E247-2	AD	2		3	3
E226-5Y	2X23	2		0	7	E250-2	AD	3		5.5	1.5
E228-1	2X23	1	2	0	6.5	E263-03	AD	5		2	6
E228-3	2X23	3		4	2.5	E263-10	AD	3		4	5.5
E228-5	2X23	1	3	3	2	E265-1	AD	2		4.5	3.5
E228-8	2X23	2		3.5	4.5	E271-1	AD	2		1	7.5
E229-16	2X23	2		0.5	6	E290-1Y	AD	5		0	7
E229-3	2X23	3		0	8	E290-6Y	AD	1	2	1	8.5
E230-13	2X23	3		2	3.5	M14-1	AD	5		0	9
E230-3	2X23	1	2	0.5	5	M14-6	AD	5		4.5	2.5
E234-7	2X23	2		0	8.5	M19-4	AD	2		3	2.5
E239-3	2X23	2		0	6	M28-3	AD	4		2	2
E246-1	2X23	3		3.5	3	M39-4	AD	3		2.5	6
E273-8	2X23	2		4.5	3.5	MSB095-2	AD	3		2	6.5
E276-5	2X23	2		7.5	1.5	MSB110-3	AD	1	3	1.5	5.5
E304-4Y	2X23	3		0	9	P88-13-4	AD	2		9	1
LEMHI RUSSET	2X23	3		4	2	P88-9-8	AD	2		0	4
P88-15-1	2X23	2		8	1	PEMBINA CH	AD	2		2	2.5
SNOWDEN	2X23	2		7	1.5	SUPERIOR	AD	2	1	6.5	1.5

Table 4 1995 Scab Trial: MSU Lines

CLONE	RATING	CLONE	RATING
E007-8	1	C122-A	3
E192-8	1	E004-5	3
E222-8	1	E006-3	3
E228-3	1	E009-4	3
MSB106-8	1	E011-10	3
C010-20Y	1.5	E011-31	3
C113-A	1.5	E013-1	3
E011-7	1.5	E021-4	3
E033-1RD	1.5	E041-1	3
E048-2Y	1.5	E218-19	3
E221-1	1.5	E230-13	3
E226-4Y	1.5	E230-3	3
E228-9	1.5	E234-3	3
E271-1	1.5	E234-7	3
MSA091-1	1.5	E239-3	3
MSB076-2	1.5	E239-5	3
P84-13-12	1.5	E246-1	3
C127-A	2	E246-5	3
E001-28	2	E265-1	3
E011-25	2	MSB095-2	3
E012-01	2	MSB110-3	3
E015-2	2	P88-9-8	3
E048-1Y	2	E011-11	3.5
E066-4	2	E018-1	3.5
E222-18	2	E030-4	3.5
E222-5Y	2	E037-4Y	3.5
E228-1	2	E218-15	3.5
E247-2	2	E218-25	3.5
E250-2	2	E228-11	3.5
E263-3	2	E229-16Y	3.5
E290-1Y	2	E276-5	3.5
E304-4Y	2	P88-15-1	3.5
MSD040-4RY	2	E010-13	4
P88-13-4	2	E011-14	4
C100-B	2.5	E026-5	4
C148-A	2.5	E031-1	4
E001-27	2.5	E040-6RY	4
E002-4	2.5	E056-2	4
E006-14	2.5	E074-2	4
E009-1	2.5	E228-5	4
E028-1	2.5	E229-3Y	4
E028-4	2.5	E263-10	4
E226-5	2.5	E273-8	4
E230-6	2.5	B007-1	4.5
E290-6Y	2.5	E218-29	4.5
MSB083-1	2.5	E218-30	4.5
MSB107-1	2.5		

Table 5 1995 BLACKSPOT SUSCEPTIBILITY STUDY

A. SIMULATED BRUISE SAMPLES

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	% BRUISE FREE	AVE SPOTS/TUBER
2X23 TRIAL									
ATLANTIC	3	6	5	6			20	15	1.700
C010-20Y	13	4	1	2			20	65	0.600
C113-A	7	4	5	3	1		20	35	1.350
C127-A	13	6	1				20	65	0.400
E001-28	7	6	4	3			20	35	1.150
E006-3	16	3	1				20	80	0.250
E011-10	1	6	5	3	2	3	20	5	2.400
E011-31	10	8	1			1	20	50	0.750
E012-01	10	7	1	1	1		20	50	0.800
E012-2	19		1				20	95	0.100
E018-1	3	2	3	6	3	3	20	15	2.650
E021-4	17	1	2				20	85	0.250
E026-5	7	6	4	3			20	35	1.150
E028-1	16	4					20	80	0.200
E028-4	12	5	2	1			20	60	0.600
E030-4	7	5	5	2	1		20	35	1.250
E037-4Y	12	5	3				20	60	0.550
E040-6RY	13	6	1				20	65	0.400 MIXED COL
E041-1	20						20	100	0.000
E048-2Y	15	2	1	2			20	75	0.500
E149-5Y	3	7	4	4	1	1	20	15	1.800
E213-2	2	6	8	2	2		20	10	1.800
E218-15	10	2	6	1		1	20	50	1.100
E218-19	2	4	6	3		5	20	10	2.500
E218-25	2	1	4	3	3	7	20	10	3.250
E218-30	13	1	5	1			20	65	0.700
E220-3	10	6	2	2			20	50	0.800
E222-5Y	1	4	7	4	1	3	20	5	2.450
E226-4Y	7	6	6		1		20	35	1.100
E226-5	4	5	6	4		1	20	20	1.700
E228-1	13	3	4				20	65	0.550
E228-3	3	9	4	4			20	15	1.450
E228-5	16	4					20	80	0.200
E228-8	8	6	3		3		20	40	1.200
E229-16Y	16	3	1				20	80	0.250
E229-3Y	6	3		1			10	60	0.600
E230-13	12	7		1			20	60	0.500
E230-3	16	2	2				20	80	0.300
E234-3	15	1	3	1			20	75	0.500
E239-3	16	3	1				20	80	0.250
E246-1	7	8	3	1	1		20	35	1.050
E276-5	7	9	3	1			20	35	0.900
LEMHI R	1		3	6	4	6	20	5	3.500
SNOWDEN	8	5	6	1			20	40	1.000
SUPERIOR	5	11	2	2			20	25	1.050

ADAPTATION

ATLANTIC	10	1	3		1		15	67	0.733
C100-B	7	5	2				14	50	0.643
C122-A	10	3					13	77	0.231
C148-A	2	5	7	1			15	13	1.467
DR NORLAND	14	3	3				20	70	0.450
E002-04	13				1		14	93	0.286
E004-05	11	3		1			15	73	0.400
E009-01	13	3					16	81	0.188
E010-13	9	4	1				14	64	0.429
E011-07	4	6	3				13	31	0.923
E011-11	8	4	3				15	53	0.667
E011-14	17	2	1				20	85	0.200
E011-25	14	3	1				18	78	0.278
E048-01Y	12	1	1				14	86	0.214
E056-02	10	5					15	67	0.333
E074-02	12	3					15	80	0.200
E080-4	14	3	2	1			20	70	0.500
E084-5	10	4	1				15	67	0.400
E192-8	13	3					16	81	0.188
E215-12	11	2					13	85	0.154
E218-29	1	7	2	1			11	9	1.273
E220-14	8	7					15	53	0.467
E221-1	10	5					15	67	0.333
E228-11	11	3	1				15	73	0.333
E228-9	14	1					15	93	0.067
E230-6	11	4					15	73	0.267
E234-3	11	4					15	73	0.267
E239-5	11	4	0	0			15	73	0.267
E246-5	16	3	1				20	80	0.250
E247-2	4	6	3	1		1	15	27	1.333
E263-10	13	2					15	87	0.133
E263-3	12	1	2				15	80	0.333
E265-1	15	2					17	88	0.118
E271-1	4	6	2	1	2	1	16	25	1.625
E290-1Y	13	2					15	87	0.133
E290-6Y	11	4					15	73	0.267
M14-1	6	4					10	60	0.400
M14-6	7	4					11	64	0.364
M19-4	7	5	2				14	50	0.643
M28-3	2	4	4	3	1	1	15	13	2.000
M39-4	11	4					15	73	0.267
MSB095-2	11	3	1				15	73	0.333
MSB110-3	6	6	2				14	43	0.714
P88-13-4	5	6	3	1			15	33	1.000
P88-9-8	7	5	2				14	50	0.643
PEMBINA CHIPPER	5	3	1				9	56	0.556
SUPERIOR	15	1					16	94	0.063

1995 BLACKSPOT SUSCEPTIBILITY STUDY

B. CHECK BRUISE SAMPLES

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	% BRUISE FREE	AVE SPOTS/TUBER
ADAPTATION									
AF1470-17	15						15	100	0.000
ATLANTIC	12	3					15	80	0.200
C100-13	14	1					15	93	0.067
C122-A	14	2					16	88	0.125
C148-A	14	1					15	93	0.067
E002-04	14	1					15	93	0.067
E004-05	14	2					16	88	0.125
E009-01	16						16	100	0.000
E010-13	13	2					15	87	0.133
E011-07	2	4					6	33	0.667
E011-11	12	1	1	1			15	80	0.400
E011-14	13	1	1				15	87	0.200
E011-25	14	1					15	93	0.067
E033-01RD	12	3					15	80	0.200
E048-01Y	14	1					15	93	0.067
E056-02	15	1					16	94	0.063
E066-04	15	1					16	94	0.063
E074-02	14	1					15	93	0.067
E080-4	12	3					15	80	0.200
E084-5	12	2	1				15	80	0.267
E192-8	15						15	100	0.000
E215-12	14	2					16	88	0.125
E218-29	11	4					15	73	0.267
E220-14	13	3					16	81	0.188
E221-1	14	1					15	93	0.067
E228-11	14					1	15	93	0.333
E228-9	14	1	1				16	88	0.188
E230-6	15						15	100	0.000
E234-3	15						15	100	0.000
E239-5	14	1					15	93	0.067
E246-5	14	2					16	88	0.125
E247-2	15						15	100	0.000
E250-2	15	1					16	94	0.063
E263-10	14						14	100	0.000
E263-3	14	1					15	93	0.067
E265-1	14	2					16	88	0.125
E271-1	14	1					15	93	0.067
E290-1Y	12	3					15	80	0.200
E290-6Y	16						16	100	0.000
M14-1	9	11					20	45	0.550
M14-6	13	2					15	87	0.133
M19-4	14	1					15	93	0.067
M28-3	14	1					15	93	0.067
M39-4	15						15	100	0.000

MSB095-2	13	2		15	87	0.133
MSB110-3	13	2		15	87	0.133
P88-13-4	13	1	1	15	87	0.200
P88-9-8	17			17	100	0.000
PEMBINA CHIPPER	13	3		16	81	0.188
SUPERIOR	14			14	100	0.000

Funding Fed. Grant/MPIC

1995 POTATO VARIETY EVALUATIONS

R.W. Chase, D.S. Douches, K. Jastrzebski, R. Hammerschmidt, C. Long, D. Maas, Peter Hudy, K. Walters and R. Leep

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

The objectives of the evaluation are to identify superior varieties for fresh market or for processing and to develop recommendations for the growers 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, 45 and 50 F storage), after cooking darkening, dormancy (at 50F), as well as susceptibilities to common scab, Fusarium dry rot, Erwinia soft rot and blackspot bruising are determined. We are now in the process of integrating late blight resistance testing into the evaluation procedure.

Six field experiments were conducted at the Montcalm Research Farm in Entrican. 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. The trials were planted to fumigated ground and supplemental irrigation was applied as needed.

Both round and long variety groups were harvested at two dates. They are referred to as the Date-of-Harvest trials. The other two field experiments were the North Central Regional and European 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 45 or 50°F for chip-processing out of storage in January and March.

Results

A. Round White Varieties

Fourteen varieties and 11 breeding lines were compared at two harvest dates. Atlantic, Snowden, Onaway and Superior were used as checks. The average yield was high as in 1994 but specific gravity values were well below normal levels. Internal brown spot was prevalent in the late harvest. The results are presented in Tables 1 and 2.

Variety Characteristics

Chaleur - medium-early fresh market variety from Canada. Yield and specific gravity were low during 4 years of testing in Michigan. Tubers were large, few per hill, and of good appearance with a very good flesh color. Internal defects are low. It is reported to have moderate resistance to scab but scab tests in 1995 suggest that it has moderate susceptibility to scab. The testing of this line will be discontinued.

Portage - early to medium-early fresh market variety. Showed good yield potential and tuber appearance was good, specific gravity low, and very susceptible to scab. Internal defects were prevalent in the previous two years. In 1995 it yielded well in the early trial but had only average yields in the later harvest. The testing of this line will be discontinued.

Prestile - very late, fresh market variety from Maine. It has shown excellent yield potential and good tuber shape, specific gravity is medium and it is resistant to scab. Internal defects have been low in previous years but IBS was prevalent in the oversize tubers in 1995. The testing of this line will be discontinued as no seed acreage has been maintained.

Mainestay (AF1060-2) - late, fresh market variety of high yield potential and excellent internal quality, but low specific gravity. It is susceptible to scab. Mainestay performed above average in the trials but has shown higher yield potential in some on-farm trials.

St. Johns - tested in 1993 as AF828-5, medium late fresh-market variety of high yield potential (but consistently lower than AF1060-2), but low specific gravity. There was some variation in shape, but general appearance was good with large tubers and excellent internal quality. In 1995 its performance was quite good, however, it is susceptible to scab infection.

MSB076-2 - this MSU selection is high yielding, has very high specific gravity, acceptable chip quality and resistant to scab. In 1995 the yield was similar to Atlantic and we observed a tendency for hollow heart in oversize tubers.

AC Ptarmigan - this protected variety from Ag Canada is a high yielding clone with excellent internal quality, low specific gravity with oval-shaped tubers. It has moderate resistance to scab. It's oblong-oval shape causes some difficultly in finding the proper market for this variety. The testing of this line will be discontinued.

ND2417-6 - a cold-chipping selection with above average yield potential, but moderate specific gravity. It has performed well in regional trials, but it is susceptible to scab.

ND2471-8 - a cold-chipping selection with below average yield potential, medium specific gravity and small tuber size. In 1995 the yield was higher than observed in previous years. Hollow heart was observed in the oversize tubers. It is very susceptible to scab and early die was also noted. The testing of this line will be discontinued.

NY102 - this selection has average yield, few oversize tubers and a moderately high specific gravity. It is moderately susceptible to scab.

AF1426-1 - a new fresh market selection from Maine which had the highest yield in the early harvest. It produced a large percentage of oversize tubers with excellent internal quality.

NY103 - a new chip-processing/fresh market selection from New York which has high yield potential, excellent internal quality and appearance,but the specific gravity may be too low.

NY101 - a light-yellow-fleshed selection from New York. This line has an excellent shape and very high yield potential over the past three years. It is resistant to scab. In 1995 we observed IBS in the oversize tubers. The tubers are netted.

NDO1496-1 - a high-yielding, late maturing selection from Oregon. This line is a cold-chipping selection with excellent internal quality. It also has a bright appearance, but is highly susceptible to scab.

Pike (E55-35) - an average yielding selection from New York. It chip-processes well and is resistant to scab similar to Superior. At times it has shown IBS in the tubers.

MSB083-1 - an MSU selection with a bright round appearance. This selection is in grower trials and its performance has been variable. In 1995 IBS was noted in the oversize tubers for the first time.

MSB107-1 - an MSU selection for the tablestock market. It is a bright-skinned round selection with excellent internal quality. This selection has been in grower trials and its performance has been variable.

NDA2031-2 - a very late-maturing selection from Idaho. It is a cold chip-processing line that produces a large number of 'B'-size tubers. It also very susceptible to scab. The testing of this line will be discontinued.

B. Long Varieties

Most of the entries in the long-type trial were late maturing resulting in low yields and small tuber size at 94 days, the first date-of-harvest (Table 3). At the second harvest on September 20 (135 days), yields for all entries had increased substantially (Table 4). Tuber size was greater, however, specific gravity values were below normal due to the warmer night temperatures during August. All entries had less culls and pickouts when compared with Russet Burbank. Hollow heart was most severe in A86102-6, occurring in 96% of the tubers over 10 ounces. Hollow heart was also greatest in Russet Burbank, JS91-95 and AO82611-7.

Variety Characteristics

JS111-28 and JS91-95 - these two entries were provided by J.R. Simplot. JS111-28 had the highest yield with good general appearance, good russeting and shallow eyes. Internal brown spot was noted in the larger potatoes. JS91-95 had a lower yield, lower specific gravity and 30% hollow heart in the larger potatoes. the type was not as smooth and uniform as JS111-28 and some "alligator" skin was noted.

A7961-1 - is an USDA-Aberdeen entry which yielded much better in 1995 at both harvest dates. It had uniform appearance, heavier russeting than RB and minimal internal defects. Tests in the Northwest have shown occasional sugar buildup in storage.

AO82611-7 - produced good yield but had a higher than average percent of pickouts and hollow heart. Reported to have some resistance to early dying. Tuber shape is long but tuber width is narrow.

Shepody - yields were good, however scab, some sprouting, hollow heart, vascular discoloration and brown center were noted in the large tubers at harvest.

Crestone Russet - is an early maturing, fresh market, long russet from Colorado. In 1994, it was very slow in emergence, however this was not noted in 1995. It had minimal internal defects, good appearance and tubers are oblong to oval and flattened.

A86102-6 - is a new entry from USDA-Aberdeen with yields slightly above average. Specific gravity was low and hollow heart severe. It is a lighter russet with some alligator-type skin.

MSB106-8 - is an entry from MSU with blocky to oblong tubers that are netted and have shallow eyes. Yields and size distribution were good and internal defects were low.

B9922-11 - is an entry from USDA-Beltsville. Its yields were higher in 1994 and average in 1995. It has medium-high specific gravity. Tubers are oblong with a heavy, dark russet and good general appearance. Some thumbnail cracks were noted following harvest.

CO083008-1 - is an Oregon selection from the Colorado breeding program. Yields were below average and specific gravity was low. The tubers were well shaped with good type.

A84118-3, A8495-1 and Russet Nugget all produced very poor yield with small tuber size and a high percentage of tubers under four ounces. Russet Nugget is not adaptable to Michigan.

C. North Central Regional Trial

The North Central Trial is conducted in a wide range of environments, in 14 states and provinces, to provide adaptability data for the release of new varieties from North Dakota, Minnesota, Wisconsin, Michigan and Beltsville, MD. In 1995, 18 breeding lines and five named varieties were tested of various tuber types in Michigan. The results are presented in

Table 5. The range of yields were wide. A Beltsville selection, B0766-3, yielded well, had a very good appearance and showed resistance to scab. ND2417-6 performed well in Michigan and other locations. The MSU selection, MSB076-2, had above average yields in this trials, and was noted as performing well in other locations.

D. Evaluation of Potato Varieties in the Upper Peninsula

R. H. Leep, J.R. Lempke and S. Mikols

Sixteen potato varieties were evaluated in the Upper Peninsula on the Jeff De Baker farm in Marquette County. The varieties were planted in plots which consisted of one row, 20 feet long. Seed spacing was 12 inches. Each variety was replicated four times. At maturity all plots were dug and graded by size and pickouts. A subsample was kept from each plot and used for specific gravity and internal defect determination.

The average yield was 270 cwt/acre of U.S.#1 potatoes. The overall specific gravity was lower than previous years due to the unusual growing season of hot conditions in the summer. In general, the overall quality was good with the average amount of U.S.#1 potatoes at 90%. Russet Burbank gave the best yields of U.S.#1 potatoes compared to russet types. NY101 shows potential for high yield in the yellow flesh varieties with the highest yield in the entire trial at 399 U.S.#1 cwt/acre.

E. European Trial

Through the support of the New Brunswick Potato Agency and Swavlof-Weibull of Sweden, 15 European varieties and advanced selections were tested. Yukon Gold and Saginaw Gold were used as checks. The rose-skinned, yellow-fleshed selection from MSU, MSD040-4RY, was also tested. The results are summarized in Table 7. Most of the varieties were late to very-late in maturity and produced a small percentage of oversize tubers. SW88-113 was high-yielding, very good appearance and excellent internal quality. It has a light yellow flesh. Lily, a yellow-fleshed variety, was high yielding but the tubers were irregular in appearance. Ofelia, also was high-yielding but had variable shape and second growth. Sante had a high overall rating. Poor tuber shapes due to either knobs and/or points were observed for Estima, Agria, Hulda, Island Sunshine, Rosamunda, SW91-102, Concorde, and Matilda.

F. Post-harvest Disease Evaluation: Fusarium Dry Rot and Erwinia Soft Rot

As part of the postharvest evaluation, resistance to *Fusarium sambucinum* (fusarium dry rot) was assessed by inoculating 10 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 disease incidence and severity of the dry rot infection. Table 8 summarizes the results from the Fusarium dry rot screening. Two columns of data are presented. In one column the average number of disease-free lesions for ten tubers is presented (Ave #). The second column is the the disease severity rating (Severity). A 1 to 9 scale was used with one indicating very little to no infection and 9 referring to unrestricted spread of the disease. In this year's screening a number of lines showed little to very little infection. As in previous years, Snowden rated higher than most varieties. Some of the best resistance was noted in the somatic fusion hybrids from Dr. J. Helgeson. We plan to retest the lines that had disease severity ratings less than three.

An Erwinia soft rot test was conducted on tuber slices this fall. Most selections from the trials were tested along with somatic fusion hybrids from Dr. J. Helgeson which were noted to have some resistance to soft rot. MSU selections can be found in the breeding report. The results are summarized in Table 8. The infection levels were rated on a 1-5 scale, with 1 indicating very little to no infection and five noting no resistance to infection spread. The lines that showed little to no infection in the first round of testing (Test 1) were retested and those scores are in the second column (Test 2).

G. Potato Scab Evaluation

Each year a replicated field trial at the MSU Soils Farm is conducted to assess resistance to common and pitted scab. The varieties are ranked on a 1-5 scale 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 should begin to identify ones that can be classified as susceptible to scab. As in 1994, the level of infection was quite high for 1995 and the levels of infection in the check cultivars were in accordance with previous observations. Our goal is to evaluate important advanced selections and varieties in the study at least three years to obtain a valid estimate of the level of resistance in each line. Table 9 summarizes the 1995 scab trial results for the lines in these trials. All MSU selections are reported in the breeding report. Many russet lines showed resistance to scab infection. Round white tablestock clones with resistance included Superior, Onaway, AC Ptarmigan (oval), Prestile, B0717-1 and AF1426-1. Yellow-fleshed selections with resistance were NY101 and SW88-109. Scab resistance was also identified in the chip-processing clones Pike, B0766-3, B0763-15 and some MSU selections MSB076-2 and MSA091-1.

H. Blackspot Susceptibility

Increased evaluations of advanced seedlings and new varieties for their susceptibility to blackspot bruising has 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 and 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 November and individual tubers were assessed for the number of blackspot bruises on each potato. These data are shown in Table 10.

Section A summarizes the data for the samples receiving the simulated bruise and Section B, 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 of 3 or more spots per tuber from the simulated bruise are approaching the bruise-susceptible rating. These data become more meaningful when evaluated over 3 years which reflects different growing seasons and harvest conditions. Bruising was more severe in 1994 than in 1995. Selections that showed the greatest blackspot incidence among the check samples were FL1863, ND2471-8, NY102 and Saginaw Gold.

Table 1

ROUND WHITES
MONTCALM RESEARCH FARM
AUGUST 10, 1995
(94 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	3-YR
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	IBS	BC	CUT	AVE
AF1426-1	387	429	90	4	80	11	6	1.062	4	0	0	0	27	---
SUPERIOR	382	449	85	12	82	3	3	1.063	1	0	0	0	13	331
PORTAGE	382	471	81	14	78	3	5	1.061	1	0	0	1	12	344
ND2417-6	376	474	79	19	76	3	2	1.066	1	0	0	0	11	292*
ST. JOHNS	375	405	92	6	85	8	1	1.060	0	0	0	1	22	317
NY103	369	416	89	8	84	4	4	1.064	0	0	0	0	16	---
ATLANTIC	364	422	86	10	82	4	4	1.075	10	0	1	0	15	317
NY101	363	421	86	11	83	4	3	1.063	1	0	0	0	12	---
PRESTILE	356	386	92	7	82	10	1	1.062	2	0	0	0	23	289
AC PTARMIG	354	415	85	9	81	4	5	1.062	2	0	0	0	12	333*
FL1833	347	378	92	6	89	3	2	1.072	7	0	0	0	11	286*
MAINESTAY	343	423	81	19	80	2	0	1.064	0	0	0	0	6	295
ONAWAY	332	393	85	11	80	5	4	1.065	0	0	0	1	15	276
FL1863	332	374	89	8	83	6	3	1.072	0	0	0	0	18	---
ND2471-8	320	404	79	18	78	1	3	1.071	3	0	0	0	4	278*
CHALEUR	295	316	93	3	81	13	4	1.060	8	1	0	0	26	234
NY102	293	367	80	18	79	1	2	1.070	1	0	0	0	4	264*
ND01496-1	283	326	87	12	84	3	1	1.071	1	0	0	0	7	---
MSB076-2	282	364	78	19	75	2	4	1.075	2	0	0	0	6	---
FL1533	260	323	80	13	75	5	7	1.065	2	0	0	2	13	227*
SNOWDEN	229	325	70	24	68	2	6	1.072	0	0	0	0	6	245
PIKE	222	286	78	21	77	1	1	1.072	0	0	0	0	2	240*
MSB083-1	196	264	74	22	72	3	4	1.065	1	0	0	0	6	---
MSB107-1	184	215	85	11	79	6	4	1.065	0	0	0	0	10	---
NDA2031-2	134	283	47	51	47	0	1	1.068	0	0	0	0	0	---

[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

* - two-year US #1 average

PLANTED MAY 8, 1995

Table 2

ROUND WHITES: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 18, 1995
(133 DAYS)

	CWT/A		PERCENT OF TOTAL[1]							TUBER QUALITY[2]				TOTAL	3-YR
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SFA	HH	VD	IBS	BC	CUT	AVE
NY101	604	648	93	5	71	22	1	1.062	--	2	0	20	0	40	605
PRESTILE	602	659	91	5	67	24	3	1.068	--	0	0	28	0	40	511
NDA2031-2	542	724	75	22	71	4	3	1.069	2.0	0	1	1	0	13	425*
ND01496-1	528	570	93	6	71	22	1	1.073	1.5	3	1	1	1	40	529*
ND2471-8	528	656	80	14	75	5	6	1.071	1.5	10	0	1	1	24	380
NY103	523	558	94	4	73	20	2	1.058	3.0	2	2	0	0	36	---
AC PTARMIG	510	583	87	6	67	21	7	1.058	--	0	7	3	0	40	445*
FL1833	492	513	96	3	73	23	1	1.072	1.5	8	0	9	0	40	444*
FL1533	484	561	86	6	57	29	7	1.068	1.5	3	0	0	1	40	488
ND2417-6	480	578	83	14	77	6	3	1.064	1.5	0	0	2	0	28	370
ST. JOHNS	473	502	94	4	60	34	2	1.063	--	2	1	4	1	40	435
FL1863	468	525	89	5	62	27	5	1.074	--	3	0	9	0	40	---
MAINESTAY	466	580	80	14	72	8	6	1.060	--	0	2	4	0	35	468
PORTAGE	452	548	82	11	75	8	6	1.061	--	3	0	6	2	23	431
SUPERIOR	447	523	85	12	81	5	3	1.061	--	5	0	1	0	17	367
ATLANTIC	443	488	91	7	76	15	2	1.078	1.5	17	0	10	1	31	442
MSB076-2	423	511	83	12	78	5	5	1.076	1.5	13	0	0	0	20	456
ONAWAY	414	491	84	10	72	12	6	1.058	--	2	4	0	1	39	362
AF1426-1	399	516	77	4	42	35	19	1.061	--	2	0	4	0	40	---
MSB083-1	397	479	83	14	73	10	3	1.067	1.5	1	0	24	0	36	332
SNOWDEN	390	486	80	11	66	15	9	1.071	1.0	5	2	1	2	36	443
NY102	377	459	82	16	79	3	2	1.068	1.5	0	0	0	0	14	341*
CHALEUR	343	353	97	3	65	32	0	1.058	--	5	2	1	2	40	316
MSB107-1	321	355	91	6	53	37	4	1.063	--	0	0	0	0	40	297
E55-35	311	364	85	12	76	10	3	1.076		1	0	16	0	34	308*
$LSD_{0.05}$	85	87						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

* - two-year US #1 average

PLANTED MAY 8, 1995

Table 3

LONG TYPES
MONTCALM RESEARCH FARM
AUGUST 10, 1995
(94 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	3-YR
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	1BS	BC	CUT	AVE
A7961-1	203	280	72	24	67	5	4	1.069	4	0	0	0	12	153*
B9922-11	201	284	71	26	65	6	4	1.076	3	0	0	1	15	---
SHEPODY	196	280	70	28	64	6	2	1.067	1	0	1	0	14	---
A082611-7	193	310	62	35	60	2	3	1.071	4	0	0	0	5	182*
GOLDRUSH	165	264	62	36	55	7	2	1.061	0	0	0	0	15	197
R BURBANK	160	294	54	33	54	0	13	1.070	0	0	0	0	0	137
CO083008-1	159	227	70	29	67	4	0	1.067	0	0	0	0	7	143*
JS111-28	158	284	55	40	55	0	4	1.069	0	0	0	0	1	---
A86102-6	148	298	50	47	48	1	4	1.068	3	0	0	0	3	---
MSB106-8	133	216	61	33	57	4	6	1.070	1	0	0	0	7	---
JS91-95	122	206	59	37	58	1	3	1.069	1	0	0	0	2	---
CRESTONE R	117	218	54	43	48	5	3	1.053	0	0	1	0	9	119*
A8495-1	64	163	40	56	39	1	5	1.068	0	0	0	0	1	74*
A84118-3	48	194	25	74	25	0	2	1.070	0	0	0	0	0	---
R NUGGET	6	53	12	88	12	0	0	----	0	0	0	0	0	---

[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

* - two-year US #1 average

Table 4

LONG TYPES: LATE HARVEST
MONTCALM RESEARCH FARM
SEPTEMBER 20, 1995
(135 DAYS)

	CWT/A		PERCENT OF TOTAL[1]						TUBER QUALITY[2]				TOTAL	3-YR
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	HH	VD	1BS	BC	CUT	AVE
JS111-28	425	561	76	18	57	19	6	1.072	5	0	6	0	40	---
A7961-1	406	484	84	11	50	34	5	1.071	2	0	0	0	40	335*
A082611-7	342	506	68	22	56	11	10	1.069	11	0	2	0	39	320*
SHEPODY	313	439	71	14	46	25	15	1.067	6	3	0	3	32	---
JS91-95	290	391	74	22	61	13	4	1.069	11	0	5	0	36	---
CRESTONE R	287	386	74	21	55	20	4	1.055	1	0	0	0	40	255*
A86102-6	284	395	72	23	62	10	5	1.067	27	0	0	0	28	---
MSB106-8	278	345	81	16	61	20	4	1.070	2	0	2	0	30	317*
B9922-11	273	338	81	17	64	17	2	1.073	4	0	0	0	32	312*
GOLDRUSH	263	358	73	23	51	22	3	1.057	1	0	0	0	32	284
R BURBANK	261	409	64	19	49	15	17	1.070	12	0	2	0	34	279
CO083008-1	228	281	81	18	71	10	0	1.064	1	0	0	1	26	239*
A84118-3	150	242	62	37	58	3	1	1.071	1	0	0	0	7	---
A8495-1	97	200	48	43	44	4	9	1.066	0	0	2	0	7	204*
R NUGGET	77	151	51	46	49	1	3	1.077	0	1	0	0	2	---
$LSD_{0.05}$	104	112						0.005						

[1]SIZE	[2]QUALITY
B - < 4 OZ	HH - HOLLOW HEART
A - 4-10 OZ	BC - BROWN CENTER
OV - > 10 OZ	VD - VASCULAR DISCOLORATION
PO - PICKOUTS	IBS - INTERNAL BROWN SPOT

* - two-year US #1 average

PLANTED MAY 8, 1995

Table 5

NORTH CENTRAL REGIONAL TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 14, 1995
(125 DAYS)

	CWT/A		PERCENT OF TOTAL[1]							TUBER QUALITY[2]				TOTAL
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SFA	HH	VD	IBS	BC	CUT
W1149	443	485	91	6	62	29	3	1.073	2.0	12	4	1	1	40
B0766-3	433	465	93	5	86	8	2	1.073	1.5	10	0	0	0	27
B0752-12	432	528	82	5	66	15	13	1.069	2.5	1	0	1	0	34
MN16191	420	509	82	12	72	10	6	1.072	3.5	0	0	13	0	22
ND2417-6	414	511	81	14	76	5	5	1.063	1.5	0	0	0	0	21
W1242	408	453	90	7	72	18	3	1.072	1.5	20	0	12	0	40
B0856-4	406	505	80	6	63	18	13	1.056	2.5	1	0	3	0	40
MN16201	404	478	85	9	57	27	6	1.053	2.0	0	0	1	0	40
RED PONTIAC	401	484	83	9	62	21	8	1.054	4.5	7	1	1	0	40
B0763-15	381	401	95	3	68	27	2	1.067	1.5	4	0	1	1	40
SNOWDEN	359	419	86	8	66	20	6	1.071	1.0	7	1	0	2	39
ATLANTIC	353	402	88	5	63	25	7	1.075	2.5	30	0	5	0	38
MSB076-2	330	429	77	16	71	6	7	1.076	1.5	6	0	0	1	17
B0717-1	305	379	80	16	78	2	4	1.067	2.0	3	1	0	0	6
MSA091-1	299	360	83	8	64	19	9	1.073	1.5	1	0	5	7	33
W1189	290	350	83	12	76	7	5	1.069	2.0	0	0	12	0	22
NORCHIP	269	364	74	9	59	15	17	1.065	1.5	3	0	3	4	34
DR NORLAND	264	335	79	11	72	7	10	1.051	4.0	1	0	1	0	17
ND2471-8	264	359	73	16	70	4	11	1.071	3.5	2	0	0	0	12
ND2225-1R	236	369	64	34	63	1	2	1.052	4.0	0	0	0	1	2
MSB007-1	203	264	77	16	74	3	7	1.062	3.0	0	0	0	0	5
P84-13-12	184	279	66	24	62	4	10	1.069	1.5	1	0	0	0	8
MN15620	153	232	66	29	66	0	4	1.064	2.0	0	0	0	0	0
$LSD_{0.05}$	86	88						0.0035						

[1]SIZE
B - < 2"
A - 2-3.25"
OV - > 3.25"
PO - PICKOUTS

[2]QUALITY
HH - HOLLOW HEART
BC - BROWN CENTER
VD - VASCULAR DISCOLORATION
IBS - INTERNAL BROWN SPOT

PLANTED MAY 12, 1995

Table 6

1995 MSU POTATO VARIETY TRIALS

DeBaker Farm
Upper Peninsula

	Yield (cwt/A)		Percent Distribution					
Variety	No. 1	Total	No. 1	<4 oz.	4-10 oz.	>10 oz.	Pick Outs	S.G.
NY101	399	423	95	5	77	17	0	1.068
Russet Burbank	369	396	92	5	74	18	3	1.079
AC Ptarmigan	331	356	92	6	66	26	1	1.056
MSB076-2	329	371	89	10	79	10	1	1.078
Shepody	327	356	92	5	56	36	3	1.073
A082611-7	326	359	91	5	61	30	4	1.077
Snowden	301	328	92	8	86	6	0	1.082
A7961-1	289	312	93	4	57	36	3	1.077
Crestone Russet	286	304	94	6	59	35	0	1.063
A84118-3	267	293	89	11	77	12	0	1.081
A8495-1	217	240	90	8	64	26	2	1.074
A86102-6	213	246	87	7	62	25	6	1.070
Chaleur	182	191	95	5	74	21	0	1.053
C0083008-1	177	199	89	11	78	11	0	1.079
Goldrush	164	195	80	20	67	13	0	1.060
Russet Nugget	142	169	84	15	74	10	1	1.079
AVERAGE	270	296	90					1.072

Planted: May 18, 1995.

