1987 MICHIGAN POTATO RESEARCH REPORT

VOLUME 19

MICHIGAN STATE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

IN COOPERATION WITH

THE MICHIGAN POTATO INDUSTRY COMMISSION

February 13, 1988

TO ALL MICHIGAN POTATO GROWERS AND SHIPPERS:

The Michigan Potato Industry Commission and the Agricultural Experiment Station of Michigan State University are happy to provide you with a copy of the results of the 1987 potato research projects.

This years report includes research projects funded by the MPIC as well as projects funded through a special federal grant that the Michigan Potato Industry Commission helped secure. The federal grant data completes the third year of a five year project. Also included are reports on projects carried out by MSU which were not funded by the industry.

Providing research funding and direction to researchers is a major function of the MPIC on behalf of Michigan growers and shippers. Input from the industry regarding research is most welcome at anytime.

Regards

The Michigan Potato Industry Commission

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

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1987 POTATO RESEARCH REPORT[1]

R.W. Chase, Coordinator
Department of Crop and Soil Sciences
Michigan State University

INTRODUCTION AND ACKNOWLEDGEMENTS

The 1987 Potato Research Report includes reports of potato research projects conducted at the Montcalm Research Farm plus those conducted at several other locations. This volume includes research projects funded by the Special Federal Grant, MPIC and other sources and have identified the source of funding for each project at the beginning of each report.

I wish to acknowledge the excellent cooperation and financial support of the Michigan Potato Industry Commission for MSU potato research. Many other contributions were made in the form of fertilizers, chemicals, seed, equipment, personal services and monetary grants. Appreciation is expressed to Dick Kitchen for his excellent coordination of the production management needs of the Montcalm station. A special thanks is also due to Theron Comden for his cooperation and assistance in many of the day-to-day operations.

WEATHER

The 1987 Montcalm Research Farm rainfall and temperature data, as compared to the average of the previous 15 years, are presented in Tables 1 and 2. The temperatures during the months of May, June and July were well above average. Whereas rainfall was very much below normal. Too much rainfall (9.78 inches) was received in August and was more than double the 15-year average for that month.

The combination of very little rainfall and higher than normal temperatures received in May, June and July was unfavorable to the growth of potatoes. In July, there were 6 days when the night temperature did not fall below 70°F and 8 days when the night temperatures were above 67°F. High night temperatures promote higher respiration rates which is detrimental to tuber bulking and dry matter accumulation. Higher rainfall in August and September interfered with some of the late season management and harvesting operations.

SOIL TESTS

Soil test results for the general plot area were:

pH	P (lbs/A)	K (lbs/A)	Ca (lbs/A)	Mg (lbs/A)	% Organic Matter
5.9	480	253	842	176	1.3

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[1] Printing and distribution of this 1987 Potato Research Report was made possible by the Michigan Potato Industry Commission.

FERTILIZERS USED

The previous crop in the plot area was alfalfa planted in April, 1986. Except in fertilizer trials where the amount of fertilizer applied are specified in the report, the following fertilizers were used in the potato trials:

plowdown	0-0-60	250 lbs/A
banded at planting	20-10-10	500 lbs/A
sidedress with irrigation	28-0-0	225 lbs/A

HERBICIDES AND HILLING

Most of the hillings were completed by the end of May. The procedure used was to delay the herbicide application until the potatoes were just cracking the ground. The potatoes were then hilled by building a wide and flattened hill and placing just enough soil over the top of the ridge to protect them. Immediately after hilling, a tank mix of metolachlor (Dual) 2 lbs/A plus metrabuzin (Lexone 4L) ½ lb/A was applied. No further tillage was required until harvest.

IRRIGATION

Ten supplementary irrigations were applied on June 18, 24, 30, July 6, 15, 20, 24, 28, 31 and August 7. Irrigation was scheduled according to the Michigan State University irrigation scheduling program. The minimum profile moisture content allowed was 50%. The amount of water applied was 0.8 to 1.0 inch per application. Urea was incorporated into irrigation water on June 17, July 6 and 28.

INSECT AND DISEASE CONTROL

Aldicarb (Temik 15G) was applied at planting at 20 lbs/A with the fertilizer. The foliar fungicide application was initiated on June 23 and 9 applications were made throughout the balance of the season. Fungicides used were Dithane M45 (5 applications) and Bravo 500 (4 applications). Foliar insecticides used were Furadan (June 23, July 1, 27, August 3, 18 and 24), Cygon (July 16, August 11 and 24) and Imidan (August 3). No serious disease or insect problems were encountered during the season.

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

Year	April		May		June		July		August		September		6-Month Average	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1973	54	36	63	42	77	58	79	60	80	60	73	48	74	51
1974	57	36	62	41	73	52	81	57	77	56	68	45	70	48
1975	48	28	73	48	75	56	80	57	79	58	65	44	70	49
1976	58	35	63	41	79	57	81	58	80	53	70	46	71	48
1977	62	37	80	47	76	50	85	61	77	52	70	53	75	50
1978	50	31	67	45	78	50	81	56	82	57	75	52	72	49
1979	50	33	66	44	74	55	82	57	77	55	76	47	71	49
1980	49	31	69	42	73	50	81	58	81	58	70	49	71	48
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
15-YR. AVG.	54	34	68	43	75	52	81	56	79	55	70	48	71	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
1973	3.25	3.91	4.34	2.36	3.94	1.33	19.13
1974	4.07	4.83	4.69	2.39	6.18	1.81	23.97
1975	1.81	2.05	4.98	2.71	11.25	3.07	25.87
1976	3.27	4.03	4.22	1.50	1.44	1.40	15.86
1977	1.65	0.46	1.66	2.39	2.61	8.62	17.39
1978	2.34	1.35	2.55	1.89	5.90	2.77	16.80
1979	2.58	1.68	3.77	1.09	3.69	0.04	12.85
1980	3.53	1.65	4.37	2.64	3.21	6.59	21.99
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
15-YR. AVG.	2.80	2.97	3.34	2.44	4.30	4.46	20.31

Funding: Federal Grant

1987 POTATO VARIETY EVALUATIONS

R.W. Chase, G.H. Silva, R.B. Kitchen, R.H. Leep and R. Hammerschmidt
Departments of Crop and Soil Sciences and Botany and Plant Pathology
Michigan State University

The potato variety evaluation and management program is designed to (a) identify improved cultivars better suited to Michigan's fresh market and the processing industry; (b) conduct intensive evaluations of selected cultivars to determine optimum production management inputs that improve potato market quality.

In all variety evaluations, special consideration was given to quality parameters. The focus was on tuber appearance, size distribution, external and internal defects, specific gravity (dry matter content), chip color, storability and culinary properties. Also of significant interest to Michigan is tolerance to common scab and bruising. Potential chipping varieties are stored in two storage environments (45 and 52°F) for subsequent quality evaluations.

A. DATES-OF-HARVEST TRIAL FOR ROUND VARIETIES

The 1987 dates-of-harvest trial was conducted at the Montcalm Research Farm. Fourteen selected varieties were tested for their marketable maturity and adaptability to Michigan. These included 7 released varieties and 7 advanced selections. The performances of these varieties were evaluated at 3 harvest dates, 98, 115 and 140 days after planting. Four replications of a randomized complete block design were harvested at each harvest date. Varieties were planted May 4 in plots 23 feet x 34 inches in size with an in-row spacing of 12 inches.

The previous crop was alfalfa. Fertilizers and Temik 15G were applied as described in the introduction. The hilling and herbicide application were all done just as the potatoes were emerging, which was May 18. Immediately after hilling, a tank mix of Dual at 2 lbs/A plus Lexone at ½ lb/A were applied for weed control and no further tillage was performed until harvest. During the growing season, the crop was irrigated 10 times according to the MSU irrigation scheduling program. The amount of water applied ranged from 0.8 to 1.0 inch per application. The minimum profile moisture content allowed was 50%. Fungicides and insecticides were applied depending on need. Fungicides for early blight control were alternated and generally scheduled at weekly intervals. An early and late blight forecasting program from Wisconsin was used as a guide to commence spraying. Relative humidity and temperature at canopy levels were monitored for this purpose. All weather data was collected with a programmed Campbell's CR21 Micrologger.

For chip color determinations, 20 tubers were taken at random and a slice from each tuber used for the test. Agtron E-10 Colorimeter was used for color measurements. For after-cooking darkening, peeled halves of 3 tubers picked at random were cooked in steam and evaluated at 0, 1 and 24 hours. Susceptibility to blackspot bruising was evaluated in artificially bruised and check treatments. Artificial bruising was done by placing 20 potatoes inside a wooden drum and turning 10 revolutions at a moderate speed. In the check treatments, potatoes were tested without artificial bruising, so that any blackspot observed occurred during harvest. The artificially bruised tubers were kept for 48 hours at room temperature prior to peeling. A Hobart peeler was used for peeling the tubers.

Results

The yield and quality parameters of potato varieties at the 3 harvest dates are presented in Tables 1, 2 and 3. In 1987, the weather conditions during the growing season was generally unfavorable for potatoes. Lack of sufficient rainfall combined with high day and night temperatures in June and July contributed to an overall reduction in tuber yield and specific gravity in all varieties. Owing to the dry conditions, early blight was minimal in the trials.

Among the early maturing varieties, Onaway produced the highest U.S. #1 yield and was free of internal defects. Conestoga produced average yields with a good chip color but the gravity was low. Eramosa matured very early and produced smooth tubers. The seed of Eramosa used for this trial had severe pitted scab.

Saginaw Gold (MSU seedling 002-171) was maintained in Ontario, Canada and in their trials it has been a consistently, excellent chipper. Yields were greatest at 115 days with excellent chip color. However, the dry matter was lower than desired for processing. A joint release of this variety between MSU and Agriculture Canada is being considered for 1988.

Among the medium to medium-late maturing varieties, MS700-83, Michigold, Atlantic, MS716-15 and MS702-80 performed well. MS70083 produced very high U.S. #1 yields, and acceptable chip color but the gravity was lower than preferred by a chipper. Michigold yielded similar to MS700-83 but with higher gravity. Atlantic had the highest gravity with average yields but was susceptible to internal defects. MS716-15 produced above average yields with excellent quality, high gravity and excellent chip color. MS702-80 produced above average yields with a high % of U.S. #1 and the chip color was exceptionally good.

Among the late maturing varieties, MS700-70 and LA01-38 were the two highest yielding lines at the second and third harvests. Both had a high % of U.S. #1 tubers, good gravity and chip color. Most varieties in the trial were free of internal defects.

In the culinary tests, undesirable levels of after-cooking darkening were found in MS700-83 and B9140-32 (Table 4). Some sloughing was observed in MS716-15 and Atlantic, which have high specific gravity. Susceptibility to blackspot was evaluated at the 115 and 140 harvest dates.

In artificially bruised treatments, the varieties highly resistant to blackspot were Conestoga and MS716-15. Moderate levels of resistance were found in MS700-70, MS702-80, Onaway, Eramosa and B9140-32. Varieties LA01-38, W832 and Atlantic were susceptible. In the check treatments, most varieties showed no blackspot. Blackspot at the 140-day harvest was slightly higher than the 115-day harvest.

Variety Characteristics

MS700-83 - Round white, mid-season maturity and above average yields with medium gravity. Has potential for chipping. In some years, after-cooking darkening has been a drawback. Possesses some scab resistance and growth crack has been noted in some trials.

Michigold - Round tubers with yellow flesh, mid-season maturity. Produces above average yields with high gravity. It sets heavy and produces a golden color chip when processed from field and short term storage.

MS702-80 - Round white, mid-season maturity with average yields. Has medium gravity but produces an excellent chip color. It has good scab tolerance, and no internal defects. Has a tendency to produce oversized tubers at a 12 inch spacing.

MS716-15 - Round white, medium late maturity with above average yields. It has high gravity, excellent chip color and no internal defects. Tubers are well shaped and a smooth general appearance.

MS700-70 - Round white, late season maturity with prolific yields. It has high gravity and the chip color is acceptable. Tubers are somewhat rough in appearance with deep eyes. Tends to produce oversized tubers at 12 inch spacing.

LA01-38 - Round white, late season maturity with prolific yields. It has a medium to high gravity with acceptable chip color. Tends to produce oversized tubers at 12 inch spacing.

Saginaw Gold - Round to oblong tubers with light yellow flesh and early to mid-season maturity. It has an excellent chip color but the dry matter content was lower than desired for processing.

W832 - Round white, mid-season maturity with below average yields. It has medium gravity and the chip color is acceptable.

Conestoga - Round to oblong white, early maturity with average yields, gravity and an excellent chip color. Early blight is a problem in some years.

Eramosa - Round-oblong white and very early maturity. The tubers have a smooth general appearance with no internal defects. Gravity is lower than Onaway. Has potential for the early fresh market.

Sunrise - Round-oblong and early to medium maturity. Has average yields with low gravity. Susceptible to growth cracks and scab in some years.

<u>Onaway</u> - Round to oblong and early maturity. Has above average yields with low gravity. Minimal internal defects. Has a tendency to produce oversized tubers and is susceptible to growth cracks and early blight.

<u>Atlantic</u> - Round white, mid to late season maturity. Above average yields with high gravity. Has excellent chip color and is the major chipping cultivar in Michigan. It is susceptible to internal brown spot (heat necrosis), hollow heart and scab.

B. DATES-OF-HARVEST TRIAL WITH COUNT PACK VARIETIES

Seventeen russet and long varieties were evaluated for the count-pack market and processing potential at 2 harvest dates, 100 and 140 days. The results are presented in Tables 7 and 8.

With few exceptions, most varieties were late maturing and did not perform well at the first harvest date. The varieties possessing good external quality at the second harvest were A78242-5, A76147-2, A79341-3, A79357-17, A74114-4 and HiLite Russet. Although Russet Norkotah had a good type, it had a high % of undersize tubers.

The after-cooking darkening data is presented in Table 9. None of the potato varieties showed undesirable levels of darkening. Blackspot susceptibility data is presented in Table 10.

In artificially bruised treatments, the varieties that appeared to be highly resistant to blackspot were Russet Norkotah, A79341-3, HiLite Russet and A81556-1. Moderate levels of resistance were found in A74114-4, Shepody and Russet Burbank. Varieties Pak-136, A76147-2 and A69868-2 were susceptible.

In the check treatments, most varieties showed no significant blackspot.

HiLite Russet and Russet Norkotah had the best appearance after peeling.

<u>Variety Characteristics</u>

<u>A76147-2</u> - Long, very light russet, late maturity with high yields and medium gravity. It has good external appearance and minimal internal defects. Has potential for count-pack market.

<u>A78242-5</u> - Good early growth and vigor. Russet, maturity is late with above average yields and gravity. Has good external appearance and a tendency to produce a high % of oversized tubers.

<u>A79341-3</u> - Very late maturing russet, with high solids. Good external appearance and quality.

<u>A79357-17</u> - Good early growth and vigor. Produced above average yields and medium gravity. Maturity is considered very late. Russet with good external appearance and quality.

A79239-8 - Has early emergence, good vine growth and early vigor. Maturity is considered late and similar to Russet Burbank.

Pak-136 - Mid to late season maturity with above average yields and gravity. Has a tendency to produce oversized tubers.

A74114-4 - Mid to late season maturity with above average yields and medium gravity. Russet, has good cooking qualities and resistance to blackspot. Has excellent external appearance and quality. Excellent potential for count-pack market.

Bak-P140 - Mid-season maturity with average yields but above average gravity.

HiLite Russet - A patented line, mid-season maturity with average yields and low gravity, somewhat similar to Russet Norkotah. Has good cooking qualities and resistance to blackspot. Has good external quality and appearance. Excellent potential for count-pack market.

Shepody - Long white, mid-late season maturity. Fared poorly in 1987 with below average yields and medium high solids. Maturity 2-3 weeks earlier than Russet Burbank normally. Some susceptibility to scab but has good external and internal qualities. Slow emergence and early establishment. Pre-cutting of seed is recommended.

Norgold Russet - Mid-season maturity with below average yields and gravity. Good external appearance and quality. Produced a high % of undersized tubers.

Krantz - Oblong russet, mid to late season maturity with below average yields and gravity in 1987.

Sh-1 - A mutant of Shepody introduced by Plant Genetics, Inc. Plant stands were very poor due to the poor condition of the seed. It had a very low % of U.S. #1 tubers because of the high proportion of pick outs.

A69868-2 - Fared poorly in 1987. Russet with below average yields and gravity. Produced a high proportion of undersized tubers.

Russet Norkotah - Oblong to long russet, early to mid-season maturity. Tubers have a very smooth external appearance with a gravity lower than Russet Burbank. Produced below average yields because of poor sizing. Because of the excellent appearance, it has potential in the count-pack market.

A81556-1 - Late season maturity with below average yields and gravity. It has excellent external appearance but the yields were too low in 1987 with a large proportion of pick outs.

C. UPPER PENINSULA TRIAL

Sixteen potato varieties were tested in a randomized completed block design with 4 replications in the Upper Peninsula. The results are presented in Table 11.

The tuber yield, size distribution and dry matter content of most varieties in this trial were excellent. The specific gravities were higher than at Montcalm trails.

D. NORTH CENTRAL REGIONAL TRIAL

This trial is conducted in 14 states and provinces with entries from various breeding programs to obtain data from a wide range of locations prior to a release decision. Three MSU lines were included in the 1987 trial. Nineteen varieties (11 round whites, 5 reds and 4 russets) were tested in a randomized complete block design with 4 replications. The results are summarized in Tables 12 and 13.

On a general merit rating based on external appearance and overall worth as a variety, the 5 top varieties in this trial were MS700-83, MS716-15, ND671-4Russ, MN12567 and Norgold Russet.

In the culinary test, undesirable levels of after-cooking darkening were observed in MS700-83, BN9803-1, NEA219.70-3, Norland, MN12331 and ND651-9 (Table 14). Blackspot data is presented in Table 15.

In artificially bruised treatments, the varieties that appeared to be highly resistant to blackspot were Norgold Russet, Norland, MS716-15, MN12331, Red Pontiac and MS700-83. Moderate levels of resistance were found in MS700-70, MN12567, ND671-4Russ and MN12945. Varieties BN9803-1, ND651-9, W848, W921, Norchip and NDT9-1068-011R were susceptible.

In the check treatments, most varieties showed no significant blackspot.

E. ADVANCED ADAPTATION TRIAL

Entries to this trial consisted of selections from the 1986 adaptation trial and new releases from other states and provinces. Included also were 14 new MSU seedlings from crosses made in 1984. In 1987, 25 selected lines were tested in a lattice design with 2 replications. The data from tuber yield, size distribution, specific gravity and chip color are summarized in Table 16. Culinary test results are presented in Table 17. Except in MS402-1 and MS402-2, after-cooking darkening was not a problem. Some varieties, with higher specific gravities, showed a tendency to slough after boiling.

Blackspot susceptibility data is presented in Table 18.

In artificially bruised treatments, the varieties that appeared to be highly resistant to blackspot were MS401-1, MS402-8, NYD195-11, Rose Gold, ND1719-5R and MS401-2. Moderate levels of resistance were found in Onaway, MS402-6, MS402-1, MS401-8, MS401-4, F72004 and MS402-4. Varieties F7411-4, ND1859-3, MS401-3, MS402-2, NYD164-9, MS402-7 and ND2109-7 were susceptible.

In the check treatments, most varieties showed no significant blackspot.

MS401-1, ND1859-3 and ND1719-5R had the best appearance after peeling.

F. ADAPTATION TRIAL

Fifty-one new seedling introductions from North Dakota and 30 from New York were tested in 8-hill unreplicated plots in a Federer's Augmented design. On the basis of external quality, U.S. #1 yield and scab resistance, 16 lines were selected in the field. The data on tuber yield, size distribution, specific gravity and chip color are summarized in Table 19. These 16 lines are being further evaluated for chip color, storability and internal defects. Only those that meet the industry requirements for fresh market and processing will be further tested in 1988 in larger plots.

Table 1. First Date of Harvest Yield Data - Round White Varieties
August 10, 1987 (98 days)

Variety	Yield cwt/a* US #1	Total	% size distribution #1	<2	2-31/4	>31/4	PO	Sp.Gr.	Agtron chip color[y]	Int. Defects[z] HH	IN	VD
MS 700-83	455	511	89	10	80	9	1	1.071	72	0	0	2
LA 01-38	423	454	93	5	75	18	2	1.077	69	0	0	0
Atlantic	408	458	88	10	80	8	2	1.083	72	0	2	1
Onaway	393	441	89	3	63	26	8	1.063	36	0	0	0
Michigold	371	428	87	12	81	6	1	1.079	70	0	0	0
MS 716-15	368	397	93	5	82	11	2	1.081	73	0	0	0
MS 702-80	363	390	92	5	72	20	3	1.071	74	0	0	0
MS 700-70	343	376	91	6	75	16	3	1.079	71	0	0	0
Saginaw Gold	333	409	81	7	75	6	12	1.073	71	0	0	0
Conestoga	323	365	88	10	83	5	2	1.069	68	0	0	0
W 832	307	319	96	4	87	9	0	1.079	61	0	0	5
Sunrise	295	331	89	9	79	10	2	1.069	66	0	0	4
Eramosa	281	331	85	12	81	4	3	1.059	51	0	0	0
B 9140-32	234	277	84	16	84	0	0	1.076	69	2	0	0
Average	349	391						1.074	66			

[z] 20 tubers cut to determine internal defects.

[y] Agtron color: >60=excellent; 55-60=good; 50-55=fair; <50=not acceptable.

[x] Yield based on the average of 4 replications of a RCB design
CV=9.9%; $s_{\bar{x}}$=17.5 at 5% for Duncan's Multiple Range Test (DMRT); LSD=49 cwt/ac

Table 2. Second Date of Harvest Yield Data - Round White Varieties
August 27, 1987 (115 days)

Variety	Yield cwt/a * US #1	Total	% size distribution #1	<2	2-31/4	>31/4	PO	Sp.Gr.	Agtron chip color [y]	Internal Defects [z] HH	IN	VD
LA 01-38	557	572	97	3	61	36	0	1.076	71	0	1	2
MS 700-70	530	558	95	3	48	47	2	1.082	69	0	0	1
MS 700-83	501	563	89	9	72	17	2	1.074	65	0	1	2
Michigold	500	551	91	8	79	12	1	1.081	66	0	1	4
Onaway	479	523	91	5	63	28	4	1.062	39	0	0	1
Atlantic	478	521	91	7	72	19	2	1.085	73	1	2	3
MS 702-80	446	478	93	4	60	33	3	1.072	74	0	0	3
MS 716-15	429	459	93	6	75	18	1	1.082	72	0	0	2
Saginaw Gold	380	435	87	10	78	9	3	1.072	69	0	0	0
Conestoga	364	415	87	10	80	7	3	1.069	67	0	2	1
Sunrise	350	390	90	9	74	16	1	1.068	67	0	1	4
W 832	341	362	94	4	81	13	2	1.078	65	0	0	4
B 9140-32	324	355	91	9	87	4	0	1.077	64	0	0	3
Eramosa	319	368	86	9	78	8	5	1.058	45	0	0	1
Average	428	468						1.074	63			

[z] 20 tubers cut to determine internal defects.

[y] Agtron color: >60=excellent; 55-60=good; 50-55=fair; <50=not acceptable.

* Yield based on average of 4 replications of a RCB design
CV= 12.7 %; $s_{\overline{x}}$ = 27.2 at 5% level for DMRT; LSD= 78 cwt/a

Table 3. Third Date of Harvest Yield Data - Round White Varieties
September 21, 1987 (140 days)

Variety	Yield cwt/a* US #1	Yield cwt/a* Total	% size distribution #1	<2	2-31/4	>31/4	PO	Sp.Gr.	Agtron chip color[y]	Internal Defects[z] HH	IN	VD
LA 01-38	523	544	96	3	58	38	1	1.076	58	0	1	2
MS 700-70	498	527	95	4	56	39	1	1.083	59	0	2	3
MS 700-83	455	518	88	9	74	14	3	1.073	55	0	0	2
Michigold	452	497	91	8	75	16	1	1.081	60	0	0	2
Onaway	451	489	92	4	54	38	4	1.061	25	0	0	1
MS 702-80	399	426	93	5	65	28	2	1.073	63	0	2	2
MS 716-15	389	425	92	6	76	16	2	1.082	61	0	0	2
Atlantic	380	425	89	8	71	18	3	1.083	59	1	3	2
Conestoga	330	377	87	10	79	8	3	1.072	70	2	0	2
Saginaw Gold	329	426	77	6	67	10	16	1.073	65	0	0	1
Eramosa	320	359	89	6	83	6	5	1.056	30	0	0	0
Sunrise	285	328	87	10	78	9	3	1.071	60	0	3	4
W 832	280	296	95	4	79	16	1	1.077	58	0	4	3
B 9140-32	261	312	83	16	80	3	1	1.076	62	0	0	0
Average	382	425						1.077				

z
20 tubers cut to determine internal defects.

y
Agtron color: >60=excellent; 55-60=good; 50-55=fair; <50=not acceptable.

*
Yield based on the average of 4 replications of a RCB design
CV= 12.8 % $s_{\bar{x}}$ = 24.5 at 5% level for DMRT LSD= 78 cwt/a

Table 4. After-cooking darkening* of potato varieties in the 1987 dates-of-harvest trial with round varieties.

Variety	0 Hours	1 Hour	24 Hours	Comments
LA01-38	1.0	1.0	1.0	
MS700-70	1	1	1	
MS700-83	1	2	2	2 tubers darkened
Michigold	1	1	1	
Onaway	1	1	1	
MS702-80	1	1	1	
MS716-15	1	1	1	Some sloughing
Atlantic	1	1	1	Some sloughing
Conestoga	1	1	1	
Saginaw Gold	1	1	1	
Eramosa	1	1	1	
Sunrise	1	1.5	1.5	1 tuber slightly dark
W832	1	1.5	1.5	1 tuber slightly dark
B9140-32	1	2	2	2 tubers darkened

*Rating based on a scale of 1-5; 1 = no darkening, 5 = severe darkening (black) overall.

Table 5. Blackspot susceptibility at 115-day harvest — 1987.

	Artificially Bruised		Check	
Variety	% tubers with blackspot	Severity*	% tubers with blackspot	Severity*
MS700-70	15	0.15	5	0.05
MS716-15	5	0.05	5	0.05
MS702-80	15	0.15	-	-
MS700-83	15	0.15	5	0.05
Michigold	15	0.20	5	0.05
Saginaw Gold	-	-	0	0
Onaway	20	0.20	0	0
Sunrise	15	0.20	5	0.05
LA01-38	45	0.70	0	0
Atlantic	30	0.40	0	0
W832	40	0.50	0	0
Conestoga	0	0	0	0
Eramosa	10	0.10	0	0
B9140-32	10	0.10	0	0
AVERAGE	18		2	

*Severity = Mean number of blackspot bruises per tuber.

Table 6. Blackspot Susceptibility at 140-day Harvest - 1987

Variety	Artificially Bruised		Check	
	% tubers with Blackspot	Severity*	% tubers with Blackspot	Severity*
MS 700-70	15	0.15	0	0
MS 716-15	10	0.10	0	0
MS 702-80	10	0.15	10	0.10
MS 700-83	15	0.20	0	0
Michigold	15	0.20	5	0.05
Saginaw Gold	20	0.25	0	0
Onaway	10	0.15	0	0
Sunrise	15	0.20	15	0.15
LA 01-38	60	1.00	15	0.15
Atlantic	30	0.35	5	0.05
W 832	40	0.60	0	0
Conestoga	5	0.05	0	0
Eramosa	15	0.25	0	0
B 9140-32	15	0.15	5	0.05
Average	20		4	

* Severity = Mean number of blackspot bruises per tuber.