Harvested: October 5, 1995.

Table 7

EUROPEAN TRIAL
MONTCALM RESEARCH FARM
SEPTEMBER 29, 1995
(144 DAYS)

	CWT/A		PERCENT OF TOTAL[1]							TUBER QUALITY[2]				TOTAL
	US#1	TOTAL	US#1	Bs	As	OV	PO	SP GR	SFA	HH	VD	1BS	BC	CUT
SW88-113	589	676	87	11	83	5	1	1.063	3.0	1	0	0	0	26
LILY	541	763	71	21	70	0	8	1.064	2.5	1	1	1	0	3
OFELIA	522	689	76	21	75	0	3	1.070	1.5	0	0	0	0	3
SANTE	488	602	81	13	76	5	6	1.075	2.0	0	3	9	0	22
ESTIMA	390	517	75	15	69	7	9	1.064	4.0	1	0	12	0	26
SAGINAW GOLD	385	457	84	9	71	13	7	1.067	1.5	4	0	1	0	29
SW91-102	360	455	79	14	77	2	7	1.084	2.0	1	0	2	0	9
SW88-109	360	486	74	20	69	5	6	1.057	3.5	1	1	1	0	21
CONCORDE	325	464	70	24	68	2	6	1.067	3.5	0	0	0	0	8
ROSAMUNDA	299	422	71	23	70	1	6	1.077	--	1	0	0	0	3
PENTA	297	386	77	21	76	1	2	1.060	3.0	0	0	0	0	3
AGRIA	287	381	75	14	71	5	11	1.064	--	4	0	0	0	14
MATILDE	262	543	48	49	48	0	2	1.082	--	0	0	0	0	0
HULDA	259	463	56	37	56	0	8	1.059	--	0	0	0	0	0
YUKON GOLD	253	307	82	12	74	9	5	1.065	--	5	1	0	0	20
MSD040-4RY	236	345	68	28	67	1	3	1.079	2.0	0	0	0	0	4
ISLAND SUN	169	287	59	40	59	0	1	1.074	--	0	0	0	0	0
BRIGHT	158	266	59	36	59	0	5	1.062	--	0	0	0	0	0
$LSD_{0.05}$	115	120						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

PLANTED MAY 8, 1995

Table 8

1995 TUBER DISEASE EVALUATION

LINE	TRIAL	ERWINIA Test1	ERWINIA Test2	FUSARIUM DRY ROT Ave.#	FUSARIUM DRY ROT Severity
A082611-7	DOH-L	2		1	6
A7961-1	DOH-L	3		2	1.5
A8498-1	DOH-L	2		2.5	6
A86102-6	DOH-L	2		3.5	3
B9922-11	DOH-L	3		4	2.5
C0083008-1	DOH-L	3		3.5	4
CRESTONE	DOH-L	3		1	7.5
GOLDRUSH	DOH-L	2		4.5	1.5
JS111-28	DOH-L	1		2.5	6.5
JS91-95	DOH-L	3		2.5	2
MSB106-8	DOH-L	3		0	7
R NUGGET	DOH-L	3		0	8.5
R. BURBANK	DOH-L	2		4.5	2
SHEPODY	DOH-L	1	2	1	5.5
AC PTARMIGAN	DOH-R	2		0	7.5
AF1426-1	DOH-R	2		0.5	7
ATLANTIC	DOH-R	3		0	7.5
B083-1	DOH-R	3		0	8.5
CHALEUR	DOH-R	2		0	7
E55-35	DOH-R	3		3.5	3.5
FL1533	DOH-R	1	1	1	4.5
FL1833	DOH-R	3		3.5	2
FL1863	DOH-R	2		4	1.5
MAINESTAY	DOH-R	3		1.5	4
MSB076-2	DOH-R	1	3	0	7
MSB107-1	DOH-R	3		0	8
ND01496-1	DOH-R	3		0.5	4.5
ND2417-6	DOH-R	1	3	3.5	3.5
ND2471-8	DOH-R	3		1.5	6
NDA2031-2	DOH-R	3		0	8
NY101	DOH-R	2		4.5	1.5
NY102	DOH-R	2		3.5	2
NY103	DOH-R	2	3	4.5	2.5
ONAWAY	DOH-R	1	2	2.5	2
PORTAGE	DOH-R	2		3.5	5
PRESTILE	DOH-R	4		1.5	6
SNOWDEN	DOH-R	3		4	1.5
ST.JOHNS	DOH-R	3		0	8
SUPERIOR	DOH-R	1		6.5	1

LINE	TRIAL	ERWINIA Test1	ERWINIA Test2	FUSARIUM DRY ROT Ave.#	FUSARIUM DRY ROT Severity
AGRIA	EURO.	3		5	2
CONCORDE	EURO.	1	1	0.5	6
ESTIMA	EURO.	3		3.5	5
ISLAND SUNSHINE	EURO.	2		7	1.5
LILY	EURO.	3		3.5	5.5
MATILDA	EURO.	1	1	4.5	3.5
MSD040-4RY	EURO.	1	2	0.5	6
OFELIA	EURO.	3		0.5	7.5
PENTA	EURO.	1	1	5	1.5
ROSAMUNDA	EURO.	2		6.5	2.5
SAG. GOLD	EURO.	2		0	8
SANTE	EURO.	2		1.5	4
SW88-109	EURO.	2		2.5	5.5
SW88-113	EURO.	4		1	6.5
SW91-102	EURO.	3		3.5	4.5
YUKON GOLD	EURO.	2		5	1.5
ATLANTIC	NC	3		0	7.5
B0717-1	NC	3		2.5	4.5
B0752-12	NC	1	1	4	2.5
B0763-15	NC	2		2	6
B0766-3	NC	3		1	6
B0856-4	NC	4		0	9
DR NORLAND	NC	3		1.5	3.5
MN15620	NC	2		4	1.5
MN16191	NC	3		2	3.5
MN16201	NC	2		3.5	2.5
MSA091-1	NC	2		2.5	4
MSB007-1	NC	2		0.5	5.5
MSB076-2	NC	2		0	8
ND2225-1R	NC	2		0	7
ND2417-6	NC	2		5	1.5
ND2471-8	NC	2		4.5	3.5
NORCHIP	NC	1	1	3	2
P84-13-12	NC	1		1.5	4.5
R PONTIAC	NC	1	1	3	1.5
SNOWDEN	NC	3		4	2
W1149	NC	1	2	3.5	1.5
W1189	NC	3		0	8
W1242	NC	2		2.5	5
HLG-115	UWM		3	3.5	2
HLG-120	UWM		2	6	1.5
HLG-244	UWM		4	5.5	2
HLG-297	UWM		2	7.5	1.5
HLG-91	UWM		3	9	1
HLG-T450	UWM		1	10	1

Table 9 1995 Scab Trial

MSU Soils Farm

CLONE	RATING	CLONE	RATING
A082611-7	1	ATL	3
A7961-1	1	B0752-12	3
A8495-1	1	BRIGHT	3
A86102-6	1	CHALEUR	3
B0717-1	1	FL1533	3
B9922-11	1	FL1863	3
C0080011-5	1	M19-4	3
C0083008-1	1	M28-3	3
GOLDRUSH	1	M39-4	3
LEMHI RUS	1	MAINESTAY	3
NY101	1	NY102	3
PIKE	1	SAG. GOLD	3
PRESTILE	1	SANTE	3
R. NUGGET	1	ST. JOHNS	3
A84118-3	1.5	SW88-113	3
AC PTARM	1.5	SW92-102	3
AF1426-1	1.5	W1189	3
B0763-15	1.5	W1242	3
B0766-3	1.5	AGRIA	3.5
M14-1	1.5	MN16191	3.5
ONAWAY	1.5	ND2417-6	3.5
PEMBINA C	1.5	ND2471-8	3.5
SUP	1.5	NDA2031-2	3.5
SW88-109	1.5	NY103	3.5
FL1833	2	SNOWDEN	3.5
LILY	2	W1149	3.5
M14-6	2	YUKON GOLD	3.5
MATILDA	2	AF1470-17	4
R BURBANK	2	CONCORDE	4
HULDA	2.5	ESTIMA	4
IS SUNSHINE	2.5	ND01496-1	4.5
MN15620	2.5	PENTA	4.5
MN16201	2.5	SHEPODY	4.5
OFELIA	2.5		
PORTAGE	2.5		
ROSAMUNDA	2.5		
R. PONTIAC	2.5		

Table 10 1995 BLACKSPOT SUSCEPTIBILITY STUDY

A. SIMULATED BRUISE SAMPLES

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	% BRUISE FREE	AVE SPOTS/TUBER
DATE OF HARVEST: ROUND WHITES									
AC PTARMIGAN	21	1	3				25	84	0.280
AF1426-1	17	5	3				25	68	0.440
ATLANTIC	15	7	1	2			25	60	0.600
CHALEUR	24	1					25	96	0.040
E55-35	15	10					25	60	0.400
FL1533	21	3	1				25	84	0.200
FL1833	13	7	3	2			25	52	0.760
FL1863	16	5	1	2		1	25	64	0.720
MAINESTAY	20	3	2				25	80	0.280
MSB076-2	14	6	3	1		1	25	56	0.800
MSB083-1	13	2	3	3	1	3	25	52	1.440
MSB107-1	17	5	2	1			25	68	0.480
ND01496-1	23	1	1				25	92	0.120
ND2417-6	11	10	4				25	44	0.720
ND2471-8	10	5	4	2	1	3	25	40	1.520
NDA2031-2	23	2					25	92	0.080
NY101	22	1	2				25	88	0.200
NY102	4	10	3	6	1	1	25	16	1.720
NY103	20	4	1				25	80	0.240
ONAWAY	23	1		1			25	92	0.160
PORTAGE	16	4	5				25	64	0.560
PRESTILE	18	6	1				25	72	0.320
ST. JOHNS	24	1					25	96	0.040
SUPERIOR	22	2	1				25	88	0.160
DATE OF HARVEST: LONGS									
A082611-7	19	6					25	76	0.240
A84118-3	25						25	100	0.000
A8495-1	22	2	1				25	88	0.160
A86102-6	23	2					25	92	0.080
B9922-11	23	2					25	92	0.080
C0083008-1	24	1					25	96	0.040
CRESTONE R	24	1					25	96	0.040
GOLDRUSH	20	5					25	80	0.200
JS111-28	19	4	2				25	76	0.320
JS91-95	25						25	100	0.000
MSB106-8	15	4	2	3	1	0	25	60	0.840
R BURBANK	23	2					25	92	0.080
R NUGGET	23	2					25	92	0.080
SHEPODY	19	5	1				25	76	0.280

A. SIMULATED BRUISE SAMPLES

	NUMBER OF SPOTS PER TUBER						TOTAL	% BRUISE	AVE
VARIETY	0	1	2	3	4	5+	TUBERS	FREE	SPOTS/TUBER
NORTH CENTRAL									
ATLANTIC	21	3	1				25	84	0.200
B0717-1	21	3	1				25	84	0.200
B0752-12	17	2	1				20	85	0.200
B0763-15	23	2					25	92	0.080
B0766-3	13	5	4	2	1		25	52	0.920
B0856-4	25						25	100	0.000
MN15620	25						25	100	0.000
MN16191	19	4	2				25	76	0.320
MN16201	22	3					25	88	0.120
MSA091-1	22	2	1				25	88	0.160
MSB007-1	18	6	1				25	72	0.320
MSB076-2	21	4					25	84	0.160
ND225-1R	20	5					25	80	0.200
ND2417-6	21	3	1				25	84	0.200
ND2471-8	23	2					25	92	0.080
NORCHIP	23	2					25	92	0.080
P84-13-12	24	1					25	96	0.040
RED PONTIAC	18	1	1				20	90	0.150
SNOWDEN	18	4	2	1			25	72	0.440
SNOWDEN	22	1	1	1			25	88	0.240
W1149	22	3					25	88	0.120
W1189	17	4	2		2		25	68	0.640
W1242	21	3	1				25	84	0.200
EUROPEAN									
AGRIA	20	4	1				25	80	0.240
CONCORDE	13	3	2	6	1		25	52	1.160
ESTIMA	21	4					25	84	0.160
LILY	22	2	1				25	88	0.160
OFELIA	21	4					25	84	0.160
PENTA	25						25	100	0.000
SAG GOLD	19		4	2			25	76	0.560
SANTE	12	8	4			1	25	48	0.840
SW88-109	17	6	2				25	68	0.400
SW88-113	17	3	5				25	68	0.520
SW91-102	16	6		2		1	25	64	0.680
YUKON G	23	1	1				25	92	0.120

B. CHECK BRUISE SAMPLES

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	% BRUISE FREE	AVE SPOTS/TUBER
DATE OF HARVEST: ROUND WHITES									
AC PTARMIGAN	16	4					20	80	0.200
ATLANTIC	12	8					20	60	0.400
CHALEUR	19	1					20	95	0.050
E55-35	18	1	1				20	90	0.150
FL1533	18	1	1				20	90	0.150
FL1833	16	2	1	1			20	80	0.350
FL1863	5	4	4	3	1	3	20	25	2.000
MAINESTAY	18	2					20	90	0.100
MSB076-2	15	4	1				20	75	0.300
MSB083-1	15	4				1	20	75	0.450
MSB107-1	16	3	1				20	80	0.250
ND2417-6	18	2					20	90	0.100
ND2471-8	12	1	5		2		20	60	0.950
NDA2031-2	17	3					20	85	0.150
ND01496-1	15	5					20	75	0.250
NY101	17	3					20	85	0.150
NY102	8	10	1	1			20	40	0.750
NY103	19	1					20	95	0.050
ONAWAY	17	3					20	85	0.150
PORTAGE	20						20	100	0.000
PRESTILE	19	1					20	95	0.050
SNOWDEN	17	3					20	85	0.150
ST. JOHNS	19	1					20	95	0.050
SUPERIOR	20						20	100	0.000
DATE OF HARVEST: LONGS									
A082611-7	18	2					20	90	0.100
A7961-1	19	1					20	95	0.050
A84118-3	16	5	1				22	73	0.318
A8495-1	18	1	1				20	90	0.150
A86102-6	20						20	100	0.000
B9922-11	22	3					25	88	0.120
C0083008-1	17	1	1		1		20	85	0.350
CRESTONE R	15	3	2				20	75	0.350
GOLDRUSH	16	4					20	80	0.200
JS111-28	16	3	1				20	80	0.250
JS91-95	15	5		1			21	71	0.381
MSB106-8	14	5			1		20	70	0.450
R BURBANK	17	3					20	85	0.150
R NUGGET	18	2					20	90	0.100
SHEPODY	16	4					20	80	0.200

B. CHECK BRUISE SAMPLES

VARIETY	NUMBER OF SPOTS PER TUBER 0	1	2	3	4	5+	TOTAL TUBERS	% BRUISE FREE	AVE SPOTS/TUBER
NORTH CENTRAL									
ATLANTIC	17	3					20	85	0.150
B0717-1	17	3					20	85	0.150
B0752-12	20						20	100	0.000
B0763-15	19	1					20	95	0.050
B0766-3	19	1					20	95	0.050
B0856-4	20						20	100	0.000
DR NORLAND	18	2					20	90	0.100
MN15620	19	1					20	95	0.050
MN16191	16	4					20	80	0.200
MN16201	19	1					20	95	0.050
MSA091-1	20						20	100	0.000
MSB007-1	18	2					20	90	0.100
MSB076-2	20						20	100	0.000
ND2225-1R	15	4	1				20	75	0.300
ND2417-6	14	5	1				20	70	0.350
ND2471-8	17	3					20	85	0.150
P84-13-12	18	2					20	90	0.100
RED PONTIAC	10	7	3				20	50	0.650
SNOWDEN	19	1					20	95	0.050
W1149	18	1	1				20	90	0.150
W1189	17	3					20	85	0.150
W1242	18	2					20	90	0.100
EUROPEAN									
AGRIA	25						25	100	0.000
CONCORDE	24	1					25	96	0.040
ESTIMA	22	2	1				25	88	0.160
LILY	25						25	100	0.000
MSD040-4RY	24		1				25	96	0.080
OFELIA	24	1					25	96	0.040
SANTE	24	1					25	96	0.040
SW88-109	22	3					25	88	0.120
SW88-113	25						25	100	0.000
SW91-102	24	1					25	96	0.040
YUKON GOLD	24	1					25	96	0.040
SAG GOLD	12	1	4	1		2	20	60	1.100
AF1426-1	17	1	2				20	85	0.250
PENTA	16	4					20	80	0.200

Funding: Fed. Grant

POTATO MANAGEMENT STUDIES

R.W. Chase, R.H. Leep and D.S. Douches

Introduction

Russet Burbank and Shepody are important potato varieties for the frozen processing industry and the recent expansion of this industry in Michigan suggested a need to evaluate selected production management practices to optimize production for this market. Yields, size distribution, specific gravity and minimal defects are qualities essential for economical production of these varieties.

Seed preparation and plant spacing are management practices which can have an effect on these qualities. Shepody has been grown in Michigan since the mid 1980's, however, it has declined in recent years for various reasons. The renewed interest in this variety suggested a need to assess both seed size and plant spacing and their effect on tuber quality.

Russet Burbank has been grown for many years in Michigan, however, there have been no recent Michigan studies comparing seed preparation prior to planting. Russet Burbank, in contrast with Shepody and Yukon Gold has numerous eyes so apical dominance and pre-plant warming could have an effect on yields and quality.

A. Procedure for Shepody Seed Size and Spacing

Shepody seed was obtained from J.R. Simplot and cut into two sizes of 1¾-2 ounce and 3-3¼ ounce seed piece size. Spacings of 9, 12 and 15 inches were compared for each size and were planted in a randomized complete block design with four replications. Plots were established at the MSU Montcalm Research Farm and at the M.J. VanDamme Farms in Cornell, MI. Plots at the MSU Montcalm Research Farm were hand planted on May 12 and harvested on September 22. At the VanDamme location, plots were hand planted on May 17 and harvested on October 20.

Results:

Table 1 shows the yield and percent size distribution of the trial at the MSU Montcalm Research Farm (MRF). There was no significant difference in the effect of seed size on yields or size distribution. Yields were greatest with the 12 inch spacing and the 1¾-2 ounce seed piece size. The greatest yield occurred at the 12 inch spacing when both seed sizes are combined. It also produced a smaller percentage of tubers under 4 ounces and a greater percentage of tubers over 10 ounces when compared with the 9 inch space.

There was no effect on specific gravity (Table 2). In terms of internal defects, hollow heart incidence was greatest at the 15 inch spacing and also with the larger seed piece size.

Table 1. Shepody Seed Size/Spacing -- MRF.

Treatment	Yield (cwt/A)		Percent Distribution				
	No. 1	Total	No. 1	<4 oz.	4-10 oz.	>10 oz.	Pick Outs
Space-Size (in.)(oz.)							
12 - 2	321	418	77	12	55	22	11
9 - 3	292	411	71	16	52	19	13
12 - 3	283	392	72	16	54	18	12
15 - 3	282	367	77	14	52	25	9
9 - 2	229	334	69	20	55	13	12
15 - 2	228	318	72	17	54	18	11
Seed Size (oz.)							
1¾-2	279	357	78	16	55	18	11
3-3¼	286	390	73	15	53	21	11
Spacing (in.)							
9	260	372	70	18	54	16	13
12	302	406	74	14	55	20	12
15	255	342	75	16	53	22	10

Table 2. Shepody Seed Size/Spacing Study -- MRF.

Treatment	S.G.	Number over 10 ounce				Total Cut
		HH	Vas.	IBS	BC	
Space-Size (in.) (oz.)						
9 - 1¾-2	1.075	5	4	0	0	31
9 - 3-3¼	1.076	6	7	0	0	40
12 - 1¾-2	1.077	3	9	0	0	39
12 - 3-3¼	1.077	9	7	0	0	40
15 - 1¾-2	1.075	10	6	0	1	39
15 - 3-3¼	1.076	13	3	0	0	37
Seed Size (oz.)						
1¾-2	1.076	18	19	0	0	109
3-3¼	1.076	28	17	0	0	117
Spacing (in.)						
9	1.076	11	11	0	0	71
12	1.077	12	16	0	0	79
15	1.076	23	9	0	1	76

At the Upper Peninsula location, there was an increase in yield from the 9 inch to the 12 inch spacing, and no appreciable increase at 15 inches (Table 3). The smaller seed size resulted in a greater yield of U.S. No. 1 potatoes and considerably less tubers under 4 ounces and a higher percentage over 10 ounces. Internal defects were minimal at the U.P. location and did not correlate with either seed size or spacing.

In both trial locations, the 9 inch spacing produced lower U.S. No. 1 yields and the 15 inch spacing was not better than 12 inches at the VanDamme Farm and much lower at the MRF. It would appear from these studies that a spacing of 10-12 inches may be beneficial. It should be emphasized that these are one year results and the spacing trial will be repeated in 1996.

Table 3. Shepody Seed Size/Spacing -- Upper Peninsula.

	Yield (cwt/A)		Percent Distribution				
Treatment	No. 1	Total	No. 1	<4 oz.	4-10 oz.	>10 oz.	Pick Outs
Space-Size (in.)(oz.)							
15 - 2	304	339	90	5	57	33	5
12 - 2	281	350	82	8	58	24	11
12 - 3	243	363	67	17	44	23	16
15 - 3	233	319	73	15	50	23	11
9 - 3	222	343	65	20	55	10	15
9 - 2	212	281	75	8	51	24	16
Seed Size (oz.)							
1¾-2	266	323	82	7	55	27	11
3-3¼	233	342	68	17	50	19	14
Spacing (in.)							
9	217	312	70	14	53	17	16
12	262	357	73	13	51	24	14
15	268	329	81	10	54	28	8

B. Procedure for Russet Burbank Seed Warming Study

Russet Burbank seed was obtained from J.R. Simplot in April and held at 40F. At 12, 6 and 2 days before planting, whole seed was removed from the 40F storage and placed in a 52F storage and held for cutting just prior to planting. A second set of seed was also removed from the 40F storage, warmed for approximately 24 hours and then pre-cut at 12, 6 and 2 days and held at 52F until planting. One lot of whole seed was removed from storage and cut and planted on the same day.

Seed size was approximately 2 ounces and was not treated. The seed was hand planted at a 12 inch spacing in plots 23 feet long with four replications on May 4, 1995 at the MRF. Soil temperature at 8 inches was 51F, the air temperature was 54F and the weather was overcast. The plot was harvested on September 28.

Results

Table 4 summarizes the yield and size distribution results and shows that the best yield performance resulted from seed which was cut and planted. Seed removed from the 40F storage the day of planting produced the best yield and the highest percentage of tubers over 10 ounces. When all of the pre-cut treatments are combined and compared with the cut and plant treatments, the No. 1 yields of the cut and plant seed were 19% greater and the percent of U.S. No. 1's were 72% compared with 67% for the pre-cut seed.

It should be emphasized that these data are from a one year trial and should be repeated over three growing seasons to obtain a cross section of seasonal environments. These results suggest that the influence of physiological aging may be a factor. Several research trials have shown that seed tubers age physiologically with both time and high storage temperature. Physiological aging generally means a reduction in productive capacity. Physiologically young seed generally has greater apical dominance, fewer main stems, fewer tubers per hill, larger tubers at harvest and higher yields.

In this study, the pre-cut Russet Burbank seed produced lower U.S. No. 1 yields and this may be related to apical dominance. Cutting of whole seed disrupts the effect of apical dominance and when combined with holding the seed a longer time at the 52F, resulted in reduced yields. Russet Burbank has many eyes, particularly when compared with a variety like Shepody. The disruption of apical dominance and the greater number of eyes per seed piece could have resulted in more stems and a greater tuber set. Stem numbers will be assessed in the 1996 trial.

Physiological aging of seed is difficult to monitor and document and some of its effects may already have occurred when the seed is removed from the seed storage. The commercial growers greatest influence would occur after the seed is received and as it is prepared for planting.

Table 4. R.B. Seed Warming Study -- MRF.

	Days Warm **	Yield (cwt/A) No. 1	Yield (cwt/A) Total	Percent Distribution No. 1	<4 oz.	4-10 oz.	>10 oz.	Pick Outs	S.G.
CP*	½	376	488	77	15	51	26	8	1.072
CP	12	348	493	71	19	53	18	11	1.073
CP	6	346	486	71	18	49	23	11	1.071
Pre	2	313	439	71	15	48	24	13	1.070
Pre	6	303	439	69	17	48	21	14	1.071
CP	2	276	408	68	18	50	17	14	1.070
Pre	12	226	369	61	21	46	16	18	1.072

*CP = cut and plant; Pre = pre cut

**Seed taken from 40° storage and placed in 52° storage for pre-plant warming.

Funding: MPIC/MDA

NITROGEN STEWARDSHIP PRACTICES TO REDUCE NITRATE LEACHING AND SUSTAIN PROFITABILITY

M.L. Vitosh, G.H. Silva, D.R. Smucker, E.A. Paul, and R.R. Harwood
Department of Crop and Soil Sciences and Montcalm Extension Service

Nitrogen fertilizer practices are currently under scrutiny as a potential source of nitrate contamination of groundwater. In Michigan, there is some urgency to adapt site-specific N management practices in order for potatoes to remain economically viable in the future. A collaborative effort by MSU crop and soil specialists, Michigan Department of Agriculture, Michigan Potato Industry Commission, and Cooperative Extension Service was initiated to demonstrate how on-farm N stewardship practices influence farm profitability and nitrate leaching to groundwater. Our objectives were to (a) establish N window plots on potato farms and evaluate petiole sap nitrate testing as a tool for adjusting mid-season N fertilization, and (b) install lysimeters and intensively monitor on-farm N leaching losses for three consecutive years, as affected by N practices and crop rotation. We were also interested in identifying peak leaching periods and quantifying nitrate losses to groundwater in relation to rainfall and irrigation.

MATERIALS AND METHODS

Installation of Lysimeters

Three types of undisturbed soil drainage lysimeters were installed on three irrigated potato farms in Montcalm county. Lysimeter types were (a) zero-tension 6-ft long, semicircular troughs of 12 inch diameter, (b) low-tension quartz soil water samplers, and (c) medium-tension soil solution access tubes (SSAT). These types were selected to increase the precision of measurements and reduce the effects of variability due to channeled flow. At each site, lysimeters were laid out into eight separate workstations, four located inside and four outside the N window plot. Each workstation comprised of one trough, one quartz, and one 3-ft long SSAT located at a depth of 3 feet and installed perpendicular to the rows. The 6-foot long troughs extended across two potato rows. These lysimeters were installed in April, before field preparation time to enable farmers to plant potatoes over the lysimeters. After the crop emerged, three additional SSAT's were installed, two at 12-inch depth, and one at 18-inch depth in the row between plants, to monitor soil solution nitrate levels in the root zone.

The soil type at Site 1 was Montcalm-McBride loamy sand, Site 2 was a Mancelona loamy sand, and Site 3 was a Montcalm loamy sand. All three soil types are highly permeable well drained soils.

Establishment of N Window Plots

During May and June, six N window plots were established on six potato farms, including the three farms with lysimeters. In close consultation with the growers, the N window plots were established on strategic locations, to serve as a reference point to judge the N status of the entire field (Figure 1). A window plot can vary in size and shape. It can be a square block 200 x 200 ft. or a strip extending the entire length of the field. The width will depend on the equipment available for applying fertilizer. The window plots receive a reduced N rate, about 60-120 lb/A less N than the conventional rate applied to the rest of the farm. The differential N rates are applied either at first cultivation or hilling.

Weekly Petiole Sap Testing for Nitrate Analysis

Weekly petiole sap testing of potatoes commenced on June 29 and continued until August 22. Four replicates of petiole samples were taken from inside the window and four replicates from outside. The test results were faxed to the growers on the next day via the Montcalm Extension Service. The results were used to assess N status of potatoes and adjust mid-season N fertilizer applications. Additionally, the sap testing service was available to other interested potato growers. Consequently about 300 samples from eight additional growers were tested.

Drainage Water Sampling for Nitrate Analysis

Weekly water sampling from lysimeters commenced on June 29. This is an on-going process to be conducted year-round. Samples were collected weekly until August 29. After that the drainage tubes were buried to permit mechanical harvesting. Water samples from the tension lysimeters will be used to measure nitrate concentration in soil water as it passes below the root zone. Water samples from the trough lysimeters will be used to measure both the volume of drainage water and nitrate N in the leachate.

Potato Harvest

Potatoes were harvested in September. The tuber yield and quality from inside and outside the N window plot were compared. At each site, four plots were harvested from inside and four from outside the window. Each plot consisted of two 50-ft long rows. Tubers were graded according to size. In the round variety Snowden, the U.S. #1 grade included tubers greater than 2-inch diameter. Tubers smaller than 2-inch diameter were graded as B's. Tubers greater than 3¼-inch were classified as oversized. In the long variety Russet Burbank, tubers under 4-oz. were graded as B's. Those weighing over 10-oz. were in the oversized category. Specific gravity was measured to determine the dry matter content. To assess residual soil nitrate N at harvest, soil samples were taken to a depth of 3 feet, in 1 foot increments at the three lysimeter sites. Surface soil samples were taken at 1 foot from the other three sites.

RESULTS AND DISCUSSION

Sap Nitrate Test

The N rates and time of application on the six N window plot sites are presented in Table 1. The weekly sap nitrate test results from inside and outside the window plots are summarized in Figures 2-7. The bar chart shows the critical sap nitrate levels we have established for that variety and planting date. Arrows point to in-season N fertilization events if they occurred during the sap testing period.

The effects of differential N fertilizer rates applied to inside and outside the window were clearly evident from the sap nitrate data. On all sites, the sap nitrate curve closely corresponded to the total amount of N and the in-season application times. As the season progressed, the sap nitrate test was quite useful to farmers as a decision support tool to manage N applications and maintain their fields at adequate N levels. We also worked closely and offered advice to private consultants who relied on the sap nitrate test to manage N on clientele farms.

Potato Yield

The potato yield data from the six N window plots are presented in Tables 2-7. On three sites (1, 3, and 5), the U.S. #1, total, and oversized yield was higher outside the window compared to inside. These yield differences were not statistically significant. On the other three sites, yields were higher inside the window compared to outside. Moreover, on two sites (2 and 4), the yields were significantly higher inside the window plot with a reduced N rate.

It was evident from the data on N economic returns that indeed N stewardship practices would be profitable on most of our potato window plot farms. Three farms produced higher economic returns at a reduced N rate compared to the conventional rate. On the other three farms, although the conventional N rate produced higher economic returns, the increments were small, and potato quality in terms of size and specific gravity were not affected.

Residual Soil Nitrate

The residual soil nitrate N at harvest are presented in Table 8. On the three lysimeter sites, the total residual soil nitrate N was higher outside the window compared to inside. Soil nitrate residues at this stage pose a high risk of leaching to groundwater in the fall. On Sites 1 and 3, the nitrate N concentrations were higher in the surface foot and decreased with depth. On Site 2, however, the nitrate N appeared to increase with soil depth, indicating that some nitrates have moved to deeper layers. This may be due to higher frequency of irrigation and the total amount of irrigated water (Table 9). On the other three sites, the nitrates were measured only on the surface foot. On two of these sites, soil nitrate N was higher outside the window compared to inside.

The presence of a substantial amount of soil nitrate residues support the proposition that a cover crop could be used to scavenge the residual nitrate before fall leaching. Because of downward movement of nitrates in the soil, however, these cover crops may have to be established immediately following harvest to enable them to utilize the nitrates in the surface foot.

Soil Water Analysis

The year 1995 was characterized by unusually long dry spells in May, August, and September. Therefore very little leaching water was obtained from the trough lysimeters. Consequently nitrate leaching was minimal during the period from June 27 to September 5. There was also considerable variability in the volume of water collected from one trough to another. This is probably attributed to preferential flow of water through the soil profile. There were three noteworthy events during the season, when a majority of troughs had drainage water and nitrate leaching appeared to have taken place. These dates were June 27, August 8, and August 22. Water balance data indicated that these events occurred immediately following periods of heavy rainfall. Most of the nitrate leaching occurred in the water samples that were collected after potato harvest, in November. This indicates that the climatic and land use factors in the fall season were conducive to nitrate leaching. The trough lysimeters may require some time to stabilize in the field. As such, we expect to get more consistent data in the fall and spring seasons when most of the nitrate leaching is bound to occur.

The nitrate N concentrations from the medium-tension SSAT lysimeters at 12-, 18-, and 36-inch depths are summarized in Figures 8-10. The nitrate N at 12- and 18-inch depths were generally higher at the beginning and decreased toward the end of the season. At these depths, the soil solution nitrate levels increased soon after in-season N application and then decreased with plant uptake and downward nitrate movement. The soil solution nitrate levels measured at 12-inch depth closely matched the petiole sap nitrate curve at each location. Thus, the use of SSAT samplers for measuring soil solution nitrate N may be another useful tool for N management of potatoes.

Unlike the surface measurements, the nitrate N measured at 36-inch depth was lower at the beginning and showed a gradual increase towards the end of the season. This was associated with the downward nitrate movement with time. Towards the end of the growing season, the nitrate N at this depth exceeded 10 mg/L level (drinking water standard) at all three sites.

The differences in the soil solution nitrate N at 36-inch depth between inside and outside the window plots are presented in Figures 11-13. These figures show that on a majority of sites, N stewardship practices are effective in reducing the nitrate N concentrations of the leachate water. The nitrates at this depth are not utilized by potatoes, and therefore could potentially leach to groundwater.

A comparison of the nitrate concentrations from the SSAT and quartz lysimeter sources were made on Site 3. Site 3 was chosen because it recorded the highest frequency of weekly leaching compared to the other two sites. Generally the nitrate levels in the SSAT lysimeters closely corresponded to those of quartz samplers (Figure 14). A comprehensive study of the soil water analysis obtained from the three sources of lysimeters will be undertaken as more data becomes available in the future.

CONCLUSIONS

Since this project was inaugurated in April 1995, we have made excellent progress towards achieving our objectives. With a combination of N window plots, sap nitrate testing, and on-farm lysimeters, we have been able to demonstrate that N stewardship practices are effective in (a) increasing potato profitability, (b) reducing soil nitrate N residues at harvest, and (c) lowering nitrate N concentration of drainage water at a depth of 36 inches, compared to conventional N practices. Furthermore, the weekly petiole sap nitrate test has gained acceptance as an excellent tactical approach for in-season N management of potatoes. Our data indicates that on most of our cooperating farms there is economical and environmental incentives to reduce the current N application rates on potatoes.

Table 1. Nitrogen application schedule on the six window plot demonstration sites 1995.

Site No.	Window	Preplant	Planting	N application and amount (lb/A)					Harvest	Total
				------------Date------------						
			5/2	5/18	6/6	6/12	7/10	7/25	9/6	
1	Inside	-	55	45	105	-	20	20		245
	Outside	-	55	45	105	60	20	20		305
			5/19	6/19	6/26	7/3	8/2	8/5	9/26	
2	Inside	21	61	-	48	45	23	35		233
	Outside	21	61	93	48	45	23	35		326
			5/12	6/10	6/15				9/13	
3	Inside	-	50	141	-					191
	Outside	-	50	141	92					283
			5/20	6/6	6/26	7/1			9/20	
4	Inside	-	34	60	69	-				162
	Outside	-	34	60	69	90				252
			5/16	5/30	6/20				9/18	
5	Inside	-	90	75	-					165
	Outside	-	90	75	100					265
			5/4	6/10	6/19	8/1			9/27	
6	Inside	-	60	60	-	30				150
	Outside	-	60	60	130	30				280

Table 2. Tuber yield, size, and specific gravity of Snowden potatoes on Site 1 - 1995.

Treatment	N rate	U.S. #1	Oversized	A's	B's	U.S. #1	Total	S.G.	N Economic Returns ($)
	lb/A	%	----------	----------	cwt/A	----------	----------		
INSIDE	245	86	23.4	301.3	53.9 a*	324.8	378.7	1.072	2089.55**
OUTSIDE	301	88	18.5	320.6	47.8 b	339.1	386.9	1.073	2170.87

*Mean potato yields in the column followed by different letters are significantly different according to Duncan's Multiple Range Test (p=0.05).

**N Economic Returns = Gross Returns - N Fertilizer Cost (based on potato price of $6.60/CWT of U.S. #1 and N fertilizer price of $0.22/lb).

Table 3. Tuber yield, size, and specific gravity of Snowden potatoes on Site 2 - 1995.

Treatment	N rate	U.S. #1	Oversized	A's	B's	U.S. #1	Total	S.G.	N Economic Returns ($)
	lb/A	%	----------	----------	cwt/A	----------	----------		
INSIDE	233	92	63.4	342.8 a*	37.7	406.2 a	443.9 a	1.078	2629.99 a**
OUTSIDE	326	91	44.6	292.1 b	35.2	336.7 b	371.9 b	1.076	2150.38 b

*Mean potato yields in the column followed by different letters are significantly different according to Duncan's Multiple Range Test (p=0.05).

**N Economic Returns = Gross Returns - N Fertilizer Cost (based on potato price of $6.60/CWT of U.S. #1 and N fertilizer price of $0.22/lb).

Table 4. Tuber yield, size, and specific gravity of Snowden potatoes on Site 3 - 1995.

Treatment	N rate	U.S. #1	Oversized	A's	B's	U.S. #1	Total	S.G.	N Economic Returns ($)
	lb/A	%	-------------------	------	cwt/A	------	-------------------		
INSIDE	191	94	43.6	302.3	24.0 b*	345.9	369.9 b	1.075	2240.92**
OUTSIDE	283	91	57.6	303.0	35.7 a	360.6	396.3 a	1.076	2317.49

*Mean potato yields in the column followed by different letters are significantly different according to Duncan's Multiple Range Test (p=0.05).

**N Economic Returns = Gross Returns - N Fertilizer Cost (based on potato price of $6.60/CWT of U.S. #1 and N fertilizer price of $0.22/lb).

Table 5. Tuber yield, size, and specific gravity of Snowden potatoes on Site 4 - 1995.

Treatment	N rate	U.S. #1	Oversized	A's	B's	U.S. #1	Total	S.G.	N Economic Returns ($)
	lb/A	%	-------------------	------	cwt/A	------	-------------------		
INSIDE	162	86	29.2	273.8 a*	29.1 a	302.9 a	332.1 a	1.072	1963.74 a**
OUTSIDE	252	87	20.7	237.0 b	38.1 b	257.8 b	295.9 b	1.073	1645.65 b

*Mean potato yields in the column followed by different letters are significantly different according to Duncan's Multiple Range Test (p=0.05).

**N Economic Returns = Gross Returns - N Fertilizer Cost (based on potato price of $6.60/CWT of U.S. #1 and N fertilizer price of $0.22/lb).

Table 6. Tuber yield, size, and specific gravity of Snowden potatoes on Site 5 - 1995.

Treatment	N rate	U.S. #1	Oversized	A's	B's	U.S. #1	Total	S.G.	N Economic Returns ($)
	lb/A	%	----------------cwt/A----------------						
INSIDE	165	90	17.2	258.5	35.9	275.7	311.7	1.074	1783.20*
OUTSIDE	265	91	33.2	272.9	31.1	306.1	337.1	1.074	1961.66

*N Economic Returns = Gross Returns - N Fertilizer Cost (based on potato price of $6.60/CWT of U.S. #1 and N fertilizer price of $0.22/lb).

Table 7. Tuber yield, size, and specific gravity of Russet Burbank potatoes on Site 6 - 1995.

Treatment	N rate	U.S. #1	Oversized	A's	B's	Pick Outs	U.S. #1	Total	S.G.	N Economic Returns ($)
	lb/A	%	-------------------cwt/A-------------------							
INSIDE	150	70	56.8	250.2	93.2	33.6	307.0	433.8	1.074	1809.00*
OUTSIDE	280	72	38.1	248.4	80.3	28.4	286.6	395.3	1.075	1657.55

*N Economic Returns = Gross Returns - N Fertilizer Cost (based on potato price of $6.00/CWT of U.S. #1 and N fertilizer price of $0.22/lb).

Table 8. Residual soil nitrate N on the six window plot demonstration sites 1995.

Site No.	Window	0-12"	12-24"	24-36"	Total
		---------lb/A NO_3N---------			lb/A
1	Inside	18.0	12.7	8.4	39.1
	Outside	34.6	16.9	9.4	60.9
2	Inside	8.3	2.2	8.6	19.1
	Outside	13.7	14.4	15.5	43.6
3	Inside	14.4	4.3	4.0	22.7
	Outside	15.1	11.9	7.2	34.2
4	Inside	29.7			
	Outside	74.2			
5	Inside	48.9			
	Outside	32.9			
6	Inside	17.4			
	Outside	31.6			

Table 9. Rainfall and irrigation on the six window plot demonstration sites 1995.

	June to August		
Site No.	Rainfall	Irrigation	Times Irrigated
	---------inches----------		
1	11.1	6.2	9
2	11.0	6.8	11
3	12.8	5.8	10
4	10.7	2.8	4
5	10.0	6.4	9
6	11.6	8.8	16

Figure 1. Diagram of on-farm window plot with eight lysimeter locations.

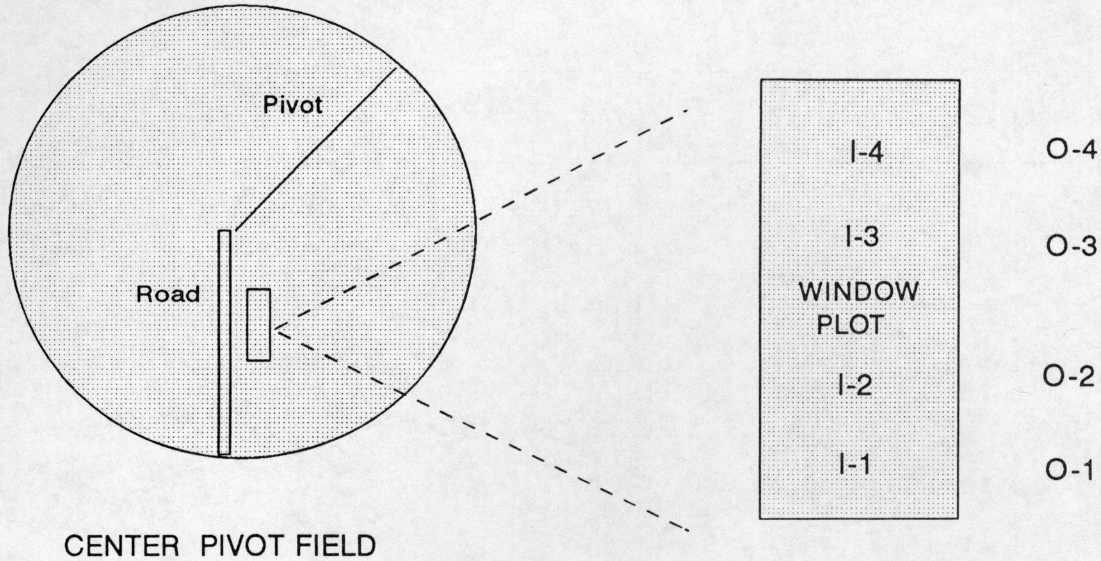


Fig 2. Petiole sap nitrate concentration in the window plot

Site 1 - Snowden 1995

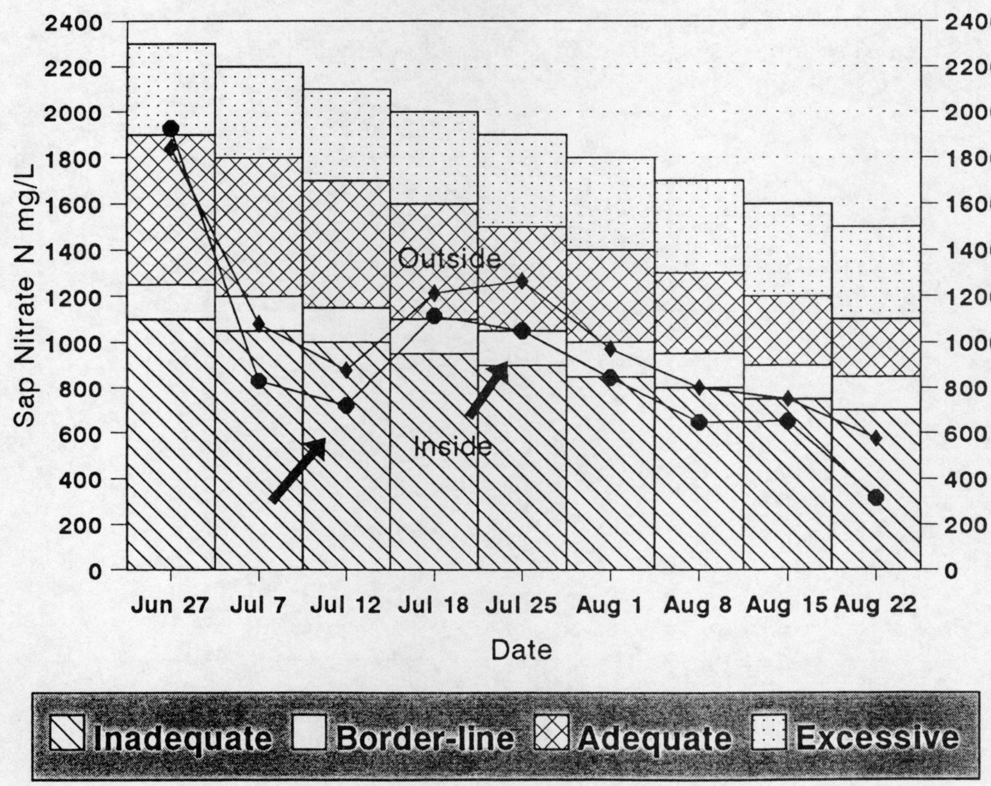


Fig 3. Petiole sap nitrate concentration in the window plot

Site 2 - Snowden 1995

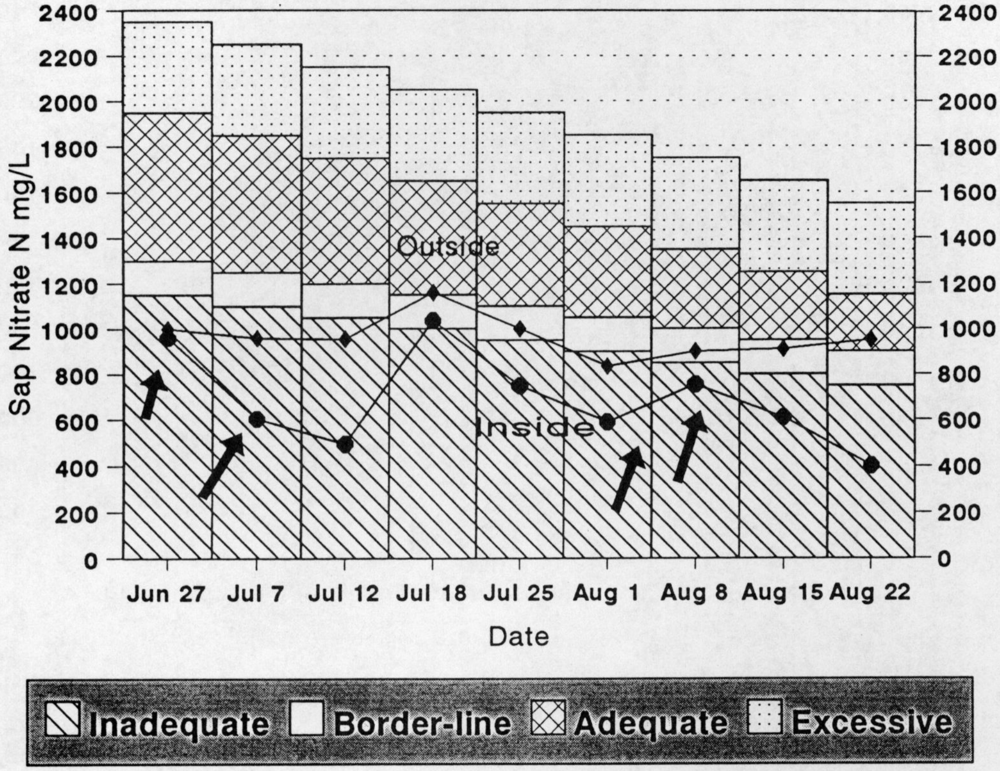


Fig 4. Petiole sap nitrate concentration in the window plot

Site 3 - Snowden 1995

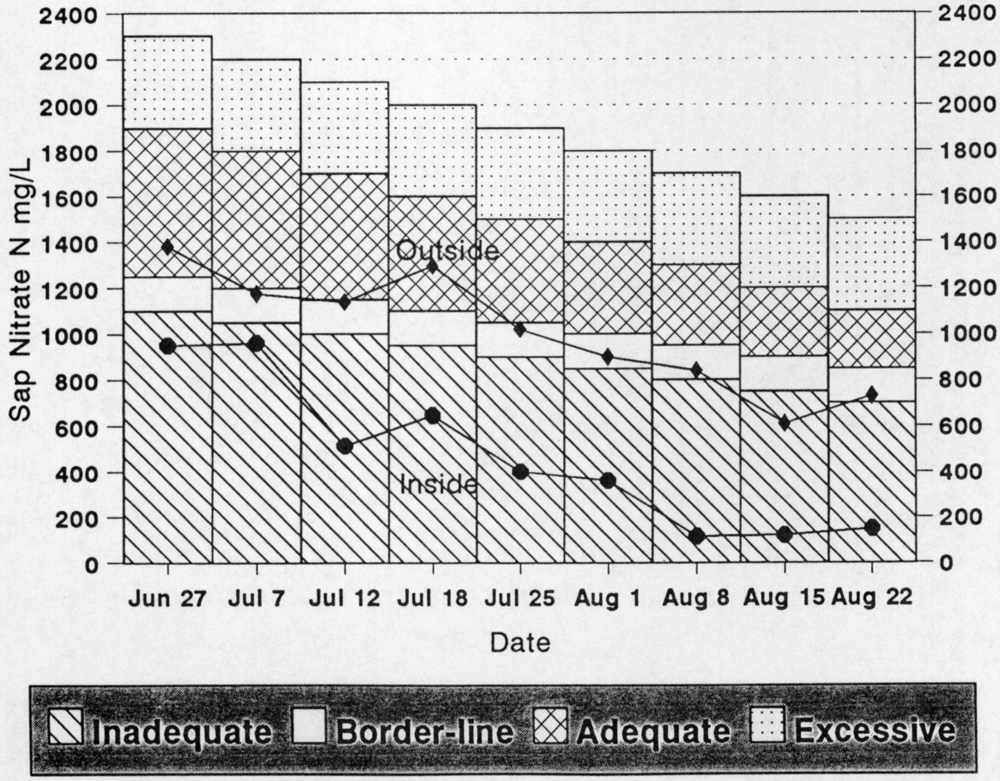


Fig 5. Petiole sap nitrate concentration in the window plot

Site 4 - Snowden 1995

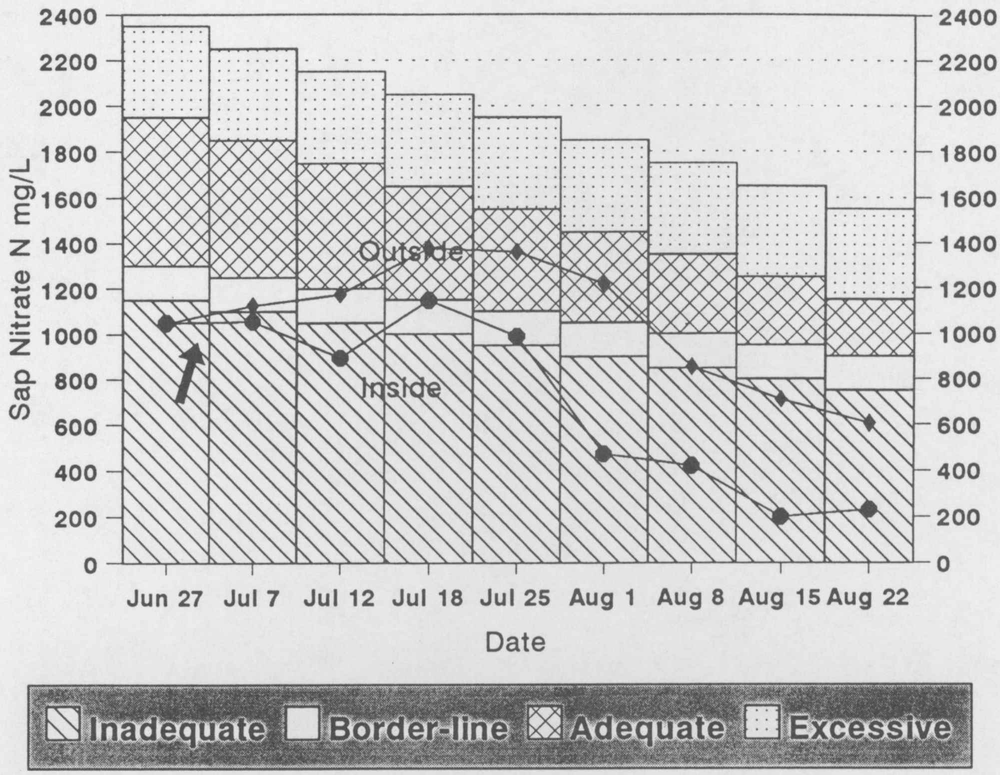


Fig 6. Petiole sap nitrate concentration in the window plot

Site 5 - Snowden 1995

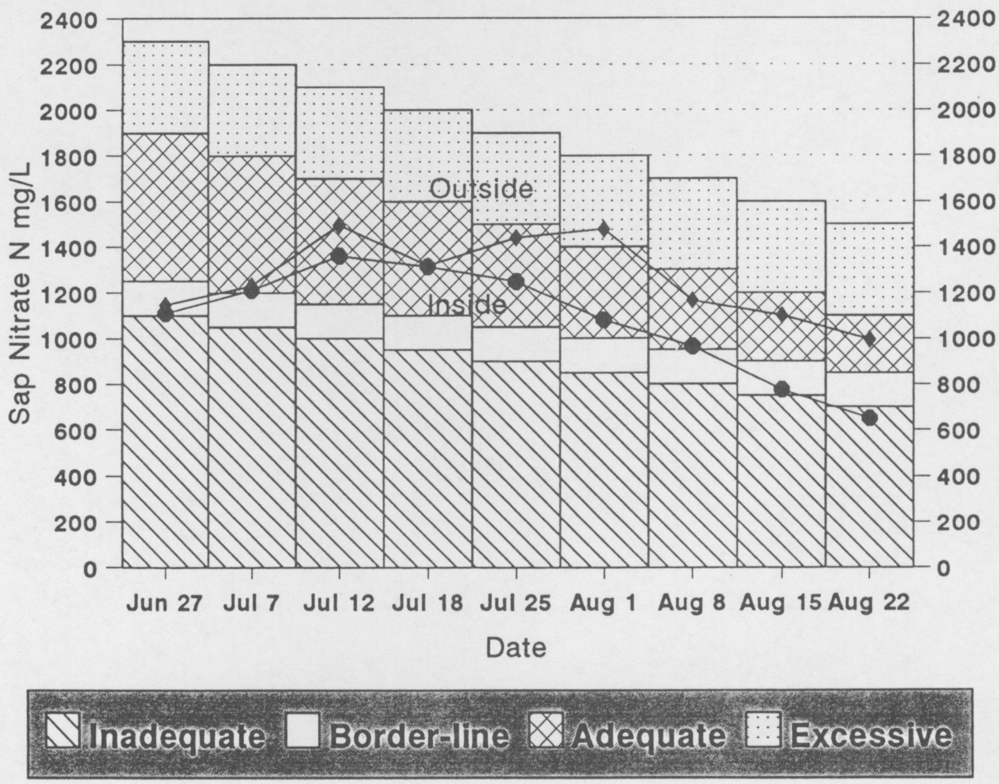


Fig 7. Petiole sap nitrate concentration in the window plot
Site 6 - R. Burbank 1995

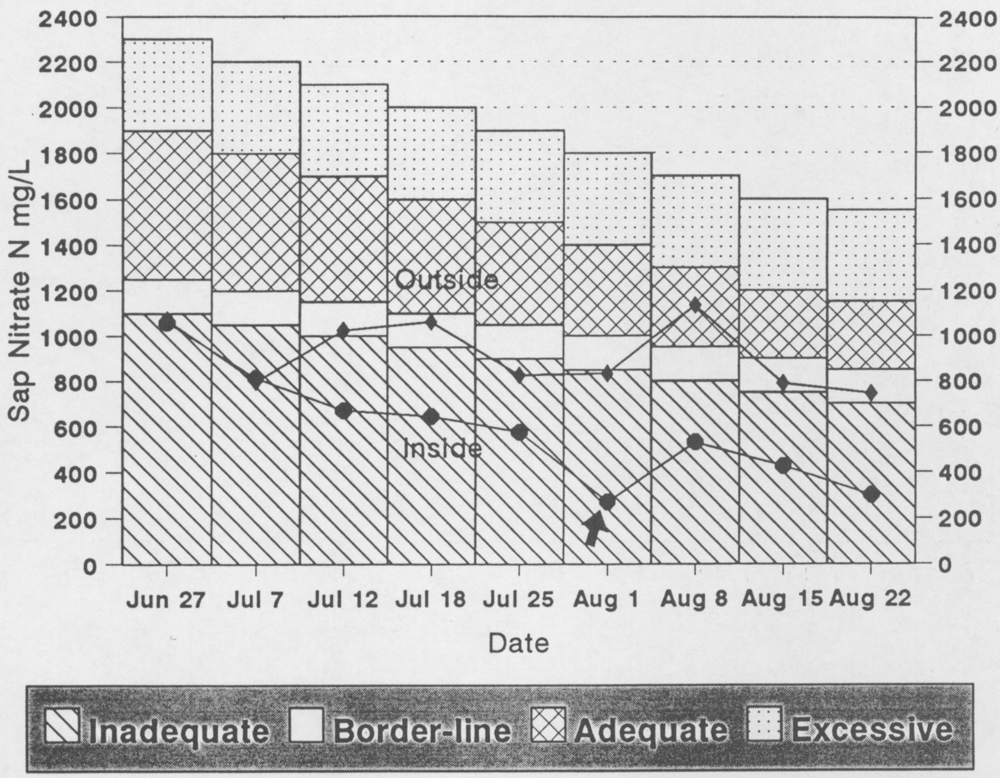


Fig. 8. Soil solution nitrate N at 3 depths measured by SSAT lysimeters
Site 1 - 1995

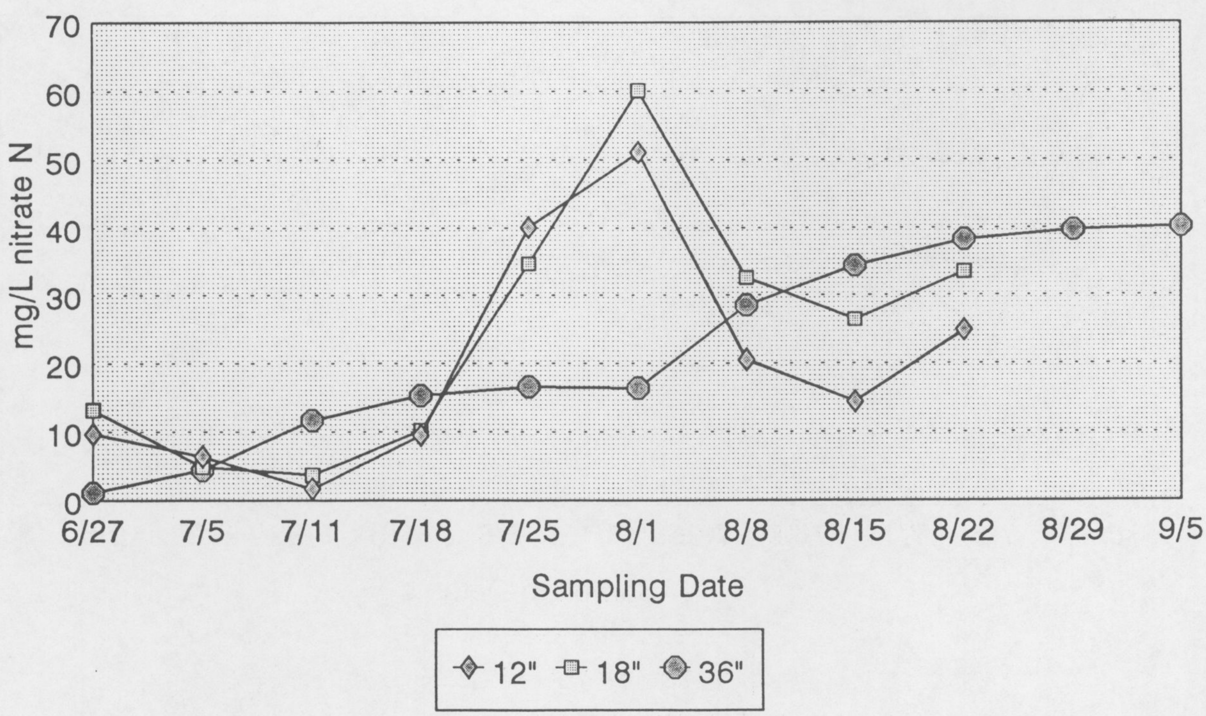


Fig. 9 Soil solution nitrate N at 3 depths measured by SSAT lysimeters
Site 2 - 1995

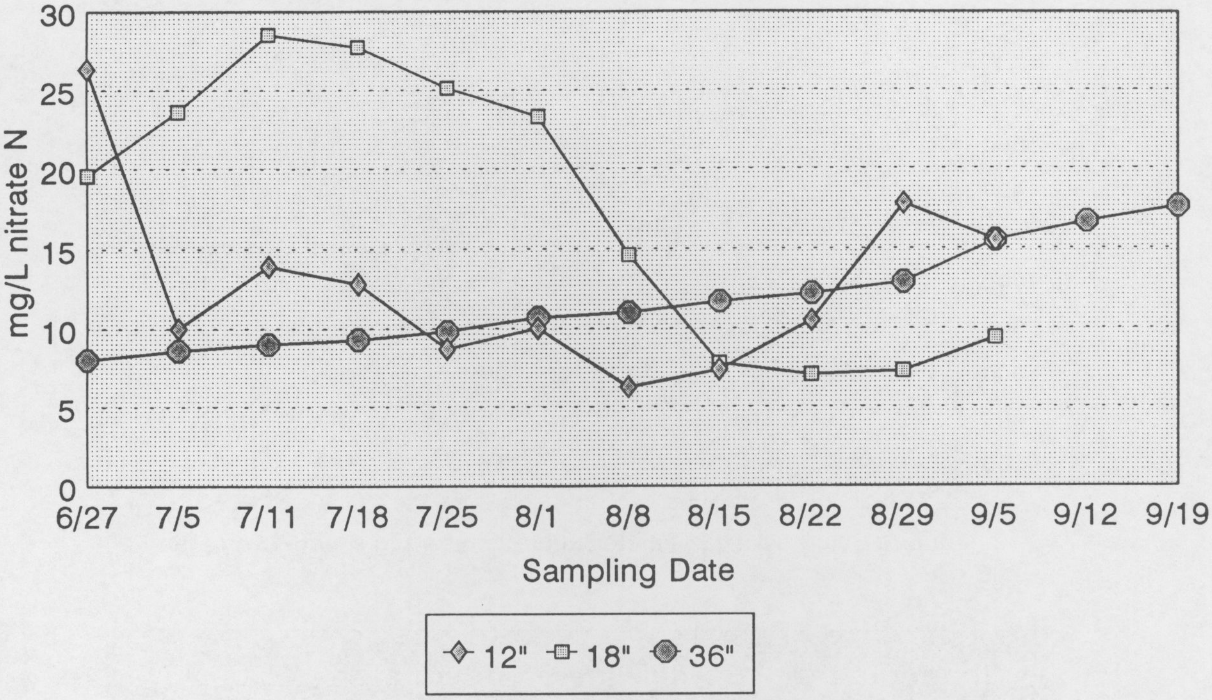


Fig. 10. Soil solution nitrate N at 3 depths measured by SSAT lysimeters
Site 3 - 1995

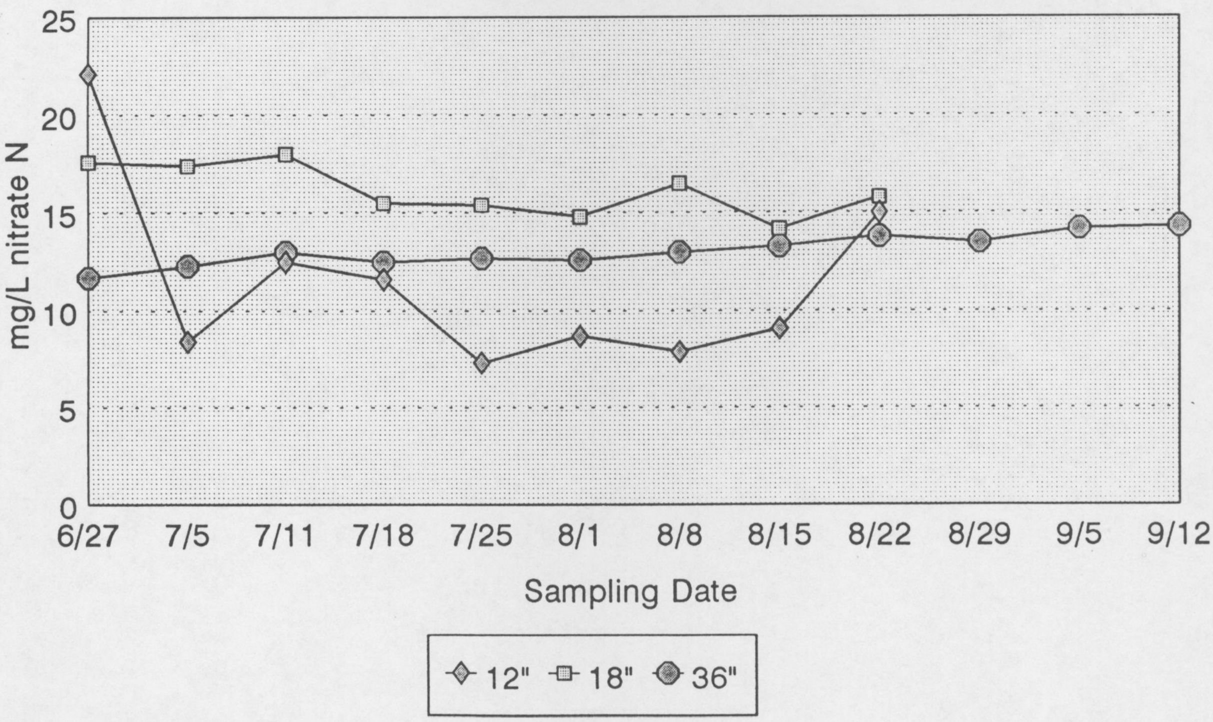


Fig.11. Soil solution nitrate N inside and outside window plot as measured by SSAT lysimeters at 36 inch depth - Site 1 1995

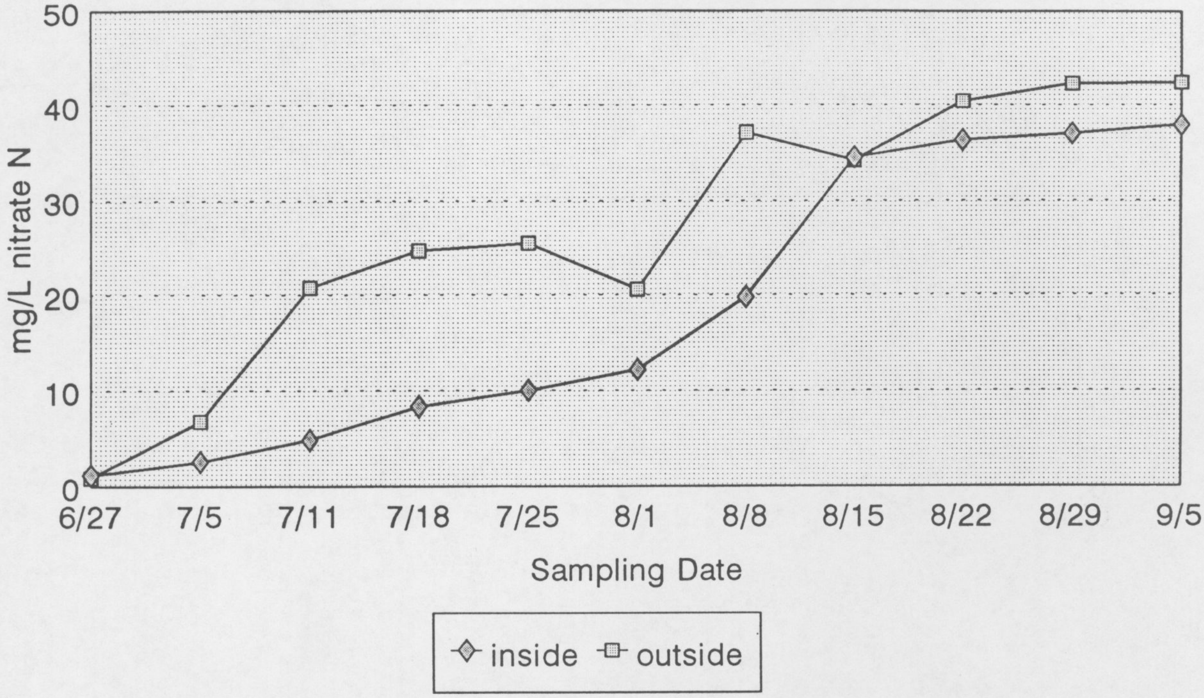


Fig.12. Soil solution nitrate N inside and outside window plot as measured by SSAT lysimeters at 36 inch depth - Site 2 1995