Table 7. First Date of Harvest Yield Data - Count Pack Varieties
August 12, 1987 (100 days)

Variety	Yield cwt/a* US #1	Total	% size distribution #1	<4	4-12	>12	P.O.	Sp.Gr.
A 76147-2	361	488	81	16	69	12	3	1.067
A 78242-5	292	418	70	7	45	25	23	1.072
A 79357-17	234	324	72	19	66	6	9	1.073
Bak P140	233	297	78	20	75	3	5	1.073
A 74114-4	226	311	73	17	59	14	10	1.067
Norgold Russet	222	322	69	26	66	3	5	1.062
HiLite Russet	208	310	67	28	63	4	5	1.065
Russet Norkotah	203	308	66	32	63	3	2	1.068
A 79341-3	200	274	72	24	62	10	4	1.077
A 79239-8	198	285	70	20	66	4	10	1.072
Russet Burbank	186	365	51	29	51	0	20	1.073
Krantz	167	245	69	23	64	5	8	1.065
A 69868-2	151	336	45	33	44	1	22	1.064
Pak-136	135	185	73	17	68	5	10	1.069
Shepody	104	214	48	46	46	2	6	1.075
Sh-1	76	164	46	38	45	1	16	1.063
A 81556-1	66	147	45	48	43	2	7	1.064
Average	192	293						1.069

* Yield based on the average of 4 replications of a RCB design
CV= 21.8% $s_{\bar{x}}$ =24.2 at 5% for DMRT LSD= 70 cwt/a

Table 8. Second Date of Harvest Yield Data - Count Pack Varieties
September 22, 1987 (140 days)

Variety	Yield cwt/a* US #1	Total	% size distribution #1	<4	4-12	>12	P.O.	Sp.Gr.
A 78242-5	405	521	78	6	40	38	16	1.072
A 76147-2	364	545	70	15	53	17	15	1.074
A 79341-3	322	405	80	10	54	26	10	1.079
A 79357-17	293	374	79	16	69	10	5	1.072
A 79239-8	281	397	71	18	57	14	11	1.081
Pak-136	279	316	88	9	65	23	3	1.075
A 74114-4	278	349	79	18	60	19	3	1.073
Bak-P140	262	327	80	19	74	6	1	1.076
HiLite Russet	241	332	73	23	64	9	4	1.068
Shepody	210	374	56	28	52	4	16	1.080
Norgold Russet	206	327	63	32	52	11	5	1.066
Russet Burbank	198	441	44	27	41	3	29	1.077
Krantz	193	261	73	19	63	10	8	1.070
Sh-1	188	436	43	20	36	7	37	1.068
A 69868-2	169	335	51	30	48	3	19	1.069
Russet Norkotah	169	290	59	39	55	4	2	1.070
A 81556-1	154	298	52	23	51	1	25	1.068
Average	248	372						1.073

* Yield based on the average of 4 replications of a RCB design
CV= 18.3% $s_{\bar{x}}$ = 22.6 at 5% level for DMRT. LSD= 64 cwt/a

Table 9. After-cooking darkening* of long-type potato varieties in the 1987 dates-of-harvest trial.

Variety	0 Hours	1 Hour	24 Hours	Comments
Russet Burbank	1.0	1.0	1.0	
A74114-4	1.0	1.0	1.0	
HiLite Russet	1	1	1	
Russet Norkotah	1	1	1	
A81556-1	1	1	1	
A79357-17	1	1	1	
A76147-2	1	1.5	1.5	
Norgold Russet	1	1.5	1.5	
Shepody	1	1	1	Some sloughing
A79239-8	1	1.5	1.5	
Bak P140	1	1.5	1.5	Some sloughing
A79341-3	1	1.5	1.5	
Sh-1	1	1	1	
A78242-5	1	1	1	
Krantz	1	1	1	
A69868-2	1	1	1	
Pak-136	1	1	1	

*Rating based on a scale of 1-5; 1 = no darkening, 5 = severe darkening (black) overall.

Table 10. Blackspot Susceptibility of Count Pack Varieties - 1987
(140 days)

Variety	Artificially Bruised		Check	
	% tubers with Blackspot	Severity*	% tubers with Blackspot	Severity*
A78242-5	25	0.55	5	0.05
A76147-2	40	0.80	0	-
A79341-3	5	0.05	0	-
A79357-17	25	0.30	0	-
A79239-8	20	0.40	0	-
Pak-136	50	1.10	15	0.15
A74114-4	15	0.30	0	-
Bak P140	25	0.35	0	-
HiLite Russet	5	0.05	0	-
Shepody	10	0.10	0	-
Norgold Russet	25	0.30	0	-
Russet Burbank	10	0.10	0	-
Krantz	20	0.20	0	-
SH-1	25	0.35	5	0.05
A69868-2	35	0.50	0	0
Russet Norkotah	0	0	0	0
A81556-1	5	0.05	0	0
Average	20		2	

*Severity = Mean number of blackspot bruises per tuber.

Table 11. Tuber yield, size distribution and specific gravity of potato varieties in the Upper Peninsula — 1987.

Variety	Yield cwt/A		% Size Distribution					Specific Gravity
	U.S. #1	Total	U.S. #1	2"	2-3¼"	3¼"	Pick Outs	
A76147-2	634	661	96	4	34	62	0	1.080
700-70	426	465	92	8	52	39	1	1.086
A7411-2	413	449	92	7	61	31	1	1.089
Atlantic	406	447	90	10	62	28	0	1.090
716-15	383	432	88	12	62	26	0	1.086
700-83	357	405	88	12	59	28	1	1.079
Russet Burbank	351	475	74	26	62	12	0	1.087
Krantz	348	400	87	12	54	33	1	1.073
Russet Norkotah	314	373	84	16	68	16	0	1.070
Shepody	309	371	83	15	59	24	2	1.085
Michigold	304	382	79	20	59	21	0	1.088
702-80	291	345	83	17	58	25	0	1.075
Acadia Russet	268	337	80	20	67	13	0	1.080
Nooksack	252	283	89	11	62	27	0	1.089
HiLite Russet	249	301	83	17	65	18	0	1.069
Norgold Russet	212	299	70	30	56	14	0	1.070
AVERAGE	345	402						1.081

1987 NORTH CENTRAL REGIONAL POTATO TRIALS

Location Michigan - Montcalm Research Farm
Soil Type McBride Sandy Loam

Fertilizer Treatment 250 lbs/A 0-0-60 - plowdown
500 lbs/A 20-10-10 - planter
100 lbs/A N-Chemigation

Date Planted May 5, 1987

Date Harvested September 16, 1987
Size of Plots Single Plots - 23 ft.

Spacing - Between Hills 12 inches
Spacing - Between Rows 34 inches

Replications 23 hills/rep
Number of Replications 4

Environmental Factors (rainfall, temperature, irrigations, etc.):

		TEMPERATURE (°F)	
	Rainfall (")	Average Maximum	Average Minimum
May	1.94	77	46
June	0.84	80	56
July	1.85	86	63
August	9.78	77	58
September	3.32	72	52

Crop irrigated 10 times (0.80 inches per application)

Sprays Applied:

5 applications - Dithane M45
4 applications - Bravo 500
6 applications - Furadan
3 applications - Cygon
1 application - Imidan

Other Data (vine killing, specific gravity, determinations, etc.):

Specific gravity determined by weight in air and water method. Plants hilled just prior to emergence. Preemergence application of Dual (2 lbs/A plus Lexone DF at 1 lb/A on May 25).

Table 12.

SUMMARY SHEET

Selection Number or Variety	Aver. Mat. [1/]	Most [2/] Representative Scab Area-Type	CWT/A Aver. Yield	CWT/A Aver. Yield US #1	Aver. Percent US #1	Ave. [3/] Total Solids	Gen. [4/] Merit Rating	Chip [5/] Color	Early [6/] Blight Reading	Comments and General Notes
EARLY										
Norland	2.0	0	451	427	95	15.8		57	3.5	Somewhat rough appearance.
ND651-9	2.5	0	384	332	87	17.5		60	3.5	Tubers generally
W832	3.5	T-1	412	381	92	19.9		62	4.5	small
BN9803-1	3.0	0	375	330	88	18.4		56	4.0	
NEA219.70-3	3.0	0	363	343	94	16.5		68	3.5	Deep eyed.
MEDIUM TO LATE										
MS700-70	4.5	T-1	603	574	95	20.1		60	5.0	High % oversize. Somewhat rough appearance.
MS700-83	3.5	T-1	538	484	90	17.7	1	62	4.5	Very good appearance
MS716-15	4.0	1-3	434	398	92	20.1	2	70	4.5	Very good appearance
MN12331	3.0	0	410	207	50	16.0		59	4.0	High % growth cracks, undersize
MN12567	3.5	0	536	466	87	17.3	4	60	4.0	Tubers somewhat flattened.
MN12945	3.0	0	321	217	67	12.2		52	4.0	Pointed ends, high % undersize.
NE A71.72-1	4.0	0	354	244	69	17.7		61	5.0	High % undersized.
ND671-4Russ	3.0	0	399	291	73	16.5	3	54	3.5	Smooth, high % undersized.
NDT-9-1068-11R	3.5	0	548	504	93	17.3		37	4.0	High % of oversize tubers.
W848	4.0	T-1	405	370	91	18.2		52	4.5	
W921	4.0	0	441	405	92	19.7		78	4.5	Good appearance, excellent chips
Red Pontiac	4.5	1-3	638	557	87	15.8		42	4.0	High yield and oversized tubers.
Norgold Russet (Super)	3.5	0	413	338	82	17.5	5	35	3.5	Smooth appearance.
Norchip	3.5	T-1	494	440	89	19.0		67	3.0	

1/ 1 - Very early-Norland maturity; 2-Early-Irish Cobbler maturity; 3-Medium-Red Pontiac maturity; 4-Late-Katahdin maturity; 5-Very Late-Kennebec or Russet Burbank maturity

2/ Area - T-less than 1%; 1 - 10-20%; 2 - 21-40%; 3 - 41-60%; 4 - 61-80%; 5 - 81-100%. TYPE - 1. Small, superficial; 2. Larger, superficial; 3. Larger, rough pustules; 4. Larger pustules, shallow holes; 5. Very large pustules, deep holes.

3/ Not total solids/acre

4/ Place top five among all entries including check varieties; disregard maturity classification. (Rate first, second, third, fourth and fifth (in order) for overall worth as a variety).

5/ Chip Color - ~~Color Chart or~~ Agtron E-10 model.

6/

Percent External Defects (1) | SUMMARY OF GRADE DEFECTS | Percent Internal Defects (2)

Selection Number or Variety	Scab (3)	Growth Cracks	Second Growth	Sun Green	Total (4) Tubers Free of External Defects	Hollow Heart	Internal Necrosis	Vascular Discoloration	Normal Tubers (5)	% Pickouts (6)
EARLY										
Norland	0	0	0	0	100	0	0	0	100	1
ND651-9	0	0	0	2	98	0	0	6	94	1
W832	4	0	0	0	96	6	0	2	92	2
BN9803-1	0	0	0	4	96	0	0	6	94	3
NEA219.70-3	0	0	0	0	100	0	2	0	98	2
MEDIUM TO LATE										
MS700-70	4	0	0	4	92	0	0	2	98	2
MS700-83	6	2	0	0	92	0	0	1	99	2
MS716-15	8	0	0	0	92	0	0	0	100	0
MN12331	0	0	12	2	86	0	0	8	92	7
MN12567	0	0	8	4	88	0	0	6	94	3
MN12945	0	0	4	0	96	0	0	4	96	11
NE A71.72-1	0	0	0	2	98	0	2	2	96	6
ND671-4Russ	0	0	0	2	98	2	2	0	96	2
NDT-9-1068-11R	0	0	4	6	90	0	0	6	94	1
W848	4	2	2	2	90	0	0	6	94	3
W921	0	2	0	2	96	0	2	2	96	3
Red Pontiac	10	0	0	0	90	4	0	0	96	10
Norgold Russet (Super)	0	0	0	6	94	2	0	0	98	1
Norchip	2	2	2	8	86	0	2	8	90	6

(1) Based on four 25 tuber samples (one from each replication). Percentage based on number of tubers.

(2) Based on four 25 tuber samples (one from each replication). Percentage based on number of tubers.

(3) Includes all tubers with scab lesions whether merely surface, pitted or otherwise and regardless of area. Be sure to count tubers with any amount of scab in this category.

(4) This total - tubers free from any external defect of any sort.

(5) Percentage normal tubers are those showing no internal defects. Some individual tubers will have more than one type of internal defect.

(6) Percent pickouts (knobs and growth cracks) by weight, determined at grading and discarded, and not included with sample.

Table 14. After-cooking darkening* of potato varieties in the 1987 North Central Trial.

Variety	0 Hours	1 Hour	24 Hours
MS700-70	1.0	1.0	1.0
ND671-4R	1	1.5	1.5
MS700-83	1.5	2	2
Norchip	1	1.5	1.5
BN9803-1	1	1.5	2
W921	1	1	1
MS716-15	1	1	1
Norgold Russet (Super)	1	1.5	1.5
W832	1	1.5	1.5
NEA219.70-3	1	1.5	2
NEA71.72-1	1	1	1.5
MN12945	1	1	1
Red Pontiac	1	1	1
Norland	1.5	2	2.5
NDT9.1068-1R	1	1.5	1.5
MN12331	2	2.5	3.5
ND651-9	1	2	2.5
W948	1	1	1
MN12567	1	1	1

*Rating based on a scale of 1-5; 1 = no darkening, 5 = severe darkening (black) overall.

Table 15. Blackspot Susceptibility of North Central Trial Varieties 1987 (135 days)

Variety[z]	Artificially Bruised		Check	
	% tubers with Blackspot	Severity*	% tubers with Blackspot	Severity*
MS 700-70	15	0.15	0	-
Red Pontiac	10	0.10	0	-
NDT 9-1068-11R	45	0.90	5	0.05
MS 700-83	10	0.10	0	-
MN 12567	15	0.15	0	-
Norchip	40	0.60	15	0.15
Norland	5	0.05	0	-
W 921	35	0.40	5	0.05
MS 716-15	5	0.05	5	0.05
W 832	25	0.45	5	0.05
W 848	35	0.60	0	-
NEA 219.70-3	25	0.55	15	0.15
Norgold Russet	0	-	0	-
ND 651-9	50	0.90	5	0.05
BN 9803-1	85	2.40	10	0.15
ND 671-4RUSS	15	0.15	10	0.10
NEA 71.72-1	20	0.20	0	-
MN 12945	15	0.15	5	0.05
MN 12331	5	0.05	0	-
Average	24		4	

* Severity = Mean number of blackspot bruises per tuber.

[z] Varieties are arranged according to their US # 1 Yield in 1987.

Table 16. Yield Data of Potato Varieties in the Advanced Adaptation Trial (Harvested Sept. 14; 133 days)

Variety	Yield cwt/a* US#1	Yield cwt/a* Total	% size distribution US#1	<2	2-31/4	>31/4	P.O.	Sp.Gr.	Chip color
MS 401-5	591	647	91	4	61	30	4	1.086	58
Onaway	524	575	91	4	50	41	5	1.062	21
MS 401-7	523	605	87	5	70	18	8	1.090	53
MS 402-6	468	504	93	6	70	23	1	1.074	55
Atlantic	456	475	96	4	74	22	0	1.086	60
MS 401-1	448	503	89	9	76	13	2	1.079	64
ND 1859-3	447	495	90	7	75	15	3	1.077	57
Rose Gold	424	463	92	7	72	20	1	1.075	41
MS 401-3	412	476	87	5	57	30	8	1.084	63
NyD 164-9	394	438	90	9	73	17	1	1.079	67
MS 402-7	372	416	89	2	54	35	9	1.073	52
MS 402-1	371	422	90	7	73	17	3	1.075	45
F 7411-4	368	474	78	10	51	27	12	1.091	60
ND 2109-7	354	418	84	13	83	1	3	1.077	64
NyD 195-11	349	355	98	2	71	27	0	1.067	61
MS 401-8	349	401	87	5	62	25	8	1.080	62
MS 402-2	348	404	86	13	80	6	1	1.069	53
MS 401-4	342	387	87	13	87	0	0	1.077	-
F 72004	337	359	94	6	78	16	0	1.068	36
ND 1719-5R	330	374	88	11	70	18	1	1.063	32
MS 401-2	327	425	77	5	56	21	18	1.081	58
MS 401-6	307	340	91	5	58	33	4	1.077	61
MS 402-4	250	257	70	28	69	1	2	1.064	39
Russet Burbank	247	442	56	20	46	10	24	1.075	47
MS 402-8	246	253	97	3	56	41	0	1.068	64
Average	384	440						1.076	

* Yield data based on the average of 2 replications of a lattice design CV= 14.7% LSD at 5%= 112 cwt/a.

Table 17. After-cooking darkening* of potato varieties in the 1987 advanced adaptation trial.

Variety	0 Hours	1 Hour	24 Hours	Comments
F7411-4	1.0	1.5	1.5	
ND1859-3	1	1.5	1.5	
F72004	1.5	1.5	1.5	
Rose Gold	1	1	1	Some sloughing
NYD164-9	1	1	1	Some sloughing
ND2109-7	1.5	1.5	1.5	Some sloughing
Onaway	1.5	1.5	1.5	
ND1719-5R	1	1	1	
NYD195-11	1	1.5	1.5	
MS401-1	1	1	1	
MS401-2	1	1	1	
MS401-3	1	1	1	
MS401-4	1	1	1	
MS401-5	1	1.5	1.5	Some sloughing
MS401-6	1	1	1	
MS401-7	1	1	1	Some sloughing
MS401-8	1	1	1	
MS402-1	1.5	2	2	
MS402-2	1.5	2.0	2.5	
MS402-4	1	1	1	
MS402-6	1	1	1	
MS402-7	1	1.5	1.5	
MS402-8	1	1.5	1.5	

*Rating based on a scale of 1-5; 1 = no darkening, 5 = severe darkening (black) overall.

Table 18. Blackspot Susceptibility of Advanced Adaptation Trial Varieties (133 days)

Variety[z]	Artificially Bruised		Check	
	% tubers with Blackspot	Severity*	% tubers with Blackspot	Severity*
MS 401-5	20	0.45	5	0.05
Onaway	10	0.10	5	0.05
MS 401-7	15	0.15	0	-
MS 402-6	10	0.15	5	0.05
MS 401-1	0	-	0	-
ND 1859-3	45	0.65	15	0.15
Rose Gold	5	0.05	5	0.05
MS 401-3	40	0.90	5	0.05
NYD 164-9	30	0.40	5	0.05
MS 402-7	30	0.35	5	0.05
MS 402-1	10	0.10	5	0.05
F 7411-4	60	1.70	5	0.05
ND 2109-7	30	0.45	0	-
NYD195-11	0	-	0	-
MS 401-8	10	0.15	10	0.10
MS 402-2	35	0.80	5	0.05
MS 401-4	10	0.25	5	0.05
F 72004	15	0.15	0	-
ND 1719-5R	5	0.15	0	-
MS 401-2	5	0.15	0	-
MS 401-6	25	0.35	10	0.10
MS 402-4	10	0.10	5	0.05
MS 402-8	0	-	0	-
Average	20		2	

* Severity = Mean number of blackspot bruises per tuber.

z Varieties are arranged according to their US #1 yield in 1987.

Table 19. Yield Data of Potato Varieties in the Adaptation Trial (Harvested Sept. 30; 145 days)

Entry No.	Yield cwt/a* US#1	Total	% size distribution US#1	<2	2-31/4	>31/4	P.O.	Sp.Gr.	Chip color
NYE 11-45	538	633	85	12	61	24	3	1.072	56
NYE 28-2	529	566	93	5	66	27	2	1.080	69
ND 2224-5R	509	556	92	8	83	9	0	1.061	53
ND 2284-2	489	566	86	12	76	10	2	1.059	64
ND 791-5R	451	547	82	9	68	14	9	1.056	54
ND 2330-3	422	547	77	16	49	28	7	1.075	73
ND 2130-11	365	422	86	12	72	14	2	1.071	77
NYE 11-28	365	384	95	5	75	20	0	1.065	59
NYE 57-13	345	432	80	20	64	16	0	1.074	72
ND 2207-8RUSS	336	441	76	15	76	0	9	1.064	-
ND 2319-3RUSS	326	460	79	18	50	29	3	1.065	-
NYE 55-41	259	267	96	4	78	18	0	1.068	71
NYE 11-15	249	317	79	18	79	0	3	1.069	70
ND 2047-12RUSS	211	267	79	21	79	0	0	1.061	-
ND 1538-1RUSS	201	298	68	29	55	13	3	1.061	-
NYD 195-25	192	211	91	9	91	0	0	1.074	63
Atlantic	480	528	91	7	76	15	2	1.083	62
Onaway	442	461	96	4	83	13	0	1.063	-
Russet Burbank	221	365	61	21	61	0	18	1.074	-

x Yield based on 8-hill unreplicated plots in a Federer's augmented design.
CV= 14.7% LSD at 5%= 112 cwt/a

Funding: Federal Grant

EVALUATION OF PRODUCTION MANAGEMENT INPUTS TO IMPROVE QUALITY AND YIELD OF FOUR PROMISING MSU SEEDLINGS

G.H. Silva, R.W. Chase and R.B. Kitchen
Department of Crop and Soil Sciences
Michigan State University

Four new potato seedlings from Michigan State University, Michigold, MS716-15, MS700-83 and MS700-70 have performed consistently well in Michigan and several other states. These varieties are candidates for release as new cultivars from MSU. Michigold is a yellow fleshed, round variety that sets heavy with above average yields and high gravity. It has potential for fresh market and chipping out-of-field and short term storage. MS716-15 is a round white, medium-late maturing variety with high specific gravity and above average yields. Tubers have a smooth general appearance and excellent chip color. MS700-83 is a round white, mid-season maturing variety with high yields and medium gravity. It has a good general appearance and has potential for fresh market and chipping. A drawback is that under certain conditions, this variety shows susceptibility to after-cooking darkening. MS700-70 is a round white, late-maturing variety with high gravity and prolific yields and a potential chipper.

The management practices recommended for new releases are generally based on standard practices adapted for commonly grown varieties. In 1987, the nitrogen and spacing requirements of the four MSU seedlings were studied using three levels of nitrogen (100, 150, 200 lbs/A) and three within-row spacings (6", 9", 12") in factorial experiments. The treatments were tested in a randomized complete block design with four replications. In addition to determining the optimum requirements of nitrogen and spacing, the economics of each input level were investigated.

The trials were planted on May 6 and 7. The fertilizers applied were 250 lbs/A 0-0-60 at plowdown and 500 lbs/A 20-10-10 with planter. First topdressing of 50 lbs N/A as urea was applied on June 9 for the 150 lb N treatment. A second topdressing of 50 lbs N/A was applied on July 3 for the 200 lb N treatment. Petioles for N analysis were taken on August 3.

Results

Michigold - The results are summarized in Tables 1, 2 and 3. In this study, the N effect on tuber yield was significant but spacing effect was not (Table 1). The highest yield of U.S. #1 tubers was obtained at 150 lbs N and 9" spacing, but this yield was not significantly different from the 7 other treatment combinations. At 100 lbs N and 6" spacing, there was a tendency to produce a higher % of undersized tubers. The specific gravity was higher at lower nitrogen levels and closer spacings but the differences were not significant. Petiole N uptake at the 200 lbs N level was significantly higher compared to 100 and 150 lbs N treatments. Nitrogen and spacing levels had no influence on chip color and after-cooking darkening (Table 2) but there was a tendency for a slightly higher % of blackspot at the 200 lb N level. Internal defects in terms of hollow heart, internal brown spot and vascular discoloration was minimal in all treatments. Nitrogen and seed cost/revenue analysis (Table 3) showed that the highest net revenue was obtained by using 150 lbs N and 9" spacing for Michigold.

MS700-83 - The results are summarized in Tables 4, 5 and 6. In this experiment, both nitrogen and spacing effects on tuber yield were not significant (Table 4). The specific gravity was highest at the lowest N and spacing levels but the differences were not significant. Petiole N uptake was significantly higher at 200 lbs N compared to 100 lbs. Nitrogen and spacing levels showed no significant influence on chip color and % blackspot (Table 5) but after-cooking darkening increased at 200 lbs N. Internal defects were minimal in all treatment combinations. Nitrogen and seed cost/revenue analysis (Table 6) showed that 150 lbs N/A and 9" spacing levels appear to be most desirable for MS700-83.

MS716-15 - The results are summarized in Tables 7, 8 and 9. In this study, both nitrogen and spacing effects on tuber yield were significant. The highest yield of U.S. #1 tubers was obtained at 200 lbs N/A and 6" spacing (Table 7). The specific gravity was highest at the lowest nitrogen and spacing level, but the differences were not significant. Petiole N uptake was significantly higher at 200 lbs N compared to 100 and 150 lb treatments. Nitrogen and spacing levels appeared to have no significant effects on chip color, after-cooking darkening and % blackspot (Table 8). The chip color was excellent in all treatments and after-cooking darkening was not present. There were no internal defects in all treatment combinations. Nitrogen and seed costs/revenue analysis (Table 9) showed that 150-200 lbs N/A and 6" spacing are the most appropriate levels for MS716-15.

MS700-70 - The results are summarized in Tables 10, 11 and 12. The nitrogen effect on tuber yield was not significant but the spacing effect was (Table 10). The highest yield of U.S. #1 tubers was obtained at 200 lbs N/A and 6" spacing. The specific gravity was highest at 100 and 150 lbs N/A and at 6" spacing but the differences were not significant. Petiole N uptake was significantly higher at 200 lbs N compared to 100 lbs N treatment. Nitrogen and spacing levels had no significant influence on chip color, after-cooking darkening and % blackspot (Table 11). After-cooking darkening was not evident in all treatments. Chip color was adversely effected by an internal necrosis problem in all treatments. Nitrogen and seed costs/revenue analysis (Table 12) indicated that 150-200 lbs N/A and 6" spacing levels are preferable for MS700-70.

In summary, the 2 mid-season maturing varieties, Michigold and MS700-83 preferred 150 lbs N/A and 9" spacing levels. The 2 late season maturing varieties, MS716-15 and MS700-70 responded well to applications of 150 to 200 lbs N/A and a 6" spacing. The interaction effects of nitrogen and spacing was not significant. The specific gravities of all 4 varieties were highest at the lower nitrogen levels and closer spacings although the differences were not significant. Michigold and MS716-15 were free of internal defects. The chipping qualities of MS716-15 and MS700-83 were excellent. The factors contributing to after-cooking darkening in MS700-83 need to be further evaluated.

Table 1. Influence of Nitrogen and Spacing on Yield & Quality of Michigold.

Nitrogen (lbs/ac)	Spacing (inches)	Yield (cwt/a) US #1*	Total	% size distribution US#1	<2"	2-31/4	>31/4	PO	Sp.Gr.	Petiole N(%)
150	9	385 a	447	87	12	80	7	1	1.081	2.0 b
150	6	370 a	438	85	15	81	4	0	1.081	2.3 ab
200	9	366 ab	422	87	12	76	11	1	1.079	2.7 ab
150	12	362 ab	412	89	11	82	7	0	1.078	2.3 ab
200	12	361 ab	405	89	10	80	9	1	1.079	2.8 a
200	6	356 ab	430	82	17	77	5	1	1.080	2.5 ab
100	12	349 ab	406	86	13	80	6	1	1.081	2.3 ab
100	9	335 ab	413	84	14	78	6	2	1.082	2.0 b
100	6	320 b	401	79	20	76	3	1	1.081	2.0 b
Nitrogen Effects (*)										
	100 lbs	334 b	406	83	15	78	5	1	1.081	2.1 b
	150	372 a	432	86	13	80	6	1	1.080	2.2 b
	200	361 a	419	86	13	78	8	1	1.079	2.6 a
Spacing Effects (ns)										
	6 inches	349	423	82	19	78	4	1	1.081	2.3
	9	362	427	85	13	79	6	1	1.081	2.2
	12	352	407	88	12	79	9	1	1.079	2.5

* Means followed by the same letter are not significantly different (Duncan's multiple range test 5%).

CV =7.2%

Table 2. Influence of nitrogen and spacing on culinary properties and blackspot bruising in Michigold.

		Chip Color[a]			% Blackspot[c]	
Nitrogen (lbs/A)	Spacing (inches)	Harvest	100 Days	After-Cooking[b] Darkening	Check	Bruised
100	6	59	60	1	0	30
100	9	52	61	1	0	30
100	12	57	60	1	0	40
150	6	62	63	1	0	30
150	9	55	62	1	0	40
150	12	50	67	1	0	30
200	6	60	63	1	5	55
200	9	63	60	1	10	30
200	12	59	61	1	10	60

[a]Agtron chip color at 100 days measured following storage at 52°F.

[b]After-cooking darkening rating 1-5; 1 = no darkening, 5 = severe darkening (black) overall. Measurements made one hour after boiling.

[c]Blackspot determinations were made similar to the dates-of-harvest trial.