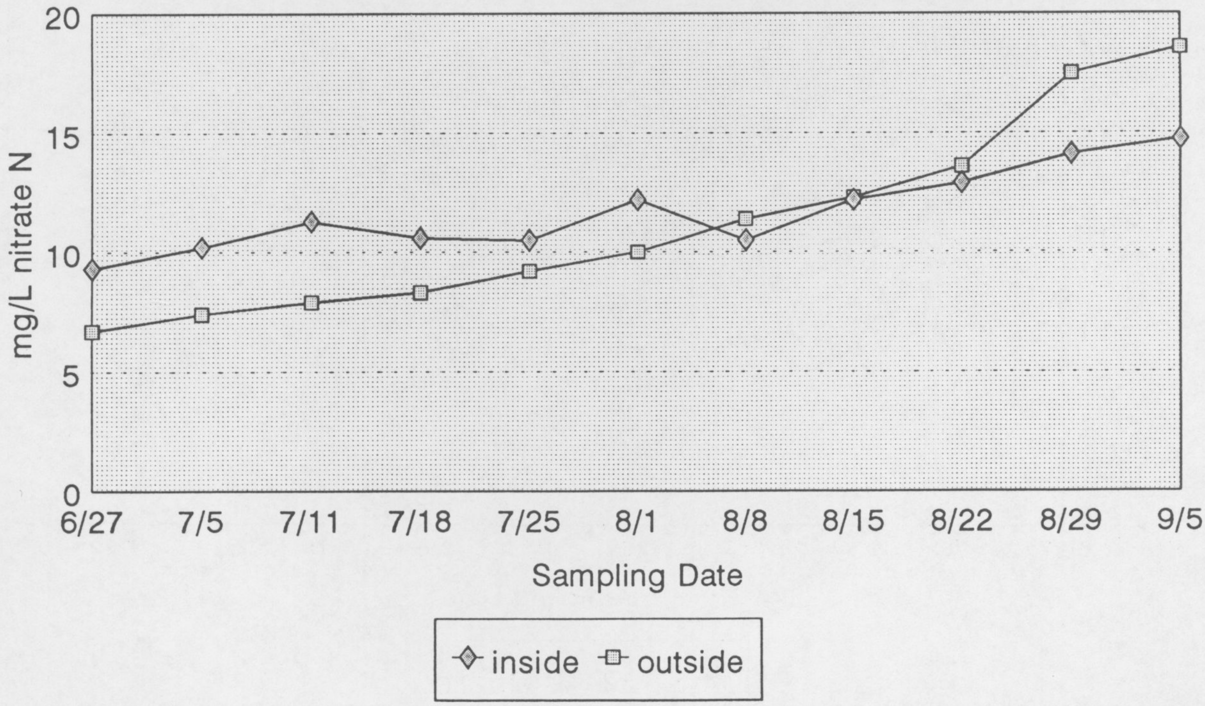


Fig.13. Soil solution nitrate N inside and outside window plot as measured by SSAT lysimeters at 36 inch depth - Site 3 1995

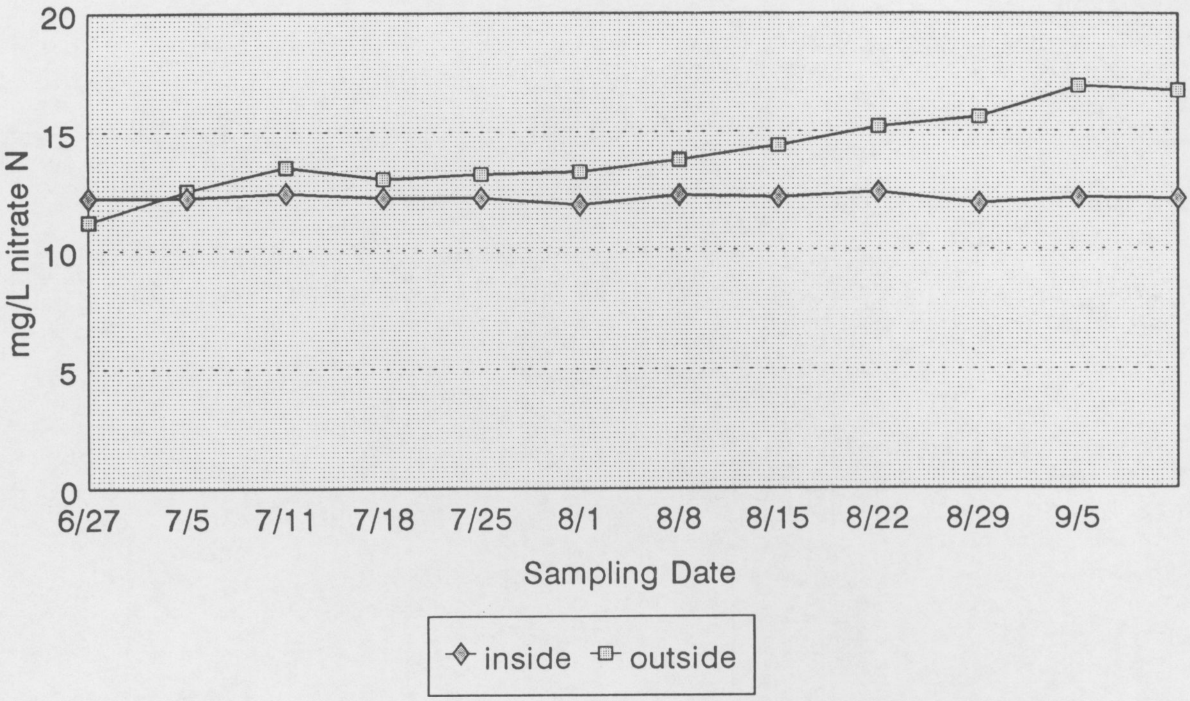
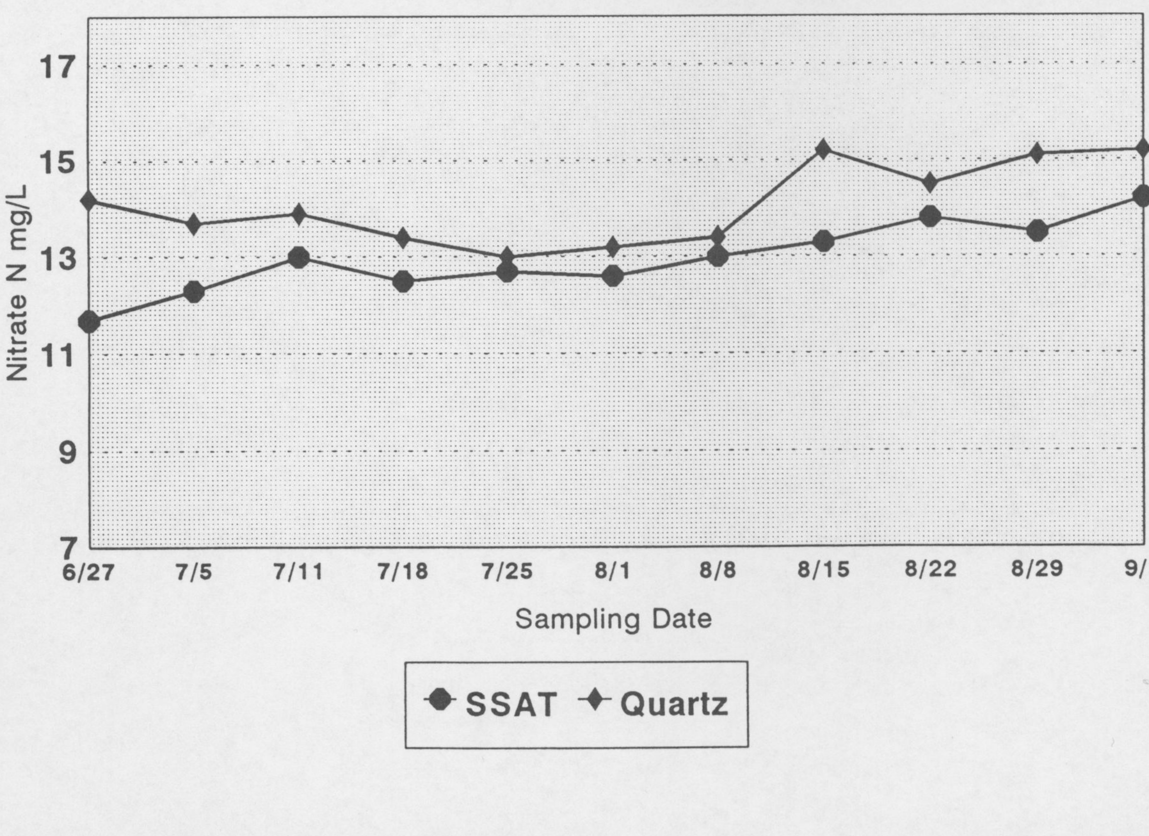


Fig. 14. Comparison of nitrate N from Quartz and SSAT lysimeters at 36-inch depth - Site 3 1995



Funding: MPIC/Industry

MANAGEMENT OF THE POTATO EARLY-DYING DISEASE COMPLEX WITH CROP ROTATIONS, GREEN MANURES AND NEMATICIDES

G.W. Bird, F.W. Warner, J.F. Davenport, and R.L. Mather
Dept. of Entomology
Michigan State University
E. Lansing, MI 48824-1115

Introduction

Successful management of plant-parasitic nematodes usually requires an integrative approach. Management of root-lesion, Pratylenchus penetrans, and northern root-knot, Meloidogyne hapla nematodes is no exception. The research reported on here are investigations of cultural, chemical and biological tactics for control of P. penetrans and M. hapla in potatoes. All the trials were conducted at the MSU Potato Research Farm in 1995

Cultural Control

Ten-Year Potato Rotation Trial

A multi-year potato rotation trial was established at the Potato Research Farm in 1991. The cropping sequences and potato yields (cv. Goldrush) for 1995 are shown in Table 1.

The highest yields are always achieved when potatoes are grown following 2 years of alfalfa. However, yields following many years out of potatoes were nearly as good. Continuous potato cropping has always resulted in the lowest yields. The relative potato yields obtained over the course of this study are presented in Table 2.

Potato yields have typically been poor on this site. These poor yields had been attributed to low petiole nitrate levels in the past. However, sap nitrate data were not collected in 1995. Potatoes following alfalfa typically have had higher sap nitrate levels, therefore possibly contributing to higher yields. However, potassium may also play a role. Preplant potassium levels were higher in the plots where alfalfa grew in 1994 (treatments 6 and 7) than in the other plots. K levels were 352 lbs/A in plots following 2 years of alfalfa and 312 following a single year on April 20, 1995. For comparison purposes, where potatoes have been grown continuously, K levels were 244 lbs/A on the April 20 sampling date. These may be adequate potassium levels but potassium deficiencies can occur in potatoes grown on sandy loam soils with low exchange capacities. Petiole K data have never been collected. Potassium is an important element for growth but higher tissue levels have often been associated with alleviation of disease symptoms in other plant species. This same effect may occur in potatoes.

Root-lesion nematode counts were relatively low within potato roots on July 6 (Table 3). In general, potato roots, particularly where potatoes have been cropped continuously, have had lower numbers of lesion nematodes. However, root-knot nematodes have increased dramatically in numbers in these plots. Over 500 root-knot nematode juveniles were recovered, on average, in the continuous potato plots on Oct. 16. Potato is a good host for the northern root-knot nematode, Meloidogyne hapla, but the crop does not appear to be highly susceptible. In addition, root-knot nematodes are not known to interact with Verticillium dahliae. Therefore, increases in M. hapla population densities and concurrent drops in lesion nematode numbers (it appears that root-knot nematodes will out compete lesion nematodes) may not be associated with yield declines. However, there is no information in the literature to support this hypothesis.

Hairy vetch is an excellent host for the lesion nematode, Pratylenchus penetrans, M. hapla and the clover cyst nematode, Heterodera trifolii (Table 3). While the crop is considered an excellent cover, it doesn't overwinter in Michigan. It's not known at this time if potatoes preceded by 2 years of hairy vetch yield as well as potatoes preceded by alfalfa.

The population densities of other plant-parasitic nematodes are also shown in Table 3. These nematodes are not considered serious pathogens of potato. However, it does demonstrate host preferences of these nematodes.

Potato-Carrot Rotation Trial

Another rotation experiment was initiated at the Research Farm in 1994 investigating potato-carrot rotations. The main crop grown in 1994 was green peas to increase numbers of root-lesion and root-knot nematodes. This objective was met as lesion nematode and root-knot nematode counts were extremely high by July, 1994. Carrots were not grown in any of the plots in 1994, but potatoes (Russet Norkotah) were included. The yield of U.S. No. 1 tubers was 171 cwt/A. The primary objectives of this research are to examine the influences of root-lesion and root-knot nematodes on potatoes and carrots grown in mineral soil. These nematodes will be managed with and without the use of nematicides and attempts will be made to correlate yield responses with nematode numbers.

Carrot plots were untreated or treated with Vapam at 50 gal/A during the spring of '95, Vydate at 2 gal/A or Deny (Burkholderi cepacia) at planting. Potato (cv. Shepody) plots were untreated or fumigated with Vapam 2 weeks prior to planting. The nematicide treatments did not result in statistically significant carrot yield increases although Vapam- treated carrots were of slightly higher quality (Tables 4 and 5). Shepody yields in fumigated plots were significantly higher than the untreated plots (Table 6).

Northern root-knot nematode counts were very high within the carrot plots at the end of the season in 1994 and 1995 (Table 7). M. hapla numbers observed at-planting were not lower in the Vapam-treated plots than the other plots. This probably explains why yield differences were not observed. Vydate did not provide root-knot nematode control. Based on these results, Vydate is not recommended for M. hapla control for carrots grown in mineral soil.

Pratylenchus penetrans numbers were lower in Vapam-treated carrot plots than untreated plots (Table 8) and in the treated potato plots (Table 6). Potatoes are more susceptible to lesion nematodes than carrots due to interactions with V. dahliae. Lesion nematodes are also easier to control with nematicides than root-knot nematodes. These differences help to explain the significant yield increases in Vapam-treated potato plots and the lack of yield responses observed in the fumigated carrot plots. Vydate did not control P. penetrans in the carrot plots.

The population densities of lesion, northern root-knot and clover cyst nematodes are presented in Tables 9-11 respectively. Hairy vetch appears to be an excellent host of all 3 species of nematode. Root-knot, as well as lesion, nematode numbers were quite low within the farrow-marigold plots. Clover cyst nematodes were recovered from the hairy vetch plots in this trial also (Table 11). These nematodes are not pathogens of potato, but other cyst nematodes are regulatory pests in Michigan. Hairy vetch is also a host for the soybean cyst nematode, so this crop should be avoided if this nematode is known to exist.

Cover Crop Study

A number of crops were planted as fall covers on Aug. 30, 1994 to investigate them as potential hosts for Pratylenchus penetrans and to examine their benefits as green manure crops preceding soybeans. Fall covers/green manure crops were also investigated in the fall of 1992 and potatoes planted in 1993 to determine if they provided benefits for root-lesion nematode management and potato yield increases. It was discovered in 1992, that all the cover crops utilized, rapeseed, canola, rye and oats were excellent hosts to P. penetrans and subsequent potato yields were not increased compared to the rye (used as the standard), unless the plots were also treated with Vapam. The crops utilized in 1994 and the counts of P. penetrans obtained that fall are shown in Table 12. For comparative purposes, the numbers of nematodes recovered in the fall of 1992 are also displayed. The wide disparities in the numbers found in 1994 compared to 1992 are excellent indicators of the annual variabilities associated with nematode populations. Although soybeans, and not potatoes, were grown in these plots in 1995, this information should still be of interest to potato producers because utilizing fall cover crops that are poor hosts to P. penetrans should lessen the dependence on nematicides. All of these crops were amended to the soil during the last week of Oct., 1994.

Both root-lesion and root-knot nematodes were recovered during the course of this study (Table 13). Differences were not observed in lesion nematode counts between soybean plots during 1995. However, at harvest differences were seen in counts of northern root-knot nematodes. Incorporation of rape provided no nematode control except root-knot nematode numbers were much lower in soybean plots at harvest when preceded by the cultivar Askari. Soybeans yields were hghest when they were preceded by black lentil (treatment 2), marigold (treatment 4) and spring barley (treatment 10). However, because these yield responses did not correlate with nematode counts, undetermined factors apparently accounted for these differences.

Chemical and Biological Control

Nematode Management Trial

An experiment was conducted to determine the efficacies of nonfumigant nematicides for control of root-lesion nematodes, P. penetrans in potatoes (cv. Snowden). Temik 15G, Mocap 10G, Mocap 6EC, Mocap gel, an experimental compound (EXP) and Vydate L were the nematicides utilized. The application rates and methods, lesion nematode counts, potato stands and yields are presented in Table 14.

Root-lesion nematode counts were low to moderate at-planting. V. dahliae assays were not preformed, but based on the length of the rotations used at the farm, it was suspected soil levels of the fungus were low. P. penetrans numbers were also low within root tissue samples collected on July 20. Differences were observed at harvest in soil samples.

No differences were observed in potato yields. This is probably due to the low numbers of P. penetrans present at planting. The numbers were lower than the economic threshold in all the plots. There were no differences in potato stands, so no treatments were rated phytotoxic based on these plant density data.

Scab Trial

Observations from Maine indicate that the incidence of common scab was reduced in fields where Mocap was applied. The mechanism to explain this phenomenon is not understood, but it has been speculated nematodes are involved. Because Mocap is an effective nematicide if applied properly and is not believed to impact soil levels of Streptomyces, reducing nematode numbers may reduce scab incidence because of a lesion nematode-Streptomyces scabies interaction. Such an interaction has not been reported but it's possible it has not been investigated.

Spring applications of compost will result in increased incidences of scab. Therefore, compost (20T/A) was applied to a number of plots in the presence or absence of Mocap and/or Deny. Nematode samples were collected and analyzed during the course of the study and potatoes were graded at harvest and rated for scab.

The treatments did not result in effective root-lesion nematode control (Table 15). However, a greater percentage of potatoes were free from scab lesions in plots where compost was not applied (Table 16). Mocap did not provide scab control. However, because the material did not provide effective nematode control, it is impossible to determine if reductions in lesion nematode numbers correlate with reduced incidences of scab.

Table 1. Potato (cv. Goldrush) yields from 10-year potato rotation trial, MSU Potato Farm, 1995.

Tmt	Cropping Sequence					No. 1	Total
	91	92	93	94	95		
1	P	P	P	P	P	171.1	223.1
2	A	P	P	P	HV		
3	A	A	P	P	TM		
4	O	A	A	P	A		
5	O	P	P	P	R		
6	O	S	A	A	P	215.6	279.6
7	O	S	KB	A	A		
8	O	S	KB	PE	RAD		
9	O	S	KB	PE	P	201.5	264.1
10	O	S	KB	PE	F		

Note: P=Potato, A=Alfalfa, HV=Hairy Vetch, TM=Tri-mix, O=Oats, R=Rye, S=Soybean, KB=Kidney Beans, PE=Peas, RAD= Oil Seed Radish.

Table 2. Cropping Sequences and Relative Yields of Potatoes in 10-Year Rotation Trial, MSU Potato Research Farm, 1991-1995.

Cropping Sequences[1]					Relative Yields, U.S. No. 1[2]				
1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
P	P	P	P	P	1.00	0.65	0.34	0.29	0.79
A	P	P	P	HV		1.00	0.54	0.34	
A	A	P	P	NM			1.00	0.57	
O	A	A	P	A				1.00	
O	P	P	P	R		0.96	0.53	0.32	
O	S	A	A	P					1.00
O	S	LRK	GP	P					0.93

[1] Crop Symbols; P = Potato; A = Alfalfa; HV = Hairy Vetch; NM = Nematode Mix (annual ryegrass, hairy vetch, marigold); O = oat; R = Annual Ryegrass; S = Soybean; LRK = Light Red Kidney Bean; GP = Green Pea.

[2] Relative Yields calculated by giving the highest annual yield a value of 1.00 and dividing the other yields by the highest value.

Table 3. Nematode counts from 10-year potato rotation trial, MSU Potato Farm, 1995.

1995 crop	Root lesion		Root knot		Cyst 10/16[2]	Ring 10/16[3]	Dagger 10/16[3]	Stunt 10/16[3]
	7/6[1]	10/16[2]	7/6[1]	10/16[2]				
Potato	30.3	9.5	19.5	557.3	0.0	0.0	0.0	1.1
Hairy vetch	**1102.5**	249.9	**1673.6**	**3221.4**	151.3	0.3	0.0	0.5
Tri-mix	90.0	119.3	187.3	89.5	0.0	77.8	4.1	0.0
Alfalfa	91.4	196.4	94.6	**2462.9**	0.0	30.4	0.8	0.0
Annual rye	38.0	295.3	2.1	19.5	0.0	36.5	1.1	40.6
Potato	12.3	6.9	26.9	161.1	0.0	16.8	0.0	2.0
Alfalfa	157.4	27.8	133.8	451.0	0.0	130.4	2.6	1.3
Oilseed Radish	82.0	74.6	7.4	4.1	0.0	0.3	0.0	2.4
Potato	47.6	14.6	4.4	182.9	0.0	0.5	0.0	3.6
Fallow	10.0	9.4	0.0	2.3	0.0	0.0	0.0	0.0

[1]Pratylenchus penetrans and Meloidogyne hapla counts from 1.0 g root tissue.

[2]Combined counts for P. penetrans, M. hapla and Heterodera trifolii of 1.0 g root tissue and 100 cm^3 soil.

[3]Nematodes recovered from 100 cm^3.

Table 4. Carrot yields from treated plots at the MSU Potato Research Farm, 1995 (wt./10 row ft.)

Treatment	Total	Market.	Stub	Fork	% Market.
Check	17.4	13.1	2.9	1.4	69.8
Vydate	10.5	6.2	2.4	1.9	51.9
Deny	14.6	11.1	3.0	0.5	77.3
Vapam	15.9	13.8	1.6	0.4	84.7

Table 5. Carrot yields from treated plots at the MSU Potato Research Farm, 1995 (no./10 row ft.)

Treatment	Total	Market	Stub	Fork	% Market
Check	97.0	70.3	20.0	6.8	72.4
Vydate	70.3	39.0	22.3	9.0	55.5
Deny	84.7	64.0	18.3	2.3	75.6
Vapam	102.7	87.7	12.7	2.3	85.4

Table 6. Mean potato (cv. Shepody) yields and nematode counts from potato-carrot rotation trial, MSU Potato Farm, 1995.

Tmt	Yields (cwt/A)		Root-lesion			Root-knot		
	No. 1	Total	May 18[1]	July 20[2]	Sept. 26[1]	May 18[1]	July 20[2]	Sept. 26[1]
Check	220.99	276.82	33.25	34.50	86.00	19.00	118.75	448.25
Vapam	263.73	344.77	1.00	0.50	4.75	11.75	5.50	135.50

[1]Counts from 100 cm^3 soil.

[2]Counts from 1 g root tissue.

Table 7. Population densities of northern root-knot nematodes, Meloidogyne hapla, observed in carrot plots at the MSU Potato Research Farm, 1994-1995.

Treatment	P_{i94}	P_{f94}	P_{i95}	P_{pt95}	P_{m95}	P_{f95}
Check	0.0	1300.0	2.3	52.3	35.5	2238.8
Vydate	0.0	1590.0	1.0	70.5	27.3	2880.0
Deny	0.0	1590.0	1.0	33.0	0.3	237.0
Vapam	0.0	3000.0	30.3	76.8	0.0	44.3

Table 8. Population densities of root-lesion nematodes, Pratylenchus penetrans, observed in carrot plots at the MSU Potato Research Farm, 1994-1995.

Treatment	P_{i94}	P_{f94}	P_{i95}	P_{pt95}	P_{m95}	P_{f95}
Check	2.8	850.0	28.8	38.0	29.3	252.0
Vydate	13.0	1950.0	37.8	45.3	23.0	243.0
Deny	13.0	1950.0	37.8	35.0	150.5	20.0
Vapam	0.0	575.0	0.8	0.0	1.3	2.7

Table 9. Population densities of northern root-knot nematodes, Meloidogyne hapla, observed in plots at the MSU Potato Research Farm, 1994-1995.

Treatment	5/94	9/94	4/95	5/95	7/95	9/95
Alf-Alf	0.0	3820.0	44.7	41.0	71.2	226.5
Vetch-Vetch	0.0	10.0	0.2	56.0	1170.0	114.5
Farrow-Mar.	0.0	47.5	3.0	2.2	0.0	24.2
Pea-Potato	0.0	340.0	10.25	19.0	118.2	448.2
Pea-Carrot	0.0	1300.0	2.2	6.0	35.5	2238.7

Table 10. Population densities of root-lesion nematodes, Pratylenchus penetrans, observed in plots at the MSU Potato Research Farm, 1994-1995.

Treatment	5/94	9/94	4/95	5/95	7/95	9/95
Alf-Alf	6.2	540.0	22.7	33.5	17.5	8.0
Vetch-Vetch	1.0	595.0	51.7	86.0	2800.0	6.0
Farrow-Mar.	5.0	105.0	86.0	33.2	7.7	14.2
Pea-Potato	8.7	2690.0	8.7	33.2	34.5	86.0
Pea-Carrot	2.7	850.0	19.7	28.7	29.5	252.0

Table 11. Population densities of clover cyst nematodes, Heterodera trifolii, observed in plots at the MSU Potato Research Farm, 1994-1995.

Treatment	5/94	9/94	4/95	5/95	7/95	9/95
Alf-Alf	0.0	0.0	0.0	0.0	0.0	0.0
Vetch-Vetch	0.0	0.0	0.0	3.0	20.0	1400.0
Farrow-Mar.	0.0	0.0	0.0	0.0	0.0	0.0
Pea-Potato	0.0	0.0	0.0	0.0	0.0	0.0
Pea-Carrot	0.0	0.0	0.0	0.0	0.0	0.0

Table 12. Fall Cover/Green Manure Crop Trial, MSU Potato Research Farm, 1994.

Fall Cover/Green Manure Crop	Root-lesion nematodes/g root	
	Oct. 25, 1994	Nov. 4, 1992
Annual Ryegrass cv.	11.6	
Black Lentil	110.4	
Canola	--	1179.2
Green Peas cv. Sugar Ann	91.6	
Hairy Vetch	106.8	
Marigold cv. Crackerjack	13.4	
Oats cv. Heritage	--	1072.0
Rapeseed cv. Askari	21.6	1764.0
Rapeseed cv. Bridger	24.4	1037.5
Rapeseed cv. Sollux	18.4	1087.2
Rye cv. Field Grade	38.0	1251.0
Spring Barley cv. Bowers	45.8	

Table 13. Mean soybean (cv. Kenwood) yields and nematode counts from cover crop study, MSU Potato FArm, 1995.

Cover crop	Soybean yield bu/A	Root-lesion		Root-knot	
		May 18[1]	Oct 25[2]	May[1]	Oct 25[2]
Annual ryegrass	37.0	25.4	33.2	4.2	123.6
Black lentil	47.5	33.0	63.0	0.8	115.2
Hairy Vetch	39.0	76.8	106.6	0.0	14.0
Marigold cv crackerjack	43.9	27.0	28.2	1.0	229.0
Peas cv. sugar ann	40.0	38.0	25.4	1.8	140.0
Rape cv. askari	38.7	83.6	86.2	0.0	11.4
Rape cv. bridger	36.4	147.6	76.8	1.8	438.8
Rape cv. sollux	37.3	29.8	72.2	0.0	121.2
Rye (field grade)	34.2	80.4	71.6	0.2	10.0
Spring barley cv. bowers	42.7	84.2	69.0	2.6	176.2

[1]Combined counts of 1.0 g root tissue and 100 cm^3 soil (cover crops).

[2]Nematodes recovered from 100 cm^3 soil at soybean harvest.

Table 14. Mean potato (cv. Snowden) yields, plant stands and root-lesion nematode counts from nematode management trial, MSU Potato Research Farm, 1995.

Treatment	Yields (cwt/A)		Plant stands (no/50 row ft)	Root-lesion		
	#1s	Total		May 30[1]	July 20[2]	Sept 26[1]
Control	215.2	245.2	32.6	14.75	11.3	78.0
Temik 15G 3.0 lb ai IF AP	242.2	273.2	34.5	15.75	0.0	19.0
Mocap 10G 3.0 lb ai 6"Band AP, Vydate 2L Foliar Sprays 21 & 35 days post	252.3	287.2	35.7	26.33	5.0	47.8
Mocap 10G 3.0 lb ai 6"Band AP	226.8	260.1	33.1	16.25	4.3	46.5
Mocap 6EC 6.0 lb ai BR-inc PP	248.9	280.3	33.6	13.75	11.7	10.7
Mocap 6EC 9.0 lb ai BR-inc PP	252.4	282.2	36.0	19.00	2.8	35.8
Mocap Gel 6.0 lb ai BR-inc PP	224.6	255.4	33.6	15.00	6.3	82.8
Mocap Gel 9.0 lb ai BR-inc PP	229.7	257.6	33.1	21.67	7.3	34.8
EXP 2.5 kg/ha BR-inj PP EXP 2.5 kg/ha BR-inc 14 Day Post	211.2	237.2	33.1	12.75	34.5	75.0
EXP 2.5 kg/ha Band-inj PP EXP 2.5 kg/ha Band-inc 14 Day Post	216.6	240.2	34.3	15.50	18.5	75.3
EXP 5.0 kg/ha BR-dr PP	236.2	264.1	35.1	9.50	5.3	40.0
Vydate 2L Foliar Sprays 21&35 Days Post	250.4	283.7	33.6	30.25	5.5	8.0

[1]Counts recovered from 100 cm^3 soil.
[2]Counts from 1.0 g potato root tissue.

Table 15. Root-lesion nematode population densities from scab trial, MSU Potato Farm, 1995.

Treatment	May[1]	July 20[2]	Sept[3]
Control	27.2	23.0	95.0
Control (no compost) Deny 1.0 pt 6"Band AP Deny 1.0 pt BR 14DayPost	19.8	19.4	63.4
Compost	7.8	17.6	83.2
Compost Mocap 10G 3.0 6"Band AP	20.0	24.0	89.8
Compost Mocap 6EC 9.0 lb BR-inc PP	30.8	13.4	80.0
Compost Deny 1.0 pt 6"Band AP Deny 1.0 pt BR 14DayPost	18.4	44.2	75.3

[1]Counts from 100 cm^3 soil.
[2]Combined counts of 1.0 g root tissue and 100 cm^3 soil.

Table 16. Mean potato (cv. Snowden) yields from scab trial, MSU Potato Farm, 1995.

Treatment	Yields (lb/17 row ft)		Scab ratings (%)[1]				
	#1	Total	0	1-10	11-30	31-70	71-100
Control	22.8	25.1	90.2	9.8	0.0	0.0	0.0
Control (no compost) Deny 1.0 pt 6"Band AP Deny 1.0 pt BR 14DayPost	22.8	25.4	88.4	9.3	2.4	0.0	0.0
Compost	20.0	22.2	75.6	18.8	2.7	1.8	0.0
Compost Mocap 10G 3.0 6"Band AP	18.2	20.6	75.6	22.3	2.1	0.0	0.0
Compost Mocap 6EC 9.0 lb BR-inc PP	20.7	22.9	81.1	18.1	0.4	0.0	0.0
Compost Deny 1.0 pt 6"Band AP Deny 1.0 pt BR 14DayPost	19.1	21.6	81.2	16.5	1.8	0.0	0.0

[1]Approximately 50 potatoes were examined per plot and rated for percent surface with scab lesions.

Funding: MPIC/NPC

Michigan Potato Research Report

RESISTANCE MANAGEMENT AND CONTROL OF COLORADO POTATO BEETLE USING TRANSGENIC POTATOES AND IMIDACLOPRID-TREATED POTATOES AS BARRIER CROPS

Investigators: M. E. Whalon, M. R. Bush, and E. J. Grafius.
Period Covered: March to September, 1995.

Test plots were set up in two locations. One location, a commercial field in Clinton County, was rotated into potato in '95 and experienced low Colorado potato beetle (CPB) density. The other location, a research plot in Montcalm County, was in continuous potato and experienced very high CPB density. Four-row barrier crops with the following treatments/varieties were planted at each location: Superior potato, Russet burbank potato, early planted R. burbank (planted 2 weeks in advance), Newleaf (*Bacillus thuringiensis* transgenic) R. burbank, and Admire (imidacloprid) treated R. burbank. Four replicates of each treatment were planted at both locations.

Objective 1

The movement of CPB adults into and through the barrier crop was monitored with black plastic-lined trench traps on either side of the barrier crop. Preliminary observations indicate that the movement of CPB through the barrier crops was similar among all treatments except for the Admire-treated rows where CPB movement was reduced by nearly half.

Objective 2

CPB density in both the barrier crop and the adjacent main crop was estimated twice during the season at each location. The following observations are based on data from the commercial plot. Inside the barrier crop, CPB density in the Superior potato treatment tended to be nearly twice as high as the normal R. burbank treatment (check). Densities were considerably lower in the Admire-treated barrier crop and were nearly non-existent in the Newleaf barrier crop. In the adjacent main crop, the Superior and the early-planted R. burbank increased CPB populations in the main crop. Meanwhile the Newleaf and Admire-treated R. burbank treatments did not seem to reduce CPB density in the main crop when compared with the check.

Objective 3

Damage estimates were taken from the barrier crops and the adjacent main crops at both locations. At the research plot location, only the Admire-treated and the Newleaf barrier crops were left standing after the second generation. The Newleaf barrier crop sustained very little damage. At the commercial location, the Admire-treated barrier crop sustained little damage with the Newleaf barrier sustaining almost no damage. In the adjacent main crop, only the admire-treated barrier significantly reduced CPB damage. The Newleaf barrier also reduced CPB damage to the adjacent main crop.

Preliminary Conclusion

Admire-treated barrier crops were effective in reducing CPB movement into adjacent main crop and reducing CPB damage. By increasing the barrier crops to 12 to 20 rows, we believe both the Admire-treated and the Newleaf treatments can reduce CPB movement, density and damage in the adjacent main crop.

Funding: MPIC/NPC

Michigan Potato Research Report

FIELD TESTING OF AN APHID RESISTANCE MONITORING TOOL FOR POTATO PRODUCTION

Investigators: M. E. Whalon & M. R. Bush
Period Covered: March to September, 1995.

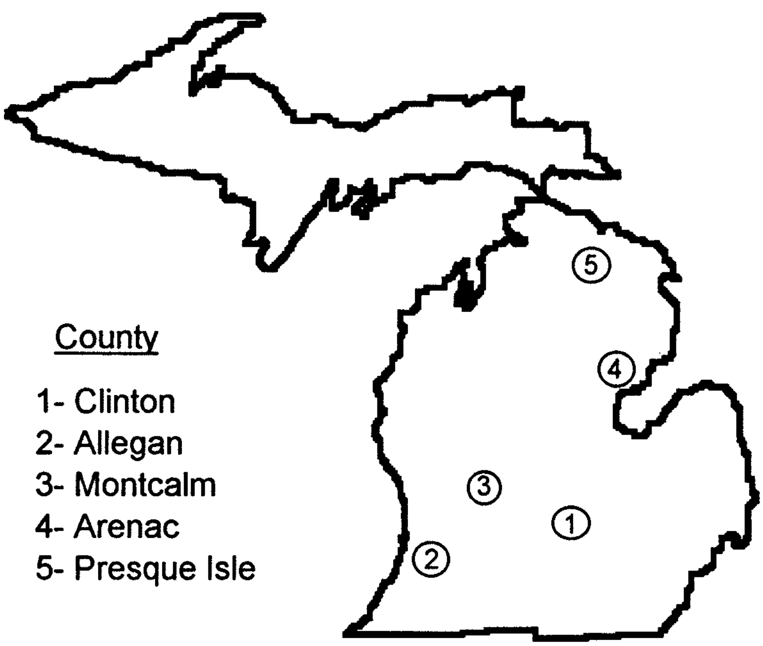
Objective 1: Development of Management Strategy- Alternating Pesticide Chemistries

In 1994, field trials were set up at five locations in Michigan (Figure 1) to evaluate alternative pesticide chemistries to control green peach aphid (GPA) resistant to organophosphate (OP) insecticides. Observations suggest that OP resistance in GPA due to enhanced esterase activity is widespread throughout the major potato-producing regions of Michigan. Nevertheless, another OP insecticide, Monitor, provided adequate control of resistant GPA. Mocap and Admire were alternative chemistries that provided good control of resistant GPA at most locations. In Allegan County, a control failure with Admire was observed in one field despite the fact that Admire had never been used in Michigan. In 1995, neighboring fields were sampled to confirm resistance. Admire was used in most fields searched and GPA populations were so low no field trials were set up. Nevertheless, laboratory colonies were started and progeny screened for resistance. No differences in GPA response was found based on a foliar dip bioassay. We will continue to perform bioassays on these GPA strains to identify any insecticide that provides enhanced control of OP-resistant compared to susceptible aphids.

Objective 2: Development of a Resistance Monitoring Kit

In cooperation with the Neogen Corporation, we have produced a monitoring kit to detect esterase-based resistance in GPA. Initially the kit was effective in distinguishing resistant from susceptible aphids, but after one week that effectiveness was lost. This loss was attributed to oxidation of the color reagent. We will repackage the kit to include the color reagent in dry form and the user will have to add water to the color reagent to perform the test for resistance detection. GPA from several locations in Michigan and other states have been collected and frozen. These aphids will be used to test the effectiveness of the repackaged kit and confirm that GPA resistance to OP is widespread throughout Michigan and other states.

Figure 1. Location of aphicide efficacy trials performed for the green peach aphid on potatoes in Michigan. Organophosphate resistance was indicated at each location.



Funding: MPIC/Industry

Colorado Potato Beetle Management
1995 Potato Research Report

Edward Grafius, Ellen McEnhill, Judith Sirota, and Anila Ikhlas
Department of Entomology
Michigan State University

Summary:

1995 was a good year for Colorado potato beetle control. Michigan growers used imidacloprid for the first time . Most fields were treated at planting. Results were outstanding; most growers did not need to apply additional insecticide for Colorado potato beetle. In some fields, immigration of summer adults resulted in the need for insecticide treatments late in the season.

Colorado potato beetle research in 1995 focused on 1) Monitoring Colorado potato beetle for resistance to Admire (imidacloprid), 2) Evaluation of breeding lines and genetically-engineered plants for resistance to Colorado potato beetle, 3) Assessment of the residual toxicity of Agri-mek and adjuvants to Colorado potato beetle, 4) Insecticide efficacy tests for Colorado potato beetle control, and 5) Evaluation of crop rotation systems for Colorado potato beetle control.

Preliminary tests on susceptible Colorado potato beetles produced baseline dose-mortality results for imidacloprid for both topical application and contact tests. These results will allow us to assess other populations for potential resistance, and to develop an on-farm resistance tests for imidacloprid. In addition, individual Colorado potato beetles that survived Admire in the field at two different locations in Michigan were collected and are in culture in our laboratory. These strains will be of great help in developing the on-farm resistance test.

Seven lines of potatoes genetically-engineered with the Cry III toxin of *Bacillus thuringiensis* (BT) and two breeding lines incorporating resistance factors from wild *Solanum* species were evaluated for resistance to Colorado potato beetle. Survival, development and feeding behavior of second stage larvae was recorded. Feeding preference for different plants was measured for both adults and larvae. Data analysis is continuing.

Laboratory feeding tests were conducted to assess the residual toxicity of Agri-mek, with and without adjuvants, to different stages of Colorado potato beetle. For most stages, there were no significant differences in mortality between Colorado potato beetles fed untreated foliage, and foliage treated with Agri-mek, Agri-mek and Silwett, or Agri-mek and Dynamic. Significant differences in mortality between treatments occurred only with first generation small larvae fed foliage the same day it was treated, and 3 days later, and with summer adults fed foliage the same day it was treated. No significant differences between treatments occurred with any stage of beetle when they were fed foliage 7 days after treatment.

Fifteen insecticides were tested for Colorado potato beetle control. Several treatments, including Admire, Asana with piperonyl butoxide (PBO), and fipronyl resulted in significant control of all beetle stages except adult. The Admire treatment also resulted in the lowest defoliation and the highest yield.

Preliminary data was gathered for a two-year study on the effect of rotation systems (continuous potatoes, potatoes rotated with seed corn, and potatoes rotated with seed corn interplanted with rye) on Colorado potato beetle numbers and predator and parasite abundance. The following areas were examined: Colorado potato beetles were marked, released and captured to study their mobility among crops; CPB flight was monitored between crops; plant sampling was done for all stages of CPB and predatory insects; egg mass predation was followed; larval parasites were reared; pupating larvae were examined for predation and parasitism; predators were sampled using pitfall traps; and ground beetles (carabids) were tested in the lab as predators of CPB larvae. A good deal of data was recorded, and it will serve as a basis for comparison when, in 1996, fields are rotated.

Monitoring Colorado potato beetle for resistance to Admire (imidacloprid)

In two fields in 1995, significant numbers of Colorado potato beetles survived imidacloprid treatment in the field. We collected survivors from both fields, brought them back to the laboratory and fed them additional imidacloprid-treated foliage. Some of the individuals collected from both locations survived this second feeding in the lab (Figure 1). These two strains are currently in laboratory culture. Our goal is to rear sufficient numbers of individuals to precisely assess their level of resistance to imidacloprid, if present.

Coated Petri Dishes (preliminary tests). Our objective is to develop an on-farm test for resistance to imidacloprid, similar to the petri dish resistance test kit we developed for other insecticides. Results from this test will save growers the expense of ineffective insecticide treatments ($600 to $2,800 for a 40-acre field) and will help growers manage resistance to this important new insecticide. Preliminary tests indicated that treated filter papers, which are used in our current resistance test, did not deliver enough pesticide, and mortality was low at all concentrations. Petri dishes were treated directly, as discussed below.

Insects. Overwintered beetles collected at the MSU Potato Research Farm in Entrican, MI (Montcalm Co.) were used for test development. This population is resistant or tolerant to most insecticides used for their control, although resistance levels are not as high as in many populations from commercial fields. Beetles were collected between June 5 and 15 and stored in a controlled environment chamber at 11(±2) °C, 16:8 L:D and fed fresh potato foliage about every week. Those used for experiments were moved to 21.6 (±2)°C and were given fresh potato foliage for 24 h before the experiment began . We picked out active beetles from the storage containers and placed them at random in clean plastic cups, 10 beetles per cup, one cup per concentration and replicate (7 replications per concentration). We observed them for at least 30 min. to determine their activity level and replaced all beetles that were not active.

Solutions. Solutions (0.00002 - 2.0 mg active ingredient/ml) were mixed using formulated Admire 2F (BAY NTN 33893, imidacloprid) and distilled water. After all solutions were mixed, Silwet was added to each dilution (0.05 ml/100 ml solution) to evenly coat the Petri dishes and decrease drying time. We pipetted 0.6 ml of solution into each Petri dish and tilted the Petri dish until the bottom surface was coated. Petri dishes were left under a chemical hood until dry (10-30 min.).

Experimental set-up. Beetles were placed in Petri dishes (10 per dish) and kept at 21.6°(±1)C, 16:8 L:D. Mortality was recorded 24 h after treatment. We recorded the number of beetles in each of three categories: dead (abdomen sunken, legs extended to the sides, no response to pinching leg with forceps), walking (beetles walked forward at least it's body length), and affected (beetles were not active or were twitching, had a sluggish response to pinching leg with forceps, could not walk forward when righted). Beetles that were recorded as "affected" were considered "dead" for analysis. Mortality was also recorded at 48 and 72 hr. (beetles were removed from the treated dish after 24 h) and almost all beetles recorded as affected died within 72 h.

Analysis. Analysis was done using POLO-PC (LeOra Software, Berkeley, CA). All concentrations for each replicate were included in the analysis. LC_{50} and LC_{90} values (concentrations killing 50 and 90% of the insects) were calculated.

Results. Survival ranged from 86% mortality in controls to 0% mortality at the higher concentrations (Table 1, Figure 2). The lethal concentration for 50% of the population (LC_{50}) was estimated as 0.54 µg/ml. Overwintered beetles were used for this test, and the LC_{50} may be higher for summer adults. Variability was also high, compared with similar tests we have conducted with standard insecticides. We plan to conduct additional tests on 1-2-week old beetles from laboratory culture and on younger beetles from the field. At low concentrations, some of the beetles recovered after 24 h (they were recorded as dead at 24 h, but recovered by 48 h); we currently plan to develop a test with 24 h data for the on-farm test, but we may have to use 48 h data if 24 h data is not reliable. We currently have three populations in laboratory culture

(Montcalm plus two from commercial potato fields) and will run comparative analyses on adults from these cultures as soon as enough individuals are available.

Topical Application (preliminary tests). The objective of these tests was to obtain precise values for Colorado potato beetles' susceptibility to imidacloprid. We conducted preliminary tests on susceptible beetles from the Montcalm research farm. Beetles from two commercial potato farms that survived imidacloprid treatment (described above) will be tested in the future and the results compared with those from susceptible beetles.
Insects. The beetles used for topical applications were from the same stock as described above. The test beetles were fed for 48 h before experiments began. Active beetles were taken from storage cups and treated immediately.
Solutions. We used technical grade imidacloprid (98.7% pure) dissolved in a 50:50 solution of acetone and ethanol for topical applications. Dilutions ranged from 0.01 μg/μl to 10 μg/μl. Acetone alone was used as a control.
Experimental set-up. We used a microliter syringe to dispense 1 μl of solution to the ventral abdominal surface of each beetle. Ten beetles per concentration (with two replications each = 20 beetles total per concentration) were treated and then placed in filter paper lined Petri dishes at 21.6°C, with a 16:8 L:D photoperiod. Mortality, as discussed above, was recorded at 24 h and 48 h post-treatment.
Analysis. POLO analysis was performed as described above.
Results. Mortality was 100% at most of the doses applied (Table 3). Only the 0.05 and the 0.01 μg/beetle doses resulted in mortality between 0% and 100% at 24 h. At 48 h one beetle in each of the 0.1 μg ai/μl and 1 μg ai/μl concentrations recovered from treatment. Results of the statistical analyses were inconclusive, since only one concentration resulted in mortality between 0 and 100%. The probit line for 24 h mortality had a very steep slope (29.4), indicating a homogeneous response to treatment with imidacloprid (Table 4). These results from preliminary tests will be used in future studies to choose several doses that will result in intermediate levels of mortality (mortality between 0 and 100%). Tests will be repeated with beetles from 1 to 2 weeks old from the three laboratory strains.

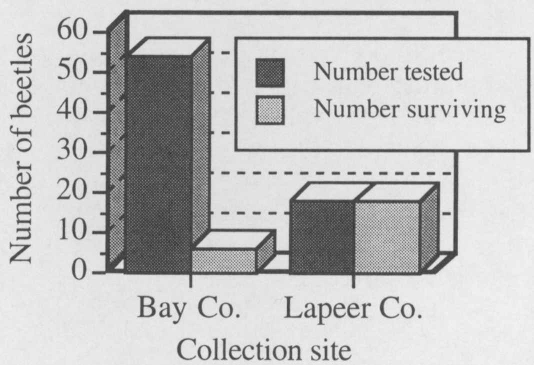


Figure 1. Survival of Colorado potato beetles collected from imidacloprid-treated commercial fields and fed MI-treated foliage again in the laboratory.

Table 1. Concentrations used and 24 hr. survival in Petri plate tests.

Concentration (mg ai/ml)	Percent survival (number tested)
0.2	0 (2)
0.02	0 (70)
0.01	11.4 (70)
0.002	35.7 (70)
0.001	50.0 (70)
0.0002	61.4 (70)
0.00002	93.3 (30)
0.0	86.0 (100)

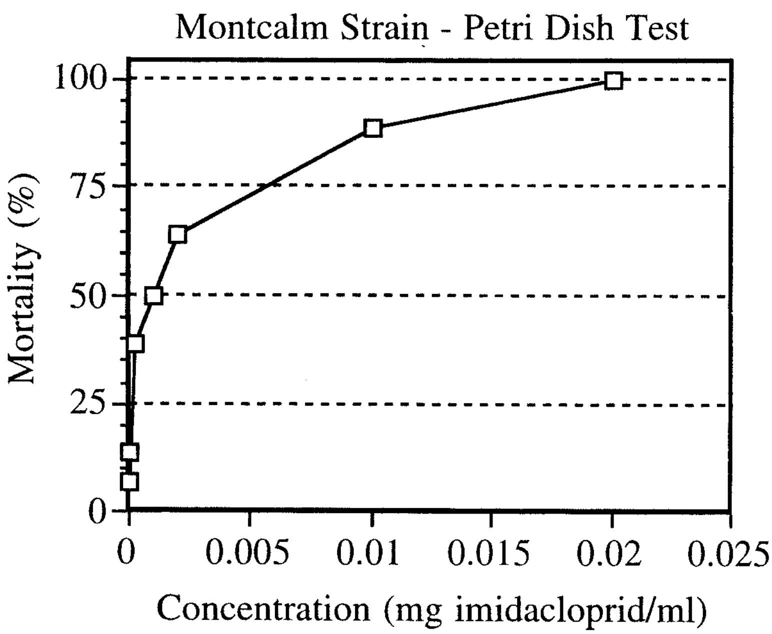


Figure 2. Percent mortality of Colorado potato beetle (Montcalm strain) after exposure to petri dishes coated with imidacloprid at different concentrations.

Table 2. POLO Analysis of Petri test results.

Number of insects	450, 70 controls
X^2	64.987
heterogeneity	1.511
g	0.118
LC_{50} (95% CL)	0.00123 (0.00054, 0.0206)
LC_{90} (95% CL)	0.01503 (0.0063, 0.02335)
Slope	1.375 ±0.19

Table 3. Doses and survival for topical application (n = 20 beetles per dose).

Dose (μg ai/beetle)	Survival (%)		
	24 hr.	48 hr.	91 hr.
10	0	0	0
5	0	0	0
1	0	0	0
0.5	0	0	0
0.1	0	0	0
0.05	65	60	70
0.01	100	100	85
0	100	100	100

Table 4. POLO results for topical application.

	24 hr.	48 hr.
N	140, 20 controls	140, 20
X2	0.0000	39.056
heterogeneity	0.0000	7.8117
g	very large	1.673
LD_{50}	0.05721*	0.05287*
LD_{90}	0.05828*	0.18716*
Slope	29.40± 0.68	2.34±0.42

* the G-value was too large for confidence limits to be calculated.

Evaluation of breeding lines and genetically engineered plants for resistance to Colorado potato beetle.

The evaluation of breeding lines and genetically engineered plants for Colorado potato beetle resistance is an important part of the potato breeding program. Genetically engineered plants may be ineffective against Colorado potato beetle because they do not express the resistance factor for a variety of reasons or expression may be too low to be effective.

Plant material tested for Colorado potato beetle resistance was genetically engineered Russet Burbank plants (seven lines plus a non-transformed line) from Dr. John Kemp, New Mexico State University. This material contained a gene for expression of the CRY III toxin of *Bacillus thuringiensis* (BT) that is toxic to Colorado potato beetle. Breeding lines, L235-4 from Cornell University and 80-1 from USDA in Beltsville were also evaluated. L235-4 incorporates sticky hairs from a wild species, *Solanum berthaultii*. Line 80-1 expresses the glycoalkaloid chaconine from *Solanum chacoense*. Studies are just beginning on Atlantic lines transformed by the MSU breeding program with CRY V BT toxin gene. CRY V BT is active against both caterpillars (Lepidoptera larvae) and beetle larvae.

We cut leaflets from greenhouse-grown plants and placed their petioles in vials of water with cotton plugs. These were placed in Petri dishes with newly-molted second instars (three larvae and one leaflet per dish). Survival and development were measured and feeding behavior was observed.

Adults and larvae were tested for their preference for leaflets from different plants. Leaflets were put in vials as above and six to eight leaflets from different plants were placed in a circle in a large Petri dish. Position of the insects and feeding on each leaflet were recorded every 15 minutes during the first hour and every 2 hours for 8 hours. Results indicate that there is no preference for either BT-transformed or non-transformed lines by larvae or adults but some of the lines are resistant to Colorado potato beetle larvae. Final data analysis has not been finished at this time.

Residual Toxicity of Agri-mek and adjuvants to Colorado potato beetle.

Snowden potatoes were planted May 10, 1995 at the MSU Montcalm Research Farm in Entrican, MI. Potatoes were planted 12 in apart within the row and 34 in between rows. Insecticide applications were made to 20 ft of single row, with buffer (untreated) rows on either side. Applications of the four insecticide treatments were made on 20 and 27 June, 17 July and 21 August. These dates were selected to target all stages of Colorado potato beetle. All applications were made with a CO_2 backpack sprayer with a hand-held single nozzle boom (60 psi and 30 GPA). Screen cages (6 x 6 x 6 ft) were placed over potatoes in mid-June to prevent CPB defoliation of some potato plants used for later applications. The cages were removed before the 17 Jul application. Foliage was only harvested from undamaged portions of the plots. Due to complete defoliation of the potato plants at the Montcalm Research Farm, the Aug 21 application was made to potatoes at the MSU Entomology Research Farm, E. Lansing, MI. The plot design here was that same as in previous plots. These potatoes had received maintenance sprays of Raven and Agri-mek periodically throughout the season and were beginning to senesce at this time.

Foliage was collected 0, 3, and 7 days after treatment. Four replicates of each insecticide treatment were set up on each collection day. Ten to thirty-five Colorado potato beetles, collected from untreated plants, were placed in 500 ml ventilated plastic containers with filter paper and treated foliage, and were kept at 22 °C. At 48 h, mortality was evaluated, fresh foliage was added and dead beetles were removed. Mortality was evaluated again at 96 h.

For most Colorado potato beetle stages, there were no significant differences in percent mortality between treatments on any day. Percent mortality tended to decrease as the time between insecticide application and foliage consumption by the beetles increased (Tables 5 &6, Figure 3). There were significant differences in percent mortality between treated and untreated foliage in first generation small larvae (1st and 2nd instars) when foliage was offered 0 and 3 days after application, but not at 7 days . There were also significant differences between treatments in percent mortality at 96 h for summer adults that were offered foliage the same day as the application was made, but not at 3 or 7 days after application.

One factor that may confound interpretation of the data is the high percent mortality in the untreated controls. Colorado potato beetles offered untreated foliage consumed it readily and mortality may have been due to crowded conditions in the containers. Conversely, beetles offered treated foliage consumed less and their environment remained cleaner. Thus, although similar in magnitude, mortality in the treatments may have been due to the insecticide while mortality in the untreated controls may have been due to overcrowding.

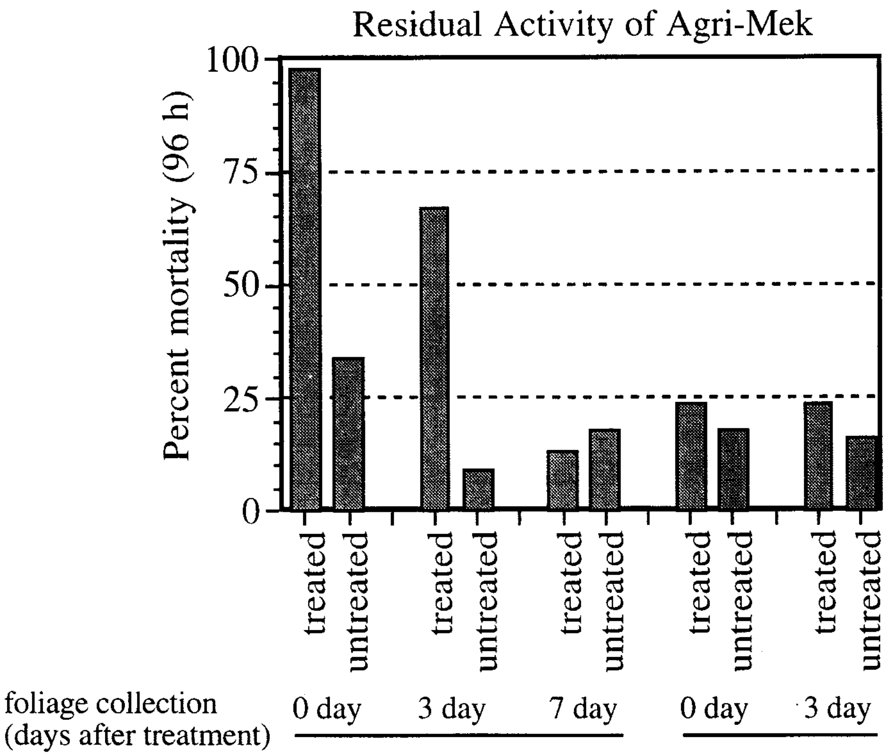


Figure 3. Percent mortality of Colorado potato beetles fed untreated foliage or foliage treated with Agri-Mek and adjuvants (Silwet and Dynamic) at 0, 3 and 7 days after treatment.

Table 5. Mean percent mortality of Colorado potato beetles fed on treated potato foliage that was collected 0, 3, and 7 days after insecticide was applied. Mortality was assessed 48 h after beetles were given foliage.

		Mean Percent Mortality--48 h				
Stage	Days After Spray	Agri-mek Alone	Agri-mek & Silwet	Agri-mek & Dynamic	Untreated	*
First Generation	0	16.9%	13.3%	22.6%	16.5%	NS
Small Larvae	3	25.4% A	14.1% AB	23.8% AB	3.3% B	
	7	1.3%	0.0%	7.2%	6.3%	NS
First Generation	0	16.8%	17.6%	16.4%	4.1%	NS
Large Larvae	3	6.8%	0.8%	0.9%	3.5%	NS
Summer Adults	0	0.0%	2.8%	4.4%	0.0%	NS
	3	1.0%	1.9%	1.0%	3.0%	NS
	7	6.9%	4.0%	8.0%	6.3%	NS
Second Generation	0	4.4%	14.0%	7.2%	24.6%	NS
Small Larvae	3	24.0%	23.9%	24.9%	20.7%	NS
	7	16.5%	12.5%	12.3%	18.4%	NS
Second Generation	0	7.5%	18.1%	15.0%	21.9%	NS
Large Larvae	3	28.3%	32.2%	32.0%	11.1%	NS
	7	21.2%	17.2%	18.8%	20.0%	NS

Table 6. Mean percent mortality of Colorado potato beetles fed on treated potato foliage that was collected 0, 3, and 7 days after insecticide was applied. Mortality was assessed 96 h after beetles were given foliage.

		Mean Percent Mortality--96 h				
Stage	Days After Spray	Agri-mek Alone	Agri-mek & Silwet	Agri-mek & Dynamic	Untreated	*
First Generation	0	98.4% A	97.9% A	97.7% A	34.5% B	
Small Larvae	3	66.7% A	36.2% B	46.4% AB	8.9% C	
	7	12.9%	6.8%	15.9%	18.4%	NS
First Generation	0	23.6%	24.3%	31.9%	18.2%	NS
Large Larvae	3	24.4%	12.7%	12.3%	15.9%	NS
Summer Adults	0	2.0% A	36.6% B	64.0% C	3.0% A	
	3	1.0%	6.7%	2.0%	4.0%	NS
	7	34.6%	25.6%	24.0%	23.9%	NS
Second Generation	0	52.9%	77.3%	74.9%	51.6%	NS
Small Larvae	3	53.6%	49.6%	64.8%	41.3%	NS
	7	67.1%	67.5%	66.1%	78.8%	NS
Second Generation	0	30.0%	56.1%	50.0%	54.2%	NS
Large Larvae	3	49.9%	58.3%	59.1%	43.3%	NS
	7	44.6%	31.8%	33.2%	38.2%	NS

*Data were analyzed with One-Way ANOVA. NS= Means in the same row are not significantly different. Means in the same row followed by the same letter are not significantly different (Tukey's HSD; P>0.05).

Insecticide Efficacy Tests for Colorado potato beetle Control.

Fifteen insecticide treatments were tested at the MSU Montcalm Research Farm, in Entrican, MI, for their control of Colorado potato beetles . 'Snowdon' potatoes were planted 12 inches apart with a 34 inch row spacing on 10 May. Treatments were replicated four times and were assigned to plots in a randomized complete block design. The plots were 40 feet long and were three rows wide. There were at least two rows of bare ground in between the plots and five feet of untreated potatoes between the plots in the same rows. Admire and Mocap were applied in furrow at planting. The Admire was applied to the row over the seed pieces using spray bottles and the Mocap was sprinkled evenly over the seed pieces by hand. The first foliar treatment was applied, at 25% Colorado potato beetle hatch, on 18 June with a tractor-mounted sprayer (30 GPA, 40 psi). Subsequent first generation Colorado potato beetle sprays were applied on 29 June and 7 July. Light rain occurred on 7 July before the insecticides had a chance to dry. Insecticide effectiveness was determined by counting the various stages of Colorado potato beetle (eggs, small larvae = 1st and 2nd instar, large larvae = 3rd and 4th instar, and adults) on two randomly chosen plants from the middle row of each plot. Counts were done on 12 June, 23 June, 3 July and 12 July. Each plot was visually assessed for percent defoliation on 3 July. Second generation foliar sprays began on 19 July, at 25% egg hatch. Two Admire treatments were sprayed with Trigard, and all the other plots were sprayed with a maintenance spray of Imidan and PBO. Subsequent sprays occurred on 26 July and 2 Aug. On 26 July, the Trigard plots were sprayed using a CO_2 backpack sprayer with a three row boom (30 gal/A, 30 psi). Second generation counts were taken on the Trigard plots on 18 July, 24 July, and 31 July. The percent defoliation was assessed on 9 August. The middle row of potatoes from each plot was harvested on 22 August, separated by size and weighed.

There were seasonal significant differences between the treatments in all but the adult stage of CPB development (Table 7). Egg masses were significantly different between treatments, with the Admire plots having less than one egg mass per plant. Small larvae numbers peaked on 23 Jun and several treatments, including the Asana/PBO, Admire and Fipronyl, had significantly fewer small larvae than the untreated plots . Large Larvae were controlled by many treatments. The most effective were Asana/PBO, Admire and Fipronyl (Figure 4). Significant differences occurred in the yield of A potatoes and in the total yields for the various treatments, with Admire treatments having the highest yield (Table 9 & Figure 5). The Admire plots had almost no defoliation on 3 Jul (Figure 6) and had less defoliation than many other treatments on 9 Aug (Table 9). CGA-215944 was targeted for aphid and white flies and did not show effectiveness against Colorado potato beetle. Means for the second generation treatments are reported in Table 8 Due to the heavy beetle pressure in this location, control plots were defoliated prior to the second generation.

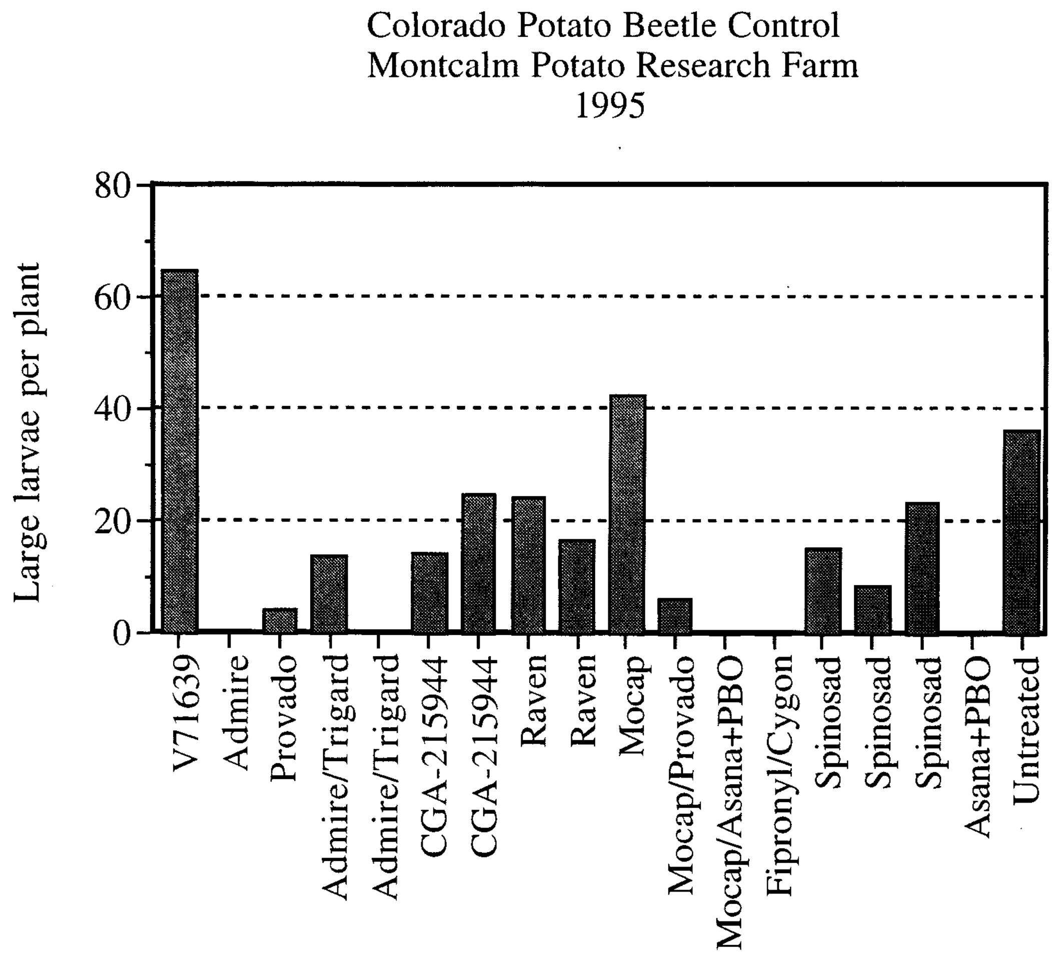


Figure 4. Mean number of Colorado potato beetle large larvae per plant in insecticide efficacy field plots.

Table 7 Seasonal mean number of first generation CPB

Treatment	Rate	Mean number of CPB per plant ± SEM[†1]			
		Egg masses	Small larvae	Large larvae	Adults
Untreated		1.7 ± 0.3 abc	10.1 ± 0.2 a	10.0 ±13.9 a	4.6 ± 0.3 a
Asana &	9.6 fl oz/A	1.8 ± 0.5 abc	0.9 ± 0.7 abcd	0.3 ± 0.1 bc	4.8 ± 0.2 a
Piperonyl Butoxide(PBO)	8.0 fl oz/100 gal				
V-71639	40 g ai/A	1.5 ± 0.4 abc	5.9 ± 1.2 ab	18.1 ±14.3 a	0.9 ± 0.1 a
Admire 2F[2]	0.9 fl oz/1000 ft	0.9 ± 0.1 abc	0.4 ± 0.2 bcd	0.2 ± 0.0 bc	1.1 ± 0.3 a
Provado 1.6F &	4.0 fl oz/A	1.5 ± 0.1 abc	2.2 ± 1.8 abcd	1.3 ± 1.2 bc	1.3 ± 0.2 a
Silwet L-77	8.0 fl oz/1000 gal				
Admire 2F[2]* &	0.9 fl oz/1000 ft	0.5 ± 0.1 c	0.0 ± 0.0 d	0.0 ± 0.0 c	1.7 ± 0.2 a
Trigard 75WP[3]	140 g ai/A				
Admire 2F[2] &	0.9 fl oz/1000 ft	0.6 ± 0.2 bc	0.1 ± 0.1 d	0.7 ± 0.6 bc	1.6 ± 0.4 a
Trigard 75WP[3]	280 g ai/A				
CGA-215944	50 g ai/A	1.8 ± 0.2 abc	3.5 ± 0.5 abcd	8.1 ± 1.7 a	1.9 ± 0.1 a
CGA-215944	100 g ai/A	1.9 ± 0.4 abc	4.7 ± 2.7 abc	11.1 ± 4.2 a	2.1 ± 0.1 a
Raven	1.5 qt/A	2.0 ± 0.1 ab	5.8 ± 1.6 a	10.1 ± 2.0 a	2.6 ± 0.2 a
Raven	2.5 qt/A	2.1 ± 0.4 a	7.6 ± 0.5 a	10.3 ± 1.0 a	2.8 ± 0.3 a
Mocap 10G[2]	2.1 lbs/1000 ft	1.7 ± 0.4 abc	7.4 ± 1.7 abcd	12.2 ± 1.7 a	3.0 ± 0.2 a
Mocap 10G[2] &	2.1 lbs/1000 ft	1.8 ± 0.4 abc	2.8 ± 2.2 abcd	2.2 ± 2.1 bc	3.3 ± 0.1 a
Provado 1.6F	4.0 fl oz/A				
Mocap 10G[2],	2.1 lbs/1000 ft	1.7 ± 0.4 abc	0.3 ± 0.1 cd	0.1 ± 0.1 bc	3.4 ± 0.3 a
Asana &	9.6 fl oz/A				
PBO	8.0 fl oz/100 gal				
Fipronyl 80WG	0.05 lb ai/A	2.2 ± 0.2 a	0.2 ± 0.2 d	0.3 ± 0.3 bc	3.7 ± 0.4 a

†Means within a column followed by diferent letters are significantly different ($P<0.05$, Tukey's HSD; $\alpha=0.05$)

[1]Data transformed for analysis with log (x+1)

[2]Treatment applied in furrow at planting

[3]Treatment applied to second generation CPB

*Analysis calculated from 3 plots instead of 4 plots

Table 8 Seasonal mean number of second generation CPB

Treatment	Rate	Mean number of CPB per plant ± SEM[†1]			
		Egg masses	Small larvae	Large larvae	Adults
Admire 2F[2]* &	0.9 fl oz/1000 ft				
Trigard 75WP[3]	140 g ai/A	1.0 ± 0.2	0.2 ± 0.1	0.0 ± 0.0	6.4 ± 3.7
Admire 2F[2] &	0.9 fl oz/1000 ft				
Trigard 75WP[3]	280 g ai/A	1.0 ± 0.2	0.3 ± 0.2	0.5 ± 0.2	9.1 ± 2.7

Table 9 Mean harvest yield and defoliation rates

Treatment	Rate	Mean Yield (lbs) ± SEM†[1] Size A	Size B	Total	Mean % Defoliation 3 Jul	9 Aug
Untreated		14.4 ±24.8 abc	1.5 ± 1.2 a	15.9 ±13.6 ab	85.8	100.0
Asana &	9.6 fl oz/A	22.1 ±15.7 abc	2.9 ± 1.1 a	25.1 ± 8.6 ab	5.0	98.3
Piperonyl Butoxide(PBO)	8.0 fl oz/100 gal					
V-71639	40 g ai/A	4.2 ± 7.9 bc	1.6 ± 0.5 a	5.7 ± 4.0 ab	91.0	100.0
Admire 2F[2]	0.9 fl oz/1000 ft	56.0 ±13.1 a	3.9 ± 0.2 a	59.9 ± 6.4 a	0.0	57.5
Provado 1.6F &	4.0 fl oz/A	30.6 ±20.56 abc	2.9 ± 1.5 a	33.5 ±11.4 ab	26.8	67.5
Silwet L-77	8.0 fl oz/1000 gal					
Admire 2F[2]* &	0.9 fl oz/1000 ft	54.3 ±14.0 a	6.7 ± 2.0 a	61.0 ±110.0 a	0.0	60.0
Trigard 75WP[3]	140 g ai/A					
Admire 2F[2] &	0.9 fl oz/1000 ft	43.9 ±15.7 ab	4.4 ± 0.9 a	48.3 ± 7.0 a	0.5	93.5
Trigard 75WP[3]	280 g ai/A					
CGA-215944	50 g ai/A	5.5 ± 3.7 abc	3.0 ± 1.1 a	8.5 ± 2.8 ab	33.8	99.75
CGA-215944	100 g ai/A	12.4 ±12.3 abc	2.4 ± 1.1 a	14.8 ± 7.1 ab	32.5	99.75
Raven	1.5 qt/A	9.8 ±10.4 abc	3.1 ± 1.3 a	12.9 ± 6.3 ab	16.3	99.5
Raven	2.5 qt/A	5.9 ± 5.6 abc	3.4 ± 0.4 a	9.3 ± 2.5 ab	33.8	100.0
Mocap 10G[2]	2.1 lbs/1000 ft	0.1 ± 0.1 c	0.7 ± 0.5 a	0.7 ± 0.4 b	98.3	100.0
Mocap 10G[2] &	2.1 lbs/1000 ft	29.9 ±30.7 abc	3.0 ± 0.8 a	32.9 ±15.8 ab	8.0	77.5
Provado 1.6F	4.0 fl oz/A					
Mocap 10G[2],	2.1 lbs/1000 ft	38.3 ±12.2 ab	3.0 ± 0.7 a	41.3 ± 5.9 a	5.5	78.8
Asana &	9.6 fl oz/A					
PBO	8.0 fl oz/100 gal					
Fipronyl 80WG	0.05 lb ai/A	41.0 ±13.0 ab	2.5 ± 0.7 a	43.5 ± 6.6 a	2.0	70.0

†Means within a column followed by diferent letters are significantly different ($P<0.05$, Tukey's HSD; $\alpha=0.05$)

*Analysis calculated from 3 plots instead of 4 plots

[1]Data transformed for analysis with log (x+1)

[2]Treatment applied in furrow at planting

[3]Treatment applied to second generation CPB

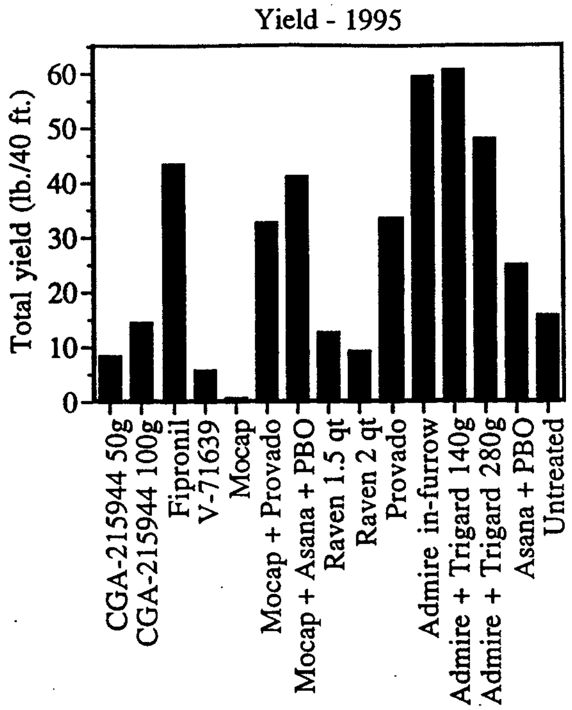


Figure 5. Mean weight of potato yield per 40 ft row in insecticide efficacy field plots.