Table 3. Management Profile : Michigold

Nitrogen and Seed Costs/Acre

N Applied (lbs/ac)	N +Appl'n cost($) A	Spacing (inches)	Seed Cost($) B	N + Seed Cost($) A+B	Yield (cwt/a)	Gross Revenue($) C	Net ($) C-(A+B)
150	39	9	182	221	385	2543	2322
150	39	6	266	305	370	2428	2123
200	52	9	182	234	366	2409	2175
150	39	12	133	172	362	2397	2225
200	52	12	133	185	361	2361	2176
200	52	6	266	318	356	2302	1984
100	26	12	133	159	349	2281	2122
100	26	9	182	208	335	2267	2059
100	26	6	266	292	320	2065	1773

Nitrogen 100, 150,and 200 1 bs applied in 1,2 and 3 applications.
Nitrogen cost = $ 0.20 /lb. Cost per application = $ 3.00/ac.
Seed cost = $7.00/cwt
Revenue on the basis of $ 6.50/cwt for tubers 2-31/4" and
$ 7.00/cwt for tubers >31/4"

Table 4. Influence of Nitrogen and Spacing on Yield & Quality of MS700-83.

Nitrogen (lbs/ac)	Spacing (inches)	Yield (cwt/a) US #1	Total	US#1	% size distribution <2"	2-31/4	>31/4	PO	Sp.Gr.	Petiole N(%)*
150	9	453	513	85	12	76	9	3	1.073	2.6 ab
150	12	449	507	89	10	75	14	1	1.074	2.6 ab
200	6	444	525	84	14	78	6	2	1.074	2.6 ab
200	9	437	504	87	12	75	12	1	1.075	2.8 ab
150	6	427	507	82	16	78	4	2	1.073	2.3 b
100	12	426	475	90	8	76 86	4	2	1.075	2.3 b
200	12	422	457	92	6	76	6	2	1.073	2.9 a
100	6	417	485	85	14	80	5	1	1.076	2.3 b
100	9	408	463	89	9	78	11	2	1.073	2.4 ab
Nitrogen effects (ns)										
100 lbs		417	474	87	10	78	9	2	1.075	2.3 b
150		443	509	86	13	76	9	1	1.073	2.5 ab
200		434	496	87	10	78	8	2	1.074	2.7 a
Spacing effects (ns)										
	6 inches	429	505	84	15	79	5	1	1.075	
	9	432	493	87	11	76	11	2	1.073	
	12	432	480	89	8	76	14	2	1.074	

* Means followed by the same letter are not significantly different (Duncan's multiple range test at 5%).

CV=5.6%

Table 5. Influence of nitrogen and spacing on culinary properties and blackspot bruising in MS700-83.

Nitrogen (lbs/A)	Spacing (inches)	Chip Color[a]		After-Cooking Darkening[b]	% Blackspot[c]	
		Harvest	100 Days		Check	Bruised
100	6	65	67	1.5	0	25
100	9	63	68	1.5	5	45
100	12	60	66	1.5	0	30
150	6	63	65	2.0	0	25
150	9	66	65	1.5	0	20
150	12	62	70	1.5	0	30
200	6	65	69	2.0	5	35
200	9	59	69	2.5	0	40
200	12	59	67	2.5	5	35

[a]Agtron chip color at 100 days measured following storage at 52°F.

[b]After-cooking darkening rating 1-5; 1 = no darkening, 5 = severe darkening (black) overall. Measurements made one hour after boiling.

[c]Blackspot determinations were made similar to the dates-of-harvest trial.

Table 6. Management Profile : MS 700-83

Nitrogen and Seed Costs/Acre

N Applied (lbs/ac)	N +Appl'n cost($) A	Spacing (inches)	Seed Cost($) B	N + Seed Cost($) A+B	Yield (cwt/a)	Gross Revenue($) C	Net ($) C-(A+B)
150	39	9	182	221	453	2857	2636
150	39	12	133	172	449	2968	2796
200	52	6	266	318	444	2882	2564
200	52	9	182	234	437	2880	2646
150	39	6	266	305	427	2712	2407
100	26	12	133	159	426	2479	2320
200	52	12	133	185	422	2449	2264
100	26	6	266	292	417	2691	2399
100	26	9	182	208	408	2703	2495

Nitrogen 100, 150,and 200 1 bs applied in 1, 2 and 3 applications.
Nitrogen cost = $ 0.20 /lb. Cost per application = $ 4.00/ac.
Seed cost = $7.00/cwt
Revenue on the basis of $ 6.50/cwt for tubers 2-31/4" and
$ 7.00/cwt for tubers >31/4"

Table 7. Influence of Nitrogen and Spacing on Tuber Yield & Quality - MS 716-15.

Nitrogen (lbs/a)	Spacing (inches)	Yield (cwt/a) US #1*	Yield (cwt/a) Total	% size distribution US#1	<2"	2-31/4	>31/4	PO	Sp.Gr.	Petiole N(%)
200	6	316a	372	85	15	80	5	0	1.080	3.3 ab
150	6	304ab	375	80	20	77	3	0	1.081	2.9 bcd
200	9	273 bc	328	82	17	72	10	1	1.080	3.5 a
150	9	242 cd	302	80	18	72	8	2	1.080	3.2 abc
200	12	241 cd	275	85	14	74	11	1	1.078	3.4 ab
100	6	234 cd	286	79	20	71	8	1	1.082	3.2 abc
100	9	232 cd	284	80	19	75	5	1	1.080	2.7 cd
150	12	232 d	281	81	18	74	7	1	1.079	3.1 abcd
100	12	193 d	268	72	20	68	4	1	1.082	2.7 cd
Nitrogen effects (*)										
100 lbs		225 b	282	80	18	72	8	4	1.081	2.9 b
150		248 b	306	81	17	74	7	2	1.079	3.1 b
200		276a	330	83	15	75	8	2	1.079	3.4 a
Spacing effects (*)										
6 inches		278a	338	82	17	77	5	1	1.081	3.2
9		247 b	304	81	18	73	8	1	1.080	3.2
12		222 b	274	81	16	72	8	3	1.080	3.1

* Means followed by the same letter are not significantly different (Duncan's multiple range test at 5%).

CV = 10.7%

Table 8. Influence of nitrogen and spacing on culinary properties and blackspot bruising in MS716-15.

		Chip Color[a]			% Blackspot[c]	
Nitrogen (lbs/A)	Spacing (inches)	Harvest	100 Days	After-Cooking[b] Darkening	Check	Bruised
100	6	71	71	1	0	20
100	9	75	61	1	0	10
100	12	70	68	1	0	5
150	6	65	69	1	0	15
150	9	73	68	1	5	25
150	12	75	72	1	0	30
200	6	66	66	1	5	15
200	9	71	61	1	10	25
200	12	72	65	1	5	10

[a]Agtron chip color at 100 days measured following storage at 52°F.

[b]After-cooking darkening rating 1-5; 1 = no darkening, 5 = severe darkening (black) overall. Measurements made one hour after boiling.

[c]Blackspot determinations were made similar to the dates-of-harvest trial.

Table 9. Management Profile : MS 716-15

Nitrogen and Seed Costs/Acre

N Applied (lbs/ac)	N +Appl'n cost($) A	Spacing (inches)	Seed Cost($) B	N + Seed Cost($) A+B	Yield (cwt/a)	Gross Revenue($) C	Net ($) C-(A+B)
200	52	6	266	318	316	2064	1746
150	39	6	266	305	304	1955	1650
200	52	9	182	234	273	1764	1530
150	39	9	182	221	242	1582	1361
200	52	12	133	185	241	1534	1349
100	26	6	266	292	234	1480	1188
100	26	9	182	208	232	1483	1275
150	39	12	133	172	232	1489	1317
100	26	12	133	159	193	1259	1100

Nitrogen 100, 150, and 200 lbs applied in 1, 2 and 3 applications.
Nitrogen cost = $ 0.20 /lb. Cost per application = $ 4.00/ac.
Seed cost = $7.00/cwt
Revenue on the basis of $ 6.50/cwt for tubers 2-31/4" and
$ 7.00/cwt for tubers >31/4"

Table 10. Influence of Nitrogen and Spacing on Yield & Quality of MS700-70.

Nitrogen (lbs/ac)	Spacing (inches)	Yield (cwt/a) US #1*	Total	% size distribution US#1	<2"	2-31/4	>31/4	PO	Sp.Gr.	Petiole N(%)
200	6	423a*	502	84	11	62	22	5	1.081	3.7 a
150	6	402ab	474	87	12	69	18	1	1.083	3.2 ab
200	9	388abc	449	87	11	69	18	2	1.081	3.3 ab
100	6	375abcd	456	83	14	67	16	3	1.085	2.7 b
200	12	362 bcde	412	89	8	63	26	2	1.080	3.6 a
150	12	332 cde	380	87	9	61	26	4	1.082	3.4 a
100	9	330 de	406	82	13	61	21	4	1.082	3.1 ab
100	12	316 e	371	85	13	69	16	2	1.080	3.1 ab
150	9	310 e	370	84	13	67	16	4	1.082	3.3 ab
Nitrogen Effects (ns)										
100 lbs		342	411	83	13	66	18	3	1.082	3.0 b
150		348	408	86	11	66	20	3	1.082	3.3 ab
200		388	454	87	10	65	22	3	1.081	3.5 a
Spacing Effects (*)										
	6 inches	404a	477	85	12	67	18	3	1.083	3.2
	9	342 b	408	84	12	68	16	3	1.082	3.2
	12	335 b	388	86	10	63	23	4	1.081	3.4

* Means followed by the same letter are not significantly different (Duncan's multiple range test 5%).

CV =9.8%

Table 11. Influence of nitrogen and spacing on culinary properties and blackspot bruising in MS700-70.

		Chip Color[a]			% Blackspot[c]	
Nitrogen (lbs/A)	Spacing (inches)	Harvest	100 Days	After-Cooking[b] Darkening	Check	Bruised
100	6	61	60	1	0	10
100	9	64	59	1	0	5
100	12	58	60	1	0	10
150	6	57	51	1	5	20
150	9	57	62	1	0	0
150	12	60	54	1	10	15
200	6	61	59	1	5	30
200	9	57	63	1	5	25
200	12	63	61	1	5	20

[a]Agtron chip color at 100 days measured following storage at 52°F.

[b]After-cooking darkening rating 1-5; 1 = no darkening, 5 = severe darkening (black) overall. Measurements made one hour after boiling.

[c]Blackspot determinations were made similar to the dates-of-harvest trial.

Table 12. Management Profile : MS 700-70

Nitrogen and Seed Costs/Acre

N Applied (lbs/ac)	N +Appl'n cost($) A	Spacing (inches)	Seed Cost($) B	N + Seed Cost($) A+B	Yield (cwt/a)	Gross Revenue($) C	Net ($) C-(A+B)
200	52	6	266	318	423	2796	2478
150	39	6	266	305	402	2723	2418
200	52	9	182	234	388	2579	2345
100	26	6	266	292	375	2496	2204
200	52	12	133	185	362	2436	2251
150	39	12	133	172	332	2198	2026
100	26	9	182	208	330	2206	1998
100	26	12	133	159	316	2079	1920
150	39	9	182	221	310	2025	1804

Nitrogen 100, 150, and 200 lbs applied in 1, 2 and 3 applications.
Nitrogen cost = \$ 0.20 /lb. Cost per application = \$ 4.00/ac.
Seed cost = \$7.00/cwt
Revenue on the basis of \$ 6.50/cwt for tubers 2-31/4" and
\$ 7.00/cwt for tubers >31/4"

Funding: Federal Grant

INFLUENCE OF IRRIGATION, NITROGEN AND CALCIUM LEVELS ON SPECIFIC GRAVITY AND INTERNAL DEFECTS OF ATLANTIC AND RUSSET BURBANK POTATOES

G.H. Silva, R.W. Chase and R.B. Kitchen
Department of Crop and Soil Sciences
Michigan State University

Dry matter content and internal defects are quality parameters that are of major concern to Michigan growers, particularly for processing. Atlantic, which is the major chipping variety, has a history of being extremely susceptible to internal brown spot (heat necrosis), particularly on Michigan's sandy soils. Likewise, Russet Burbank often falls short of growers expectations in terms of dry matter, off-types and internal defects.

In 1987, 3 irrigation levels (irrigation scheduling, over-irrigation and non-irrigation), 3 nitrogen levels (100, 150 and 200 lbs/A) and 2 calcium levels (0, 500 lbs/A) were tested to determine their influence primarily on specific gravity, internal brown spot (IBS) and hollow heart (HH). Two varieties, Atlantic and Russet Burbank were planted in 2 separate experiments in a split-split plot design with 4 replications.

A drip irrigation system was installed to facilitate application of varying quantities of water to the plot area. Irrigation scheduling treatment was based on the Michigan State University irrigation scheduling system. Accordingly, this treatment received 9" of irrigation during the season. Over-irrigation treatment was applied during the last month prior to harvest. This treatment received an excess of 5.5" of water during this period in 8 separate irrigations. At each irrigation, these plots received more water than the field capacity requirements. The non-irrigated plots received only rainfall. The total rainfall during the growing season was 13.5".

The trials were planted on May 6. The fertilizers applied were 250 lbs/A 0-0-60 at plowdown and 500 lbs/A 20-10-10 with planter. The first topdressing of 50 lbs N/A as urea was applied on June 7 for the 150 lbs N treatment. A second topdressing of 50 lbs N/A was applied on July 20 for the 200 lbs N treatment. Calcium was applied in the form of gypsum to the surface of the row on May 15, just prior to hilling. Soils tests done before the trial indicated that the experiment site had 880 lbs Ca/A.

Petiole samples for nutrient analysis were taken on August 4. Following harvest, tuber peel samples were taken from each treatment for calcium analysis. The Atlantic trial was harvested on September 15 and Russet Burbank on September 30.

The results obtained with Atlantic are summarized in Table 1. The specific gravity was highest in the irrigation scheduling treatment. Over-irrigation combined with excess rainfall during the last month prior to harvest resulted in a decrease in specific gravity compared to irrigation scheduling, and also had the highest frequency of HH. Specific gravity decreased with increased nitrogen levels but the differences were not significant. Nitrogen and calcium levels in this experiment showed no significant effects on HH. No increase in tuber yield was evident above 150 lbs N/A. Petiole N uptake was significantly higher at 150 and 200 lbs N levels compared to 100 lbs N/A. The tuber yield was significantly higher in irrigated than non-irrigated plots. The non-irrigated plots produced the lowest specific gravity and a darker, inferior chip color. Very little rainfall combined with unusually high day and night temperatures during June and July contributed to a high % of tuber deformities.

Placement of gypsum in the row prior to hilling resulted in an increase in the Ca uptake of 20% in the petioles and 14% in the tuber peel. Calcium treated plots showed a greater than 50% reduction in the occurrence of IBS compared to untreated plots. Calcium treatments produced no significant effects on specific gravity, hollow heart and tuber yield.

The results obtained with Russet Burbank are summarized in Table 2. Generally the responses were similar but to a lesser degree than Atlantic. The specific gravity was highest in the irrigation scheduling treatment. Over-irrigation combined with excess rainfall late in the season decreased the specific gravity and increased the frequency of HH. Specific gravity was slightly higher at the 100 lbs N level. Nitrogen and calcium levels had no significant effects on HH. Tuber yields were generally poor but increased with increasing N levels. Petiole N uptake was significantly higher at 200 lbs N compared to 100 and 150 lbs N levels.

Placement of gypsum in the row prior to hilling did not result in a significant increase in Ca uptake in petioles. Calcium treated plots showed a reduction in the occurrence of IBS, but unlike Atlantic, the effects were not significant. Calcium treatments did not significantly influence specific gravity, hollow heart and tuber yield.

Calcium is important to cell wall structure and membrane functions of the plant. Therefore calcium treatments have important ramifications to other metabolic processes. The tubers harvested from this trial are currently being tested for wound healing ability, resistance to soft rot and dry rot, after-cooking darkening and blackspot susceptibility.

Table 1. Influence of irrigation, nitrogen and calcium levels on tuber yield, specific gravity and internal defects in Atlantic.

	Yield*									
	U.S. #1 (cwt/a)	Total (cwt/a)	U.S. #1 (%)	Specific Gravity	Chip Color	Petiole N (%)	Petiole Ca (%)	Hollow Heart (%)	IBS (%)	Periderm Ca (g/kg)
Non-Irrigated	249 b	326 b	76	1.071 c	55	2.6 a	1.53 a	1 b	9 b	4.1 a
Irri. Schedule	457 a	500 a	91	1.088 a	65	2.4 ab	1.37 ab	5 b	8 b	3.6 b
Over-Irrigated	473 a	583 a	81	1.080 b	61	2.3 b	1.34 b	11 a	13 a	3.9 ab
Nitrogen 100 lbs	378 b	429 b	88	1.081	59	2.2 b	1.42	4	11	3.8
150	408 a	462 a	88	1.080	60	2.5 a	1.40	5	10	3.8
200	393 ab	447 ab	87	1.078	62	2.6 a	1.41	7	9	3.9
Calcium 0 lbs	393	451	87	1.080	61	2.4	1.28 b	5	14 a	3.6 b
500	396	443	89	1.080	60	2.5	1.54 a	6	6 b	4.1 a

*Yields are based on the average of 4 replications of a split-split plot design: irrigation as the main plot, nitrogen as the sub-plot and calcium as the sub-sub plot. Means followed by the same letter are not significantly different.

Table 2. Influence of irrigation, nitrogen and calcium levels on tuber yield, specific gravity and internal defects in Russet Burbank.

	Yield*							
	U.S. #1 (cwt/A)	Total (cwt/A)	U.S. #1 (%)	Specific Gravity	Petiole N (%)	Petiole Ca (%)	Hollow Heart (%)	IBS (%)
Non-Irrigated	60 b	214 b	28	1.068 b	3.4	1.30 a	1 b	9
Irri. Schedule	174 a	351 a	50	1.079 a	3.3	0.90 b	4 b	8
Over-Irrigated	178 a	342 a	52	1.076 a	3.3	0.97 b	10 a	10
Nitrogen 100 lbs	131	304	43	1.075	3.1 b	1.09	4	9
150	134	296	45	1.074	3.3 b	1.02	4	8
200	145	318	46	1.074	3.6 a	1.00	6	9
Calcium 0 lbs	133	317	42	1.075	3.4	1.01	4	10
500	142	298	48	1.074	3.4	1.10	6	7

*Yields are based on the average of 4 replications of a split-split plot design: irrigation as the main plot, nitrogen as the sub-plot and calcium as the sub-sub plot. Means followed by the same letter are not significantly different.

Funding: Federal Grant

PRE-CUTTING AND FUNGICIDE TREATMENT OF POTATO SEED

R.W. Chase, G.H. Silva and R.B. Kitchen
Department of Crop and Soil Sciences
Michigan State University

Delayed emergence, slow early development and uneven plant stands are problems often associated with cultivars Shepody and Yukon Gold in Michigan. Pre-cutting and fungicide treatment of seed are two management practices suggested to overcome these deficiencies. Preliminary results of 1986 indicated that the use of pre-cut seed was effective in promoting earlier emergence and vigor in Shepody. In 1987, this investigation was expanded and retested to further examine the merits of pre-cutting and fungicide treatment of seed.

For pre-cutting, seed potatoes of Shepody and Yukon Gold were taken out of storage (40°F) 2 weeks prior to planting. Tubers were hand cut to obtain seed pieces between 50-60 grams. Fungicide treatment (Tops 2.5D®) was done on one-half of the cut seed pieces immediately after cutting at the recommended rate (1 lb/100 lbs cut seed). Pre-cut seed pieces were then stored at 55-60°F and 85-90% RH until planting.

Factorial experiments were used to evaluate the performances of pre-cut and Tops 2.5D® treatment over fresh cut and untreated seed. Fresh cut seed refers to seed pieces cut and planted on the same day. Two fresh cut seed treatments were used. Seed tubers taken out of 40°F storage 2 days before planting, warmed to 55°F and cut and planted on the same day, were designated Freshcut(1). Seed tubers taken out of 40°F 2 weeks before planting, and stored in the same environment as the pre-cut seed until planting and cut and planted on the same day were designated Freshcut(2). The treatments were tested in a randomized complete block design with 4 replications.

The trial was planted on May 7, 1987. The fertilizers applied were 250 lbs/A 0-0-60 at plowdown, 500 lbs/A 20-10-10 with planter, and 100 lbs/A N as 28% urea as chemigation. Management practices were similar to those applied for the dates-of-harvest study. Data on emergence, plant stand, tuber yield and quality were recorded. The Yukon Gold trial was harvested on September 10 and Shepody on September 25.

The results are summarized in Tables 1 and 2. Pre-cut seed of both cultivars exhibited early vigor and higher plant stands compared with fresh cut seed. In Shepody (Table 1), the pre-cut seed showed a 75% emergence count 6 days earlier, and 18% increase in plant stand compared to fresh cut seed. In Yukon Gold (Table 2), the emergence pattern was similar to Shepody and the plant stand increased by 14%. Pre-cut seed of both cultivars produced a significantly higher yield of U.S. #1 tubers compared to fresh cut seed. No significant yield responses were observed due to Tops 2.5D® treatment.

Proper handling of the pre-cut seed prior to planting was important to maintain the vitality. At 55-60°F and 85-90% RH, the weight losses of the pre-cut seed in both fungicide treated and untreated lots were minimal, less than 4%.

Based on 2 years of experimentation, pre-cutting of seed (2 weeks before planting), was found to be beneficial for Shepody and Yukon Gold in Michigan. Pre-cut seed promoted early emergence and vigorous early growth. This will facilitate more effective weed and pest control early in the season. Tops 2.5D® produced no significant effects at the Montcalm Research Farm. Fungicide treatments of cut seed could be beneficial in other locations and seasons when the field conditions become more favorable to seed piece decay caused by rot organisms.

Table 1. Effects of Pre-cutting and Fungicide treatment of Shepody.

Treatment	Yield(cwt/a)* US#1	Total	% size distribution #1	<4	4-10	>10	PO	Sp.Gr.	# of Days 75% Emer.	# of Stems per hill	% Stand
Precut/No Tops	215a	349a	63	21	51	12	16	1.079	22	3.2	95
Precut/Tops	200ab	338a	61	18	54	7	19	1.082	23	3.1	96
Freshcut(2)/No Tops	183 bc	322ab	56	23	53	3	20	1.078	28	2.5	87
Freshcut(1)/Tops	177 bc	292 b	61	22	56	5	16	1.078	28	2.6	88
Freshcut(2)/Tops	166 c	281 b	59	20	53	6	21	1.075	31	2.8	75
Freshcut(1)/No Tops	159 c	301 b	53	32	49	4	15	1.079	27	3.0	74
Time of Cutting:	(*)										
Pre-cut	207a	343a	63	19	53	10	18	1.081	23	3.2	96
Freshcut	171 b	299 b	58	24	53	5	18	1.078	29	2.7	81
Tops treatment:	(ns)										
Tops	182	304	60	20	54	6	19	1.078	27	2.8	86
No Tops	187	324	58	25	50	8	17	1.079	26	2.9	85
Interaction:	(ns)										

* Mean separation by Duncan's Multiple Range Test at 5%. Means followed by the same letter are not significantly different.

CV =9.3%

Table 2. Effects of Pre-cutting and Fungicide treatment of Yukon Gold.

Treatment	Yield(cwt/a)* US#1	Total	% size distribution #1	<2	2-31/4	>31/4	PO	Sp.Gr.	# of Days 75% Emer.	# of Stems per hill	% Stand
Precut/No Tops	388a*	419a	93	4	58	35	3	1.079	24	2.5	94
Precut/Tops	381a	417a	91	5	62	29	4	1.080	23	2.5	96
Freshcut(1)/Tops	364ab	396ab	93	5	65	28	2	1.079	29	2.8	84
Freshcut(2)/No Tops	342 b	386ab	88	4	60	28	8	1.078	29	2.5	82
Freshcut(1)/No Tops	340 b	374 b	90	6	64	26	3	1.078	28	2.6	81
Freshcut(2)/Tops	337 b	376 b	89	5	58	31	5	1.077	33	2.0	83
Time of Cutting:	(*)										
Pre-cut	385a	418a	92	5	60	32	3	1.080	24	2.5	95
Freshcut	346 b	383 b	90	5	62	28	5	1.078	30	2.4	83
Tops treatment:	(ns)										
Tops	361	396	91	5	62	29	4	1.079	28	2.4	88
No Tops	357	393	90	6	60	30	4	1.078	27	2.5	86
Interaction:	(ns)										

* Mean separation by Duncan's Multiple Range Test at 5%. Means followed by the same letter are not significantly different.

CV =6.4%

Funding: MPIC

Legume-Potato Rotations: Nitrogen Contributions, Pest Populations and Economics

Report to the Michigan Potato Industry Commission

O.B. Hesterman, R.W. Chase, G.W. Bird and T.S. Griffin

Michigan State University

Introduction:

Nitrogen-fixing legumes have been used in crop rotations for many years. Research has shown that legumes contribute nitrogen to subsequent non-legume crops, disrupt weed, disease and insect cycles and improve soil aeration and fertility. Legume-based crop rotations were less widely used when low-cost nitrogen fertilizer and effective chemical pesticides became available. Recently, there has been much attention focused on reducing purchased inputs (eg. nitrogen fertilizer) in cropping systems, on environmental contamination by nitrates and pesticides and on diversification in agriculture. For these reasons, there has been a renewed interest in rotational cropping systems.

Production of potatoes in Michigan typically involves nitrogen fertilizer applications of 150-200 lb/a. Since the estimated nitrogen contribution from legumes like alfalfa ranges from 40 to 150 lb/a, legumes have the potential to significantly reduce nitrogen fertilizer inputs in potato production. Economic analysis of research in this area can aid in selecting optimal rotational systems with different legume species, management schemes, fertilizer rates and input costs.

Potato Early Die (PED) disease, caused by the root-lesion nematode (RLN) and Verticillium root fungus, is a considerable problem in potato production. The population dynamics of these organisms can vary, depending on the host plant species in crop rotations. The influence of different inorganic nitrogen sources on PED has been documented, but the influence of organic nitrogen contributions are uncertain. If legume-based crop rotations are to be viable, it is important to determine the effect of legume species and management on the populations of these organisms.

Field Experiments:

Two-year crop rotations were established in 1987 at the Montcalm Potato Research Farm (MC) and the Kellogg Biological Station (KB) to examine several aspects of legume-potato rotations. The rotation crops in 1987 were: 'Saranac' alfalfa, green manaure (GM) and hay; 'Mammoth' red clover, GM and hay; 'Viking' birdsfoot trefoil, GM and hay; 'Nitro' alfalfa, hay (KB only); sweetclover, GM (MC only); hairy vetch, GM (spring seeded); potatoes followed by hairy vetch, GM (fall seeded); corn; fallow; and continuous potatoes ('Shepody' at MC, 'Atlantic' at KB). The objectives of this experiment are:

1. To determine the nitrogen contibution of legumes to the subsequent (1988) potato crop.

2. To determine the effect of legume management (GM versus hay) on nitrogen contribution.

3. To monitor populations of root-lesion nematode and Verticillium root fungus for all rotation sequences.

4. To determine economically optimum crop rotations at different input costs and product prices.

Experimental plot size was 24' by 50'. Legumes, potatoes and corn were planted on April 20, May 4 and May 9, 1987, respectively. Potato and corn plots were split into subplots fertilized at 0, 67, 134 and 200 lb N/a (as ammonium nitrate). In 1988, all plots will be planted to potatoes and fertilized at same N rates as in 1987. Legumes were harvested as hay on July 9, August 10 and October 30, 1987. Potatoes and corn were harvested September 3 and October 10, respectively. Soil samples for RLN were taken April 20, July 23 and November 5. Above- and below-ground legume samples for end-of-season dry matter and nitrogen yields were taken on October 20.

Results:

The primary concern in 1987, the initial year of the crop rotations, was the successful establishment of the forage legumes. Because of this, much of the data collected in 1987 relates to forage dry matter (DM) yield, N yield and hay quality.

End-of-season legume dry matter yield (Table 1) and N yield (Table 2) can be used to estimate the relative value of legume species N contribution. For example, sweetclover contained 222 lb N/a at the end of the season, compared to 136 lb N/a for alfalfa (GM). The N contribution to the subsequent potato crop is expected to be greater for sweetclover than for alfalfa (GM).

Fertilizer Replacement Values (FRV) have been widely used in determining the N contribution of legumes in crop rotations. The FRV is defined as the amount of inorganic N fertilizer required to produce an identical response, and is determined by comparing N fertilizer response of continuous potatoes with potatoes following a legume without N fertilizer. The FRV for all legumes used will be determined in 1988, and the relationship between FRV, legume N yield and legume management will be examined in more detail.