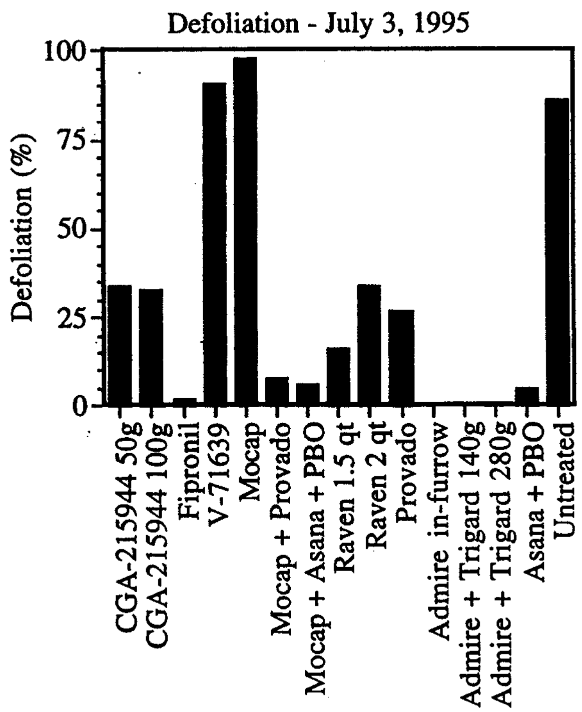


Figure 6. Mean percent defoliation of the insecticide efficacy field plots after the first generation of CPB.

Crop Rotation Systems for Colorado Potato Beetle Control.

Large plots were set up at the Montcalm Potato Research Farm, Entrican, MI, and the Collins Road Entomology Facility, E. Lansing, MI, to explore the effects of crop rotation on control of Colorado potato beetles. The two year study includes rotation of potatoes with seed corn or seed corn interplanted with rye. Plots were 50' X 100' at Montcalm and 50' X140' at Collins Road. Each plot was divided into two subplots. At Montcalm plots were planted with corn and potatoes, corn/rye and potatoes, or both sides with potatoes. At Collins Road the double potato plots were excluded from the design. Insecticide sprays were used to keep CPB numbers down, but not to control them. Fertilizer, herbicides and fungicides were applied as needed.

In 1995 we gathered background data on Colorado potato beetle numbers and predator and parasite abundance. The following areas were examined: Colorado potato beetles were marked, released and captured to study their mobility among crops; CPB flight was monitored between crops; plant sampling was done for all stages of CPB and predatory insects; egg mass predation was followed; larval parasites were reared; pupating larvae were examined for predation and parasitism; predators were sampled using pitfall traps; and ground beetles (carabids) were tested in the lab as predators of CPB larvae.

Beetles that were marked and released in potatoes generally stayed in the subplots in which they were released. Those released in corn or corn/rye readily dispersed. This was contrary to our expectation that beetle movement out of these crops would be inhibited. However, because of cool, wet weather the corn and rye were planted later than planned. The plants, therefore, were not tall enough and the rye not dense enough to deter movement of CPB into potatoes.

Colorado potato beetle activity was very similar between the Montcalm and Collins Road sites. The size of the population at Montcalm was much higher than at Collins Road but we found more beetles than expected at Collins Road. The sites conform to our premise of Montcalm as a high density site and Collins Road as a low density site. This year we found no differences in Colorado potato beetle colonization or development in potato subplots bordered by corn, corn/rye or potatoes. Slight differences in numbers occurred among treatments, but the difference was not strong enough to be a treatment effect. Next year, when the rotations are implemented, we should find differences in numbers as well as development if beetles have difficulty finding or take a longer time to colonize the rotated potatoes.

Our highest flight interception trap catch was on 5 June, indicating that we had missed some of the first flight activity. Very low numbers of beetles were captured, possibly because the traps may have been too high off of the ground. No differences were observed between troughs facing east or west, except on 2 dates. Trap catch on these days could have been influenced by wind direction. On a few dates there were differences in the numbers of beetles caught flying from one crop to another; generally more beetles were flying from corn to potatoes than out of potatoes or between potato subplots. Next year, when the crops are rotated, we may find more beetles flying from corn and corn/rye to potatoes than between subplots of potatoes.

The greatest difference between Montcalm and Collins Road was in predator diversity and abundance in both plant and pitfall trap samples. There were generally more potential Colorado potato beetle predators at Montcalm than Collins Road. This is not unexpected since the Montcalm site has been planted to potatoes for many years, allowing predatory insects to become established. However, it is surprising to find so many and such a diversity of predators since the Montcalm site has had intense insecticide treatment for many years. There were no differences in predator numbers in potatoes next to corn or corn/rye at either site, but that may change with rotation.

Whole plant sampling appeared to be more effective than pitfall traps for detecting predatory lady beetles, lacewings, stink bugs, phalangids (harvestmen), and nabids (damsel bugs). Carabids, however, were more effectively sampled using pitfall traps. Their ground-dwelling habit makes them more vulnerable to being captured in pitfall traps. Carabids often drop off of plants and escape into cracks in the soil before they are seen by the observer. The presence of a predator on a potato plant in association with CPB indicates that it is a CPB predator. Some predators and parasites were never detected on plants but were fairly abundant in pitfall traps. These include centipedes, spiders, staphylinid (rove) beetles, and parasitic wasps. We do not know if these insects are predators of Colorado potato beetles but they probably have a role in biological control in this system.

There were no consistent or striking differences in predators found in pitfall traps from corn, corn/rye or potatoes, except that the predators that feed primarily Colorado potato beetles were found more often in potatoes. The 12-spotted lady beetle, nabids, and stink bugs were found almost exclusively in potatoes. Other predatory insects were observed in all crops. Identification of carabid species might show that there is a crop preference for some species. However, carabids are very difficult to identify to species. Because there were so many types of carabids found in pitfall traps at these sites, it would probably take one person working full time to identify them.

Predation of egg masses by both chewing and sucking insects was observed at Montcalm throughout June. However, we cannot say which predators were abundant at that time. Both chewing and sucking predators were present during peak egg laying and began to decline as egg laying declined.

About 60% of the pupating larvae that were followed were dead from unknown causes. No predation or parasitization was detected. The density of the predaceous carabid *L. grandis* and tachinid fly parasites is extremely low at Montcalm. Using the tethered larva method of detection may require that hundreds of larvae be tethered to make accurate estimates of pupal predation. Detection of tachinid fly parasites by rearing Colorado potato beetle fourth instars was successful for the Montcalm site. However, the population of tachinid fly parasites there is extremely low. Only 4 flies were reared from about 2000 CPB larvae. Rearing flies from several thousand larvae would give a more accurate estimate of their density. No tachinid flies were detected at Collins Road probably because no potatoes had been planted there in previous years. The flies may colonize the Collins Road site in the future.

Many species of carabid beetles ate or partially ate Colorado potato beetle larvae in the lab. Medium and large carabids were more likely to feed on Colorado potato beetles than small carabids. Some carabids ate eggs as well as larvae. Large and small larvae were consumed by most large and medium sized carabids. About 70% of the carabids killed most of the larvae that they were given. The carabid fauna at Montcalm is diverse, abundant, and holds some potential for biological control of Colorado potato beetles. In the lab they attacked about 2 larvae per day. However, we often did not give the beetles more food than they could eat in a day. Also, the carabids were confined to a small dish, and so were not as active as they might be in the field. The actual feeding rate in the field may be much higher than we observed.

This year's study provided a lot of data for comparison with next year. We should be able to compare the effect of crop rotation not only on Colorado potato beetles but also on predators and parasites.

Funding: Fed. Grant

RESISTANCE OF POTATO TO FUSARIUM DRY ROT

Ray Hammerschmidt and Heather Ray
Department of Botany and Plant Pathology

Dave Douches
Department of Crop and Soil Sciences
Michigan State University

INTRODUCTION

Fusarium dry rot, caused by *Fusarium sambucinum*, is one of the most serious post-harvest diseases of potato. The disease has become much more severe with the onset of resistance of this fungus to thiabendazole, the only fungicide that is registered for post-harvest control of the disease. Because of this, one alternative strategy for the control of the disease is through understanding resistance of tubers to *F. sambucinum*.

Part of the mechanism that the pathogen uses to successfully infect potato tubers is related to the ability of the fungus to inactivate the natural antibiotics that the tubers produce after infection by the fungus. The pathogen is, however, blocked from further infection by a well developed periderm in all varieties of potato. Thus, a better understanding of the development of these barriers could lead to enhanced disease control. In addition, there are potato cultivars that have some resistance to infection by the pathogen, and part of this resistance may be the result of barrier formation. Part of the research conducted this year was to evaluate the role of barrier formation and the related enzymes involved in barrier formation in relation to resistance.

Another factor which was considered in the work was the variability in the pathogen and its ability to cause disease. We tested several isolates of the fungus for differences in pathogenicity . In addition, this pathogen is also able to reproduce sexually, and thus produce new isolates of the pathogen with potentially new virulence traits. To begin to understand how pathogenicity is controlled in the fungus and what effect sexual reproduction has on virulence in offspring of these crosses, a genetic analysis of the fungus was initiated.

RESULTS

Resistance mechanisms and sources:

Three potato lines BR6316-6 (BR6), A69868-2 (A6) and Gold Rush (GR) were used in this study. BR6 and A6 are reported to have some resistance to dry rot and GR was used as a known susceptible variety. BR6 was shown to have the greatest amount of resistance to Fusarium infection as shown by a limited amount of infection. In addition, infection of this variety resulted in a very sharply delimited infection zone suggestion a very uniformly expressed resistance reaction. A6 exhibited an intermediate amount of resistance.

Attempts to identify the nature of the resistance revealed that measurements of total lignin deposition and peroxidase activities were not reflective of the resistance. However, localization of lignin and peroxidase in the tissue showed that both factors may be important in the restriction of pathogen development in the tissue.

The one factor that appeared to be correlated with resistance was phenoloxidase. BR6 contained a higher endogenous level of phenoloxidase than did A6 or BR. In addition, infection of BR6 resulted in a more rapid increase in this enzyme than was seen in A6 or GR. Phenoloxidase activity in BR6 was higher in all tuber tissues than observed in A6 or GR.

Peroxidase transformation

Peroxidase is an enzyme that is important in the suberization of wounded plant tissues (including potato tubers) and in defense against pathogens. We successfully transformed potato with a disease resistance-associated peroxidase from cucumber. Unfortunately, the amount of increased resistance was minimal. However, it is possible that the transformed tubers may suberize and develop pathogen barriers more quickly upon wounding. Since this is an important factor in controlling dry rot, studies are now in progress to assess the effect of expressing this gene in tubers on the ability to suberize and develop resistance as a result of enhanced suberization.

Genetics of virulence in F. sambucinum:

Various isolates of F. sambucinum are able to mate and recombine genetically through sexual reproduction. We have crossed several highly virulent and less virulent isolates of F. sambucinum in an attempt to determine how many genes are involved in virulence and how genetic recombination can effect virulence in progeny. Thus far, we have analyzed several crosses and it appears that at least two genes may be involved in virulence on potato tuber tissue. Of some importance is the observation that some of the offspring of these crosses were more virulent than the most virulent parent. We have also observed that the tuber tissue responds differently to the less virulent progeny than to the more virulent progeny. The observations suggest that phenoloxidase or a related plant defense factor may be involved in this resistance expression. Inheritance of TBZ resistance in relation to virulence is also being evaluated.

Funding: Industry

CHEMICAL CONTROL OF MUCK VEGETABLE AND POTATO DISEASES-1995

M. L. Lacy and B. D. Cortright

Department of Botany and Plant Pathology

INTRODUCTION

The spray trials described here were carried out at the MSU Muck Soils Experimental Research Farm, Bath, MI. Planting, inoculation and spray dates as well as data on maintenance sprays for weed and insect control and irrigation data are given in individual reports. Fertilizer was drilled into plots prior to planting according to results of soil tests and for the recommendations for the crop being planted. Maximum, minimum, and average air and soil (½ inch deep) temperatures, high, low, and average percent relative humidities, amounts of precipitation (including irrigation), and leaf wetness periods were recorded for each day by an ENVIROCASTER weather station located in our onion spray plots (Appendix 1).

Sprays were applied with a tractor-mounted John Bean boom sprayer operated at 100 PSI at a ground speed (2.3-2.7 mph) calculated to deliver 50 gallons of liquid per acre. Onions and carrots were sprayed with three D3-45 cone nozzles placed directly over each row of the three-row bed. Celery and potatoes were sprayed with three D2-25 nozzles per row, 2 nozzles being placed on both sides of each row at a 45 degree angle and 1 nozzle placed directly over the row for increased foliar surface coverage. The sprayer was calibrated several times during the spray season (28 Jun-31 Sep) and all calibrations were in close agreement. All treatments were replicated four times in a randomized block design. Rates of application are given as amount of formulation per acre in the tables.

All spray plots (Tables 1-3) were inoculated with spore suspensions of conidia of disease-causing fungi applied in the late afternoon or evening hours on days when conditions were favorable for disease development. Dates of inoculations are given in individual sections of the report.

NOTE: Some of the pesticides mentioned in this report are not registered for the use mentioned, and these results do not constitute a recommendation for the use of any pesticide. These are experimental results only. Consult labels for current pesticide clearances and extension bulletins for recommendations.

CHEMICAL CONTROL OF POTATO LATE BLIGHT

Potato plots were planted with a pick-type planter on 17 May 1995 into two row by 50 foot plots (34 inch row spacing) replicated four times using Snowden cut seed and were hilled 23 Jun and 5 Jul. The center 5 foot section of each 2-row plot was inoculated with sporangia of the late blight fungus on 10 Jul, 19 Jul, 20 Jul, 1 Aug and 3 Aug. Irrigation was applied on 16 May (0.8 inch), 29 Jul (0.8 inch), 1 Aug (0.9 inch) and 15 Aug (0.1 inch). The US-1 genotype (Ridomil-sensitive, A1 mating type) was used in the first three inoculations and both the US-1 and the US-8 genotype (Ridomil-insensitive, A2 mating type) were used in the final two inoculations to ensure disease. Fungicide sprays began on 28 Jul and ended on 28 Aug (10 applications). Sprays were applied weekly unless indicated otherwise (Table 1).

Herbicides were applied as follows (rates are formulation per acre):

Herbicides applied	Rate/acre	Date(s)
Dual 8E	1 qt.	19 May
Basagran	1 qt.	5 Jun & 3 Jul
Poast	1.5 pt.	8 Aug
Diquat	1 pt.	6 Sep & 8 Sep

Insecticides were applied as follows (rates are formulation per acre):

Insecticides applied	Rate/acre	Date(s)
Admire 2 F	20 oz.	17 May
Sevin 80 S	1.25 lb.	1 Jul, 26 Jul
Thiodan 3EC	2.33 pt.	8 Jul, 9 Aug & 15 Aug
Pounce 3.2EC	8 oz.	14 Jul
Lannate	1 lb.	21 Jul & 2 Aug

Plots were visually rated for % late blight affecting the foliage in the inoculated 5 foot center section of the two row plots on 8 Aug, 14 Aug, 17 Aug, 28 Aug, and 5 Sep. The total number of row feet containing any late blight lesions (out of a total of 50 feet) was also recorded. Plots were harvested on 18 Sep and potatoes from individual treatments were weighed and graded.

Results: All fungicide treatments reduced late blight incidence below that of the untreated control on all evaluation dates (Table 1). By 5 Sep, treatments fell into four different groups. Those treatments with % disease ratings followed by the letter "a" had significantly lower disease ratings than those followed by the letter "c" or "d", and those followed by the letters "a" and "b" also had acceptable levels of control. Treatments followed by the letter "c" were judged unacceptable on Sep 5. By this time unsprayed controls were 87% infected. Progression of disease can be visualized in Fig.1, where the height of the bar represents % disease. The untreated control appears on the right side of the graph, and other treatments can be seen relative to that treatment. Treatment numbers at the bottom of the graph match treatment numbers in Table 1. When amount of row infected with late blight at various observation dates was graphed, treatments 2, 9, 13, 18, and 20 had 33% or less of the row infected on Sep 5, whereas other treatments had more (Fig. 2).

Table 1 . Control of potato late blight with fungicides, 1995.

Chemical	Rate Form./A	Spray Schedule	% Late Blight[1]					Yield (CWT/A)	
			8/8	8/14	8/17	8/28	9/5	>2" diam.	Total
1. Champ 2 FL	2.67 pt.	7 day[2]	0.0 a[3]	1.9 a	3.0 a	12.5 c	21.8 c	285 a	317 a
2. Champ 2 FL + Bravo Zn 4 FL	1.33 pt. 1.50 pt.	7 day	0.3 a	0.5 a	0.4 a	0.8 a	1.3 a	281 a	315 a
3. Champ 2 FL +Penncozeb 75 DF	1.33 pt. 1.00 lb.	7 day	0.2 a	2.0 a	2.6 a	15.5 d	19.3 c	254 a	287 a
4. Curzate 72 WP	1.00 lb.	7 day	0.0 a	1.1 a	1.3 a	4.3 a	4.8 ab	342 a	373 a
5. Curzate 72 WP	1.25 lb.	7 day	0.0 a	0.9 a	0.3 a	1.9 a	3.3 ab	322 a	354 a
6. Curzate 72 WP	1.50 lb.	7 day	0.1 a	0.8 a	0.8 a	1.8 a	3.3 ab	321 a	351 a
7. Untreated			3.5 b	15.5 b	21.3 b	65.0 e	87.0 d	231 a	269 a
8. Polyram 80 DF +Silwet +Bond	2.00 lb. 0.19 pt. 0.13 pt.	7 day	0.0 a	0.5 a	0.3 a	1.5 a	2.0 a	281 a	308 a
9. Polyram 80 DF +SuperTin 80 WP Polyram 80 DF +SuperTin 80 WP	1.50 lb. 0.13 lb. 2.00 lb. 0.16 lb.	7 day 4 apps. 7 day remaining apps.	0.0 a	0.3 a	0.5 a	0.6 a	1.0 a	287 a	319 a
10. Kocide 2.4 FL +Penncozeb 75 DF Kocide 2.4 FL +Penncozeb 75 DF	1.60 pt. 1.00 lb. 2.67 pt. 1.50 lb.	7 day 4 apps. 7 day remain.	0.0 a	0.6 a	0.4 a	3.0 a	5.5 ab	343 a	376 a
11. Kocide 2.4 FL +Penncozeb 75 DF	2.67 pt. 1.50 lb.	7 day	0.0 a	0.9 a	1.6 a	4.3 a	5.8 ab	323 a	357 a

[1]Percent of foliage infected as estimated visually on dates indicated.
[2]Applications began on 6/28/95 and were completed on 8/28/95.
[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, P=0.05).

Table 1 (con't).

Chemical	Rate Form./A	Spray Schedule	% Late Blight[1]					Yield (CWT/A)	
			8/8	8/14	8/17	8/28	9/5	>2" diam.	Total
12. Dithane 75 DF Ridomil MZ 72 WP	2.00 lb. 2.50 lb.	14 day alter. 14 day alter. 3 apps.	0.0 a	0.9 a	0.1 a	1.8 a	1.0 a	318 a	349 a
13. Bravo 720 6 FL Ridomil-Bravo 81 WP	1.50 pt. 2.00 lb.	14 day alter. 14 day alter. 3 apps.	0.5 a	0.4 a	0.9 a	1.4 a	2.0 a	283 a	308 a
14. Ridomil 50 WP +Bravo 75 WP Bravo 720 6 FL	0.36 lb. 1.50 lb. 1.50 pt.	14 day altern. 3 apps. 14 day altern.	0.1 a	0.3 a	0.9 a	1.4 a	3.0 a	277 a	310 a
15. Dithane 75 DF Ridomil MZ 72 WP	2.00 lb. 2.50 lb.	7 day until L.b. then 14 day alter. 2 apps.	0.1 a	0.3 a	1.1 a	0.9 a	2.3 a	310 a	342 a
16. Bravo 720 6 FL	1.50 pt.	7 day	0.1 a	0.4 a	0.6 a	1.0 a	1.3 a	301 a	333 a
17. Bravo Zn 4 FL	2.20 pt.	7 day	0.2 a	0.6 a	0.1 a	0.6 a	1.0 a	305 a	338 a
18. Bravo 720 6 FL Dacobre 48 WDG	1.50 pt. 4.00 lb.	7 day 6 apps. 7 day remain.	0.0 a	0.4 a	0.4 a	1.3 a	1.3 a	286 a	317 a
19. IB 11925 6 FL	1.75 pt.	7 day	0.0 a	0.1 a	0.6 a	2.3 a	2.0 a	286 a	319 a
20. Bravo Ultrex 82.5 WDG	1.40 lb.	7 day	0.1 a	0.1 a	0.6 a	1.4 a	1.3 a	260 a	295 a
21. EXP 10625A 70 WDG	0.25 lb.	7 day	0.0 a	2.5 a	3.3 a	10.0 b	8.5 b	255 a	287 a
22. EXP 10625A 70 WDG	0.50 lb.	7 day	0.0 a	1.3 a	1.0 a	3.0 a	3.3 ab	277 a	309 a

[1]Percent of foliage infected as estimated visually on dates indicated.
[2]Applications began on 6/28/95 and were completed on 8/28/95.
[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, P=0.05).

Fig. 1

Potato Late Blight Disease Progression

MSU Muck Farm 1995

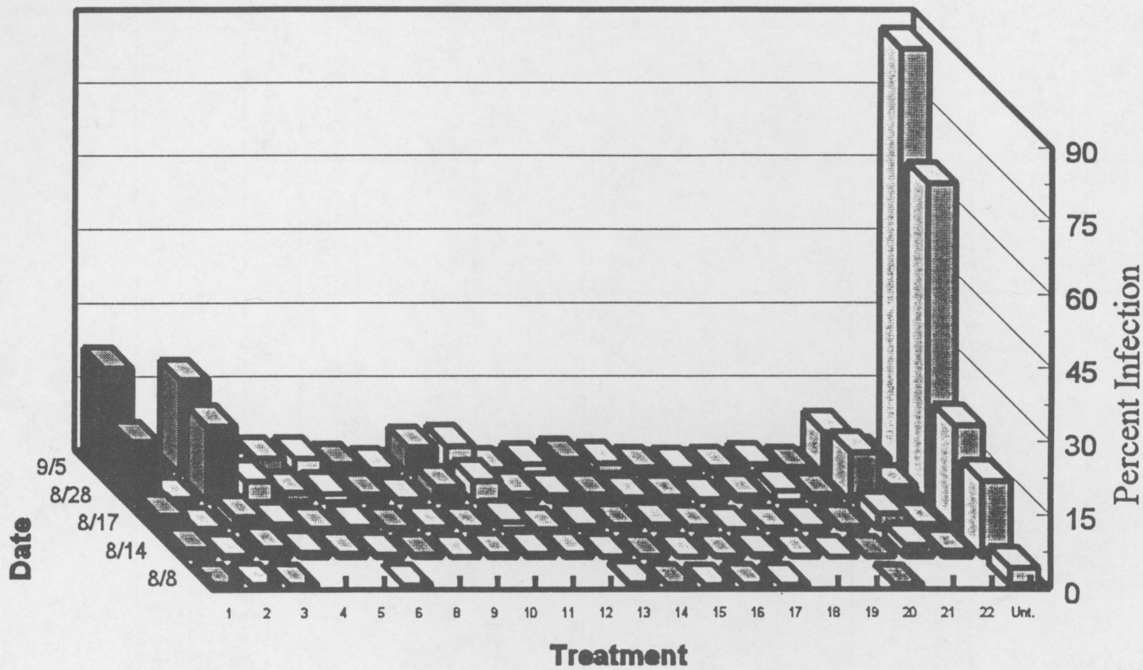


Fig. 2

Potato Late Blight Disease Spread

MSU Muck Farm 1995

Funding: Industry

CHEMICAL CONTROL OF POTATO LATE BLIGHT 1995

W.W. Kirk and B. D. Cortright

Department of Botany and Plant Pathology

INTRODUCTION

Two spray trials were carried out at the MSU Muck Soils Experimental Research Farm, Bath, MI. In trial A, fungicides were applied as a protectant program according to protocols defined by the sponsors. The spray application timings used in trial B were delayed until late blight had become established throughout the experimental block. The objective of trial A (protectant program) was to evaluate the comparative efficacy of several fungicides compared to two standard programs and to establish dose responses for chemicals as required. Trial B was initiated to evaluate the ability of different fungicides to contain established late blight in the field. In trial B, the efficacy of the fungicides registered under the Section 18 applied after the establishment of disease were compared with other containment treatments.

METHODS

Potato plots were planted with Snowden cut seed using a pick-type planter on 17 May 1995 into two rows by 50 foot plots (34 inch row spacing) and hilled on 23 June and 5 July. Fertilizer was drilled into plots before planting, formulated according to results of soil tests. Maximum, minimum and average air and soil (½ inch deep) temperatures; high, low and average percent relative humidity; amounts of precipitation (including irrigation) and leaf wetness periods were recorded for each day by an ENVIROCASTER weather station (Appendix 1).

Sprays were applied with a tractor-mounted John Bean boom sprayer operated at 100 PSI at a ground speed (2.7 mph) calculated to deliver 50 gallons of liquid per acre. The plots were sprayed with three D2-25 nozzles per row; two nozzles placed on both sides of each row at a 45-degree angle and one placed directly over the row for increased foliar surface coverage. The sprayer was calibrated several times during the spray season (28 Jun-31 Sep.) and all calibrations were in close agreement. All treatments for both trials were replicated four times in a randomized block design. Treatments together with rates of application (amount of formulation per acre) are shown in the tables.

Both trials were inoculated with spore suspensions of *Phytopthera infestans*. Inoculations were carried out in the late afternoon or evening hours on days when conditions were favorable for disease development. The center five foot section of each block was inoculated with spore suspensions (suspensions contained about 500,000 sporangiophores/ml) on 10, 19 and 20 July and 1 and 3 August. Irrigation was applied on 16 May (0.8 inch), 29 July (0.8 inch), 1 August (0.9 inch) and 15 August (0.1 inch). Fungicide sprays began on 28 July and ended on 28 August (10 applications) in trial A. Sprays were applied weekly (Table 2 and 3). In trial B, the first spray was applied when foliar infection was about 10% (visual assessment) and received only three applications at seven day intervals. (This method is not recommended for disease containment and was followed for experimental reasons).

Herbicides and insecticides were applied as shown in Table 1.

Table 1a) Herbicide applications. (Rates are formulation per acre)

Herbicides applied	Rate/acre	Date(s)
Dual 8E	1 qt.	19 May
Basagran	1 qt.	5 Jun. & 3 Jul.
Poast	1.5 pt.	8 Aug.
Diquat	1 pt.	6 Sep. & 8 Sep.

Table 1b) Insecticide applications (rates are formulation per acre)

Insecticides applied	Rate/acre	Date(s)
Admire 2 F	20 oz.	17 May
Sevin 80 S	1.25 lb.	1 Jul, 26 Jul.
Thiodan 3EC	2.33 pt.	8 Jul., 9 Aug. & 15 Aug.
Pounce 3.2EC	8 oz.	14 Jul.
Lannate	1 lb.	21 Jul. & 2 Aug.

The plots were visually rated for % foliar late blight infection on 8, 14, 17, 21 and 28 August and 2 and 6 September. The plots were harvested on 26 Sep. and individual treatments weighed and graded (Trial A only). Samples of tubers were stored for evaluation of tuber blight and storage rots (Trial A and B).

Results and Discussion: In trial A, all fungicides in the test delayed the development and reduced the level of foliar late blight infection significantly in comparison with the untreated checks (Table 2 and Figure 1). No treatments gave significantly better disease control than the standard treatment programs, Ridomil MZ 72WP/Dithane DF and Bravo 720 6FL. Until 8/28 no treatment was significantly different from any other. Treatments followed by the same letter in Table 2 were not significantly different ($p = 0.05$) from treatments followed by the same letter. The propamocarb-based treatments (Tattoo and Tattoo C, treatments 10 - 15), the Ridomil MZ-based program (treatment 7), Penncozeb 75DF (treatment 8) and Bravo 720 6FL (treatment 6) all gave excellent disease control throughout the growing season. By 9/2 the EXP 10673A and EXP 10683A programs (treatments 2 - 5) and TD 2343-02 3.5FL (treatment 9) were clearly less effective than the other treatments. The infection spread rapidly through the untreated check but all treatments delayed the progress of the disease (Table 3 and Figure 2). By 8/21, some of the propamocarb-based treatments (treatments 12 and 15), EXP 10673 (treatment 2, 2pt/acre) and Penncozeb (treatment 8) showed the least spread of late blight through the plots. The disease was evenly spread throughout all treatments in all plots by 8/28.

All treatments gave statistically significant higher marketable and total yields than the untreated check (treatment 1) but not all were significantly greater than check 2 (treatment 16), see Tables 2, 4 and Figure 3. Average yields were higher in some treatments than in others but no significant yield differences between treatments were measured. There were no significant differences between any of the propamocarb-based treatments with respect to disease development or yield (Tables 2 and 3, Figures 1, 2 and 3). The full yield analysis (Table 4) indicated that there may be a yield reduction at the high rate of application of Tattoo C and Tattoo (propamocarb + mancozeb) in size grading >3". The plots received 4 applications in total of Tattoo products and 6 x Penncozeb (2 lb).

In trial B, treatments were not applied until the disease had progressed evenly through the experimental block and had reached 10% foliar infection. All treatments decreased the foliar infection after the first application (Table 5 and Figure 4). The initial curative reaction may have been due to the assessment technique that does not allow for canopy growth. The disease progression was significantly delayed by Acrobat MZ, Tattoo C 6.3FL and Polyram 80DF + SuperTin 80WP in comparison with Curzate M8 72WP and Champ 2FL + Bravo ZN 4FL. All treatments significantly decreased disease development in comparison with the untreated check plots. Curzate M8 was not applied as recommended by DuPont, i.e. with additional mancozeb. The performance of Curzate M8 applied as a containment strategy as recommended by DuPont may have produced a different performance to that recorded in this trial.

During August, the average air temperature and relative humidity were higher than in 1994. Precipitation was lower than in 1995 and the average leaf wetness during august was also lower (Figure 5). The combined effect of these factors may have been responsible for the less severe epidemic of late blight in 1995.

NOTE: Some of the pesticides mentioned in this report are not registered for the use mentioned, and these results do not constitute a recommendation for the use of any pesticide. These are experimental results only. Consult labels for current pesticide clearances and extension bulletins for recommendations.

Table 2. Control of potato late blight with fungicides, 1995 .

Chemical	Rate Form/A	Spray Schedule	% Late Blight[1]							Yield (cwt/A)	
			8/8	8/14	8/17	8/21	8/28	9/2	9/6	>2" diameter	Total
1. Untreated		7 day	0.0a	3.25 b	5.00 c	9.3 c	75.0 d	86.3 g	92.5 g	222.6 d	246.7 c
2. EXP10673A 4.5SC + NuFilm 17	2.00 pt 1.00 pt	7 day	0.0a	0.02a	0.05a	0.5a	3.5a	6.5 d	9.0 cd	275.6ab	295.3ab
3. EXP10673A 4.5SC + NuFilm 17	3.00 pt 1.00 pt	7 day	0.0a	0.38a	0.08a	0.3a	3.8a	6.0 cd	7.8 bcd	323.3a	351.9a
4. EXP10683A 3SC	3.00 pt	7 day	0.0a	0.28a	0.35a	1.1a	12.5 c	19.0 f	22.5 f	279.3ab	309.3ab
5. EXP10683A 3SC	4.58 pt	7 day	0.0a	0.35a	0.90a	1.3a	6.3 b	10.5 e	13.5 e	269.4ab	303.0ab
6. Bravo 720 6FL	0.75 pt 1.67 pt	7 day 4 appns 7 day rem'ing	0.0a	0.28a	0.35a	1.0a	1.6a	4.3abc	6.3abcd	303.1ab	322.4ab
7. Dithane DF Ridomil MZ 72WP	2.00 lb 2.50 lb	14 day alt'nate 14 day alt'nate	0.0a	0.05a	0.18a	0.2a	2.0a	3.5ab	4.5ab	291.3ab	314.7ab
8. Penncozeb 75DF	2.00 lb	7 day	0.1 b	0.13a	0.15a	0.6a	1.3a	2.0a	4.8abcd	328.1a	351.2a
9. TD 2343-02 3.5FL	3.43 pt	7 day	0.0a	0.25a	0.10a	0.3a	4.3 b	6.3 d	9.5 d	283.9ab	309.3ab

[1]Percent of foliage infected as estimated visually on dates indicated

[2]Applications began on 6/28/95 and were completed on 8/28/95

[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Table 2 continued

Chemical	Rate Form/A	Spray Schedule	% Late Blight[1]							Yield (cwt/A)	
			8/8	8/14	8/17	8/21	8/28	9/2	9/6	>2" diameter	Total
10.Tattoo 4.6FL Penncozeb 75DF	2.73 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00a	0.03a	0.3a	1.5a	1.0a	2.5a	289.5ab	312.6ab
11. Tattoo 4.6FL Penncozeb 75DF	3.50 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.13a	0.63a	1.3a	3.0ab	2.5a	3.8a	325.2a	348.6a
12. Tattoo 4.6FL Penncozeb 75DF	4.24 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00a	0.03a	0.03a	2.0a	1.5a	2.8a	314.9a	341.7a
13. Tattoo C 6.3FL Penncozeb 75DF	1.68 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00a	0.05a	0.3a	2.0a	1.8a	2.5a	310.4ab	335.6a
14. Tattoo C 6.3FL Penncozeb 75DF	2.23 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.65a	0.43a	0.8a	2.1a	2.3a	3.8a	326.7a	353.3a
15. Tattoo C 6.3FL Penncozeb 75DF	2.73 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00a	0.00a	0.0a	1.3a	1.8a	3.0a	302.7ab	326.7ab
16. Untreated			0.10 b	1.00a	3.00 b	6.0 b	73.8 d	85.0 g	92.5 g	248.2 cd	277.7 bc

[1]Percent of foliage infeced as estimated visually on dates indicated

[2]Applications began on 6/28/95 and were completed on 8/28/95

[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Table 3. Spread of potato late blight with fungicides, 1995

Chemical	Rate Form/A	Spray Schedule	% Spread of Late Blight[1]			
			8/14	8/17	8/21	8/28
1. Untreated		7 day	52.3 b	82.5 c	100 d	100a
2. EXP10673A 4.5SC + NuFilm 17	2.00 pt 1.00 pt	7 day	0.0a	12.5ab	10ab	100a
3. EXP10673A 4.5SC + NuFilm 17	3.00 pt 1.00 pt	7 day	0.0a	12.5ab	50 bc	100a
4. EXP10683A 3SC	3.00 pt	7 day	0.0a	27.5ab	50 bc	100a
5. EXP10683A 3SC	4.58 pt	7 day	0.0a	13.3ab	34 bc	100 a
6. Bravo 720 6FL	0.75 pt 1.67 pt	7 day 4 appns 7 day rem'ing	2.5a	25.0ab	56 bc	100a
7. Dithane DF Ridomil MZ 72WP	2.00 lb 2.50 lb	14 day alt'nate 14 day alt'nate	0.0a	0.0ab	20 bc	100a
8. Penncozeb 75DF	2.00 lb	7 day	0.0a	2.5ab	13ab	100a
9. TD 2343-02 3.5FL	3.43 pt	7 day	0.0a	12.5ab	36 bc	100a

[1]Percentage of plot length with foliage infection on dates indicated
[2]Applications began on 6/28/95 and were completed on 8/28/95
[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Table 3 continued

Chemical	Rate Form/A	Spray Schedule	% spread of late blight[1]			
			8/14	8/17	8/21	8/28
10.Tattoo 4.6FL Penncozeb 75DF	2.73 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00ab	26 c	100a
11. Tattoo 4.6FL Penncozeb 75DF	3.50 pt 2.00 lb	7 day 2 appns then 14 day alternate	6.30a	31.3ab	37 bc	100a
12. Tattoo 4.6FL Penncozeb 75DF	4.24 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00ab	8a	100a
13. Tattoo C 6.3FL Penncozeb 75DF	1.68 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00ab	16ab	100a
14. Tattoo C 6.3FL Penncozeb 75DF	2.23 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	6.3ab	38 bc	100a
15. Tattoo C 6.3FL Penncozeb 75DF	2.73 pt 2.00 lb	7 day 2 appns then 14 day alternate	0.00a	0.00ab	8a	100a
16. Untreated			25.0 b	50.0 b	100 d	100a

[1]Percentage of plot length with foliage infection on dates indicated
[2]Applications began on 6/28/95 and were completed on 8/28/95
[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Table 4. Control of potato late blight with fungicides, 1995. Full yield analysis.

Chemical	Rate Form/A	Spray Schedule	Yield (cwt/A)			
			<2" diameter	2-3" diameter	>3" diameter	Total
1. Untreated		7 day	24.0a	209.5a	13.2 cd	246.7 c
2. EXP10673A 4.5SC + NuFilm 17	2.00 pt 1.00 pt	7 day	20.7a	238.0ab	36.6abcd	295.3ab
3. EXP10673A 4.5SC + NuFilm 17	3.00 pt 1.00 pt	7 day	28.6a	275.7 b	47.6abc	351.9a
4. EXP10683A 3SC	3.00 pt	7 day	29.9a	245.5ab	33.9abcd	309.3ab
5. EXP10683A 3SC	4.58 pt	7 day	33.6a	235.8ab	33.7abcd	303.0ab
6. Bravo 720 6FL	0.75 pt 1.67 pt	7 day 4 appns 7 day rem'ing	19.3a	252.3ab	50.8ab	322.4ab
7. Dithane DF Ridomil MZ 72WP	2.00 lb 2.50 lb	14 day alt'nate 14 day alt'nate	23.4a	245.5ab	45.8abc	314.7ab
8. Penncozeb 75DF	2.00 lb	7 day	23.1a	260.5ab	67.6a	351.2a
9. TD 2343-02 3.5FL	3.43 pt	7 day	25.4a	254.4ab	29.5 bcd	309.3ab

[2]Applications began on 6/28/95 and were completed on 8/28/95

[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Table 4 continued

Chemical	Rate Form/A	Spray Schedule	Yield (cwt/A)			
			<2" diameter	2 - 3" diameter	> 3" diameter	Total
10.Tattoo 4.6FL Penncozeb 75DF	2.73 pt 2.00 lb	7 day 2 appns then 14 day alternate	23.1a	255.0ab	34.5abcd	312.6ab
11. Tattoo 4.6FL Penncozeb 75DF	3.50 pt 2.00 lb	7 day 2 appns then 14 day alternate	23.4a	272.3 b	52.9ab	348.6a
12. Tattoo 4.6FL Penncozeb 75DF	4.24 pt 2.00 lb	7 day 2 appns then 14 day alternate	26.8a	291.3 b	23.6 bcd	341.7a
13. Tattoo C 6.3FL Penncozeb 75DF	1.68 pt 2.00 lb	7 day 2 appns then 14 day alternate	25.2a	280.4 b	30.0 bcd	335.6a
14. Tattoo C 6.3FL Penncozeb 75DF	2.23 pt 2.00 lb	7 day 2 appns then 14 day alternate	26.6a	274.1 b	52.6ab	353.3a
15. Tattoo C 6.3FL Penncozeb 75DF	2.73 pt 2.00 lb	7 day 2 appns then 14 day alternate	24.0a	282.7 b	20.0 bcd	326.7ab
16. Untreated			29.5a	238.2ab	10.0 d	277.7 bc

[2]Applications began on 6/28/95 and were completed on 8/28/95

[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Table 5. Control of potato late blight with fungicides after infection is established.

Chemical	Rate Form/A	Spray schedule	% late blight[1]					% stem blight
			8/17	8/21	8/28	9/2	9/6	9/6
1. Untreated			13.3a[3]	22.5a	83.8a	88.8a	95.0a	45.0a
2. Champ 2FL + Bravo ZN 4FL	1.33 pt 1.50 pt	7 day[2]	7.8a	14.8ab	36.2 b	42.5 b	50.0 b	23.8 b
3. Polyram 80DF + SuperTin 80WP	2.00 lb 0.16 lb	7 day	6.0ab	13.3ab	21.3 c	26.3 c	30.0 c	7.5 c
4. Tattoo C 6.3FL	2.23 pt	7 day	3.8 b	6.8 b	12.5 c	16.3 c	25.0 c	9.5 c
5. Acrobat MZ	2.23 lb	7 day	3.8 b	6.5 b	10.8 c	15.0 c	20.0 c	7.5 c
6. Curzate M8 72WP	1.25 lb	7 day	7.0ab	12.0ab	23.8 c	36.7 b	41.3 b	18.8 b

[1]Percent of foliage infected as estimated visually on dates indicated
[2]Applications began on 8/10/95 when late blight infected about 10% of the foliage and were completed on 8/21/95
[3]Means followed by the same letter are not significantly different (Student-Newman-Keuls test, p=0.05)

Fig 1. Potato Late Blight Disease Progression
MSU Muck Farm 1995

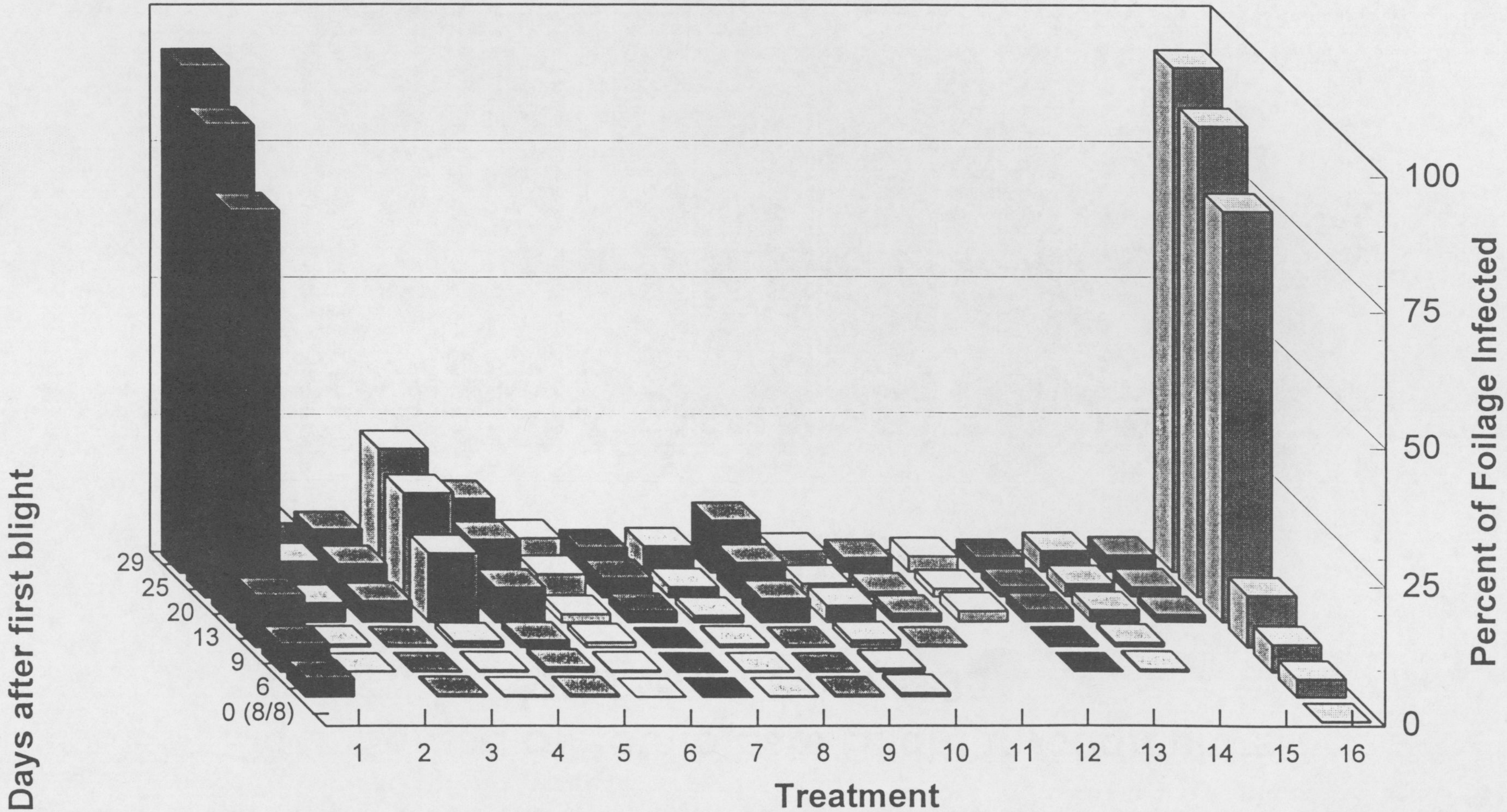


Fig 2. Spread of Potato Late Blight through plots
MSU Muck Farm 1995

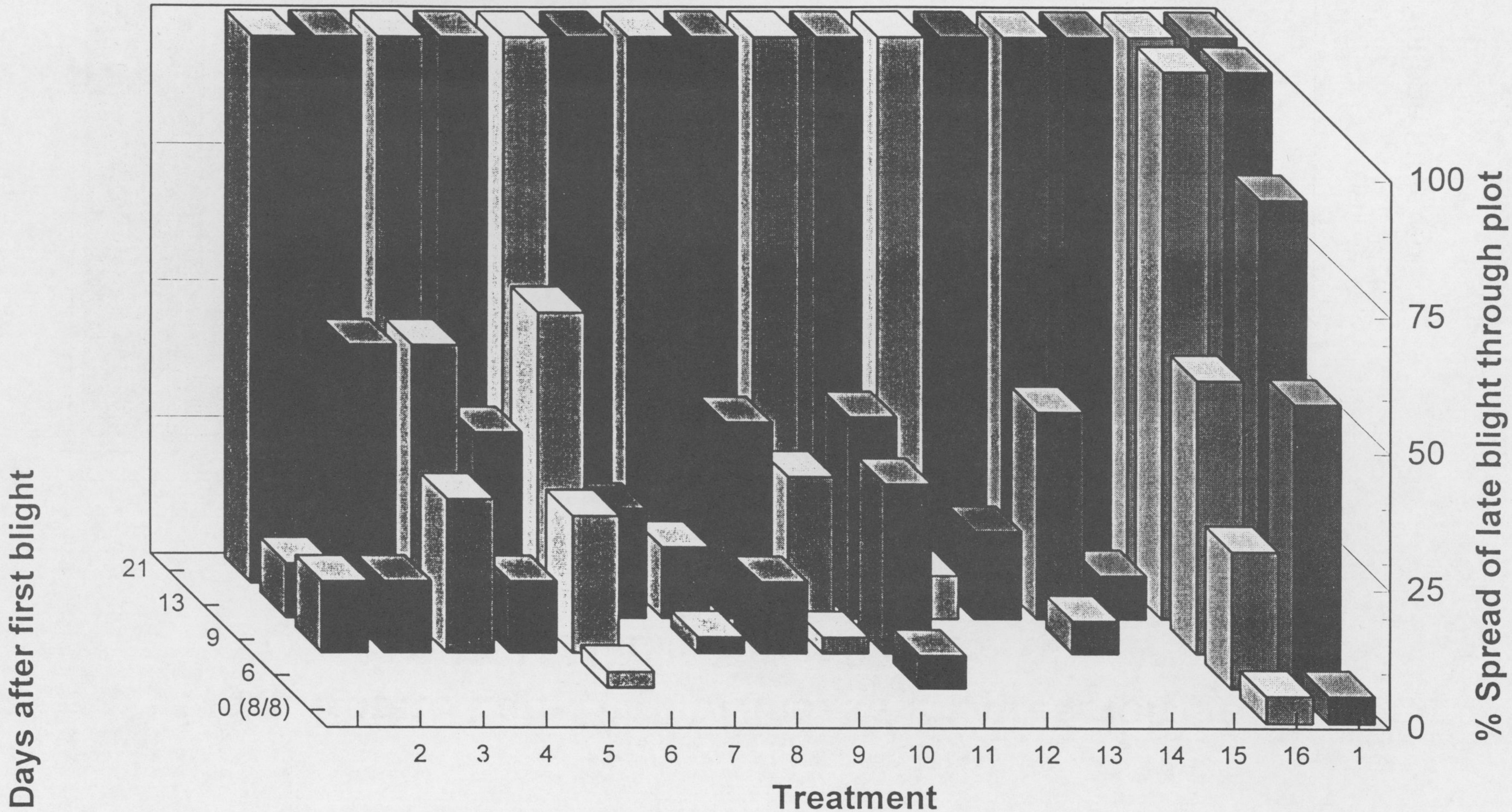
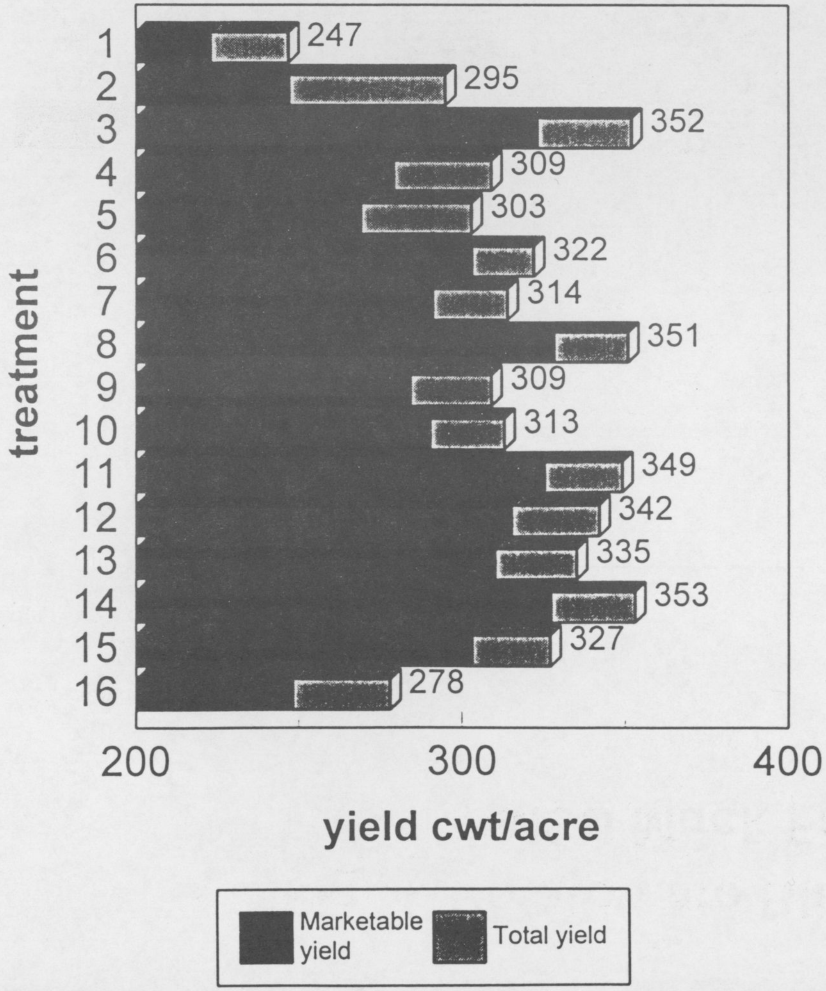


Fig. 3 Potato Late Blight
MSU Muck Farm 1995
1) Yield analysis (cwt/acre) 2) % yield increase cf untreated (1)



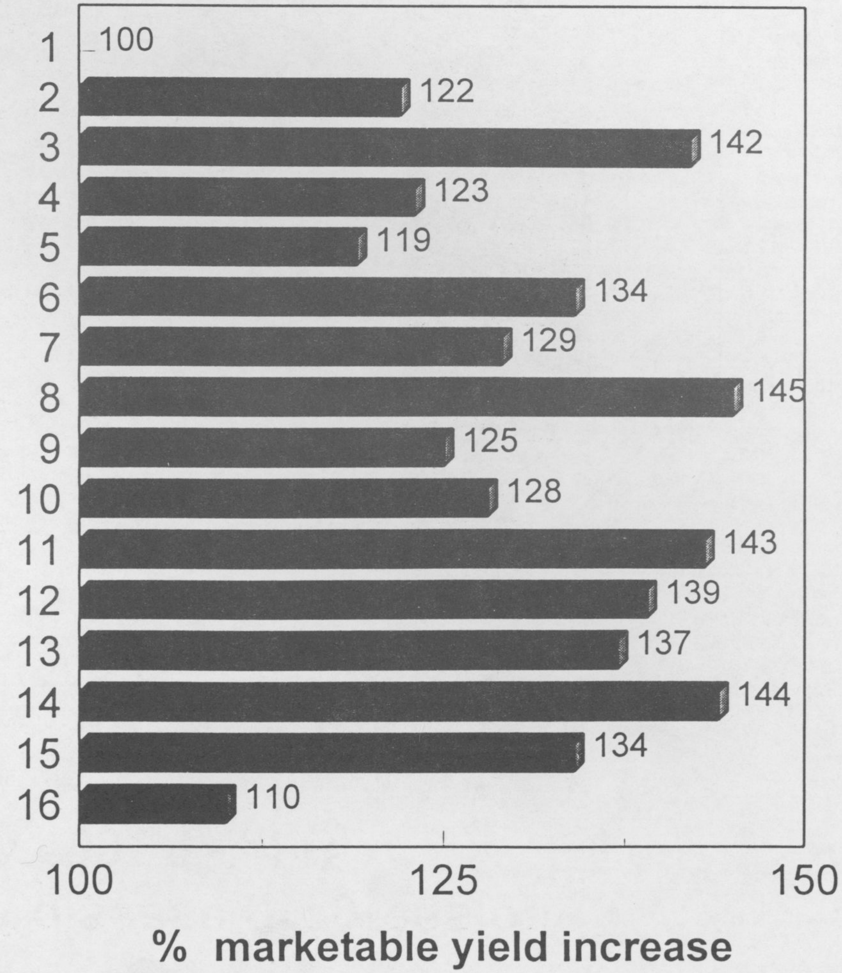


Fig. 4 Potato Late Blight disease progression
MSU Muck Farm 1995 Trial B

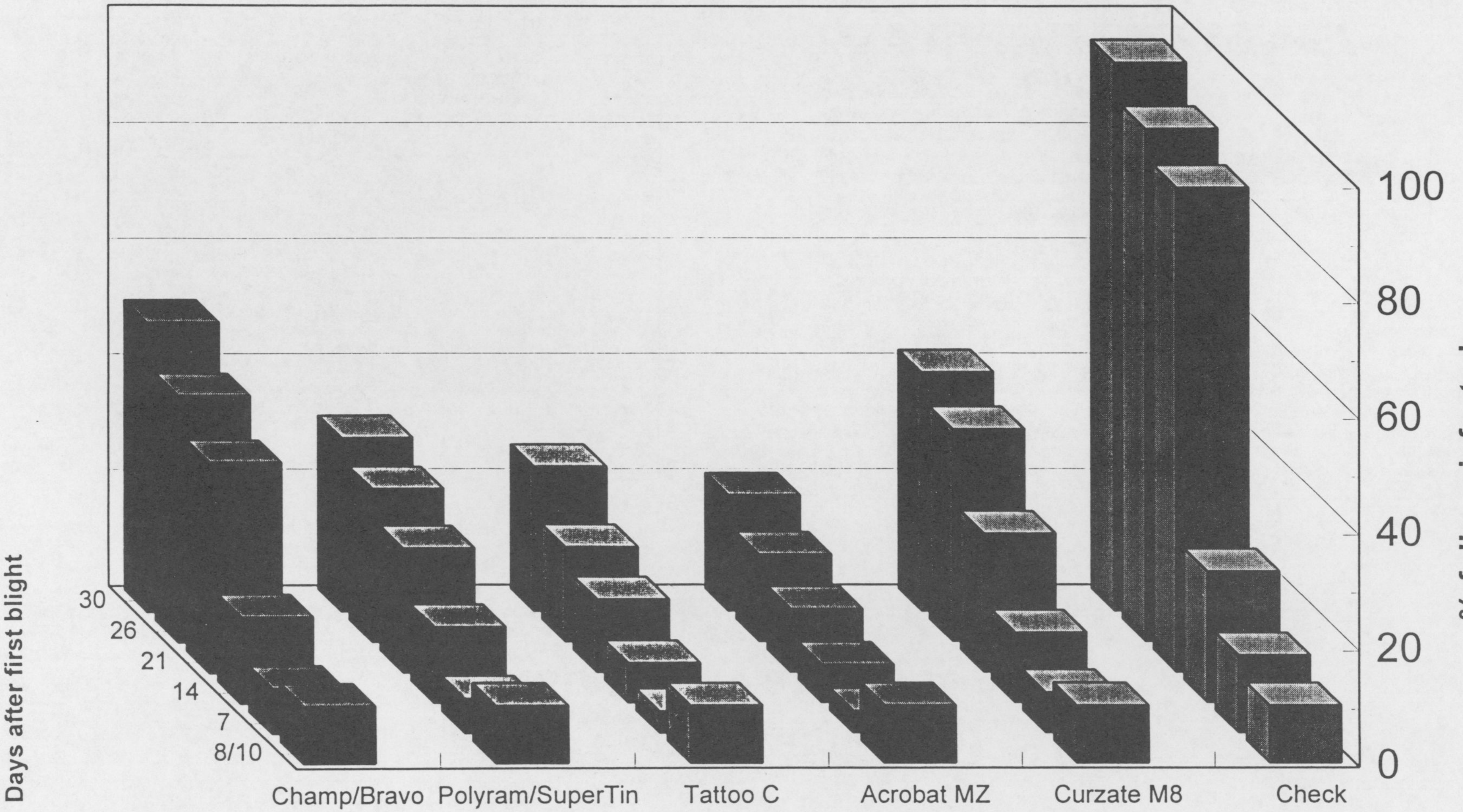
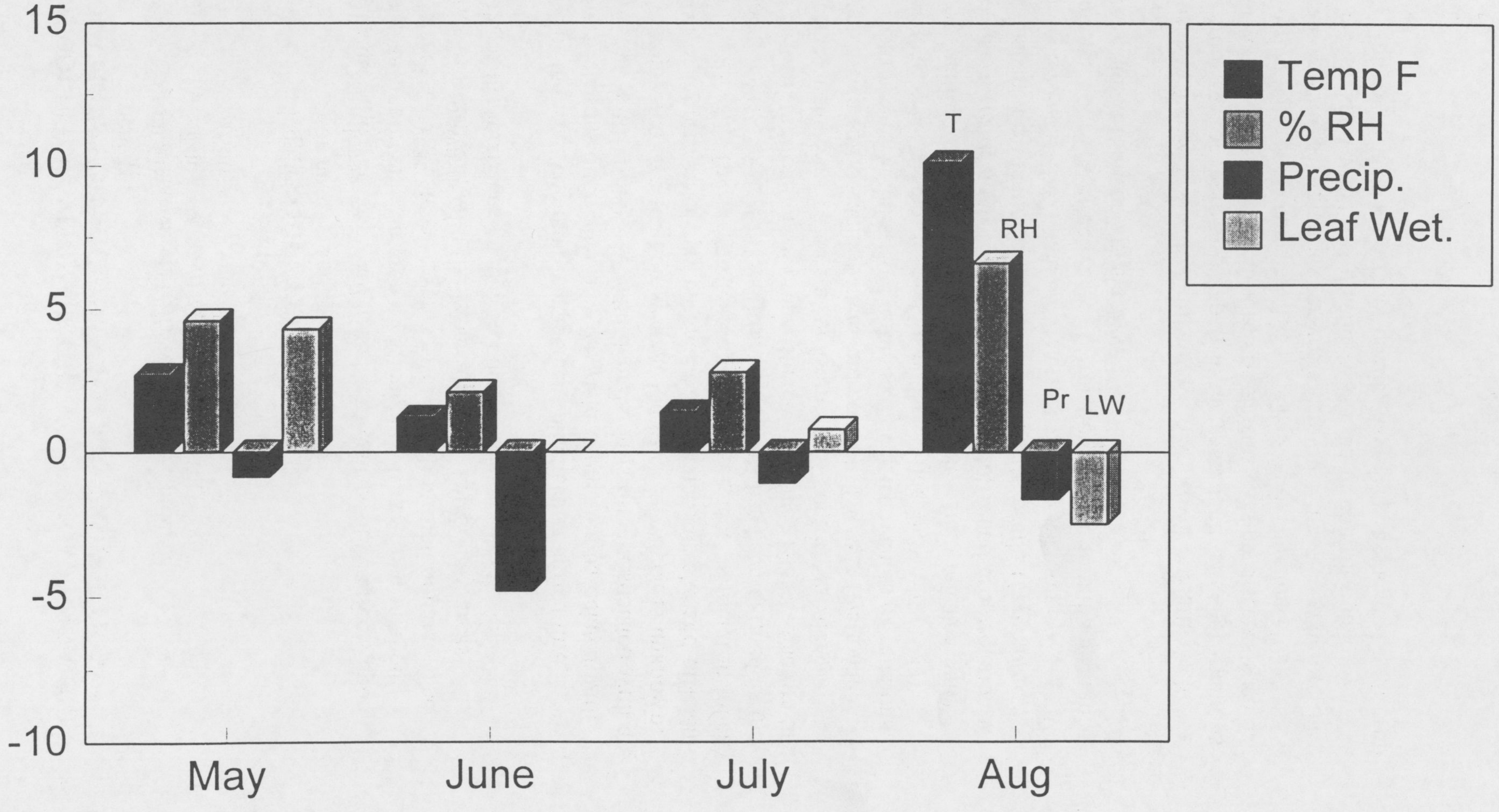


Fig. 5. Differences in Weather 95-94



Funding: MPIC

IDENTIFICATION AND DOCUMENTATION OF THE MOST PROMISING COVER CROPS AND ROTATIONS FOR MICHIGAN POTATO PRODUCTION

Richard Leep, Richard Harwood, Cliff Kahl, Don Smucker,
Mike Staton, Murari Suvedi, and Anil Shrestha

INTRODUCTION

Crop rotation and the use of cover crops can have significant positive effects upon potato production. Potato is an important cash crop of Michigan. It is grown in about 50,000-60,000 acres and fetches a farm gate cash value of over 100 million dollars. The crop is grown in 33 counties in Michigan, with the Montcalm and Bay County areas representing more than 50% of the total acreage and production (Chase, 1993).

Crop rotation is one of the most common management practices in agriculture (Schoenemann, 1984). Crop rotations often alleviates the yield depression associated with continuous cropping (Crookston et al., 1988). A yield depression is often associated with a continuous cropping system compared to a rotation system, the cause of which is unknown. But, the positive yield effect of crop rotation may be linked to enhanced uptake and efficient use of water (Copeland et al., 1993). The use of the term 'rotation effect' is found in much of the literature on crop rotations (Heichel, 1987). 'Rotation effect' has been defined as the difference in yield associated with the rotation of crops (Pierce and Rice, 1988). Factors that contribute to the rotation effect include increased soil moisture, pest control, greater availability of nutrients, increase in soil organic matter, and control of weeds (National Research Council, 1989). Various researchers have discussed the effectiveness of rotations in controlling various pathogens, insects, and diseases in potato. Hide and Reid (1987) mention the effectiveness of rotation of potato with spring barley on a field infested with Potato cyst nematode (*Globodera rostochiensis*). Roush et al. (1990) found crop rotation was an important and effective management tactic for the Colorado potato beetle (*Leptinotarsa decemlineata* Say). Specht and Leach (1987) studied the effect of crop rotation on *Rhizoctonia* disease of white potato. The effectiveness of rotations on the initial appearance of early blight has also been studied (Shtienberg and Fry, 1990).

Crop rotation has been practiced in potato cultivation for well over a century. It means, spacing the potato crops two or more years apart in the same land. Longer rotations are often recommended for reducing losses by soil-borne organisms causing diseases such as scab, *Verticillium* and *Fusarium* wilt (Schoenemann, 1984). Glass and Thurston (1978) mention the use of mandatory seven-year rotations for potatoes by the Incas even before the arrival of the Spanish. It is now known that this practice was used to control potato cyst nematode (Sieczka, 1989). Improved yields and tuber quality have been associated with crop rotations in potato cultivation.

The use of cover crops in cropping systems is also gaining importance. Cover crops are legumes, cereals, or appropriate mixtures of both, grown specifically to protect the soil from eroding; ameliorating soil structure; enhancing soil fertility; and suppressing weeds, insects, pathogens and nematodes (National Research Council, 1989). The use of cover crops is reported as early as 3,000 years ago in China, where they were used to improve soil productivity (Pieters, 1927).

In northern latitudes, most cover crops are grown during the cold season. They include crops such as rye (*Secale cereale* L.), clover (*Trifolium* sp.), or vetch (*Coronilla* and *Vicia* spp.). They are grown to fill gaps in space or time when cash crops would leave the ground bare (Lal et al., 1991). Rye is an important cover crop grown in a potato based cropping system. It is commonly planted as a winter cover crop in the mid-Atlantic region as a nitrogen trap crop (Evanylo, 1991). Jansson and Lecrone (1991) studied the effect of sorghum-sudangrass hybrid cover crop management in the control of wireworms in potato in Florida. They found that the planting date of the cover crop had a significant effect in the reduction of wireworm in the following potato crop. However, cover crops may not provide immediate economic returns.

The concern of groundwater contamination, environmental pollution, human health hazards, and risk to beneficial organisms and wildlife have necessitated the development of cropping systems that limit chemical fertilizer inputs; enhance the control of pathogens, insects, diseases, and nematodes; and limit herbicide use (National Research Council, 1989). The use of cover crops and an efficient crop rotation may address some of these issues in potato cultivation in Michigan.

Documentation of actual producer practices and perceptions of crop rotations and cover crops in potato in Michigan is lacking. Such information should be helpful in planning and developing strategies for producing high yielding, high quality potato tubers while minimizing adverse impacts to the environment. The objectives of this study were:

(i) To survey Michigan potato growers for identification of most promising cover crops and rotation being used on their farms.

(ii) To conduct a search of the current literature on research on rotations and cover crops in potato production.

(iii) To use this information as a basis of future research upon the impacts of crop rotation and cover crops upon potato production in Michigan.

MATERIALS AND METHODS

This study followed a descriptive survey methodology. A questionnaire was developed to gather information needed for this study. The instrument was reviewed by faculty members, researchers, and extension agents at Michigan State University and mailed to all potato growers in Michigan during Summer, 1994. All potato producers in Michigan were requested to participate in this study through an announcement in the Michigan Potato Industry Commission Newsline publication. The questionnaire of 3 pages consisted of 12 major sections requesting information on: acreage, major rotation, major cover crops, date of seeding, tillage methods, seeding rate and fertilizer use in cover crops, fertilizer use in major crops, test for and use of chemicals for nematodes and *Verticillium wilt* control, soil and petiole nitrate tests, practices used to manage nitrogen, and benefits obtained from cover crops. A sample of the questionnaire is presented in Appendix I. A follow-up letter was sent to non-respondents requesting them to complete and return the questionnaire. As of March 1995, 70 potato growers returned the questionnaires. Four respondents returned the survey incomplete and indicated that they were no longer growing potatoes or indicated unwillingness to participate in the study. Thus, this study is based on responses from 66 potato growers. The information collected from the survey was entered in a SPSS PC+ software system for analysis. Both descriptive and categorical data were entered. Analysis of the data were done using chi-square test, binomials, analysis of variance, and correlations.

RESULTS AND DISCUSSION

Farm size and rotations practiced: Surveys were returned by 70 growers representing about 55% of potato acreage in Michigan. The average farm size was 1,074 acres, and the average area under potato cultivation was 413 acres.

Findings indicated that, a large number of potato farmers in Michigan practice some kind of crop rotation. Respondents were asked to specify 3 different kinds of rotations followed on their farm. Altogether, 13 major cropping patterns were identified. Findings in Table 1 show that the use of rotation was more prevalent than continuous potato, and 7 of the rotations consisted of a legume crop.

Among the rotations, potato-small grain-potato and potato-corn-potato were the most frequently used patterns. Other patterns followed by Michigan potato growers included continuous potato, potato-beans-potato, potato-beans-corn-potato, potato-small grains-beans-potato, potato-small grains-alfalfa-potato, potato-corn-beans-small grain-potato, potato-small grain-corn-potato, potato-alfalfa-potato, potato-corn-alfalfa-potato, potato-sorghum-potato, and potato-small grain-sorghum-potato.

Table 1. Major types of rotation practiced by the farmers.

Type of rotation	Frequency* (n = 66)	Percentage
Continuous potato	10	9.1
Potato-Corn-Potato	24	21.8
Potato-Small Grains-Potato	25	22.7
Potato-Beans-Potato	12	10.9
Potato-Beans-Corn-Potato	6	5.5
Potato-Small Grains-Beans-Potato	7	6.4
Potato-Small Grains-Alfalfa-Potato	6	5.5
Potato-Corn-Beans-Small Grain-Potato	8	7.3
Potato-Small Grain-Corn-Potato	5	4.5
Potato-Alfalfa-Potato	3	2.7
Potato-Corn-Alfalfa-Potato	1	0.9
Potato-Sorghum-Potato	2	1.8
Potato-Small Grain-Sorghum-Potato	1	0.9

* Frequency exceeds 66 because of multiple responses.