Previous research has shown that RLN populations can be strongly influenced by the presence of different rotation crop species. Soil and root samples taken in 1987 support this conclusion (Table 3). Although many of the legumes used in this experiment supported similar RLN populations (eg. alfalfa, red clover and birdsfoot trefoil), hairy vetch greatly increased RLN (563 RLN/1.0 g root) and sweetclover reduced RLN

(53 RLN/1.0 g root). Such influences on pathogen populations are becoming more important, as the future use of pesticides like Temik is uncertain.

Legume-potato rotations may be desirable for many reasons, including N contributions and soil fertility improvements. However, the economic feasibility of such rotations must be demonstrated if they are to be adapted by producers. Table 4 contains gross revenues ($/a) for four selected rotations in 1987 (costs are not included). In 1988, when rotations are terminated, profit (or loss) for each rotations will be determined, based on current and predicted input costs and product prices. These estimates will include monetary values for the N contribution of the legumes (from FRV determination).

Table 1. Legume shoot and root biomass of green manure (GM) crops and hay crops (following final forage harvest) in 1987.[a]

Legume Species	Shoot Biomass	Root Biomass	Total Biomass
	----------------	lb DM/a	------------
Alfalfa (GM)	2291	2608	4899
Alfalfa (Hay)	1755	3841	5596
Red Clover (GM)	4737	2417	7154
Red Clover (Hay)	1710	3924	5634
Birdsfoot Trefoil (GM)	1119	887	2006
Birdsfoot Trefoil (Hay)	958	1004	1962
'Nitro' Alfalfa (Hay)	1115	3469	4584
Sweetclover (GM)	3660	3618	7278
Hairy Vetch (GM)	5031	571	5602

[a] Average of MC and KB.

Table 2. Legume shoot and root N yield of green manure (GM) and hay crops (following final forage harvest) in 1987.[a]

Legume Species	Shoot N	Root N	Total N
	---------------	lb N/a	--------------
Alfalfa (GM)	65.6	71.1	135.7
Alfalfa (Hay)	56.6	106.4	163.0
Red Clover (GM)	137.4	64.5	210.9
Red Clover (Hay)	58.5	95.0	153.5
Birdsfoot Trefoil (GM)	29.1	22.5	51.9
Birdsfoot Trefoil (Hay)	26.1	25.5	51.6
'Nitro' Alfalfa (Hay)	36.8	110.6	147.4
Sweetclover (GM)	116.0	106.0	222.0
Hairy Vetch (GM)	185.0	19.1	204.1

[a] Average of MC and KB.

Table 3. Soil and root populations of root-lesion nematode (RLN) in legume-potato rotations at Montcalm.[a]

Species	Soil RLN (100cc soil)	Root RLN (1.0 g root)
Alfalfa (GM)	10.8	119.5
Alfalfa (Hay)	18.3	409.5
Red Clover (GM)	13.9	248.8
Red Clover (Hay)	12.1	244.0
Birdsfoot Trefoil (GM)	15.6	251.1
Birdsfoot Trefoil (Hay)	17.4	385.4
Sweetclover (GM)	6.7	52.5
Hairy Vetch (GM)	21.4	563.5
Corn	4.1	19.8
Fallow	9.8	109.5

[a] Sampled on July 23, 1987.

Table 4. Gross revenues for selected legume-potato rotation sequences in 1987 (costs not included).

Rotation Crop	Gross Revenue ($/a)
Alfalfa (GM)	0.0
Alfalfa (Hay)	309.0 [a]
Corn	193.2 [b]
Potatoes	1350.0 [c]

[a] 3.85 ton/a at $80.06/ton.
[b] 96.6 bu/a at $2.00/bu.
[c] 270 cwt/a at $5.00/cwt.

Funding: Federal Grant

Annual Report

Improved Production and Utilization
Technology for Michigan Potatoes
USDA Project ORD. NO. 38543 and 40818

Soil Management through Tillage for Improved Quality and Yield of Potatoes and Erosion Control

F. J. Pierce, C. G. Burpee, and R. W. Chase
Crop and Soil Sciences Department

Quality improvement of potatoes represents the major objective of potato growers in Michigan. A major factor affecting potato quality is the physical condition of the soil in the zone of rooting and tuber development. Wind and water erosion are serious problems on the sandy and organic soils which dominate potato acreage in Michigan. Conventional practices for potato production in Michigan use cover crops for overwinter protection of soil and limit plowing to spring primary tillage followed directly by planting to avoid excessive tillage and soil structure degradation. Michigan farmers, therefore, are well aware of the potential limitations of poor soil physical conditions and soil erosion. However, the potential for serious problems related to poor soil physical condition and erosion remain. Excessive traffic, often with heavy axle loads repeated over several years, has created compact soil conditions below the depth of normal tillage and degraded soil structure in the tillage zone. Soil erosion potential in Michigan from wind and water is highest during the period from tillage and planting to hilling or canopy closure when the soil is bare and unprotected.

Tillage systems, designed to fracture soil in a zone in-the-row (zone tillage) amd leave the interrow undisturbed with a cover of standing rye as protection against wind and water erosion, were evaluated in field experiments in 1985 and 1986. In 1985, zone tillage treatments tended to improve yield and quality of Russet Burbank potatoes although the 35 hundred weight per acre increase was not significant. In 1986, zone tillage treatments significantly increased yield of Russet Burbank potatoes up to 78 hundred weight per acre with a corresponding trend for improved quality. Whole plant samples taken during the growing season in 1986 showed significantly higher tuber numbers in zone tillage treatments early in the season, but no difference later in the season. Related experiments in 1986 showed significant differences in size distribution due to seed spacing.

These early results suggest that the zone tillage system offers a significant advantage over conventional plow systems for improved yield and quality of potatoes, for erosion control, and improved trafficability associated with the untilled rye-covered interrow. These experiments were continued in 1987 to further document the performance of zone tillage for potato production. The objectives of this research were (1) to develop and evaluate aternatives to existing tillage systems on sandy soils that improve tuber quality and yield and reduce the potential for wind and water erosion and (2) to determine the impact of the physical environment induced by tillage on potato growth and development.

Methods:

Tillage treatments in 1987 included conventional tillage (spring disk and moldboard plowing followed immediately by planting) and zone tillage, accomplished with the use of a Bush Hog Ro-till and a paratill in-the-row subsoil tools. Zone tillage was done either in the fall or in the spring. Four varieties - Russet Burbank, Shepody, Atlantic, and Onaway - were grown in subplots on the spring tillage treatments only. Russet Burbanks were planted at seed spacings of 10 and 14 inches.

All cultural practices such as fertilizer and pest control followed recommended practices for each variety.

Roots of Russet Burbank potatoes were measured biweekly by obtaining video images of roots at various soil depths using a video camera inserted in plastic tubes inserted in the soil and in the row at 45 degree angles. Roots were also destructively sampled at two times during the growing season to a depth of 18 inches. Root lengths were determined from roots separated from the soil by washing. Whole plant samples were taken from 10 feet-of-row at three times during the growing season at three week intervals beginning at early bloom stage. Total biomass was determined including above ground and below ground components, including root weight and tuber numbers, weight and size distribution.

At harvest, size distribution, specific gravity and incidence of hollow heart were measured on potatoes harvested from two 50 foot rows for each tillage, variety, and seeding rate treatment.

Results and Discussion:

Yields of Russet Burbank potatoes as affected by tillage and seeding rate are given in Table 1. When plant spacing in the row was 14 inches, there were no differences in yield due to tillage. However, yield of No. 1 potatoes (%) was significantly lower in the paratill treatments than the conventional tillage treatment, 57 versus 66 %, respectively. No differences in this quality measure were observed in the previous two years where the trend was for higher No. 1 potatoes in zone tillage. Incidence of hollow heart (number out of 10 > 10 oz potatoes with hollow heart) was significantly higher in the zone tillage treatments than conventional tillage at the 14 inch seed spacing. When planted at 10 inch plant spacing, Russet Burbank yields were significantly increased in both zone tillage treatments, 447 and 426 cwt/acre for the paratill and Bush Hog Ro-till treatments, respectively, versus 377 cwt/acre for the conventional tillage treatment. Yield of No. 1 potatoes (%) was significantly less for the paratill treatment than the other treatments, just as in the other seeding rate. However, closer seed spacing reduced the incidence of hollow heart in the zone tillage treatments, with the paratill treatments showing significantly lower incidence than conventional or Bush Hog treatments. Specific gravity was low, averaged 1.067 g/cm3 overall, and was not affected by tillage. It would appear that zone tillage is beneficial to Russet Burbanks only when sufficient plant populations are present in the field. In the 1985 and 1986 experiments, significant yield increases were obtained in part because seed spacing in the main tillage experiments was 11 inches.

Yields of the Shepody variety as affected by tillage are given in Table 2. There were no significant differences in yield due to tillage, although the paratill treatment resulted in significantly lower No. 1 potatoes than either the conventional or Bush Hog treatments. Yields of Shepody were higher than Russet Burbank. Specific gravity averaged 1.078 gm/cm3, was significantly higher than Russet Burbanks, and was not affected by tillage. The question remains as to the effect of seed spacing on response to zone tillage, as this variety may respond similarly to that of Russet Burbanks. Seed spacing will be addressed in the 1988 field experiments.

Yields of two round white potato varieties, Onaway and Atlantic, as afected by tillage are given in Table 3. Yields of both varieties were significantly lower in the paratill treatments than the Bush Hog or conventional tillage treatments. There were no significant differences in % No 1 potatoes or incidence of hollow heart due to tillage. However, Onaway and Atlantic varieties differed significantly from each other in size distribution and quality characteristics. Specific gravity of Onaways was low and significantly less than Atlantics, 1.056 versus 1.081 gms/cm3, respectively. The effect of seed spacing on response to tillage may also be an issue with round white varieties and will be evaluated in the 1988 field experiments.

Figures 1, 2, and 3 summarize data from whole plant samplings obtained three times during the growing season. Figure 1 plots the number of tubers per plant at each sampling date. No significant differences were noted due to tillage at any sampling date. However, there appeared to be a trend toward fewer tubers per plant for the fall zone tillage treatments at the first sampling date. Also the spring Bush Hog treatment showed a trend for increased tuber numbers at the August 10th sampling date. Figure 2 plots total tuber weight at the three sampling dates. The spring Bush Hog treatment showed significantly higher tuber weights at the August 10th sampling. No other tillage of sampling time comparison was significant. Figure 3 illustrates no significant differences in above ground biomass per plant due to tillage at any sampling date. This is consistent with visual observations that little differences exist in the above ground biomass production even when significant tuber yields occur.

Root counts obtained from video images taken throughout the growing season are not completely analyzed. Some 25,000 images were obtained with this technique and roots in these images are being counted and the data summarized. Roots obtained from the destructive samples have been analyzed and the data for root length densities are presented for two sampling dates in Figures 4 and 5. At the June 25th sampling date, root length density is significantly greater below 30 cm in the paratill treatment than in either the conventional or Bush Hog treatments but are not different in the 0 to 30 cm depth. Root length densities in the conventional tillage treatment increased just above the plow layer. At the August 12th sampling date, there were greater root length densities at all depths for the paratill and at all but two depths for the Bush Hog treatment when compared to conventional tillage. As occurred at the June 25th sampling, root length densities increased above the plow layer in the conventional tillage plots.

The yield response in Russet Burbank potatoes was unexpected. This has implications for whole plant and root samples since they were all obtained from the 14 inch row spacing treatment. We would expect more differences in the 10 inch seed spacing treatment based on the yield response given in Table 1. The issue of seed spacing and response to tillage will be a major focus of experiments in 1988.

Table 1. Yield and quality of Russet Burbank potatoes as affected by tillage and seed spacing in 1988 at the Montcalm Potato Experiment Farm.

	Tillage					
	Conventional		Bush Hog Ro-till		Paratill	
	Seed Spacing					
	10"	14"	10"	14"	10"	14"
	cwt/acre					
< 4 oz	54a	40b	53a	44b	67a	47b
4 - 6 oz	87a	79b	89a	71b	76a	70b
6 - 10 oz	98b	107b	133a	103b	123a	93b
> 10 oz	44a	62a	53a	54a	49a	41a
PO < 10 oz*	49a	44a	54ab	51ab	68b	56b
PO > 10 oz	45a	43a	45a	45a	65b	52b
Total	377a	373a	426b	366a	447b	358a
No. 1 %	61a	66a	65a	62a	56b	57b
Specific Gravity	1.068a	1.066a	1.068a	1.067a	1.067a	1.067a
Hollow Heart (#/10)	1.0b	0.8b	1.0b	2.5c	0.3a	2.0c

means in the same row followed by the same letter are not significantly different using LSD = 0.05.
*PO = Pick Outs

Table 2. Yield and quality of Shepody potatoes as affected by tillage in 1988 at the Montcalm Potato Experiment Farm.

	Tillage		
	Conventional	Bush Hog Ro-till	Paratill
	cwt/acre		
< 4 oz	44	38	53
4 - 6 oz	87	74	75
6 - 10 oz	125	142	112
> 10 oz	93	93	66
PO < 10 oz *	27	30	34
PO > 10 oz	27	38	40
Total	404	418	380
No. 1 %	75a	75a	67b
Specific Gravity	1.076	1.079	1.077
Hollow Heart (#/10)	1.0	1.8	1.0

means in the same row followed by the same letter are not significantly different using LSD = 0.05.

* PO = Pick Outs

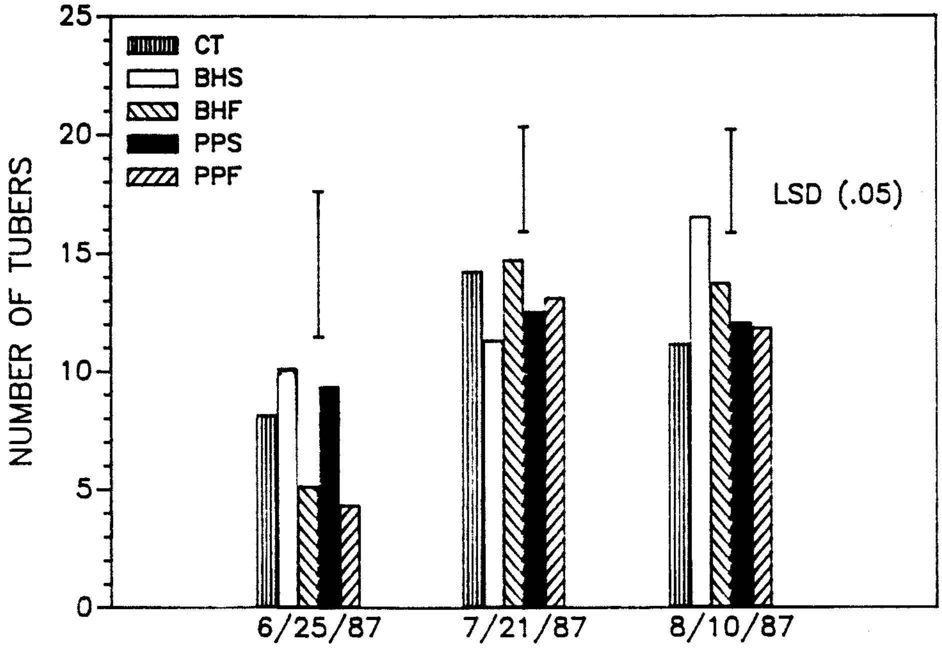
Table 3. Yield and quality of Onaway and Atlantic varieties as affected by tillage in 1988 at the Montcalm Potato Experiment Farm.

	Tillage					
	Conventional		Bush Hog Ro-till		Paratill	
	Onaway	Atlantic	Onaway	Atlantic	Onaway	Atlantic
	cwt/acre					
< 2 inch	25	11	24	14	24	12
2 - 3 1/4 inch	336	296	337	294	304	271
> 3 1/4 inch	90	159	86	144	91	156
PO < 3 1/4 inch *	4	3	2	2	3	5
PO > 3 1/4 inch	1	5	1	3	2	4
Total	454a	474a	449a	458a	423b	447a
No. 1 %	94a	96b	94a	96b	93a	95b
Specific Gravity	1.056a	1.082b	1.057a	1.079b	1.056a	1.082b
Hollow Heart (#/10)	2.0a	0b	1.0a	0b	2.8a	0b

means in the same row followed by the same letter are not significantly different using LSD = 0.05.

* PO = Pick Outs

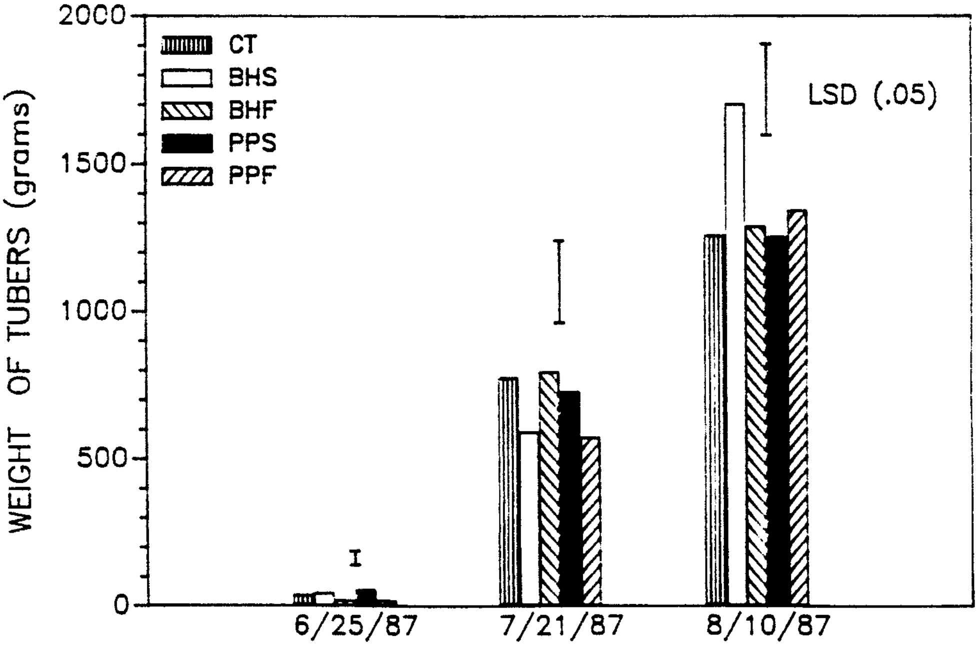
1987 POTATOES, MONTCALM EXPERIMENT STATION



SAMPLING DATE
TUBERS PER PLANT

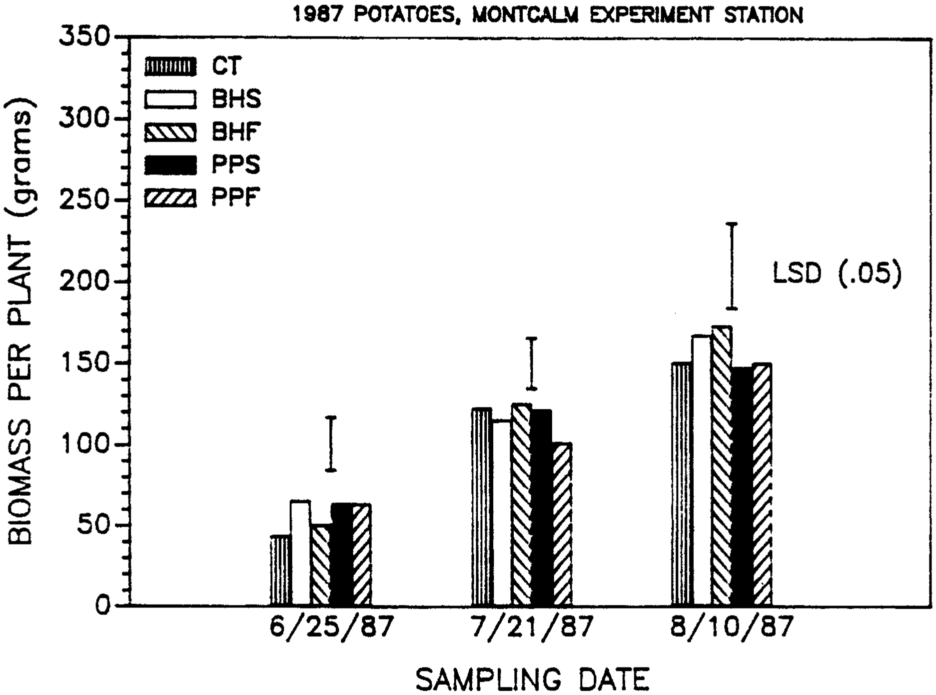
FIGURE 1

1987 POTATOES, MONTCALM EXPERIMENT STATION



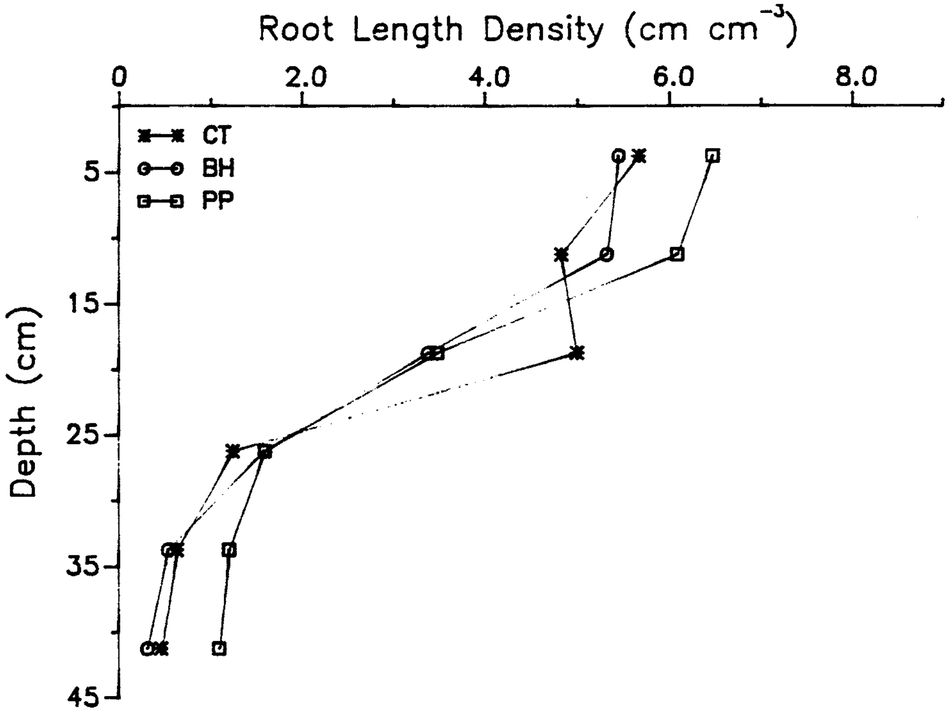
SAMPLING DATE
TUBER WEIGHT PER PLANT

FIGURE 2



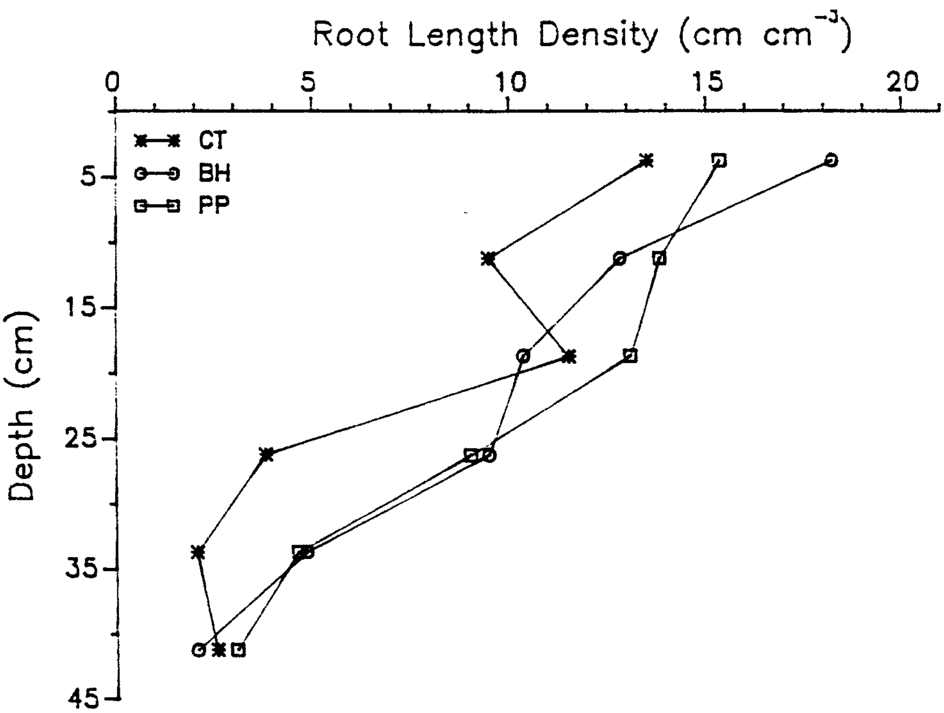
ABOVE-GROUND BIOMASS PER PLANT

FIGURE 3



6/25/87 MECHANICAL ROOT SAMPLING

FIGURE 4



8/12/87 MECHANICAL ROOT SAMPLING

FIGURE 5

Funding: MPIC

Adaptability of New Tillage Practices to Commercial Potato Farms

F. J. Pierce and R. W. Chase
Crop and Soil Sciences Department

G. Mansell, D. Smucker, and B. Stanley
Cooperative Extension Service

Introduction

Quality improvement of potatoes represents the major objective of potato growers in Michigan. A major factor affecting potato quality is the physical condition of the soil in the zone of rooting and tuber development. Wind and water erosion are serious problems on the sandy and organic soils which dominate potato acreage in Michigan. Conventional practices for potato production in Michigan use cover crops for overwinter protection of soil and limit plowing to spring primary tillage followed directly by planting to avoid excessive tillage and soil structure degradation. Michigan farmers, therefore, are well aware of the potential limitations of poor soil physical conditions and soil erosion. However, the potential for serious problems related to poor soil physical condition and erosion remain. Excessive traffic, often with heavy axle loads repeated over several years, has created compact soil conditions below the depth of normal tillage and degraded soil structure in the tillage zone. Soil erosion potential in Michigan from wind and water is highest during the period from tillage and planting to hilling or canopy closure when the soil is bare and unprotected.

The objective of this project was to domonstrate and evaluate zone tillage systems for potato production which have been shown through research at MSU to improve tuber quality and yield and reduce the potential for wind and water erosion.

Experimental Methods and Results:

Tillage tools designed to subsoil in the row were evaluated in replicated experiments with conventional potato production methods in Bay, Allegan, Antrim, and Montcalm counties in Michigan. The intention was to restrict tillage in these systems to the zone in the potato row (zone tillage) and leave the interrow area untilled with a cover of standing rye as protection against wind and water erosion. The tillage treatments evaluated were as follows:

1. Conventional tillage - light disking, moldboard plowing followed immediately by planting
2. Bush Hog Ro-till - one pass (this is an in-the-row subsoiler equipped with surface tillage tools)
3. Paraplow in-the-row (a subsoiler that fractures the soil with minimal surface disturbance).
4. Rotary Cultivator followed by planting (at Bay County site only).

In Bay county, yields of Oneway potatoes were not significantly different for zone versus conventional tillage methods. The paratill had the highest yields, but large variations in replications resulted in a coefficient of variation of 45.4 percent. Quality and specific gravity were unaffected by tillage treatment. The rye cover crop in the interrow area protected the field from a severe wind erosion episode in June which decreased stand and yield in adjacent fields. Although not significant, this demonstration showed the potential for success of the zone tillage system.

Bay County Joe Groulx and Sons Farm

Variety: Oneway

Tillage System	Yield	Number 1	Specific Gravity
	cwt/ac	%	g/cm3
Conventional	302	83	1.062
Bush Hog	309	85	1.057
Paratill	359	83	1.061
Rotary Cultivator	285	85	1.061

In Allegan county, the demonstration was installed on a muck soil also highly susceptible to wind erosion. Yield of Atlantic potatoes were not significantly different. However, zone tillage plots allowed harvest under wet conditions this fall where equipment was unable to operate in the conventionally tilled areas. It would appear that compact conditions in the muck soils and their susceptiblity to wind erosion makes the zone tillage system very attractive to potato growers in this area.

Allegan County Ray Bourdo and Sons Farm

Variety: Atlantic

Tillage System	Yield	Number 1	Gravity
	cwt/ac	%	g/cm3
Conventional	303	91	1.069
Bush Hog	305	92	1.069
Paratill	316	93	1.069
Paratill (Post)	315	92	1.067

In Antrim county, yields of Atlantic potatoes were not affected by tillage. However, quality was affected in that the percent Number 1 potatoes, specific gravity and 2-3 1/4 inch potatoes (important for seed producers) were less in conventional than zone tillage systems. The potential for zone tillage for potato production in this area of the state appears to be good.

Antrim County Dick Shields Farm

Variety: Atlantic

Tillage System	Yield	Number 1	Gravity	2 -3 1/4
	cwt/ac	%	g/cm3	cwt/ac
Conventional	263	76b	1.079b	145b
Bush Hog	257	86a	1.084a	185a
Paratill	257	84a	1.082a	161ab

In Montcalm county, yields of a numbered Frito Lay variety were not affected significantly by tillage. Due to heavy rains, all but the conventional plots were under water for some extended period in August and September. This may be responsible for the lower specific gravities in these tillage treatments. The field had been chiseled prior to establishing the demonstration. This may have affected the results of the zone tillage study.

Montcalm County Vachel Perkins Farms

Variety: Numbered Frito Lay

Tillage System	Yield	Number 1	Gravity
	cwt/ac	%	g/cm3
Conventional	391	90	1.079a
Chisel	388	88	1.071b
Bush Hog	364	87	1.073b
Paratill	393	90	1.072b

It is our conclusion that the zone tillage system was successfully deomonstrated to potato growers in Michigan. It is projected that zone tillage will be adopted by some portion of the potato growers over the next few years. Further field trials are warranted in 1988.

Funding: ARS/USDA Cooperative Agreement

CONTROL OF SCAB

R. Hammerschmidt and M.L. Vitosh
Department of Botany and Plant Pathology
Department of Crop and Soil Sciences

INTRODUCTION

Scab continues to be a problem in the production of high quality potatoes. In 1985 and 1986 we demonstrated that this disease could be reduced in severity by use of ammonium sulfate as the N form in combination with maintaining soil moisture levels below 50 cb of tension. Research was carried out to further confirm these observations.

PROCEDURE

The research was carried out at the MSU soils farm in a plot known to be infested with the scab organism. The Atlantic variety of potato was used in the trials. The soil pH at this site was 6.9. Each fertilizer treatment (Table 1) was replicated four times in fifty foot rows under high or low irrigation. The high irrigation side was irrigated (as needed) starting at tuber initiation in order to maintain a soil moisture level below 50 cb. The low irrigation side was irrigated every other time the high side was irrigated.

RESULTS

Maintaining soil moisture levels below 50 cb during the tuber initiation and development stages resulted in significantly less scab that maintaining dryer soil conditions (Table 2). Use of ammonium sulfate as the only N source also tended to reduce the severity of the disease. The best overall control was observed when the soil moisture was maintained below 50 cb and ammonium sulfate was used. No significant differences were observed in relation to yield (Tables 3). However, the lack of differences and low yields may have been due to poor stands. The specific gravity averaged 1.086 across all treatments. There were no significant differences among the various treatments.

CONCLUSIONS

Our research over the last three years has demonstrated that maintaining soil moisture levels below 50 cb during tuber initiation and development will significantly reduce scab. In addition, the use of an acid forming N source will also aid in reduction of scab severity. A combination of control measures, including resistant varieties when applicable, should be used to help reduce the severity of this disease.

TABLE 1
FERTILIZER TREATMENTS

N FORM	FERTILIZER COMPOSITION (LBS/A)*				
	N	P	K	S	Ca
Urea	225	100	100	0	0
Ammonium sulfate	225	100	100	114	0
Urea+Am. Sulfate	225	100	100	57	0
Calcium Nitrate	225	100	100	0	129
Urea+Gypsum	225	100	100	98	129

TABLE 2
SCAB CONTROL

TREATMENT	% 5% SCAB	% SCAB FREE
IRRIGATION		
HIGH	88.1A**	55.0A
LOW	65.6B	34.5B
N FORM		
AS	81.4	48.2
U	76.9	46.7
AS+U	77.7	44.4
CaN	76.0	42.9
U+Gyp	71.1	41.7
N FORM X IRRIGATION		
HIGH IRRIGATION		
AS	94.3	62.5
U	87.0	54.0
AS+U	92.0	53.8
CaN	84.8	53.3
U+Gyp	80.3	50.3
LOW IRRIGATION		
AS	68.5	33.8
U	66.7	39.3
AS+U	63.3	35.0
CaN	68.0	32.5
U+Gyp	61.8	33.0

*High irrigation= soil maintained at 50 cb or less; low irrigation= plots irrigated every other time the high irrigation plots were irrigated. A=ammonium sulfate; U=urea; A+U= urea+ammonium sulfate; CaN=calcium nitrate; U+Gyp=urea+gypsum.
**Significant differences (p 0.05) were only found between the irrigation treatments.

TABLE 3
YIELD RESULTS

TREATMENT	%TOTAL YIELD*	%NO. 1
IRRIGATION		
HIGH	52.0	85.6
LOW	47.0	83.9
N FORM		
AS	45.5	81.9
U	50.6	84.7
AS+U	51.6	83.8
CaN	52.3	92.1
U+Gyp	47.9	89.1
N FORM X IRRIGATION		
HIGH IRRIGATION		
AS	50.2	84.3
U	51.9	85.5
AS+U	53.4	87.1
CaN	55.4	85.0
U+Gyp	49.3	85.8
LOW IRRIGATION		
AS	40.7	79.4
U	49.2	83.9
AS+U	49.7	80.5
CaN	49.2	82.5
U+Gyp	46.4	92.9

*High irrigation= soil maintained at 50 cb or less; low irrigation= plots irrigated every other time the high irrigation plots were irrigated. A=ammonium sulfate; U=urea; A+U= urea+ammonium sulfate; CaN=calcium nitrate; U+Gyp=urea+gypsum.

**Yield expressed as lbs/50 ft plot

Funding: MPIC

COLORADO POTATO BEETLE MANAGEMENT

1987 Research Report to the Michigan Potato Industry Research Committee

E. Grafius, P. Ioannidis, and B. Bishop
Department of Entomology
Michigan State University

Summary: Research in 1987 included 1) monitoring of insecticide resistance from different populations in Michigan, 2) identification of resistance modes of action using synergists to block specific enzyme groups, 3) experiments on initial appearance and inheritance of resistance and 4) evaluation of new insecticides for Colorado potato beetle control.

Results indicate moderate to high levels of resistance present in many populations. All beetles evaluated showed resistance to at least one insecticide group. Some showed resistance to all tested insecticides. Synergist studies indicate that esterase and mixed-function oxidase enzymes are used for detoxification and that nerve insensitivity (target site insensitivity or knock-down resistance) is also probably a major mechanism. Beetles from the Montcalm Research Farm went from susceptible to completely immune to Furadan in 3 generations. New insecticides evaluated in 1987 and in the past 2 years include Kryocide, M-1 (a bacterial spore preparation), rotenone, and several insect growth regulators.

Practical applications: Data from the 1987 and previous years research has been used to apply for section 18 emergency registration for Kryocide in 1988, support federal registration for M-1, and design management schemes for potato beetle management under low, moderate and high beetle pressures.

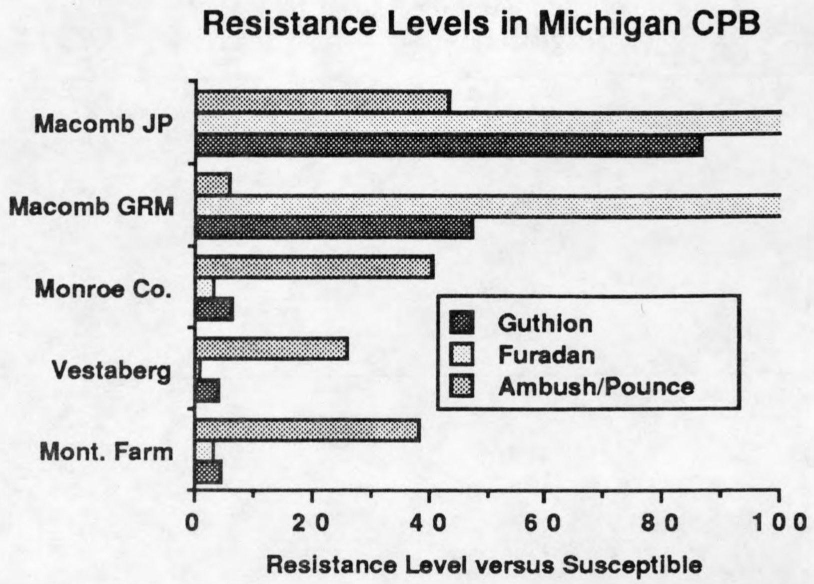
1) Monitoring of Insecticide Resistance

Resistance monitoring was conducted as a basis for subsequent resistance studies as well as to provide essential background data for section 18 emergency registration of a new insecticide and for future research grant applications.

Colorado potato beetle adults or larvae were collected from 15 locations in southern and central Michigan. The insecticides tested were some of the most commonly used in Michigan for controlling potato beetles: Guthion (an organophosphate), Ambush/Pounce (pyrethroid), and Furadan (carbamate). These three chemicals represent the three major groups of insecticides. DDT was tested on some of the beetles showing Ambush/Pounce resistance to determine any cross-resistance. Technical grade (95 - 99% pure) insecticide dissolved in acetone was applied on the abdomen of the beetle or larva with a hand applicator, 2 micrograms (µg) of solution per beetle All tests were conducted at approximately 75°F. Mortality was estimated for Furadan and Guthion after 3 days, and for Ambush/Pounce and DDT after 5 days. LD50 values (dose lethal to 50% of the beetles) were estimated from dosage-mortality regression lines based on at least four points.

Results indicate that all populations tested are resistant to at least one group of insecticides. A sample of the data is shown in Figure 1. Several of the populations were tolerant or resistant to Ambush/Pounce, Guthion, and Furadan (DDT too, where tested). These farms experienced severe control problems and in one case, applied 15 applications of combinations of insecticides and still did not obtain adequate control.

Figure 1



2) Identification of Resistance Modes of Action

The object was to evaluate the effects of synergists on insecticide resistance in the Colorado potato beetle. Synergists act by blocking specific enzymes used to degrade insecticides and synergist activity can be used to determine the resistance mechanism. Bioassays were conducted as described above. Synergists were applied 1 hour before insecticides.

The synergists used were: piperonyl butoxide (PBO), a specific inhibitor of mixed-function oxidases; DEF, a specific inhibitor of esterases; diethyl maleate, an inhibitor of glutathione-s-transferase; and chlorfenethol (DMC) an inhibitor of DDT dehydrogenase.

Results:

Results are given from the most resistant field strain of beetle (collected from the Macomb Co. area).

Resistance to Guthion was found to be 81 fold (Table 1). The population was heterogeneous, containing both suceptible and resistant individuals, as indicated by the high X^2 value. With the addition of PBO, resistance was reduced approximately 15 fold, indicating mixed-funciton oxidase activity. The resistance ratios were calculated by dividing the LD50 of an insecticide by the LD50 of the insecticide plus synergist. The response of the beetles to Guthion plus PBO was homogeneous, a more uniform level of resistance, as indicated by the low X^2 value. This suggests that the main mechanism for resistance to Guthion is mixed-function-oxidase.

Table 1. Resistance and insecticide synergism of JP Macomb population to Guthion.

	LD_{50} (µg/beetle)	Synergism Ratio	X^2
Guthion	24.3*	-	7.0
+ PBO	1.6	14.9	0.6
+ DEF	12.2	2.0	1.1
+ diethyl maleate	22.3	1.1	4.9

*(susceptible LD50 = 0.3µg)

Actual resistance levels to Furadan could not be determined for the Macomb GP population because lethal levles of technical grade material could not be applied in high enough amounts to cause mortality. LD50 values were estimated as approximately 2000 fold (Table 2).The synergism of Furadan with both PBO and DEF was low. This lack of synergist activity plus other observations discussed below suggest a change in the target site of the insecticide as the mode of resistance.

Table 2. Resistance and insecticide synergism of JP Macomb population to Furadan.

	LD_{50} (µg/beetle)	Synergism Ratio	X^2
Furadan	>1000*	-	
+ PBO	198.1	>5	6.24
+ DEF	422.8	>2	0.67

*(susceptible LD50 = 0.2µg)

With Ambush/Pounce a fairly good synergistic ration was found with PBO (6.5 times) (Table 3). The addition of the synergist PBO returns the highly heterogeneous responses with Ambush/Pounce alone to a homogeneous response (low X^2 value), also suggesting the involvement of mixed-function oxidases. However, resistance of Colorado potato beetle to Ambush/Pounce cannot be explained sufficiently by the detoxification mechanisms using PBO and DEF. Resistance levels to DDT are also high for this population (Table 4). Therefore, a possible additional resistance mechanism to Ambush/Pounce is the kdr factor (knock-down resistance). This cross-resistance to DDT may help explain populations that are tolerant to pyrethroids (Ambush/Pounce, Pydrin/Asana) when these materials are first used in a field.

Table 3. Resistance and insecticide synergism of JP Macomb population to Ambush/Pounce.

	LD_{50} (µg/beetle)	Synergism Ratio	X^2
Ambush/Pounce	16.8*	-	13.3
+ PBO	2.5	6.9	1.9
+ DEF	6.2	2.7	6.3

*(susceptible LD50 = 0.39µg)

Table 4. Resistance and insecticide synergism of JP Macomb population to DDT.

	LD_{50} (µg/beetle)	Synergism Ratio	X^2
DDT	>1000*	-	0.45
+ PBO	253	-	3.6
+ DMC	898	-	6.3

*(susceptible LD50 = 10.0µg)

Conclusions for synergist studies

The conclusions drawn are based on twelve field strains tested in our laboratory. With all tested strains, the resistance to Guthion can be reversed significantly by applying piperonyl butoxide, strong evidence that mixed function oxidases are primarily responsible for resistance to Guthion.

The field populations resistant to Guthion were also highly resistant to Furadan. In one case 85-fold resistance to Guthion was accompanied by more than 300-fold resistance to Furadan.

By studying and comparing the resistance patterns of the Colorado potato beetle in Michigan and in other areas, one can observe that the rate of development of resistance is much more rapid for Furadan than for Guthion.

For Furadan, we found low synergism with piperonyl butoxide. We also tested another inhibitor of mixed-function oxidase II, the MGK 265. We did not find any synergism. The synergism by DEF is also low. These results suggest that acetylcholinesterase insensitivity is mainly responsible for resistance to Furadan.

With Ambush/Pounce almost all the tested field strains were to some extent resistant. The maximum observed field resistance was about 50-fold. Resistance of Colorado potato beetles to this chemical cannot be explained sufficiently by the detoxification mechanisms using PBO and DEF. Another possible mechanism for Ambush/Pounce and DDT resistance is th kdr factor.

Finally, it seems that the beetles can use all the available mechanisms to resist insecticides (Table 5). Therefore, according to different field selection pressures, beetles develop one or multiple resistance mechanisms. More physiological and biochemical studies are needed in vitro to further interpret the above studies. The above results, together with genetic analysis of resistance which has already started in our laboratory, will provide essential information in the research, and will provide a good background for insecticide recommendations and appropriate integrated management systems for the Colorado potato beetle. Management recommendations include effective alternation and mixing strategies and the use of synergists to aid in potato beetle control.

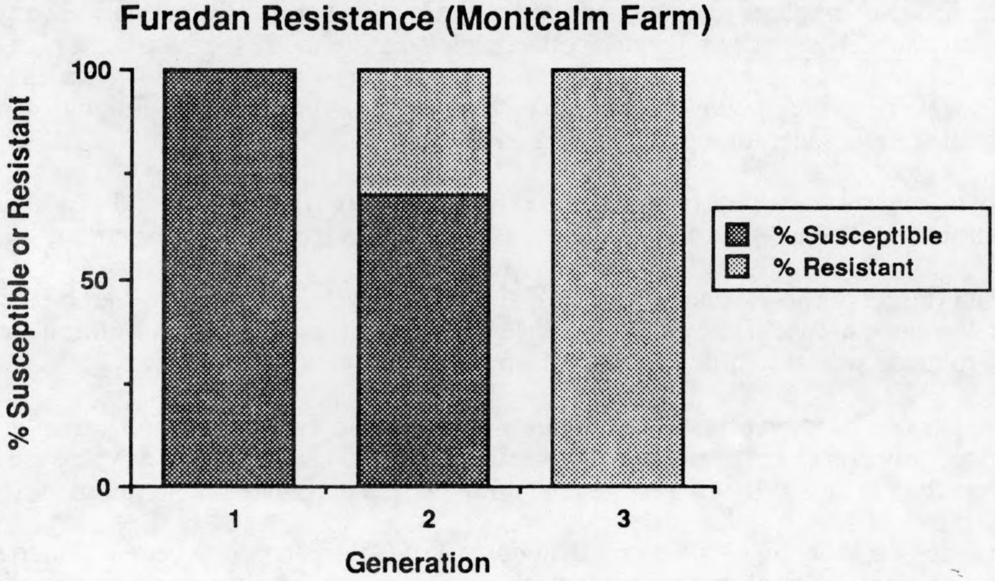
Table 5. Probable mechanisms used for insecticide resistance.

Insecticide	Synergism	Probable Resistance Mechanism
Guthion	PBO	MFO
	DEF (low)	Esterase
Furadan	PBO (low)	MFO
	DEF (low)	Esterase
	-	Target insensitivity?
Ambush/Pounce	PBO	MFO
	DEF (low)	Esterase
	-	kdr factor?
DDT	PBO (low)	MFO
	-	kdr factor?

3) Experiments on Initial Appearance and Inheritance of Resistance

Studies were started in the field and the laboratory to determine the rate of development of resistance, from susceptible to resistant. In one study, larvae at the Montcalm Research Farm were treated in the field with Furadan and the survivors were returned to the laboratory for further rearing and selection. Approximately 40 to 50 larvae survived out of the original 250,000 larvae that were treated. These were returned to the laboratory for rearing and their progeny were treated again with Furadan. Survival here was approximately 40 out of 300. Progeny of these survivors were again tested and all were resistant to Furadan at very high levels. Thus, resistance to Furadan at very high levels appeared within 3 generations (Figure 2). At least one commercial grower in Michigan reported similar failure after intensive use within one season in the field. This information has been transmitted to FMC Corporation and incorporated into their Furadan use recommendations for Michigan growers.

Figure 2



4) Evaluation of New Insecticides

Potatoes were planted April 24, 1987 at the MSU Montcalm Potato Research Farm. Plots received normal fungicide and herbicide treatments, and approximately weekly irrigation. Plots were 3 rows wide (34 inch row spacing) by 40 feet long. Two unsampled rows were left between adjacent plots. Treatments were arranged in a randomized complete block design with 4 blocks per treatment. Treatments were applied as foliar sprays with a tractor-mounted boom sprayer at 30 gal/acre, 40 psi, with a cluster of three nozzles over each row. The middle nozzle directed spray down over the top of the plant, and the other nozzles directed the spray at the sides of the plant.

Treatments for control of first generation colorado potato beetle were applied on June 15 and June 22 (with the exception of the DPX-EY059 treatment, which was applied only on the first date). Insects were counted on June 10 (pre-treatment count), June 18 (after first treatment), and June 25 (after second treatment). Randomly selected plants from the middle row of each plot were sampled (three plants/plot on the first date, and two plants/plot for each of the post-spray dates were sampled). Damage ratings both on a per plot and a per plant (2 plants per plot) basis were made on June 25. Damage ratings were based on a scale of 1 to 5, where 1 indicated no damage (per plant or per plot), 2 indicated 0-5% defoliation (per plant or per plot), 3 indicated 5-25% defoliation, 4 indicated 25-50% defoliation, and 5 indicated 50-100% defoliation.

Beetle numbers were low in first generation plots on June 25, but rose sharply again in July (due to emergence of second generation beetles). To maintain differences in yield and foliage damage levels due to first generation beetles, these plots were sprayed with Furadan 4F (1 lb. ai/A) on July16 and again on August 18. Damage ratings were again taken of first generation plots on a per plot basis on July 28 (about 1 month after last treatment application). New growth of badly damaged plants had made the previously used damage scale unusable, so damage ratings were made on the basis of percentage of soil visible in plots (1= No soil visible--least damage, 2= 1-5% of soil visible, 3= 5-25% of soil visible, 4= 25-50% soil visible, and 5= 50-100% of soil visible--most damage).

Treatments for control of second generation Colorado potato beetle were applied on July 17 and July 23 (again, with the exception of the DPX-EY059 treatment, which was applied only on the first date). Insects were counted on 2 randomly selected plants from the middle row of each plot on July 14 (pre-treatment count), July 21 (after first treatment), and July 28 (after second treatment).

Furadan 4F was sprayed on second generation plots on June 23 to suppress first generation beetles. Nonetheless, damage occurred to these plots before treatments were applied. To check for significant differences in damage between plots before the first treatment, a plot damage rating was made on June 14. Damage ratings were also made on a per plot and a per plant basis, according to the scale described previously, on July 28 (after second treatment). Furadan 4F was again sprayed on all second generation plots on August 18.

Potatoes were harvested from middle row of each plot (first and second generation plots) on October 7. The weight of the potatoes harvested was recorded for each plot.

Data (insect numbers, damage ratings, and harvest weight) were analyzed by a two-way Analysis of Variance at .05. Tukey's test was used to test for non-additivity. Multiple comparisons (SNK) were made where significant results were obtained.

Results of Colorado potato beetle counts are shown in Tables 6 and 7. Large larvae were more effectively controlled than any other beetle stage. Numbers of large larvae were higher in untreated plots than in any of the treated plots in both the first and second generation.

Furadan 4F (1 lb. ai/A) gave excellent control of Colorado potato beetle. Furadan plots contained low numbers of all beetle stages in both the first and second generations. Furadan 4F was also the only treatment to show significantly lower numbers of small larvae than untreated plots (Table 7). Imidan 50W (1 lb. ai/A), the other standard, while less effective than Furadan, gave the second-best control of large larvae.

The Bacillis thuringiensis treatments (M-1) resulted in minimal control of large larvae at the lowest rate (1 Qt./A), but the numbers of large larvae in M-1 plots decreased significantly as the rate increased. Increasing rates of UC 84572 also gave increased control of large larvae.

The high number of adults and egg masses present in the Asana plots on June 25 (Table 6) may have been due to migration of adults from adjacent, more damaged plots. The damage in Asana plots was lower than in any other treatment except Furadan 4F on June 25 (Table 8). This indicates that Asana gave effective control of large larvae. However, Asana, unlike Furadan, apparently did not control adult beetles.

The addition of piperonyl butoxide to Asana decreased beetle numbers in almost all stages in both the first and second generations. The Rotenone-piperonyl butoxide treatment (Table 7) gave only moderate control of Colorado potato beetle.

Damage ratings in first generation plots (Table 8, Figure 3) generally reflected the number of large larvae present in plots. Harvest weights were inversely related to damage rates. It is interesting to note that the differences in numbers of large larvae in the first generation plots resulted in differences in damage ratings that persisted for at least a month after the last treatments were applied. This early damage had a large effect on yield. Harvest weights of first generation plots varied widely and were negatively correlated with damage ratings, and numbers of large larvae (Figure 4). However, differences in damage due to different numbers of large larvae in the second generation had less effect on yield. The harvest weights of second generation plots did not differ significantly (Table 8).

COLORADO POTATO BEETLE CONTROL IN POTATOES
MSU MONTCALM POTATO RESEARCH FARM
ENTRICAN, MI---1987

Table 6. FIRST GENERATION COLORADO POTATO BEETLE:

Chemical	Rate	Mean Number of Egg Masses Per Plant [a] 6-10	6-18 [b]	6-25	Post-Spray Totals[c]	Mean Number of Small Larvae Per Plant[a] 6-10	6-18	6-25	Post-Spray Totals[c]
DPX-EY059	.4#ai/A	7.7	4.8	2.4ab	7.1	20.8	70.9	14.5	83.4
DPX-EY059	.8#ai/A	5.5	4.1	2.0ab	6.1	26.9	31.5	13.3	44.8
M-1	1 Qt/A	5.3	1.4	0.9 b	2.3	22.0	77.0	7.9	84.9
M-1	2 Qt/A	7.5	7.1	0.5 b	7.6	26.9	82.6	11.9	94.5
M-1	3 Qt/A	9.8	3.1	1.5ab	4.6	23.4	60.6	13.4	74.0
M-1	4 Qt/A	7.3	2.1	1.9ab	4.0	24.3	62.5	19.1	81.6
UC 84572	.01#ai/A	7.9	4.4	1.1ab	5.5	16.8	73.4	11.9	85.3
UC 84572	.03#ai/A	9.0	6.9	1.5ab	8.4	11.3	57.1	10.6	67.8
Imidan 50WP	1.0#ai/A	7.6	4.5	0.8 b	5.3	13.1	18.8	0.9	19.6
Furadan 4F	1.0#ai/A	7.3	4.4	0.0 b	4.4	21.4	7.8	0.1	7.9
Asana	.5#ai/A	5.0	4.0	3.6 a	7.7	19.8	32.6	11.0	43.6
Asana & PBO	.5#ai/A 1.0#ai/A	8.1	6.3	1.5ab	7.8	26.3	34.1	1.3	35.4
Untreated		7.7	5.5	0.6b	6.1	9.8	66.3	13.5	79
		*NS	*NS		*NS	*NS	*NS	*NS	*NS

Chemical	Rate	Mean Number of Large Larvae Per Plant[a] 6-10	6-18	6-25[b]	Post-Spray Totals [c]	Mean Number of Adults Per Plant[a] 6-10	6-18	6-25	Post-Spray Totals[c]
DPX-EY059	.4#ai/A	1.7	23.4bcde	38.3a	61.6 bc	1.2	0.6	0.8	1.4 ab
DPX-EY059	.8#ai/A	4.9	31.4abcd	28.8a	60.1 bc	1.2	0.6	0.6	1.3 ab
M-1	1 Qt/A	2.1	44.9ab	32.3a	77.1 b	2.7	0.5	0.4	0.9 ab
M-1	2 Qt/A	1.8	26.3bcde	30.9a	57.1 bc	2.0	0.6	0.3	0.9 ab
M-1	3 Qt/A	1.6	27.6bcde	30.5a	58.1 bc	2.3	0.4	0.1	0.5 ab
M-1	4 Qt/A	0.6	24.6bcde	23.6a	48.3 c	1.5	0.6	0.0	0.6 ab
UC 84572	.01#ai/A	3.5	39.5abc	26.6a	66.1 bc	2.8	0.4	0.0	0.4 b
UC 84572	.03#ai/A	2.1	14.6cde	15.4ab	30.0 d	2.5	0.6	0.3	0.9 ab
Imidan 50WP	1.0#ai/A	1.7	3.1de	0.8c	3.9 e	2.1	0.6	0.0	0.6 ab
Furadan 4F	1.0#ai/A	1.5	0.1e	0.3c	0.4 e	2.3	0.0	0.0	0.0 b
Asana	.5#ai/A	2.1	7.6de	6.3b	13.9 de	1.2	0.6	1.4	2.0 a
Asana & PBO	.5#ai/A & 1.0# ai/A	4.2	7.0de	2.3c	9.3 de	2.6	1.3	0.1	1.4 ab
Untreated		1.3	54.1a	43.5a	97.6 a	1.0	0.9	0.1	1.0 ab
		*NS				*NS	*NS	*NS	

[a] Means followed by the same letter are not significantly different at the .05 level

*NS Means are not significantly different at the .05 level

[b] Log (x+1) transformation was used on data

[c] Total number per plant---June 18 and June 25

COLORADO POTATO BEETLE CONTROL IN POTATOES
MSU MONTCALM POTATO RESEARCH FARM
ENTRICAN, MI---1987

Table 7. SECOND GENERATION COLORADO POTATO BEETLE:

		Mean Number of Egg Masses Per Plant[a]				Mean Number of Small Larvae Per Plant [a]			
Chemical	Rate	7-14[b]	7-21[b]	7-28 [b]	Post-Spray Totals[c]	7-14[b]	7-21[b]	7-28[b]	Post-Spray Totals[c b]
DPX-EY059	.4#ai/A	7.4	4.5	2.5ab	7.0	24.3	23.0 a	2.5	25.5 a
DPX-EY059	.8#ai/A	8.6	3.8	2.3ab	6.0	18.3	27.1 a	1.5	28.6 a
UC 84572	.01#ai/A	4.6	4.0	2.1ab	6.1	19.0	20.4 ab	3.5	23.9 a
UC 84572	.03#ai/A	6.8	5.0	2.6ab	7.6	27.4	30.3 a	1.5	31.8 a
Imidan 50WP	1.0#ai/A	6.6	5.8	0.9ab	6.6	13.5	8.8ab	3.9	12.6 a
Furadan 4F	1.0#ai/A	6.0	4.1	0.1 b	4.3	6.8	1.9 b	0.0	1.9 b
Asana	.5#ai/A	5.4	3.4	3.6 a	7.0	16.3	28.1 a	0.3	28.4 a
Asana & PBO	.5#ai/A 1.0#ai/A	6.3	4.0	4.4 a	8.4	13.5	17.9ab	0.9	18.8 a
Rotenone & PBO	.4#ai/A .7#ai/A	5.9	7.6	2.1ab	9.8	9.5	36.5 a	2.9	39.4 a
Untreated		4.8	4.8	1.0ab	5.8	6.8	13.6 a	3.5	17.1 a
		*NS	*NS		*NS	*NS		*NS	

		Mean Number of Large Larvae Per Plant[a]				Mean Number of Adults Per Plant[a]			
Chemical	Rate	7-14 [b]	7-21[b]	7-28 [b]	Post-Spray Totals [c b]	7-14[b]	7-21	7-28	Post-Spray Totals[c]
DPX-EY059	.4#ai/A	0.6	4.9 ab	6.4ab	11.3 b	10.6	2.1 ab	1.1	3.3ab
DPX-EY059	.8#ai/A	0.9	1.4 bc	6.0ab	7.4ab	4.6	2.3 ab	2.1	4.4ab
UC 84572	.01#ai/A	0.0	10.8 ab	0.6bc	11.4ab	6.3	3.4 ab	0.8	4.1ab
UC 84572	.03#ai/A	0.4	5.1 bc	1.8bc	6.9 b	6.1	5.0 a	0.9	5.9 a
Imidan 50WP	1.0#ai/A	0.1	3.1 bc	0.0 c	3.1bc	7.1	1.1 b	0.4	1.5 b
Furadan 4F	1.0#ai/A	0.8	0.0 c	0.0 c	0.0 c	6.5	0.9 b	0.1	1.0 b
Asana	.5#ai/A	0.5	4.6 ab	3.3abc	7.9 ab	5.4	2.4 ab	0.8	3.1ab
Asana & PBO	.5#ai/A 1.0#ai/A	0.1	6.6 b	4.4bc	11.0 b	7.9	2.6 ab	1.6	4.2ab
Rotenone & PBO	.4#ai/A .7#ai/A	0.1	4.8 ab	2.3bc	7.0 ab	7.5	3.3 ab	1.0	4.3 ab
Untreated		0.1	17.5 a	15.3 a	32.8 a	4.8	1.8 ab	1.3	3.0 ab
		*NS				*NS		*NS	

[a] Means followed by the same letter are not significantly different at the .05 level
*NS Means are not significantly different at the .05 level
[b] Log (x+1) transformation was used on data
[c] Total number per plant---July 21 and July 28

COLORADO POTATO BEETLE CONTROL IN POTATOES
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Table 8. DAMAGE AND YIELD RATINGS

FIRST GENERATION COLORADO POTATO BEETLE:

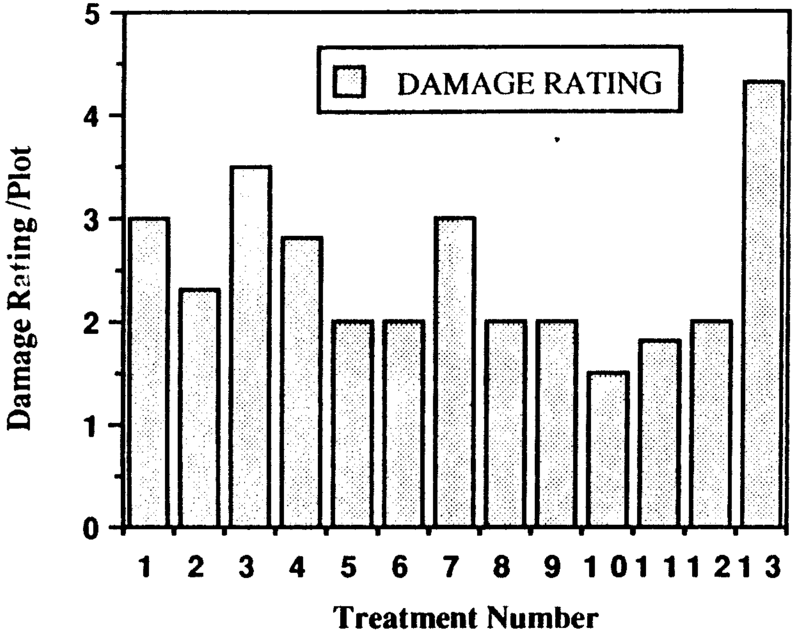
Chemical	Rate	Mean Damage Rating Per Plant 6/25[a]	Mean Damage Rating Per Plot 6/25[a]	Mean Damage Rating Per Plot 7/28[a]	Mean Harvest Weight Per Plot (Lbs/40 ft)[a]
DPX-EY059	.4#ai/A	2.8 bc	3.0 bc	3.0 bcd	68.8 ab
DPX-EY059	.8#ai/A	2.6 bc	2.3 de	2.8 bcd	77.5 ab
M-1	1 Qt/A	3.5 b	3.5 b	3.8 ab	54.3 ab
M-1	2 Qt/A	2.6 bc	2.8 cd	3.3 bc	54.4 ab
M-1	3 Qt/A	2.6 bc	2.0 e	2.5 bcd	69.3 ab
M-1	4 Qt/A	2.4 bc	2.0 e	2.3 bcd	64.0 ab
UC 84572	.01#ai/A	3.5 b	3.0 bc	2.8 bcd	68.1 ab
UC 84572	.03#ai/A	2.4 bc	2.0 de	2.5 bcd	79.1 ab
Imidan 50WP	1.0#ai/A	1.7 c	2.0 de	1.5 d	81.9 a
Furadan 4F	1.0#ai/A	1.7 c	1.5 e	2.3 bcd	74.9 ab
Asana	.5#ai/A	2.0 c	1.8 e	1.8 cd	79.3 ab
Asana & PBO	.5#ai/A 1.0# ai/A	2.0 c	2.0 de	2.3 bcd	81.6 a
Untreated		4.7 a	4.3 a	4.5 a	31.1 c

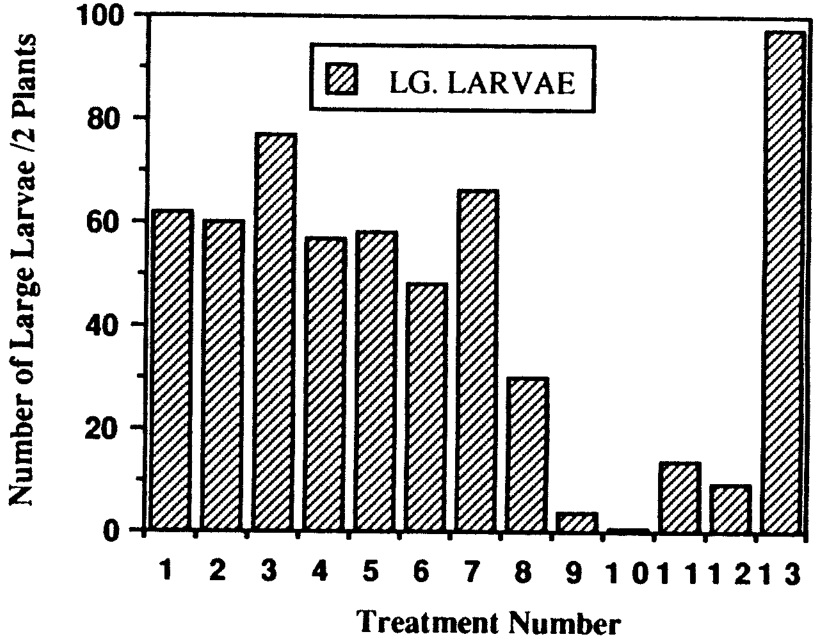
SECOND GENERATION COLORADO POTATO BEETLE:

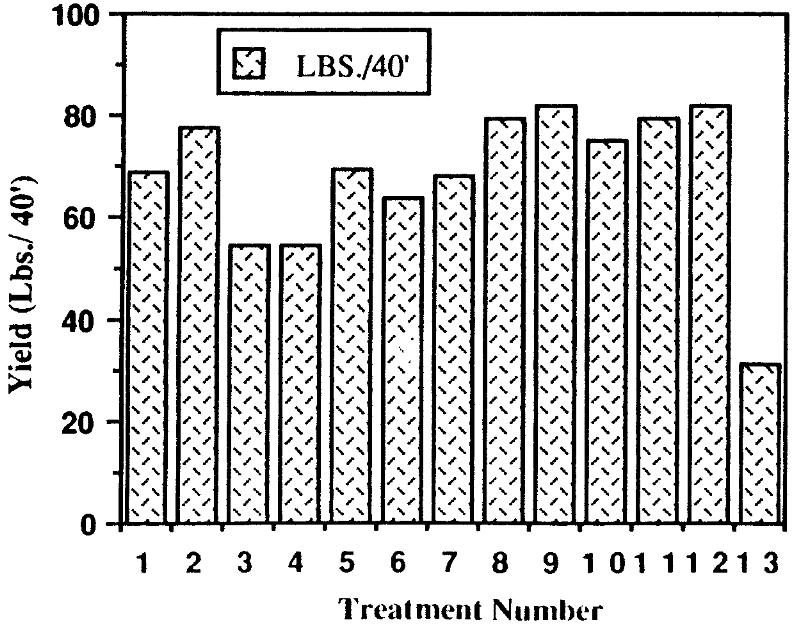
Chemical	Rate	Mean Initial Damage Rating Per Plot 7/14	Mean Damage Rating Per Plot 7/28[a]	Mean Plot Damage Rating Change[a]	Mean Damage Rating Per Plant 7/28[a]	Mean Harvest Weight Per Plot (Lbs/40 ft)
DPX-EY059	.4#ai/A	2.2	2.5 bc	+0.3 ab	2.7 bc	44.6
DPX-EY059	.8#ai/a	2.5	2.8 bc	+0.3 ab	3.2 abc	40.3
UC 84572	.01#ai/A	3.0	3.3 ab	+0.3 ab	3.6 ab	42.1
UC 84572	.03#ai/A	2.3	2.0 bc	-0.3 ab	2.9 abc	51.1
Imidan 50WP	1.0#ai/A	2.5	1.7 c	-0.8 b	2.6 bc	45.4
Furadan 4F	1.0#ai/A	2.8	2.0 bc	-0.8 b	2.5 bc	44.1
Asana	.5#ai/A	2.5	2.2 bc	-0.3 ab	2.5 bc	42.8
Asana & PBO	.5#ai/A 1.0#ai/A	2.5	2.2 bc	-0.3 ab	2.2 c	50.1
Rotenone & PBO	.4#ai/A .7#ai/A	2.5	2.0 bc	-0.5 b	2.2 c	47.3
Untreated		2.5 *NS	3.8 a	+1.3 a	3.9 a	39.3 *NS

[a] Means followed by the same letter are not significantly different at the .05 level.

*NS Means are not significantly different at the .05 level.

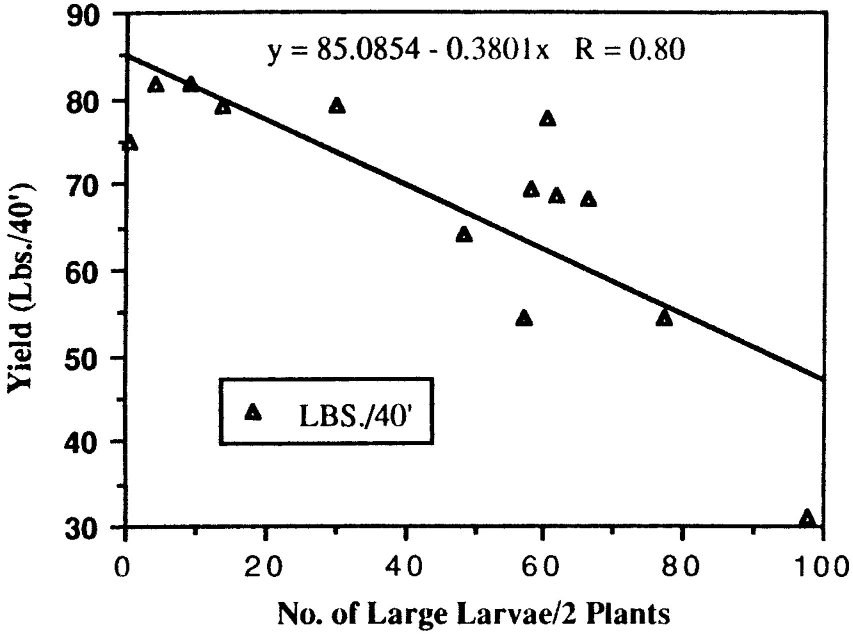


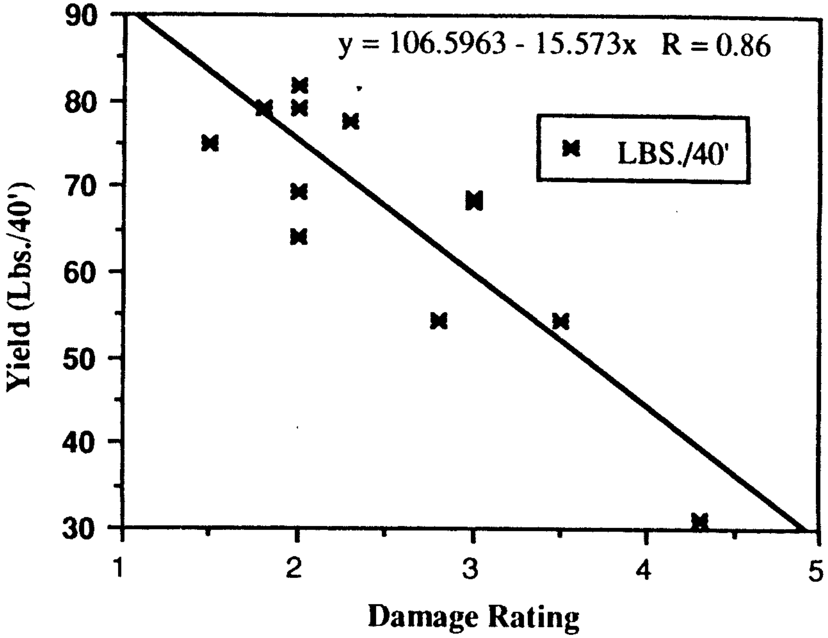




TREATMENT NUMBER	CHEMICAL	RATE (LB ai/A)
1	DPX-EY059	0.4
2	DPX-EY059	0.8
3	M-1	1 Qt/A
4	M-1	2 Qt/A
5	M-1	3 Qt/A
6	M-1	4 Qt/A
7	UC 84572	0.01
8	UC 84572	0.03
9	Imidan 50WP	1.0
10	Furadan 4F	1.0
11	Asana	0.5
12	Asana &	0.5
	PBO	1.0
13	Untreated	

Figure 3. Number of large Colorado potato beetle larvae per two plants, plot damage ratings, and harvest weights (lbs. per 40 ft) in different treatments in potatoes.





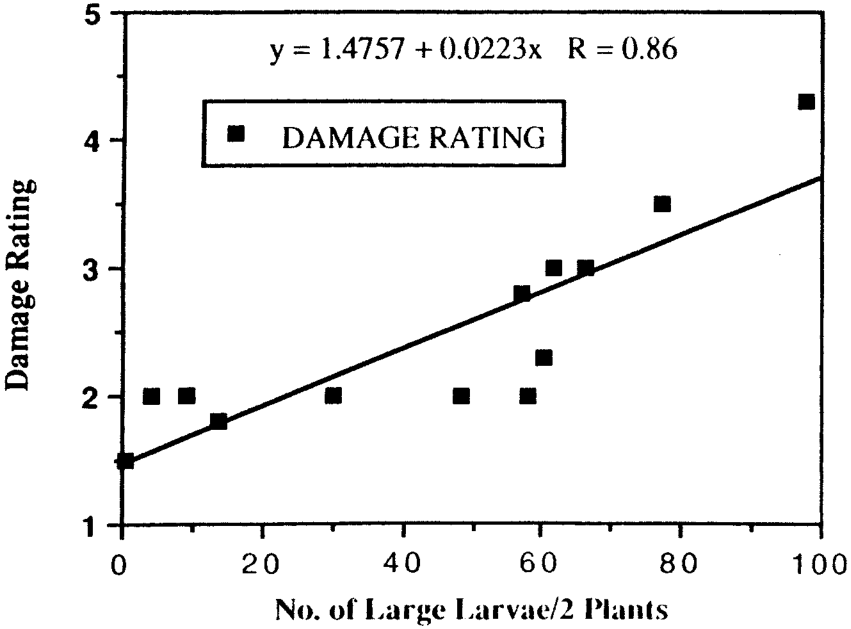


Figure 4. The relationship between the number of Colorado potato beetle large larvae per two plants, the plot damage rating, and the harvest weights (lbs. per 40 ft) in potatoes.

Funding: MPIC

Evaluation of Edovum puttleri Grissel for Biological Control of the Colorado Potato Beetle

Frank Drummond and Debbie Miller
Department of Entomology

A study was conducted to evaluate the potential of Edovum puttleri Grissel to control the Colorado potato beetle in Michigan. Edovum puttleri is a small Eulophid wasp that both parasitizes and feeds upon the eggs of the Colorado potato beetle. It is not a native animal of the U.S. and will not overwinter here. Since 1983 the USDA has made Edovum puttleri a priority biological control project. Since the parasitoid can not overwinter, a mass rearing facility has been set up in Brownsville, Texas. The strategy is to supply potato growers with this parasitoid on an annual basis. Researchers from different regions of the country have evaluated the effectiveness of this parasite to control the Colorado potato beetle on potato, eggplant, and tomato. There have been encouraging reports of its capability for biological control on eggplant in New Jersey and on potato in Maryland. Our objectives were to evaluate this parasitoid under Michigan growing conditions. The justification for this research lies in the tremendous ability of the Colorado potato beetle to develop resistance to insecticides.

METHODS:

In 1986, research was conducted at the Kellogg Biological Station in Hickory Corners, MI. Releases of adult E. puttleri were made in 1/8 acre plantings of Russett Burbank potato and Black Beauty eggplant. Potatoes were planted on May12 and eggplants were transplanted on June 7. No pesticides were applied to the research plots. Weed control was performed by hand and tractor cultivation. Parasitoids were obtained from the USDA-APHIS facility at Brownsville, Texas. A total of eight thousand parasitoids were released seven times during the egg laying period of the Colorado potato beetle. Eggs were sampled 2-3 times a week for parasitism and seasonal percent parasitism was calculated using an algorithm we developed specifically for estimation of field-level parasitism by E. puttleri.

In 1987, research was conducted at both the Kellogg Biological Station in Hickory Corners, MI and at the Montcalm Potato Research Farm. At the Kellogg Biological Station field experiments were designed to evaluate: 1) the efficacy of this parasitoid parasitizing Colorado potato beetle eggs associated with potato versus eggplant (a repeat of the 1986 experiment), and 2) the effect of the size of the potato plant on parasitoid search efficiency for eggs. This second experiment involved the use of 10x10 m plots replicated three times, planted so that every other potato plant within and between rows was planted on May 15 and the other planted on June 5. Three releases of 500 parasitoids per plot were made during the Colorado potato beetle's egg laying period. Laboratory experiments were also conducted at Kellogg. These were designed to test the effect of the presence of a nectar source on the longevity of the adult parasitoids and evaluate the effect of soil moisture and soil texture on adult parasitoid longevity.

At the Montcalm Research Farm we released E. puttleri inorder to evaluate the parasitoid under Michigan potato production practices (except insecticides). A 1/8 acre planting of Russett Burbank potatoes spaced 12" apart within thw row and 30" between rows was used for the release of 2,000 adult parasitoids on each of three dates (June 6, June 20, and July 4). Density estimates of Colorado potato beetle egg masses both unparasitized and parasitized were made every two weeks. Parsitoids were obtained from the USDA-APHIS facility at Brownsville, Texas.

RESULTS:

1986

Figure 1 shows the results of estimates of parasitism of Colorado potato beetle eggs by E. puttleri for both potato and eggplant, not corrected for differential residence times. The development time of a parasitized egg mass (time that it takes for parasites to emerge from an egg) is approximately 4.5 times longer than the time required for unparasitized egg masses to hatch. Therefore, if sample estimates of parasitism are considered without correcting for this differential in residence time then greatly inflated estimates of parasitism will result. Figure 1 shows that parasitism on both potato and eggplant appeared to be 100% by the end of the season. Figure 2 shows the corrected percent parasitism estimates along with density estimates of Colorado potato beetle egg masses on both eggplant and potato (a physiological development time model based on degree days with a base temperature of 10 C is used to correct seasonal egg mass densities). The resulting parasitism turns out to be only 12.5% in potato and 23% in eggplant. There are two significant points about this data that are worth mentioning. The first is that single point estimates of parasitism or seasonal estimates that exhibit bias due to differential residence time will yield extremely inaccurate results. Unfortunately, much of the previous research in the U.S. designed to evaluate this parasitoid has not addressed this issue and as a result unwarranted optimism about the effectiveness of this parasitoid has prevailed. This has had as a consequence a focus on E. puttleri by the USDA which has excluded other potential candidates for biological control.

Another point that we feel is important, since it relates to the effectiveness of this parasitoid as a biological control agent, is its better performance on eggplant (23% parasitism) than on potato (12.5%). This finding has also been documented by Dr. J.H. Lashomb in New Jersey. In fact, all of his research with this parasitoid is aimed at biological control of the Colorado potato beetle in eggplant not potato because of the consistently higher parasitism rates on eggplant. Three reasons are speculated for this phenomenon. The first, is that eggplant is more closely related to the host plant that the particular race of E. puttleri the USDA is using is associated with in the wild. The feeling is that this parasitoid may que in on host plant volatiles as part of its searching behavior. Another is that eggplant being a transplanted crop, is planted later in the season than potato, resulting in some regions of the country a later colonization by the potato beetle. It is felt that the warmer temperatures associated with the delay in colonization and hence the warmer temperatures at the time of parasitoid release needed for control in eggplant versus potato could be an important factor in better parasitoid performance. The third possible explanation as to why this parasitoid performs better in eggplant production than in potato production is due to the difference in plant architecture, mainly foliage density. A potato plant in June that was planted at the end of April will have significanly more foliage leaf area per plant than a newly transplanted eggplant. Since these parasitoids search the individual leaves for potato beetle egg masses foliage density could be an important factor. We designed our 1987 field and laboratory experiments to test some of these hypotheses and to evaluate E. puttleri under Michigan commercial potato production practices.

1987

We were not able to recover any parasitized egg masses from the first field release in either Montcalm or at the Kellogg Biological Station in 1987. The parasitoids were not handled in any way different from 1986. We did observe, however, that upon relese many of the parasioids that hopped on to the ground appeared to have difficulty flying. Inspection of some of these animals under the microscope revealed that they were covered with dust particles. The spring of 1987 was an extremely dry one and the soil surface was quite dusty. We designed a laboratory experiment to assess the impact of dry soil conditions on the survival of these adult parasitoids, the results are shown in fig. 3a. It can be seen that survival is much greater in wet soil than in dry dusty soils. This has serious implications if E. puttleri is to be used as an insecticide under a variety of conditions. Subsequent releases of this parasitoid were not made at Montcalm due to a mistake that was made in applying Furidan on our plots. Releases were continued at the Kellogg Biological Station, but significant parasitism did not result. Because of this we were not able to test the effect of plant size on parasitoid efficiency. It appeared in these releases that the parasitoids were dispersing out of the plots without searching for egg masses to parasize. Dr. David Ferro at the University of Massachusetts has shown that In its native habitat in South America E. puttleri is attracted to and feeds on insect honey dew and nectar. He has also observed E. puttleri associated with aphids and their honey dew in potato fields. As we were not using insecticides in any of our plots aphids were not present nor were any nectar bearing plants. It is possible that these sources of sugar keep the parasitoid from dispersing. A laboratory study we conducted shows that honey substituted as a nectar source has a significant effect upon parasitoid longevity (fig. 3b).

CONCLUSION:

The inability of E. puttleri to overwinter in the United States restricts the ways in which it can be utilized. Basically, it has to be mass reared and released on an annual basis similar in many ways to the use of an insecticide. Apart from this major draw back, the parasitoid is just not effective for control of the Colorado potato beetle on potato in Michigan. It may , however, be important as a biological control agent on eggplant or on potato in the southern states. Temperature is a major consideration since the adult parasitoids are not active at temperatures less than 17 C. We have shown that soil moisture and the presence of a nectar source can have a significant effect upon its longevity. Because all these factors appear to be important in affecting the degree of biological control by this parasitoid, we feel that more emphasis has to be placed on the exploration for and evaluation of biological control agents for the Colorado potato beetle, over and above the effort which now exists for E. puttleri. There is no doubt that insecticide resistance will be a major threat to the Michigan potato industry in the very near future. Research and implementation of biological control must begin now.