Tillage methods used for planting potatoes: Respondents were asked to indicate tillage methods used for planting potatoes. Findings in Table 2 show that the popular method was moldboard plowing. Disc-moldboard and tandem disc harrow were other frequently used tillage practices.

Table 2. Tillage methods used for planting potatoes.

Tillage method	Frequency* (n = 66)	Percentage
Moldboard plow	36	38.7
Disc and moldboard plow	21	22.6
Tandem disc harrow	20	21.5
Coulter chisel plow	9	9.7
Chisel plow	3	3.2
Disc chisel plow	3	3.2
Disc and roto-till	1	1.1

* Frequency exceeds 66 because of multiple responses.

Planting date of potatoes: Planting date of potatoes in Michigan was found to range from as early as the third week of April to as late as the second week of June (Figure 1). The most frequently used planting date in terms of frequency was the first week of May.

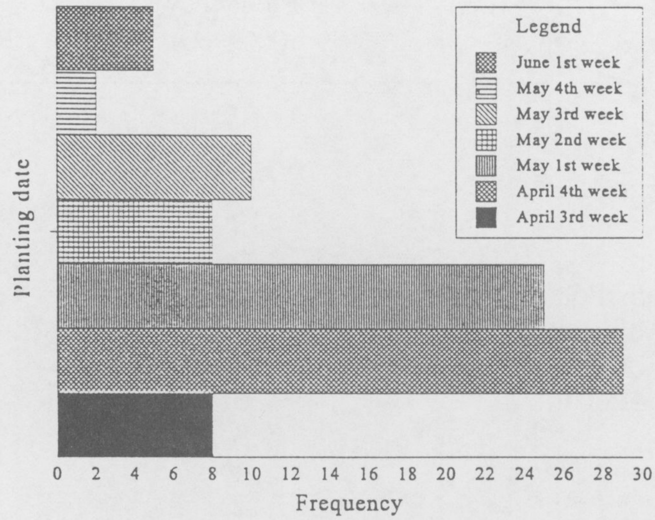


Figure 1. Frequency of planting dates of potato.

Use of cover crops: Use of cover crops is an important practice among potato growers, as 97% of the respondents indicated planting some kind of cover crop. The most popular cover crop was rye (Figure 2). Other cover crop species included oats (*Avena sativa* L.), red clover (*Trifolium pratense* L.), barley (*Hordeum vulgare* L.), alfalfa (*Medicago sativa* L.), and wheat (*Triticum* sp.). Among these, only red clover and alfalfa are legumes.

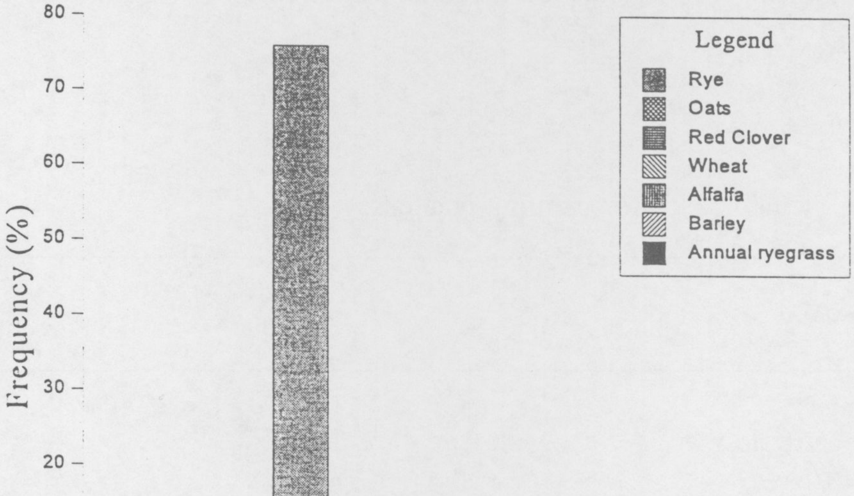


Figure 2. Choice of cover crops after potato harvest.

Seeding rates and methods of rye cover crop: The range of seeding rates and methods used for planting rye are shown in Table 3. The most common seeding method was broadcasting.

Table 3. Seeding rates and methods of rye cover crop.

	Frequency	Percentage
Seeding rate (bu/ac)		
1.0 - 1.5	7	11.3
1.6 - 2.0	32	51.6
2.1 - 2.5	11	17.7
> 2.5	12	19.4
Seeding Method		
Broadcast	51	81.0
Drilled	12	19.0

Fertilizer use in rye cover crop: The response for fertilizer use on rye cover crop showed that 59% of the respondents did not use fertilizers. A binomial test showed that, there was no significant difference at 0.05 level between the number of respondents applying and those not applying fertilizer in the cover crop. The mean application rate and standard deviation of nitrogen, phosphorus, and potash in rye was 48 ($\pm$26), 23 ($\pm$24), and 24 ($\pm$24) lbs/acre, respectively.

Fertilizer use in potato: The range and frequency of amount of chemical fertilizer used in potato are shown in Table 4. Findings indicate that most of the farmers use nitrogen, phosphorus, and potash in the range of 101-200 lbs/acre. But, the mean application rate of nitrogen, phosphorus, and potash was 207.7, 120.7, and 222.9 lbs/acre respectively (Table 4).

Table 4. Fertilizer use in potato.

		Frequency*	
Amount (lbs/ac)	Nitrogen	Phosphorus	Potash
1 - 100	2 (3.7%)	17 (34%)	-
101 - 200	23 (42.6%)	30 (60%)	16 (32%)
201 - 250	18 (33.3%)	3 (6%)	15 (30%)
251 - 300	10 (18.5%)	-	16 (32%)
> 300	1 (1.9%)	-	3 (6%)
Mean (lbs/ac)	214.2	126.8	241.9
Standard Deviation	57.1	43.9	59.4

* N = 54, 50, and 50 respectively for nitrogen, phosphorus, and potash.

Test for nematodes and *Verticillium*: Analysis of the frequency of responses for whether the potato growers conducted nematode and *Verticillium* wilt test on the soils showed that there was a significant association between nematode test and *Verticillium* wilt test being practiced by the growers (Table 5). Findings indicated that a grower was likely to test for both nematode and *Verticillium* wilt, or not to test for any of these two ($P \leq 0.05$). The likelihood of conducting only one out of these two tests was low.

Table 5. Test for nematodes and *Verticillium* wilt in the potato fields.

	Verticillium Wilt Test*	
Nematode Test*	Yes	No
Yes	41 (62.1%)	3 (4.6%)
No	2 (3%)	20 (30.3%)

* The frequency N = 66 respondents.

The time period of nematode and *Verticillium* wilt test was categorized into 4 different categories; test every year, every 2 years, every 3 years, and every 4 years (Table 6). Most of the growers tested for these factors every three years.

Table 6. Time period of nematode and *Verticillium* wilt tests.

Time period of tests	Frequency*
Every year	7 (18.9%)
Every 2 years	12 (32.4%)
Every 3 years	15 (22.7%)
Every 4 years	3 (4.5%)

* Frequency N = 37 respondents.

Control of nematodes and *Verticillium* wilt: Analysis of the responses for control of nematodes and *Verticillium* wilt showed that 59.1% of farmers were using chemical control methods. The chemicals used for control of nematodes and *Verticillium* wilt included Mocap 10G, Vapam, Busan, and Disyston. It was found that Mocap 10G was the most frequently used chemical. The frequencies and rate of applications of these chemicals are provided in Table 7.

Table 7. Chemicals used for the control of nematodes and *Verticillium* wilt and their rate of application.

Name of chemical	Frequency	Mean rate of application (gal/ac)
Mocap 10G	24 (53.3%)	24 ± 11.3
Vapam	13 (28.9%)	50.8 ± 2.8
Busan	7 (15.6%)	42 ± 11.5
Disyston	1 (2.2%)	0.25

Cultural control: The respondents were asked to specify whether the use of crop rotation and/or cover crops were effective in the reduction of nematodes and *Verticillium* wilt. Analysis of the responses by a binomial test revealed that the respondents felt crop rotation was significantly effective in reducing both nematodes and *Verticillium* wilt ($P \leq 0.05$). While, there was no significant difference in the responses for effectiveness of cover crops in reduction of nematodes and *Verticillium* wilt (Figure 3).

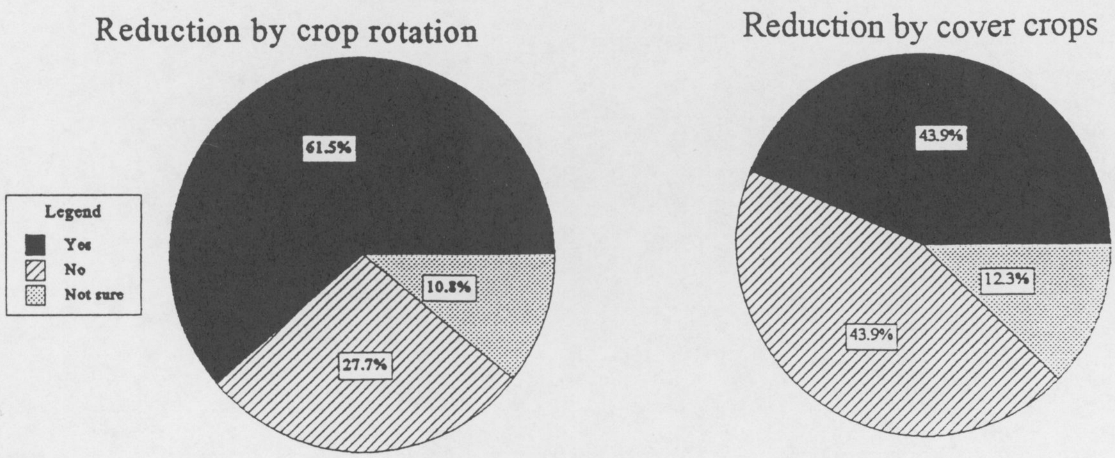


Figure 3. Effectiveness of cultural practices in reduction of nematodes and *Verticillium* wilt.

Soil nitrate and petiole nitrogen testing: There were no significant differences in the number of people testing or not testing for soil nitrate and for petiole nitrogen (Table 8). Phi coefficient test was also performed to see whether there was an association between these two tests. Findings showed no significant association between these practices.

Table 8. Soil nitrate and petiole nitrogen testing.

Tests	Yes	No	Acres Tested (Mean) 1992	1993
Soil nitrate	18 (27.7%)	47 (72.3%)	253.6	345.3
Petiole nitrogen	30 (46.2%)	35 (53.8%)	219.4	244.1

Practices used to manage nitrogen: A chi-square analysis of the practices used to manage nitrogen showed that there was significant difference in the number of potato growers calculating nitrogen contributions from legumes. Whereas, significantly more ($P \leq 0.05$) growers set realistic yield goals, used split application of nitrogen, and scheduled irrigation. However, significantly more ($P \leq 0.05$) growers did not calculate nitrogen contributions from manure and nitrate in irrigation water. Likewise, significantly more growers did not practice fertigation (Table 9).

Table 9. Practices used by farmers to manage nitrogen (N).

Practices	Frequency and percentage Yes	No
Calculation of N contributions from legumes	26 (43.3%)	34 (56.7%)^{NS}
Calculation of N contributions from manure	6 (11.1%)	48 (88.9%)*
Set realistic yield goals	58 (98.3%)	1 (1.7%)*
Split application of N	53 (86.9%)	8 (13.1%)*
Irrigation scheduling	33 (58.9%)	23 (41.1%)^{NS}
Calculation of nitrate in irrigation water	2 (3.8%)	50 (96.2%)*
Fertigation	19 (40.4%)	28 (59.6%)^{NS}

* Frequencies within the row are significantly different at 0.05 level.

Growers' perceptions of benefits from cover crops: Analysis of growers perceptions of benefits from cover crops showed that the most important contribution was protection from soil erosion. Other contributions in descending order of frequency of responses included addition of humus/organic matter to the soil, improves soil fertility, conserves soil moisture, controls weeds, and controls nematodes. The frequency of the responses are shown in Figure 4.

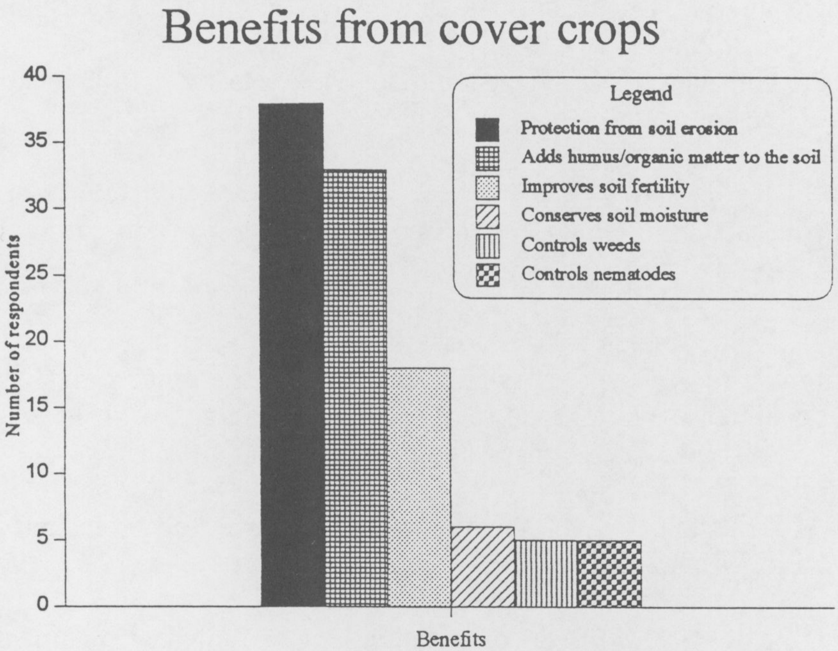


Figure 4. Growers' perceptions of benefits from cover crops.

SUMMARY AND CONCLUSIONS

A survey of the potato growers in Michigan confirmed that crop rotation and use of cover crops are prominent practices in potato cultivation. The most widely used patterns are potato-small grains-potato and potato-corn-potato and the most commonly used cover crop is rye. Rye was generally broadcast seeded after harvest of potato in Fall. Majority of the producers did not apply fertilizers in the cover crop. Producers were concerned about the presence of nematodes and *Verticillium* wilt in the soil as, a majority of them tested regularly for the presence of these organisms in the potato fields. Most of the respondents surveyed used chemicals to control these organisms, and the most commonly used chemical was Mocap 10G. Many producers agreed that cultural practices such as crop rotation and use of cover crops were helpful in reduction of these organisms. However, the growers felt that crop rotation was more effective in reduction of these organisms than the use of cover crops. Somewhat surprisingly, most of the respondents to the survey did not test for soil nitrate and petiole nitrogen even though the majority of them set realistic yield goals and calculated nitrogen contributions from legumes. Split application of nitrogen and irrigation scheduling was a common practice used to manage nitrogen. Producers mostly felt that the use of cover crops was helpful in protection from soil erosion, adding humus/organic matter to the soil, and improving soil fertility. Very few growers thought that cover crops were helpful in controlling weeds and conserving soil moisture. The results of the survey suggest that efforts should be made to offer new legume cover crops to the growers that can add nitrogen to the system and reduce chemical nitrogen use, and break disease and pest cycles. Ways should also be developed to increase the efficiency of cover crops and crop rotations in controlling weeds and conserving soil moisture.

REFERENCES

Chase, R.W. 1993. Potatoes. Status and potential of Michigan agriculture - Phase II. Special Report No. 54. Michigan State University/Agricultural Extension Services.

Copeland, P.J., R.R. Allmanas, R.K. Crookston, and W.W. Nelson. 1993. Corn-soybean rotation effects on soil water depletion. Agron. J. 85:203-210.

Crookston, R.K., J.E. Kurle, and W.E. Leuschen. 1988. The relative ability of soybean, fallow, and triacontanol to alleviate yield reductions with growing corn continuously. Crop Sci. 28:145-147.

Evanylo, G.K. 1991. Rye nitrogen cycling for corn and potato production. pp. 101-103. *In* W.L. Hargrove (ed.) Cover crops for clean water. The proceedings of an international conference West Tennessee Experiment Station, April 9-11, 1991, Jackson, TN. Soil and Water Conservation Society.

Glass, E.H. and H.D. Thurston. 1978. Traditional and modern crop protection in perspective. Bio. Science 28:109-115.

Hide, G.A. and P.J. Reid. 1991. Effects of rotation length, fungicide treatment of seed tubers and nematicide on diseases and the quality of potato tubers. Ann. Appl. Biol. 119:77-87.

Heichel, G.H. 1987. Legumes as a source of nitrogen in conservation tillage systems. pp. 29-35. *In* J.F. Power (ed.) The role of legumes in conservation tillage systems. Ankeny, IA, Soil Conservation Society of America.

Jansson, R.K. and S.H. Lecrone. 1991. Effects of summer cover crop management on wireworm (Coleoptera: Elateridae) abundance and damage to potato. J. Econ. Entomol. 84:581-586.

Lal, R., E. Regnier, D.J. Eckert, W.M. Edwards, and R. Hammond. 1991. pp. 1-11. Expectations of cover crops for sustainable agriculture. *In* W.L. Hargrove (ed.) Cover crops for clean water. The proceedings of an international conference West Tennessee Experiment Station, April 9-11, 1991, Jackson, TN. Soil and Water Conservation Society.

National Research Council. 1989. Research and Science. Alternative Agriculture. National Academy Press, Washington, D.C. 448 p.

Pierce, F.J. and C.W. Rice. 1988. Crop rotation and its impact on efficiency of water and nitrogen use. pp. 21-42. *In* W.L. Hargrove (ed.) Cropping strategies for efficient use of water and nitrogen. ASA Spec. Publ. 51. ASA, CSSA, and SSSA, Madison, WI.

Pieters, A.J. 1927. Green manuring principles and practices. John Wiley and Sons, Inc., New York, NY. 356 pp.

Roush, R.T., C.W. Hoy, D.N. Ferro, and W.M. Tingey. 1990. Insecticide resistance in the Colorado potato beetle (Coleoptera: Chrysomelidae): influence of crop rotation and insecticide use. J. Econ. Entomol. 83:315-319.

Schoenemann, J. 1984. Rotation - planning for the future. Am. Veg. Grower 32:60-61.

Shtienberg, D. and W.E. Fry. 1990. Influence of host resistance and crop rotation on initial appearance of potato early blight. Plant Dis. 74:849-852.

Sieczka, J.B. 1989. Some negative aspects of crop rotation. pp. 259-272. *In* J. Vos, C.D. van Loon, and G.J. Bollen (eds.) Effects of crop rotation on potato production in the temperate zones. Proceedings of the International conference on effects of crop rotation on potato production in the temperate zones, August 14-19, Wageningen, The Netherlands. Kluwer Academic Publishers, Dordrecht/Boston/London.

Specht, L.P. and S.S. Leach. 1987. Effects of crop rotation on Rhizoctonia disease of white potato. Plant Dis. 71:433-437.

Funding: Fed. Grant

CHIP POTATO RESPONSE TO LONG TERM STORAGE

Roger Brook and Kevin Halfmann
Agricultural Engineering Department
Michigan State University

RATIONALE:

The market decides the definition of quality. For seed potatoes, quality includes the ability to produce a maximum yield of potatoes that will maintain acceptable market quality at harvest and during subsequent storage. For potato processors, market quality includes a low reducing sugar content for acceptable process color. The reducing sugar content of the potato is affected by several factors, including variety, growing conditions, maturity at harvest, and the storage environment. To avoid the build up of reducing sugars, a storage environment must be maintained that will inhibit the low temperature conversion of starch to sugar while enhancing tuber respiration to remove existing reducing sugars.

Another factor in the definition of quality is the amount of sprouting. Sprout inhibitors have been commonly applied to processing potatoes during storage. The potato industry is interested in reducing the use of chemicals, including those used for sprout inhibition. Low temperature storage of "cold chipping" varieties offers hope of reducing or eliminating the use of chemical sprout inhibitors.

Prolonged exposure to low temperatures and stress (e.g. handling, rapid temperature change, oxygen depletion) can cause starch conversion to reducing sugars, which will cause dark colored processed products (a result of a Maillard reaction between the reducing sugars and amino acids in the potatoes). A better understanding of post harvest storage management response of new and existing varieties will assist growers in better managing their potatoes in storage. It may also lead to reduced chemical input for sprout inhibition.

Storage management profiles for potential new varieties need to be established to help producers understand the effect of storage temperature on potato quality, including sprouting, reducing sugars and subsequent tuber yield and quality characteristics from seed potatoes. Tied together with sugar monitoring during storage, these will allow potato producers to evaluate the potential for new varieties, and to better understand the effect of storage temperature management.

RESEARCH GOAL:

The goal of the research is to study the sugar changes of chip potatoes during long-term storage, as affected by variety, pre-storage conditions (physiological age) and storage temperature management strategies.

LONG-TERM STORAGE EXPERIMENTS:

Objective:

To investigate the effect of potato tuber pre-storage temperature treatment (physiological age) on sugar changes during long term storage of selected chip potato varieties.

Methods and Materials:

Tubers of three varieties were collected from two growers:

- W870/1 and E5535
- W870/2 and Snowden

Storage treatments were:

- storage at 45°F after wound healing
- storage at 50°F after wound healing
- storage at 65°F for one month after wound healing, then storage at 50°F
- storage at 65°F for 2 months after wound healing, then storage at 50°F

Samples weekly for glucose, sucrose and sprout observations; chip samples processed monthly

Results:

Glucose results for the samples tested are shown in Figure 1. The Snowden variety showed little response to the different temperature management strategies. With the exception of the 45°F storage temperature, the W870 and E5535 varieties showed little response to the temperature management strategies for the first four months of storage.

SELECTED CHIP VARIETY EXPERIMENTS:

Objective:

To monitor sugar changes in selected chip potato varieties during long term storage at 45°F.

Methods and Materials:

- Tubers of 12 varieties were harvested from the Snack Food variety trial plots of Dr. Chase.
- Tubers were stored in temperature and humidity controlled cubicles at Michigan State University
- Storage conditions were maintained at 55°F and 95% relative humidity for two weeks for wound healing; temperature was then reduced at 0.5°F per day to final storage conditions of 45°F and 95% relative humidity
- Samples weekly for glucose, sucrose and sprout observations; chip samples processed monthly

Results:

Glucose results for the samples tested are shown in Figure 2. The top graph in Figure 2 indicates that only four of the selected varieties responded favorably to the low temperature storage temperature.

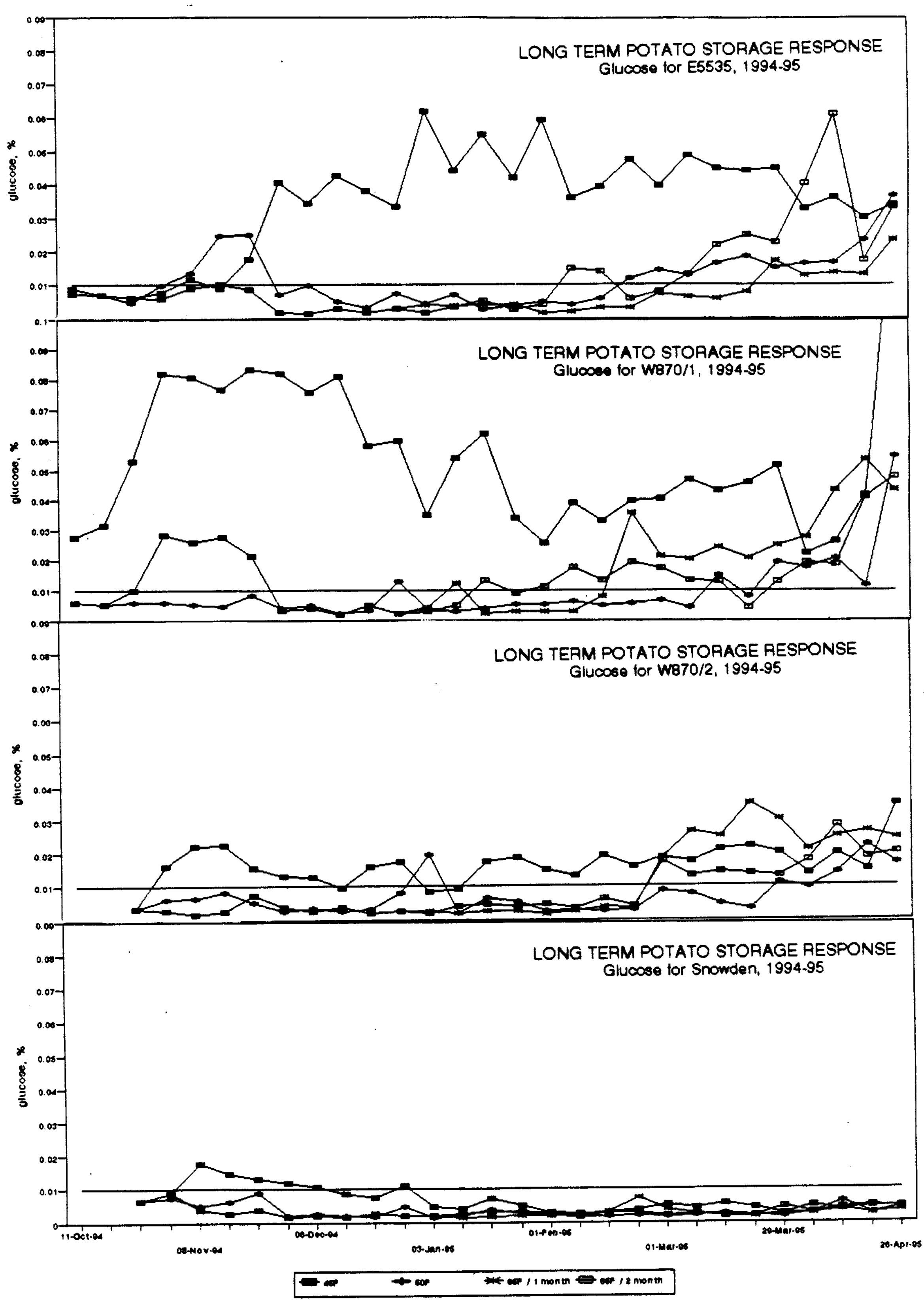


Figure 1. Long term storage response of selected potato varieties to early season temperature management strategies, 1994-95 storage season.

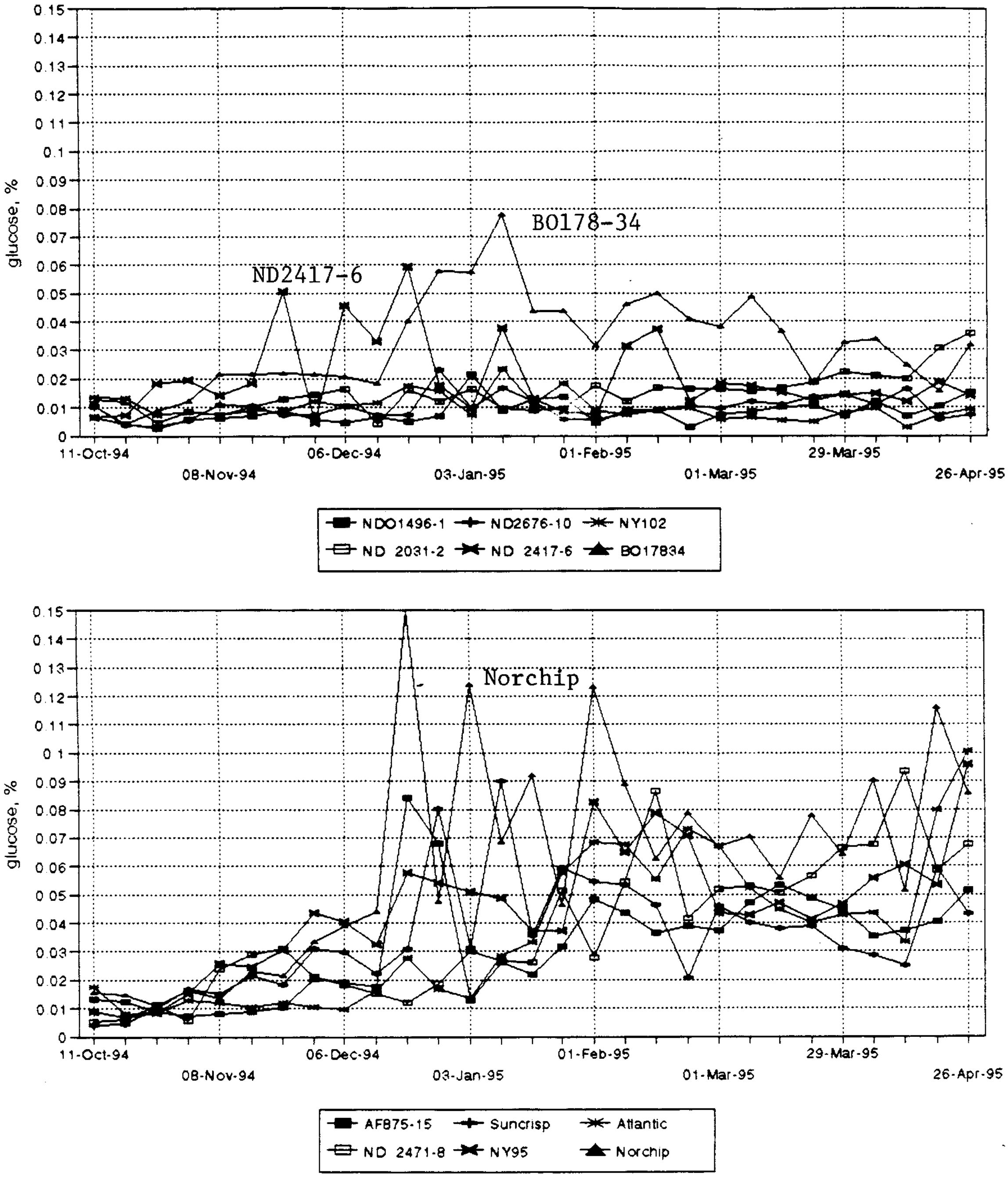


Figure 2. Long term storage response of selected varieties from the 1994/95 Snack Food Variety trials in Michigan.

EXPERIMENTAL BIN RESEARCH FOCUSES ON TEMPERATURE, COLOR

Objective:

To monitor the response of selected varieties of potatoes to long term storage, using different temperature management strategies, using the experimental potato storage center at Bishop Farms.

Method and Materials:

- Dates and temperature management information is presented in the table below.
- The bins were sampled bi-weekly with analysis for sugars and chip color done by Techmark, Inc.

	Bin 21	Bin 22	Bin 23	Bin 24
Variety	W-870	Snowden	Snowden	Snowden
Fill Date	10/14/94	10/14/94	10/04/94	10/04/94
Harvest Temp	55°F	56°F	55°F	55°F
Gas Date (sprout)	11/08/94	11/08/94	11/08/94	11/08/94
----- conditioning and suberization information -----				
Temperature	55°F	55°F	55°F	55 °F
Time Used	29 days	29 days	38 days	38 days
on Oct. 27, the storage and handling committee decided to pursue the following strategy				
From 55°F Cooling Step 1	0.4°F daily	0.4°F daily	0.4°F daily	0.8°F daily
To Temperature	50°F	50°F	50°F	50°F
Cooling Step 2	0.2°F daily	0.2°F daily	0.2°F daily	0.4°F daily
Final Storage	48°F	42°F	45°F	45°F

Results:

The results of the sample analysis are presented in Figure 3. Note especially the changes in glucose that occurred in early April. The samples from all the bins had indicated a general uptrend in sucrose about one month prior to that time. The glucose values climbed for each bin. However the pattern of change indicates that those bins with a "warmer" temperature profile (i.e. higher storage temperature and slower cooling rate) changed more or faster than the "cooler" temperature profile bins. This observation is consistent with previous potato storage research.

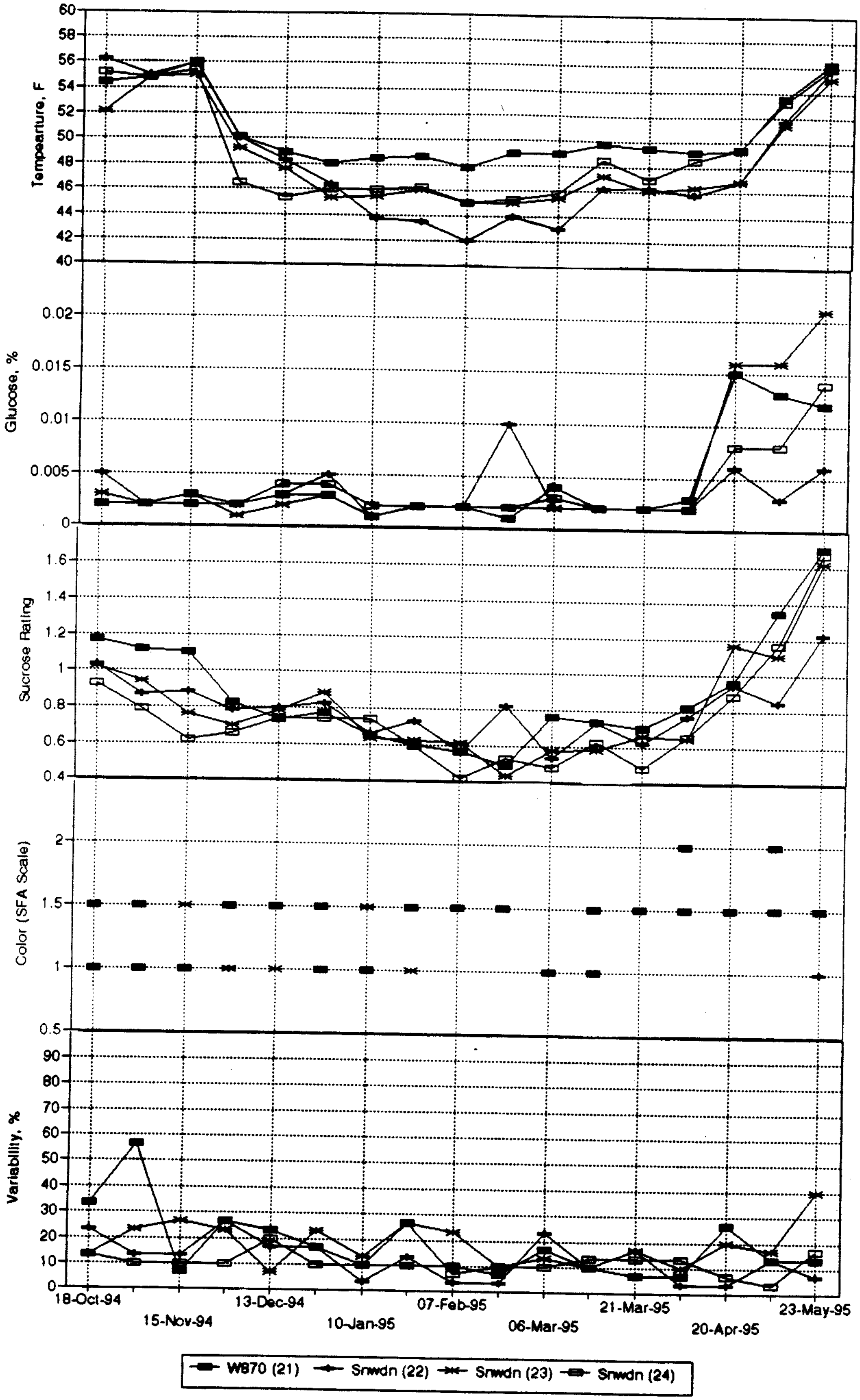


Figure 3. Sample results for the MPIC / MSU experimental bins for the 1994/95 storage season.