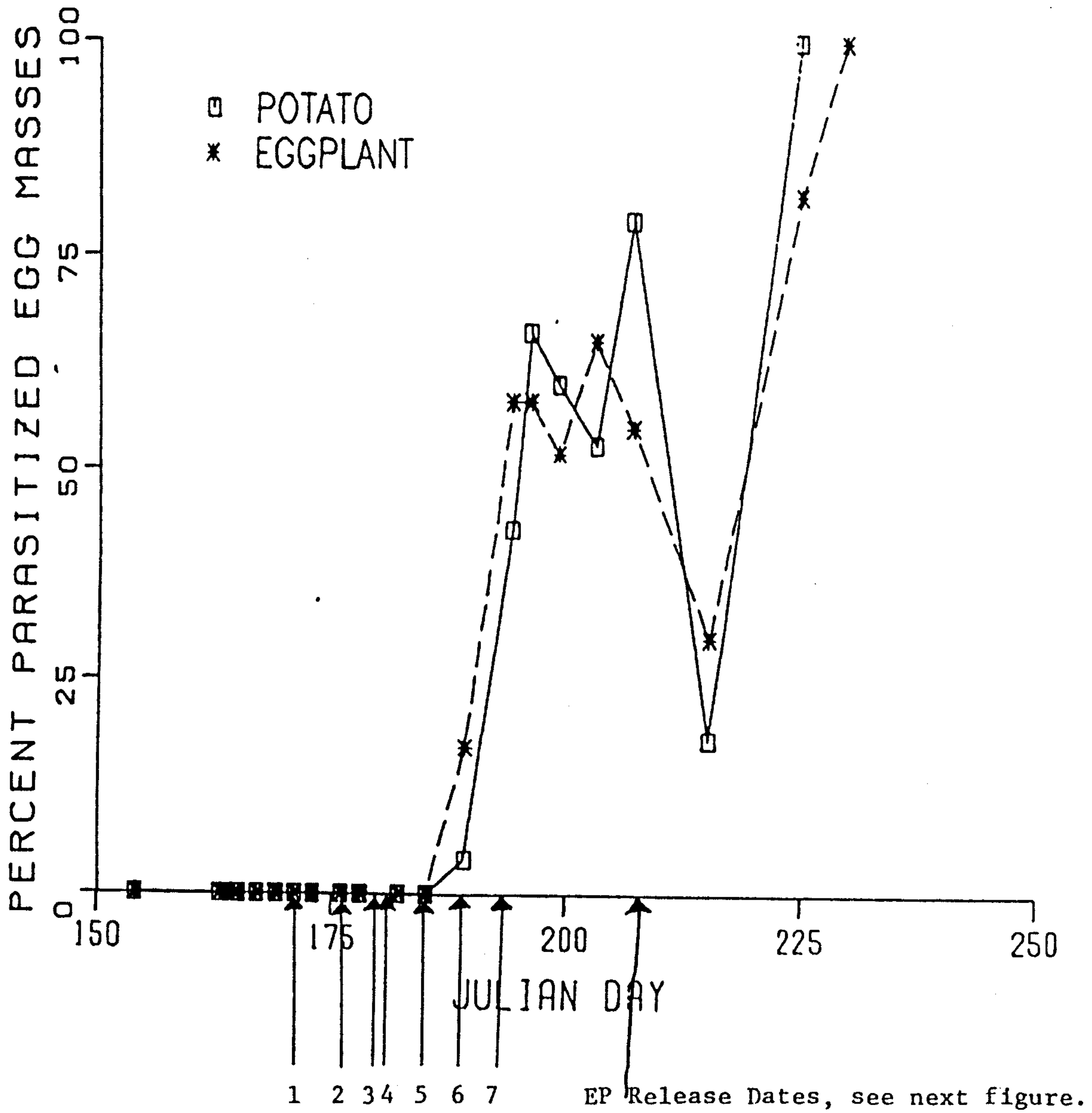
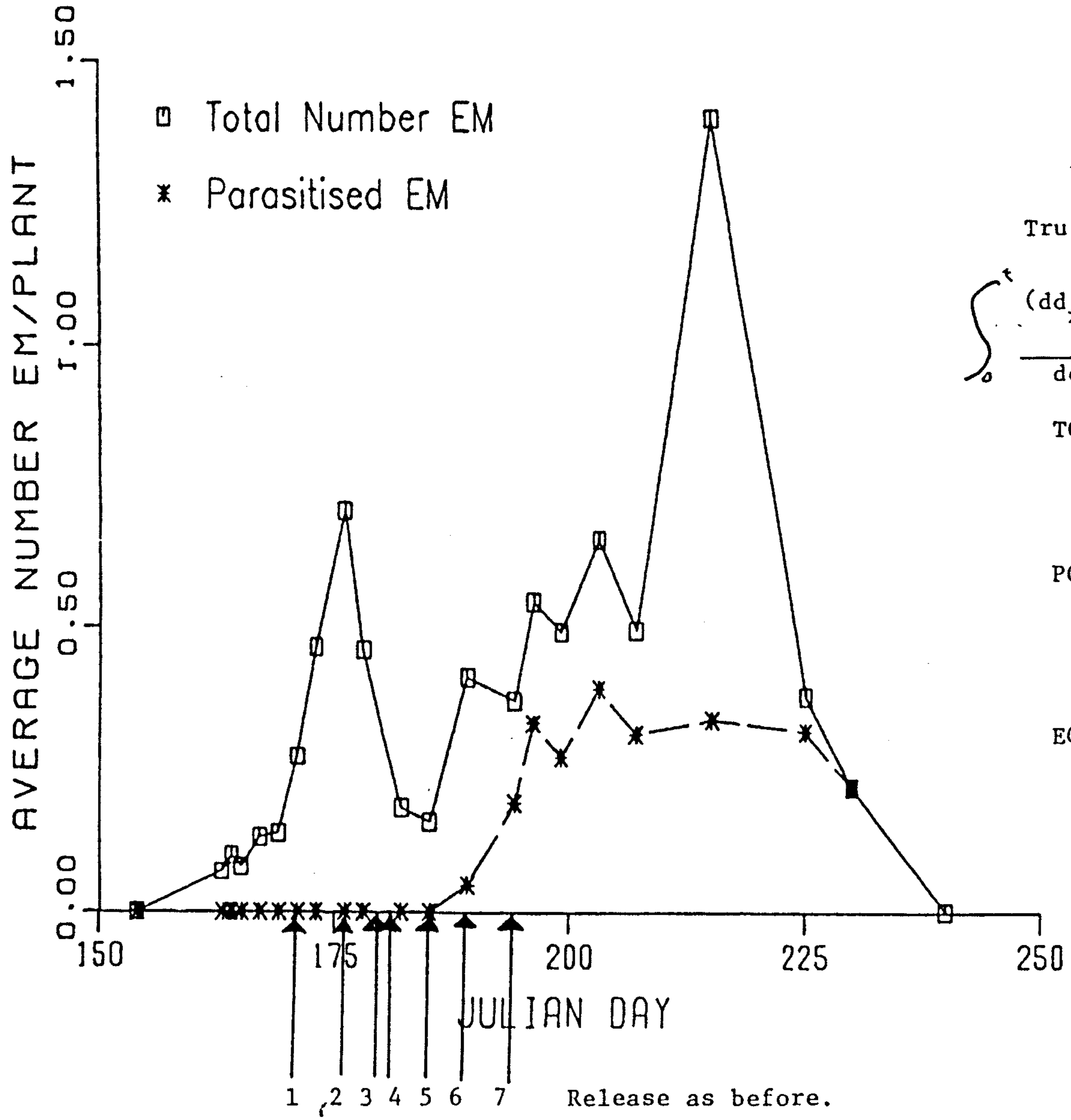


Fig. 1. Uncorrected estimates of E. puttleri parasitism, 1986.

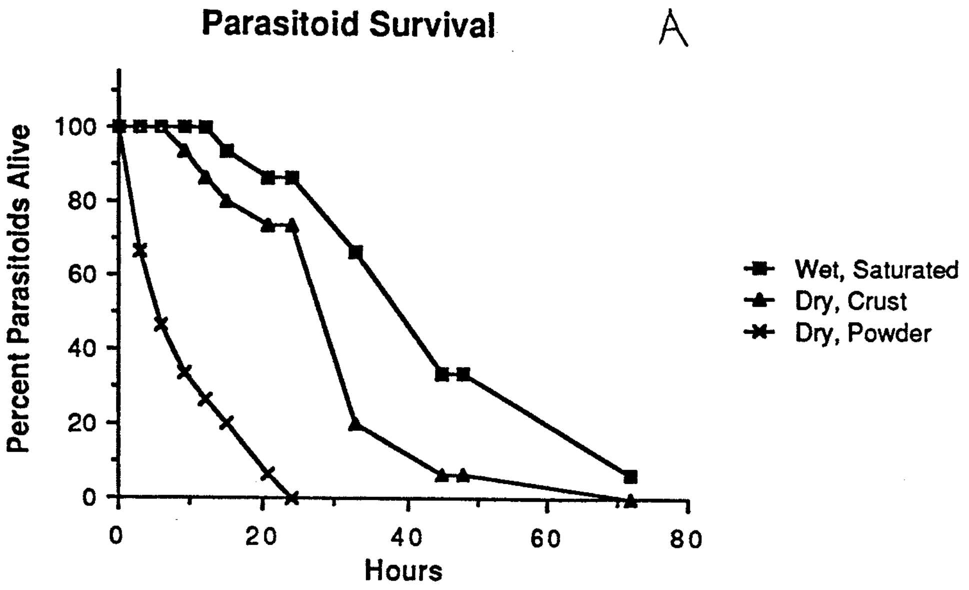


True Seasonal Density as determined by:

$$\int_0^t \frac{(dd_x - dd_{x-1})\left(\frac{N_x + N_{x-1}}{2}\right)}{\text{dd residency}}$$

	# EM	%
TOTAL PLOT		
parasitized	243	18
unparasitized	1100	
POTATO ONLY		
parasitized	78	12.5
unparasitized	546	
EGGPLANT ONLY		
parasitized	168	23.0
unparasitized	553	

Fig. 2. Corrected *E. puttleri* parasitism estimates, 1986.



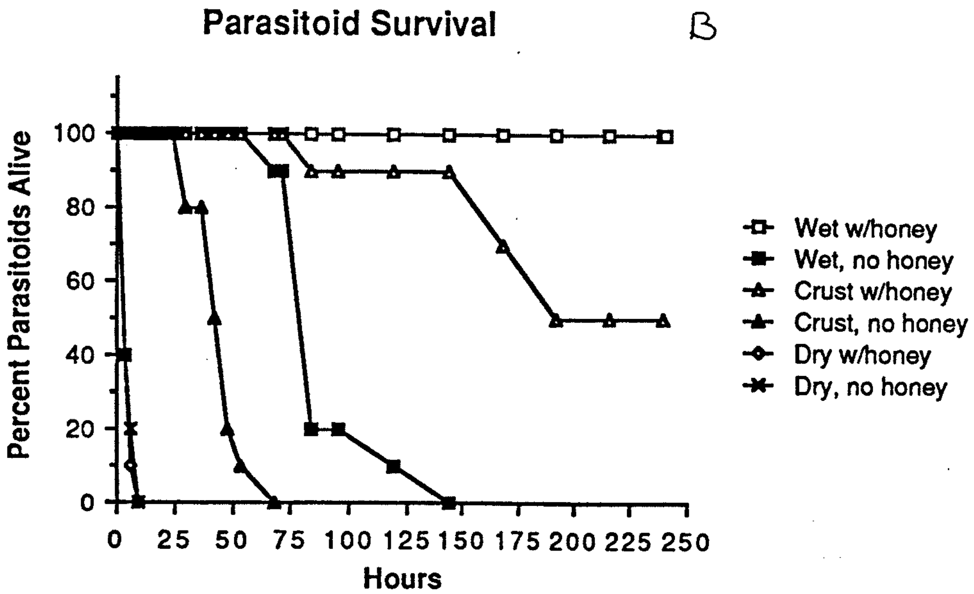


Fig. 3a,b. Laboratory studies on the effect of a: soil moisture and texture, and b: nectar source and soil condition; on survival of E. puttleri adults.

EFFECT OF INCREASING NITROGEN RATES UPON PRODUCTION OF RUSSET BURBANK POTATOES IN THE UPPER PENINSULA 1987

R.H. LEEP
Department of Crop & Soil Sciences
Michigan State University

This study was continued from the previous year to evaluate the effect of increasing nitrogen rates upon the production of russet burbank potatoes grown in the Upper Peninsula. Several differing opinions by growers about how much nitrogen should be used for optimum yields has lead to questions about current recomended rates by Michigan State University. Another problem which is being addressed by this study is that of the difficulty of potato vine killing at harvest using a dessicant. The effect of nitrogen rates is being evaluated in this study.

PROCEDURE

The study was established on the Paul VanDamme Farm in Marquette County on an Onaway Sandy loam. The previous crop was alfalfa which was fall plowed. The treatments were arranged in a randomized complete block experimental design with 4 replications. 1000 pounds of 6-24-24 per acre was applied in the row at planting. Nitrogen treatments consisted of 0, 60, and 120 pounds nitrogen per acre sidedressed applied as Ammonium Nitrate. This gave a total of 60, 120, and 180 pounds nitrogen per acre for the treatments. Potato petiole sampling was done on July 21 and August 17 and analyzed for nitrate content. All plots were rated for percent vine kill with diquat herbicide to determine the effect of nitrogen rate upon the efficacy of diquat. The plots were planted on May 2 and harvested on October 2, 1987.

RESULTS

Yields, percent size distribution, and specific gravity is given in Table 1. Nitrogen rate had a very significant affect upon the total yield of tubers with the 180 lb./A Nitrogen treatment resulting in the highest yield. The same treatment resulted in a significantly higher yield of No. 1 tubers than the 60 lb./A Nitrogen treatment but not the 120 lb./A Nitrogen treatment. There was no significant difference in size distribution between treatments with the exception of over ten ounce tubers where the 60 lb./A Nitrogen treatment resulted in a higher percentage of over 10 oz. tubers. Although specific gravity tended to decrease with increasing rates of Nitrogen there was no significant differences between treatments.

The influence of Nitrogen treatments upon potato vine kill with Diquat is given in Table 2. Ratings of percent vine kill were made 5, 8, and 14 days after the initial one pint per acre Diquat was applied on September 20. A second treatment of Diquat at one pint per acre was applied on September 26, 1987. Ratings at 5 days after the initial one pint application of Diquat showed vine kill ranged from 40 to 65 percent. At 14 days after two pints per acre Diquat was applied the vine kill ranged from 70 to 97 percent. The percent vine kill decreased with increasing nitrogen applications. The decrease in vine kill with the higher nitrogen treatments resulted from much greater vine growth of these treatments. Rank growth of foliage and vines with higher nitrogen rates is probably one of the main reasons some growers experienced difficulty in vine kill with Diquat this past year.

In summary, potato yields were significantly affected by nitrogen treatments with the 180 lb./A Nitrogen treatment resulting in the highest total and number 1 tuber yield. Increased nitrogen rate resulted in decreased vine kill from applied Diquat herbicide.

Table 1. Influence of nitrogen fertilizer upon yield, size distribution and specific gravity upon Russet Burbank potatoes in the Upper Peninsula

	Yields cwt/A		Percent Size Distribution					
Nitrogen Rate lb. N/A	Total	No. 1	No. 1	Under 2"	2" to 3 1/4"	Over 3 1/4	Pick Outs	Specific Gravity
60	374 c	249 b	67	14	33	34 A	19	1.086
120	436 b	292 ab	67	17	42	25 AB	16	1.084
180	494 a	342 a	69	15	46	23 B	16	1.083
Mean	435	294	68	15	40	27	17	1.084

1.) Means followed by different letters are significantly different as determined by the least significant difference test.

Table 2. Influence of nitrogen fertilizer upon efficency of vine kill with diquat herbicide

Nitrogen Rate lb. N/A	Days after diquat application		
	5	8	14
		% Vine Kill	
60	65	80	97
120	55	65	78
180	40	50	70

1.) Diquat herbicide applied at 1 pint on 9/20 and 9/26.

Funding: MPIC

NITROGEN MANAGEMENT STRATEGIES FOR RUSSET BURBANK POTATOES

M.L. Vitosh, D.A. Hyde, B.P. Darling, and B.C. Joern
Crop and Soil Sciences Department
Michigan State University

Introduction

Potatoes are a shallow rooted, highly irrigated crop grown on coarse textured soils. These factors and the high nitrogen (N) requirement of the crop make nitrogen management a critical practice in the prevention of groundwater contamination. There is a need to develop effective N management strategies that will reduce the potential for nitrate leaching and maintain high yields. The primary objective of this study was to evaluate several N management strategies for maintaining high yields while limiting the amounts of fertilizer N left in the soil, thereby minimizing the potential for groundwater contamination through nitrate leaching.

Procedure

A long term study was initiated in 1986 at the Montcalm Research farm on a Montcalm-McBride sandy loam soil to evaluate different strategies for N management. A three year rotation sequence of potatoes-rye-corn-rye was established. The potato part of the rotation consisted of 6 N treatments (2 N rates and 4 splits). The split applications in 1987 were; at planting on April 28, and topdressing on June 10, July 9, and August 10. The experimental design was a randomized complete block with 4 replications.

In 1987, corn was grown on the 1986 potato area without the addition of any fertilizer or irrigation water, to determine the crops ability to remove any residual N left over from the 1986 potato crop.

Soil samples were taken to a depth of 3 feet before and 4 feet after the experiment for both the potato and corn studies. The samples were analyzed for ammonium and nitrate to determine the inorganic N levels in the soil prior to planting and to account for the residual fertilizer N left in the soil after harvest.

1987 Results

The potato yield data are shown in Table 1. Neither yield nor tuber size was significantly affected by the rate of N or time of application. We conclude that 180 lbs of N was sufficient for optimum yields of Russet Burbank's on this site in 1987. A similar finding was observed in 1986.

The soil nitrate and ammonium data in Table 2 may help to explain the lack of response to the highest rate of N or to the time of N fertilizer application. An average of 3.6 (ppm) parts per million pounds of nitrate N and 1.6 ppm of ammonium was found in the 3 foot spring samples. This represents 43 lbs of nitrate N and 19 lbs of ammonium N for a total of 62 lbs of residual inorganic N in the 3 foot profile. This is twice as much as was observed in 1986 prior to planting. This amount of residual N is difficult to explain in light of the extremely wet fall of 1986. The excess rainfall in the fall of 1986 should have leached nearly all of the nitrate N from the profile. One explanation may be that the rye crop in 1986 was not removed but was clipped and all residues returned to the soil surface.

At the end of the season much higher levels of nitrate and ammonium were found in the profile and the concentrations of nitrate were directly related to the amount of total N fertilizer applied. An average of 11.7 ppm of nitrate was found in the 4 foot profile of plots treated with 180 lbs of N fertilizer, while plots treated with 240 lbs of N averaged 15.0 ppm. This represents 187 lbs and 240 lbs of nitrate N in the 4 foot profile, respectively. Because we sampled only 3 feet in the spring prior to planting, we can only calculate the change in the top 3 feet of the profile. Our calculation show an average increase of 112 lbs of N in the 180 lb N plots compared to 147 lbs of N for the 240 lb N plots. Stated another way, only 68 and 93 lbs of the applied N is unaccounted for. A 300 cwt yield of potatoes contains approximately 100 lbs of N, thus we conclude that after remove of the crop our balance shows that very little N was lost from the 3 foot profile by leaching during the growing season.

Two sources of N change in soils, which we cannot account for in this study, is N mineralization and N immobilization from soil organic matter. However, most researchers believe that heavily fertilized soils have already reached a steady state condition and that immobilization is equal to mineralization. If this assumption is correct, then our statement that very little N was leached from the soil profile during the growing season is correct. The greatest potential for loss of N by leaching comes after harvest.

The second part of our study was to find out how much residual N could be recovered by next years corn crop. Corn was planted on the 1986 potato site. This site was seeded to rye after potatoes in the fall of 1986, however the rye obtained very little growth in the fall and less than 6 inches of grow in the spring before it was killed with a herbicide to plant no-till corn. No irrigation water was applied to allow the crop to root as deep as possible and to minimize expenses.

The corn yield data are shown in Table 3. Yields ranged from 90 to 107 bushels per acre but these values were not significantly different from each other due to high variability.

Plant population , grain moisture and percent barren stalks at harvest were also unaffected by the previous years treatments.

Data on nitrate and ammonium in soil samples prior to planting and after corn harvest are shown in Table 4. There is a slight decline in the amount of N in the profile from spring to fall, but only small amounts of inorganic N were found in the spring of 1987 (an average of 5.6 ppm nitrate and 1.6 pm ammonium for all plots). This however, does represent 67 lbs of nitrate N and 20 lbs of ammonium N for a total of 87 lbs of N in the 3 feet profile for the spring sampling. Only 35 lbs of nitrate N was found in the three foot profile in the fall of 1986 after 16 inches of rain. The only explanation of the slight build up of nitrate between the fall of 1986 and spring of 1987 is that some of the variation may be due to sampling procedures and storage, some small amount of mineralization from organic matter or possible additions of N in winter precipitation. All three may be responsible for the small change.

Data on fresh weight of corn stalks and ears harvest on September 1, 1987 and their respective N contents are shown in Table 5. The previous years N applications did not significantly affect fresh weight or N content. Table 6 shows the calculated dry matter yields and N uptake. These data likewise are not significantly associated with the previous years N application treatments. Nearly 100 lbs of N was found in the above ground corn crop on September 1 in all plots regardless of the previous years application.

We conclude that the 1987 corn crop grown without added N fertilizer or irrigation water was able to take up a significant amount of N (nearly 100 lbs) that may potentially have been leached to groundwater. We would estimate that approximately 40 of the 100 lbs of N may have come from mineralization of soil organic matter. The remaining 60 lbs of N represent approximately 70 % of the residual N (87 lbs) found in these plots in the spring of 1987. We might also conclude that approximately 30 % or 26 lbs of N is unaccounted for. Better accounting of the fate of N fertilizer can only be obtained with the use of isotopically labeled fertilizers. Deep rooted crops such as corn and alfalfa have greater potential for removing large quantities of residual N. The potential for corn to remove residual N; however, will be limited if applications of N fertilizer are applied to the crop.

We would also conclude that most of the residual nitrate remaining after potatoes reached maturity in the fall 1986 was lost before the fall soil samples were taken in that year. In the fall of 1987, the nitrates were still in the profile at the time of sampling. These plots will again be sampled in the spring of 1988 to determine how much nitrate N has been lost over winter. The plots will also be cropped with corn to determine the amount of residual N that can be recovered.

Table 1. The effect of N rate and application time on yield of Russet Burbank potaotes grown on a Montcalm-McBride sandy loam soil.

N fertilizer rate [1]					Yield [2]					
N application date					Size distribution					
4-28	6-10	7-09	8-10	Total N	Off type	Under 4 oz.	4-10 oz.	Over 10 oz.	U.S. no.1	Total yield
lbs. N per acre					cwt. per acre					
60	60	60	0	180	72	50	164	18	182	304
60	60	60	60	240	71	64	161	15	176	311
120	60	0	0	180	63	47	165	22	187	297
120	60	60	0	240	73	50	152	17	169	292
60	120	0	0	180	70	44	185	19	204	318
60	120	60	0	240	70	52	151	24	175	297

1 All treatments received 60 lbs of N per acre through the planter. All other amounts of N fertilizer were topdressed as amonium nitrate over the row.

2 None of the means were found to be statistically significant at the .05 probability level.

Table 2. Spring and fall soil nitrate and ammonium levels as influenced by rate and time of 1987 nitrogen fertilizer applications to Russet Burbank potatoes grown on a Montcalm-McBride sandy loam soil.

N fertilization rate					Nitrate and ammonium levels						
N application date				Total	Soil	Soil sample collection time					
						Spring [1]		Fall [2]		Difference	
4-28	6-10	7-09	8-10	N	depth	$NO3^-$	$NH4^+$	$NO3^-$	$NH4^+$	$NO3^-$	$NH4^+$
lbs. N per acre					-in-	parts per million					
60	60	60	0	180	0-12	5.67	3.40	18.10	3.65	12.43	0.25
					12-24	3.19	0.87	11.04	0.13	7.85	-0.74
					24-36	2.13	1.01	8.83	0.00	6.70	-1.01
					36-48	—	—	8.32	0.33	—	—
					Average	3.66	1.76	11.57	1.03	8.99	-0.50
60	60	60	60	240	0-12	6.39	4.25	22.91	2.49	16.52	-1.76
					12-24	2.76	0.56	16.15	0.05	13.39	-0.51
					24-36	1.61	0.41	13.69	0.00	12.08	-0.41
					36-48	—	—	12.89	0.10	—	—
					Average	3.59	1.74	16.41	0.66	14.00	-0.89
120	60	0	0	180	0-12	5.34	3.14	20.45	3.51	15.11	0.37
					12-24	3.00	1.01	11.35	0.34	8.35	-0.67
					24-36	2.00	0.48	6.96	0.00	4.96	-0.48
					36-48	—	—	6.08	0.07	—	—
					Average	3.45	1.54	11.21	0.98	9.47	-0.26
120	60	60	0	240	0-12	5.56	3.74	18.62	2.07	13.06	-1.67
					12-24	2.75	0.23	12.14	0.27	9.39	0.04
					24-36	1.43	0.21	13.25	0.00	11.82	-0.21
					36-48	—	—	11.88	0.14	—	—
					Average	3.25	1.39	13.97	0.62	11.42	-0.61
60	120	0	0	180	0-12	6.60	3.68	18.22	1.45	11.62	-2.23
					12-24	3.28	0.99	12.37	0.08	9.09	-0.91
					24-36	1.81	0.28	9.44	0.00	7.63	-0.28
					36-48	—	—	8.96	0.28	7.63	-0.28
					Average	3.90	1.65	12.25	0.45	9.45	-1.14
60	120	60	0	240	0-12	6.60	4.12	21.54	3.86	14.94	-0.26
					12-24	3.05	0.30	11.93	0.34	8.88	0.04
					24-36	1.99	0.63	11.90	0.02	9.91	-0.61
					36-48	—	—	13.31	0.18	—	—
					Average	3.88	1.68	14.67	1.10	11.24	-0.28

1 Sampled April 20, 1987
2 Sampled October 15, 1987

Table 3. 1987 grain yield and other selected characteristics of Pioneer 3744 corn grown on the 1986 potato site without fertilizer or irrigation water.

1986 N rate [1]					Selected characteristics [2]			
N application date				Total	Plant	Grain	Grain	Barren
5-15	6-15	7-15	8-15	N	population	moisture	yield	stalks
lbs. N per acre					plants per acre	--%--	bu per acre (15% H2O)	--%--
60	60	0	0	120	22825	31.3	90.6	9.1
60	60	60	0	180	22738	31.8	106.7	-1.5
60	60	0	60	180	22913	30.7	102.5	12.1
60	60	60	60	240	22303	30.9	96.0	4.5
120	60	60	0	240	21867	31.4	94.7	7.5
120	60	0	60	240	21519	31.4	107.2	-1.8

1 No nitrogen fertilizer or irrigation water was applied in 1987.
2 None of the treatment means were found to be statistically different at the 0.05 probablity level.

Table 4. Spring and fall soil nitrate and ammonium levels as influenced by 1986 fertilization rate and uptake by Pioneer 3744 corn on a Montcalm-Mcbride sandy loam soil.

1986 N rate						Nitrate and ammonium levels					
						Soil sample collection time					
N application date				Total	Soil	Spring [1]		Fall [2]		Difference	
5-15	6-15	7-15	8-15	N	depth	NO_3^-	NH_4^+	NO_3^-	NH_4^+	NO_3^-	NH_4^+
lbs. N per acre					-in-	parts per million					
60	60	0	0	120	0-12	6.76	4.38	4.16	1.88	-2.60	-2.50
					12-25	3.38	0.35	3.42	0.02	0.04	-0.33
					24-36	4.31	0.15	3.26	0.07	-1.05	-0.08
					36-48	---	---	4.11	0.10	---	---
					Average	4.82	1.63	3.74	0.52	-1.20	-0.97
60	60	60	0	180	0-12	7.71	3.19	5.12	2.03	-2.59	-1.16
					12-24	6.83	0.34	3.34	0.19	-3.49	-0.15
					24-36	3.62	0.39	3.96	0.21	-2.54	0.03
					36-48	---	---	5.17	0.05	---	---
					Average	6.05	1.31	4.40	0.62	-2.87	-0.43
60	60	0	60	180	0-12	7.56	5.85	5.07	2.37	-2.49	-3.48
					12-24	3.62	0.39	3.96	0.21	0.34	-0.18
					24-36	4.75	0.37	3.05	0.11	-1.70	-0.26
					36-48	---	---	3.99	0.03	---	---
					Average	5.31	2.20	4.02	0.68	-1.28	-1.31
60	60	60	60	240	0-12	6.78	2.42	5.00	1.96	-1.78	-0.46
					12-24	3.92	0.04	3.88	0.09	-0.04	0.05
					24-36	5.12	0.09	3.39	0.02	-1.73	-0.07
					36-48	---	---	4.54	0.14	---	---
					Average	5.27	0.85	4.20	0.55	-1.18	-0.16
120	60	60	0	240	0-12	8.42	2.97	4.80	2.02	-3.62	-0.95
					12-24	4.04	0.42	4.08	0.12	0.04	-0.30
					24-36	4.34	0.32	3.62	0.00	-0.72	-0.32
					36-48	---	---	4.11	0.02	---	---
					Average	5.60	1.24	4.15	0.54	-1.43	-0.52
120	60	0	60	240	0-12	8.73	6.88	5.30	2.07	-3.43	-4.81
					12-24	5.48	0.57	3.55	0.22	-1.93	-0.35
					24-36	5.62	0.38	3.38	0.04	-2.24	-0.34
					36-48	---	---	3.23	0.06	---	---
					Average	6.61	2.61	3.86	0.60	-2.53	-1.83

1 Sampled April 20, 1987.
2 Sampled October 15, 1987.

Table 5. Fresh weight and N content of corn stalks and ears for Pioneer 3744 corn grown on the 1986 potato site without fertilizer or irrrigation water. (Sampled 9-01-87)

1986 N rate: N application date 5-15	6-15	7-15	8-15	Total	Fresh Weight: Stalks	Ears	N content: Stalks	Ears
lb. N per acre					lb/10 plants[1]		%[1]	
60	60	0	0	120	6.6	4.5	.72	1.23
60	60	60	0	180	7.2	5.0	.76	1.34
60	60	0	60	180	6.9	4.5	.68	1.19
60	60	60	60	240	6.1	4.4	.71	1.23
120	60	60	0	240	6.9	4.6	.68	1.25
120	60	0	60	240	7.0	4.8	.74	1.32

1 None of the treatment means were determined to be significantly different at the 95 % probability level.

Table 6. Dry matter and N uptake data for Pioneer 3744 corn grown on the 1986 potato site without fertilizer or irrigation water.

1986 N rate: N application date 5-15	6-15	7-15	8-15	Total	Dry matter yields: Stalks	Ears	Total	N uptake: Stalks	Ears	Total
lb. N per acre					lb. per acre[1]					
60	60	0	0	120	4058	4815	8873	28.8	59.1	87.9
60	60	60	0	180	4535	5710	10245	34.8	78.0	112.8
60	60	0	60	180	4304	5164	9469	29.2	61.4	90.6
60	60	60	60	240	4048	4924	8973	28.4	60.8	89.2
120	60	60	0	240	4524	5334	9859	30.7	67.6	98.3
120	60	0	60	240	4498	5580	10078	33.4	74.1	107.6

1 None of the treatment means were determined to be significantly different at the 95 % probability level.

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NITROGEN MANAGEMENT FOR POTATOES GROWN IN ORGANIC SOIL

Darryl D. Warncke
Department of Crop and Soil Sciences

Nitrogen fertilization of potatoes grown in organic soils has not been widely studied. Hence, the appropriate nitrogen rates to use for potatoes grown in organic soils are questionable. In an effort to gain useable information in this area, a nitrogen management study for potatoes was established in a Houghton muck on the Keilen Farm north of East Lansing, MI. Five potato cultivars, Atlantic, Superior, Norchip, Shepody and Russet Burbank, were grown with ten different nitrogen management treatments. The nitrogen managements were the main plots and consisted of combinations of nitrogen rates applied at one or more times during the growing season (see Table 1). Urea was broadcast and plowed under at rates from 40 to 120 pounds per acre prior to planting the potatoes. The Atlantic, Superior and Norchip potatoes were planted 6 inches apart and the Shepody and Russet Burbank potatoes were planted 8 inches apart in 25 foot rows 32 inches apart on May 15. The main plots were separated by a border row of potatoes.

On June 19 soil samples were taken from all nitrogen management plots. Since the potatoes had been hilled by the grower, samples were taken from the top 6 inches between the potato rows and in the hilled row. The soil samples were dryed at 55°C and then extracted with 1 N KCl. The extracts were analyzed for nitrate and ammonium. These soil samples were expected to reflect the effect of the nitrogen preplant broadcast treatments. Samples taken between the rows showed no significant differences in nitrate or ammonium concentrations (Table 1). However, the soil nitrate concentrations were consistently higher where 120 pounds of nitrogen per acre had been applied. Nitrate and ammonium levels were appreciably higher in the hilled soil. Although the nitrate-nitrogen concentrations were higher in the hilled soil where 120 pounds of nitrogen were applied, the differences between the various treatments were not as great as expected. The ammonium concentrations in the hilled soil were quite variable. The nitrogen concentrations in the no nitrogen plots were surprisingly similar to the treated plots. Perhaps the soil micro-organisms assimilated much of the applied nitrogen thus moderating the nitrate concentrations in the soil. At the same time an appreciable quantity of nitrate-nitrogen was apparently mineralized from the soil organic matter. After the soil samples were collected, appropriate nitrogen rates (middle rate listed in the tables) as ammonium nitrate were sidedressed in the plots.

On July 9 potato petioles were collected from all cultivars in all nitrogen plots. Petioles from the youngest fully expanded leaves were collected. After drying and grinding, the nitrate-nitrogen was extracted with 1 N KCl. The nitrate-nitrogen concentrations in these petioles reflected the effects of the preplant plus first sidedress nitrogen applications (Table 2). The nitrate concentration was consistently the highest across all five cultivars in plots which had received 120 pounds of nitrogen preplant plus 80 pounds sidedress. Table 3 shows the main effects. Across all five cultivars the petiole nitrate-nitrogen concentrations increased as the preplant nitrogen rate was increased, especially where the sidedress nitrogen rate was 40 pounds per acre. However, the nitrate-nitrogen concentrations at this stage of growth were more than adequate in all treatments. Petiole nitrate concentrations were highest in the Shepody and lowest in the Atlantic potatoes.

Potatoes in all plots were harvested on October 8. Diquat and copper had been used for vine killing about three weeks prior to harvest. Nitrogen management did not appear to have a significant effect on the rate of vine kill. The Shepody and Russet Burbank died slowly whereas the other cultivars were killed fairly easily. In fact, the Superiors had died naturally prior to spraying the vine killer. Yield and specific gravity data for the five cultivars are presented in Tables 4 to 8. Yields tended to be somewhat variable. This may have been related to the extremely hot weather during the 1987 growing season. Although irrigation was applied periodically some mid-day wilting did occur. With the Atlantics the nitrogen managements had no consistent effect on the total or No. 1 potato yields (Table 4). The highest yield of No. 1 potatoes occurred with 80 pounds of nitrogen preplant plus 40 sidedressed. Some of the nitrogen treatments did significantly increase the specific gravity. With the Superior potatoes, applying either 80 or 120 pounds of nitrogen per acre preplant followed with 80 pounds per acre sidedress produced significantly better yields of No. 1 potatoes (Table 5). Applying 120 pounds nitrogen per acre preplant produced the highest total yields but a higher percentage was of the less than 2 inch size. Specific gravities varied with nitrogen treatments but were not statistically significant. The highest yields of Norchip potatoes (Table 6) were produced with 80 pounds nitrogen per acre preplant plus 40 pounds sidedressed twice. However, 40 pounds nitrogen per acre preplant plus 40 pounds sidedressed produced nearly identical yields. Variability in yields makes it difficult to really determine which nitrogen management was the best. Specific gravities were increased slightly by some of the nitrogen treatments.

With Russet Burbank potatoes the highest yields occurred with 40 pound of nitrogen preplant plus 40 pounds sidedress followed by the 80 plus 40 treatment (Table 7). However, over all the nitrogen managements yields varied greatly and were extremely inconsistent. Although not significant specific gravities decreased with nitrogen additions. For Shepody the top potato yields occurred where 80 pounds of nitrogen was applied preplant followed by 40 pounds sidedress. The percentage of cull potatoes was quite high in Shepody due to many large misshapen tubers. Specific gravities were increased by all nitrogen managements.

In summary potato yields of all five cultivars were extremely variable and inconsistent relative to the various nitrogen treatments. In this study very good yields of Atlantic potatoes grown in a Houghton muck were produced with little or no supplemental nitrogen. Superior potatoes yielded best with relatively high rates of nitrogen, 160 to 200 pounds per acre. Norchip, Russet Burbank and Shepody produced the top yields with 80 to 120 pounds of nitrogen per acre. With the exception of Russet Burbank, nitrogen application increased the specific gravity of the potato tubers. Soil nitrate levels did not reflect well the nitrogen fertilizer treatments which raises the question as to what is happening to the applied nitrogen. As a whole this study was variable and inconclusive, but does indicate that potato cultivars respond differently to applied nitrogen when grown in organic soil.

Table 1. Effect of preplant nitrogen rate on the nitrate and ammonium-N concentrations in a Houghton muck under potato production.[z]

Nitrogen Management[y]	Between Rows		In Hill	
	NO_3	NH_4	NO_3	NH_4
lb N/A	--- lb N/A ---		--- lb N/A ---	
0	39	5.0	82	6.0
40 + 40 + 0	35	5.3	80	12.2
40 + 40 + 40	40	5.4	83	12.3
40 + 80 + 0	40	5.1	79	9.1
80 + 40 + 0	44	5.3	85	13.4
80 + 40 + 40	37	5.3	101	10.8
120 + 40 + 0	51	5.3	95	12.4
80 + 80 + 0	42	5.2	90	9.9
120 + 80 + 0	62	5.2	99	8.2
120 + 40 + 40	55	5.1	108	5.8
HSD .10	NS	NS	19	NS

[y] Nitrogen was applied as urea preplant + ammonium nitrate sidedressed on June 19 + July 9.

[z] Soil samples were taken from the top 8 inches either between the rows or in the hilled row.

Table 2. Nitrate-N petiole content in five potato cultivars as affected by the nitrogen management program.[z]

Nitrogen Management[y]	Cultivars				
	Atlantic	Superior	Norchip	Shepody	R. Burbank
lb N/A	-------- % NO_3-N in petioles ----------				
0	2.13	2.20	2.52	3.45	3.01
40 + 40 + 0	2.47	2.76	3.69	3.50	2.92
40 + 40 + 40	2.79	3.25	3.29	3.84	3.07
40 + 80 + 0	2.80	3.48	3.43	3.98	3.33
80 + 40 + 0	2.93	2.77	3.38	3.48	2.92
80 + 40 + 40	2.90	3.39	3.35	4.17	3.22
120 + 40 + 0	2.79	3.43	3.51	4.24	3.46
80 + 80 + 0	2.86	3.14	3.48	4.15	3.79
120 + 80 + 0	3.36	3.33	3.65	4.25	3.77
120 + 40 + 40	2.85	3.22	3.59	4.08	3.37
HSD .10	0.89	0.70	0.69	0.68	0.68

[y] Nitrogen was applied preplant as urea + ammonium nitrate sidedressed on June 19 + July 9.

[z] Petiole samples were collected prior to nitrogen sidedress applications on July 9.

Table 3. Effect of nitrogen application on the nitrate concentration of potato petioles.[z]

Nitrogen Applied Preplant	Sidedress	Petiole NO_3-N
- - - - - - - lb/A - - - - - - - - -		%
0	0	2.66
40	40	3.16
80	40	3.25
40	80	3.43
120	40	3.45
80	80	3.48
120	80	3.67

[z] Main effects across all five cultivars. Petioles were collected on July 9.
[y] Nitrogen was sidedressed on June 19.

Table 4. Effect of various nitrogen management programs on Atlantic potato production in organic soil.

Nitrogen Management*	Yield Total	No. 1	Size Distribution <2"	2-3 1/4	> 3 1/4	Culls	Specific Gravity
	- - cwt/A - -		- - - - - - - - % - - - - - - - - -				
0	529	430	17	73	8	2	1.066
40 + 40 + 0	514	431	15	67	16	2	1.071
40 + 40 + 40	496	393	17	68	11	4	1.079
40 + 80 + 0	536	430	15	66	15	5	1.070
80 + 40 + 0	545	467	12	66	21	1	1.077
80 + 40 + 40	444	359	17	75	6	2	1.069
120 + 40 + 0	501	398	18	62	17	3	1.079
80 + 80 + 0	525	438	14	67	17	3	1.072
120 + 80 + 0	453	363	16	62	18	4	1.072
120 + 40 + 40	541	452	15	68	16	1	1.076
HSD .10	NS	NS	4	NS	4	1	.011

* Nitrogen was applied preplant + on June 19 + on July 9. Urea was applied preplant and ammonium nitrate was sidedressed.

Table 5. Effect of various nitrogen management programs on Superior potato production in organic soil.

Nitrogen Management*	Yield		Size Distribution				Specific Gravity
	Total	No. 1	<2"	2-3 1/4	> 3 1/4	Culls	
	- - cwt/A - -		- - - - - - - - %	- - - -	- - - -	- -	
0	380	308	14	73	8	5	1.059
40 + 40 + 0	425	349	16	72	10	2	1.062
40 + 40 + 40	418	352	13	76	8	3	1.059
40 + 80 + 0	409	320	19	70	8	3	1.058
80 + 40 + 0	418	335	18	69	11	2	1.056
80 + 80 + 40	426	347	16	76	7	3	1.067
120 + 40 + 0	385	285	20	71	3	6	1.060
80 + 80 + 0	466	409	10	77	11	2	1.063
120 + 80 + 0	506	410	15	68	13	4	1.059
120 + 40 + 40	406	321	16	67	12	5	1.063
HSD .10	119	96	6	NS	4	2	NS

* Nitrogen was applied preplant + on June 19 + on July 9. Urea was applied preplant and ammonium nitrate was sidedressed.

Table 6. Effect of various nitrogen management programs on Norchip potato production in organic soil.

Nitrogen Management*	Yield		Size Distribution				Specific Gravity
	Total	No. 1	<2"	2-3 1/4	> 3 1/4	Culls	
	- - cwt/A - -		- - - - - - - - %	- - - -	- - - -	- -	
0	337	271	17	76	6	1	1.059
40 + 40 + 0	439	355	13	69	12	6	1.064
40 + 40 + 40	375	272	16	63	10	11	1.060
40 + 80 + 0	348	264	21	69	7	3	1.058
80 + 40 +	320	268	14	77	7	2	1.064
80 + 40 + 40	441	358	14	73	8	5	1.064
120 + 40 + 0	334	268	16	73	7	4	1.059
80 + 80 + 0	372	287	14	65	12	9	1.059
120 + 80 + 0	375	297	16	72	7	5	1.061
120 + 40 + 40	355	287	12	64	17	7	1.053
HSD .10	103	18	6	24	4	3	.011

* Nitrogen was applied preplant + on June 19 + on July 9. Urea was applied preplant and ammonium nitrate was sidedressed.

Table 7. Effect of various nitrogen management programs on Russet Burbank potato production in organic soil.

Nitrogen Management*	Yield Total	Yield >4 oz	Size Distribution <4oz	4-10 oz	>10 oz	Culls	Specific Gravity
	- - cwt/A - -		- - - - - - - % - - - - - - - - -				
0	395	274	25	54	15	6	1.071
40 + 40 + 0	443	338	16	60	14	10	1.065
40 + 40 + 40	366	256	24	63	7	6	1.066
40 + 80 + 0	321	225	26	64	6	4	1.063
80 + 40 + 0	414	274	23	55	11	11	1.064
80 + 40 + 40	367	250	22	60	8	10	1.067
120 + 40 + 0	264	175	27	60	6	7	1.067
80 + 80 + 0	328	223	30	62	6	2	1.065
120 + 80 + -	309	226	20	65	8	7	1.064
120 + 40 + 40	386	274	19	63	8	10	1.063
HSD .10	101	70	8	NS	4	3	NS

* Nitrogen was applied preplant + on June 19 + on July 9. Urea was applied preplant and ammonium nitrate was sidedressed.

Table 8. Effect of various nitrogen management programs on Shepody potato production in organic soil.

Nitrogen Management*	Yield Total	Yield >4 oz	Size Distribution <4 oz	4-10 oz	>10 oz	Culls	Specific Gravity
	- - cwt/A - -		- - - - - - - % - - - - - - - - -				
0	435	286	17	38	28	17	1.066
40 + 40 + 0	451	303	12	31	36	21	1.071
40 + 40 + 40	340	196	20	36	21	22	1.079
40 + 80 + 0	402	203	20	36	14	30	1.070
80 + 40 + 0	489	338	10	33	36	21	1.077
80 + 40 + 40	393	226	21	40	17	21	1.069
120 + 40 + 0	439	240	19	34	21	26	1.079
80 + 80 + 0	434	251	13	34	24	29	1.072
120 + 80 + 9	272	117	29	33	10	28	1.072
120 + 40 + 40	346	195	16	41	15	28	1.076
HSD .10	112	68	6	12	8	9	.012

* Nitrogen was applied preplant + on June 19 + on July 9. Urea was applied preplant and ammoniumn nitrate was sidedressed.

Funding: MPIC

1987 NEMATOLOGY RESEARCH

G.W. Bird, Nematology

Six potato nematology experiments will be summarized in this research report. These include three nematicide trials, a variety investigation, one experiment on seed piece spacing, and observations on the occurrence of the root-lesion nematode in potato stolon tissue. The results are part of a larger potato nematode research project designed for the development of improved procedures for management of the potato early-die disease complex caused by the root-lesion nematode (Pratylenchus penetrans) and the Verticillium wilt fungus (Verticillium dahliae).

Nematicide Trials

A trial was initiated at the Montcalm Potato Research Farm to evaluate nine potential nematicide tactics for control of the root-lesion nematode. Some of the treatments were applied in the fall of 1986 and some in the spring of 1986. Spring application of metham (Vapam) results in the highest tuber yields and best nematode control (Table 1). The results support the benefits of applying soil fumigants in the fall, and that row treatment is as good as broadcast application.

A second 1987 nematicide trial was conducted at a commercial potato farm in Montcalm County. This experiment was designed to evaluate twelve potential nematicide tactics for control of the root-lesion nematode. The highest tuber yields were obtained with Temik 15G at a rate of 3.0 lb a.i. per acre (Table 2). The 30-day post-plant treatment with Temik 15G did not provide early enough nematode control for optimal yields. The Mocap treatments were applied in a 12" band at planting. The results with Mocap would have been greatly improved if the material had been applied on a broadcast basis with optimal soil incorporation. Current potato planting equipment is a constraint to proper at-planting application of Mocap.

A chemigation trial was initiated in the fall of 1984 to evaluate the long-term impact of different rates of metham on the root-lesion nematode and Verticillium wilt fungus. Excellent 1985 potato yield increases were obtained at 27, 53 and 103 gal/A of metham (Table 3). The optimal rate, however, was 53 gal/A. Root-lesion nematode and Verticillium dahliae population densities were monitored throughout 1985, 1986, and 1987. The 103 gal/A treatment maintained the root-lesion nematode density at below a detectable level through the end of the 1987 growing season. Root-lesion nematode control was originally obtained with all three rates of metham. Only the highest rate of metham provides control of V. dahliae. The population of V. dahliae had increased in all of the metham treatments by the end of the 1987 growing season.

Variety Trial

A 1987 variety trail was designed to evaluate the susceptibility of eight potato cultivars to the potato early-die disease complex. Monona, Yukon Gold, Atlantic, Shepody, Superior, Onaway, Kennebec, and Russet Burbank were all susceptible to early-die, based on their response to nematode control with Temik 15G (Table 4). The 1987 rankings for Superior, Onaway, Kennebec and Russet Burbank were the same as reported in 1973 Michigan potato nematode research with the root-lesion nematode.

Seed Piece Spacing Trial

An experiment was conducted to determine if the potato early-die disease complex has any impact on the optimal spacing for potato seed pieces. This trial was conducted at the Montcalm Potato Research Farm in 1987. Spacings of 8, 12, 15 and 30 inches were evaluated. Treatment with Telone C-17 and aldicarb significantly increased tuber yields, and provided excellent nematode control (Table 5). Although there was some indication that different planting spacings are optimal for different type of potato plant health, the sensitivity of the investigation was not adequate to demonstrate that at a statistical level of $P = 0.05$.

Stolon Infection

In the seed piece spacing experiment where the early-die disease complex was controlled with Telone C-17 and aldicarb, both the soil and root population densities of the root-lesion nematode were maintained at very low population densities through the entire potato growing season (Figs. 1 and 2). An additional component of the population density of this nematode was confined to stolon tissue (Figs. 3 and 4). Nematodes were recovered from stolon tissue as early as 32 days after planting, and were present in stolon tissue at all subsequent sampling dates. The population density of P. penetrans reached a maximum of 26 per 5.0 grams of stolon fresh weight 96 days after planting.

Table 1. Montcalm Potato Research Farm Nematicide Evaluation.

Treatments	Yield cwt/A A's	Yield cwt/A B's	Yield cwt/A J's	Yield cwt/A total	Root lesion/100 cm^3 soil fall 86 before fumigation	Root Lesion/100 cm^3 soil spring 87 before fumigation	Root Lesion/ 100 cm^3 soil and 1 gr root 7-22-87	Root lesion/ 100 cm^3 soil at harvest
Nontreated Control	290.7b	10.1a	69.2a	370.0c	29.2a	32.4ab	104.2a	62.0a
Vorlex 4 GPA In-row Fall	394.9ab	10.7a	101.9a	507.7ab	34.4a	15.8b	40.4 ab	11.4cd
Telone II 6 GPA In-row Fall	366.9ab	12.1a	85.7a	464.7abc	24.4a	10.6b	76.6ab	17.2cd
Nemacur 3S 6 lbs ai/A Broadcast Fall	334.5ab	12.6a	97.3a	444.3abc	46.0a	21.4ab	9.8ab	22.6bcd
Nemacur 3S 9 lbs ai/A Broadcast	306.9b	13.6a	94.4a	414.9bc	47.6a	28.0ab	35.8ab	34.6bc
Vorlex 12 GPA Broadcast Spring	368.0ab	11.9a	108.2a	488.1abc	38.4a	23.0ab	14.8ab	17.4cd
Telone II 6 GPA Broadcast Spring	297.1b	11.5a	64.1a	372.1c	48.4a	44.2a	93.2ab	63.0a
Telone II 12 GPA Broadcast Spring	314.3b	12.4a	67.5a	394.1bc	44.0a	41.2a	61.4ab	45.4ab
Telone II 18 GPA Broadcast Spring	366.3ab	15.3a	80.6a	462.2abc	54.0a	27.8ab	21.6ab	8.0d
Vapam 105 GPA Spring	418.5a	13.6a	112.0a	544.1a	36.0a	45.4a	3.2b	0.0d

Table 2. 1987 Montcalm County Nematicide Evaluation.

Treatments	Yield cwt/A A's	Yield ctw/A B's	Yield cwt/A J's	Yield cwt/A total	Root Lesion/ 100 cm^3 soil (5-11-87)	Root Lesion 1 gr root (7-14-87)	Root Lesion/ 100 cm^3 soil (7-14-87)	Root Lesion/ 100 cm^3 soil (9-22-87)
Nontreated Control	156b	40a	16a	212ab	70a	27a	11ab	100a
DiSyston 15G (3.0 lb ai/A APIFF)	182ab	30a	10a	223ab	80a	51a	12ab	30b
Thimet 20G (3.0 lb ai/A APIFF)	185ab	38a	4a	234ab	69a	19a	11ab	80ab
Temik 15G (3.0 lb ai/A APIFF)	257a	44a	8a	308a	62a	6a	2b	12b
Temik 15G (2.0 lb ai/A 30 day post plant)	193ab	48a	14a	255ab	68a	6a	15ab	23b
Vorlex (10 gpa broadcast)	198ab	56a	14a	268ab	81a	15a	3b	25b
SN556 (10 gpa broadcast)	176ab	55a	14a	245ab	62a	1a	4b	12b
DiTrapex (6 gpa broadcast)	175ab	38a	7a	220ab	58a	15a	6ab	46ab
Temik 15G + Mocap 20G (2.0 & 2.0 lb ai/A APIFF)	198ab	54a	16a	269ab	35a	13a	5b	22b
Temik 15G (2.0 lb ai/A APIFF)	218ab	44a	15a	276ab	63a	10a	18ab	26b
Mocap 20G (2.0 lb ai/A 12" band AP)	146b	43a	16a	205ab	70a	70a	25a	81ab
Mocap 20G (3.0 lb ai/A 12" band AP)	146b	29a	3a	178b	85a	12a	20ab	42ab
Mocap 20G (4.0 lb ai/A 12" band AP)	152b	48a	7a	207b	74a	24a	8ab	25b

Table 3. Influence of metham on Pratylenchus penetrans and Verticillium dahliae.

Metham	Potato yields (cwt/A) (9-9-85)	Population density of P. penetrans			V. dahliae colonies[2]		
		(7-24-85)	(8-22-86)	(8-20-87)	(7-24-85)	(8-22-86)	(8-20-87)
Metham 0 gal/A							
- Temik	300	182	248	78	20	4	3
+ Temik	349	1	211	204	42	6	16
Methan 27 gal/A							
- Temik	417	13	280	196	19	4	7
+ Temik	399	0	10	39	26	3	15
Metham 53 gal/A							
- Temik	490	8	62	129	0	2	11
+ Temik	465	0	--	138	22	--	8
Metham 103 gal/A							
- Temik	485	0	0	0	0	1	3
+ Temik	480	0	--	0	0	--	5

[1]No. per 1.0/gram root
[2]Colonies per 1.0 gram soil
[3]Site in alfalfa in 1986-87.

Table 4. 1987 PED Susceptibility Rankings.

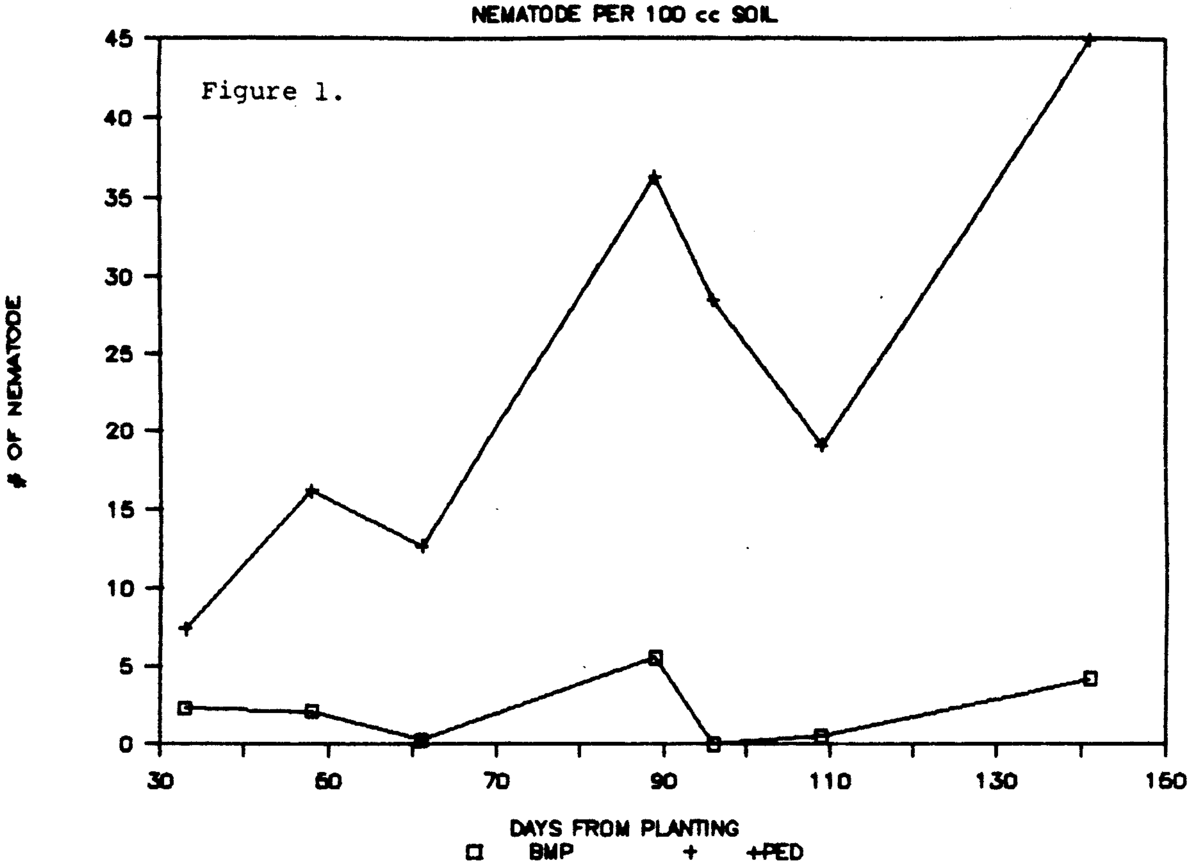
Variety	PED Susceptibility	
	1973	1987[1]
Monona	---	1 (17.4a)
Yukon Gold	---	2 (13.3 ab)
Atlantic	---	3 (10.0 ab)
Shepody	---	4 (6.4 ab)
Superior	1	5 (5.8 ab)
Onaway	2	6 (4.7 ab)
Kennebec	2	7 (4.7 ab)
Russet Burbank	4	8 (-69 b)

[1]Susceptibility ranking based on yield differences, lbs/40 row ft; (+ Temik yield) - (no Temik yield), P = 0.05.

Table 5. Montcalm Potato Farm, 1987.

Treatment	Tuber yield (cwt/A)				
	A's	B's	J's	K's	Total
Telone II and Aldicarb					
1.5 plants/ft	177ab	161a	11ab	29a	378a
1.0 plants/ft	183ab	115ab	12ab	44a	353a
0.8 plants/ft	212a	108abc	21ab	32a	372a
0.4 plants/ft	179ab	52dc	29a	51a	312a
No PED Control					
1.5 plants/ft	170ab	108abc	7ab	33a	319a
1.0 plants/ft	151ab	111abc	12ab	37a	311a
0.8 plants/ft	151ab	70bcd	9ab	41a	272a
0.4 plants/ft	82c	47d	2b	2a	181a
1.0 plants/ft - foliar fungicides	138b	92bcd	8ab	44a	281a
Telone II and Aldicarb	188q	109q	18q	39q	354q
No PED Control	138r	86r	7q	41q	272r
1.5 plants/ft	174x	135x	9x	31y	348x
1.0 plants/ft	157xy	105y	10x	41xy	315x
0.8 plants/ft	182x	89y	15x	37xy	322x
0.4 plants/ft	130y	49z	16x	51x	246y

MONTCALM MI 1987 NEMATODE DATA



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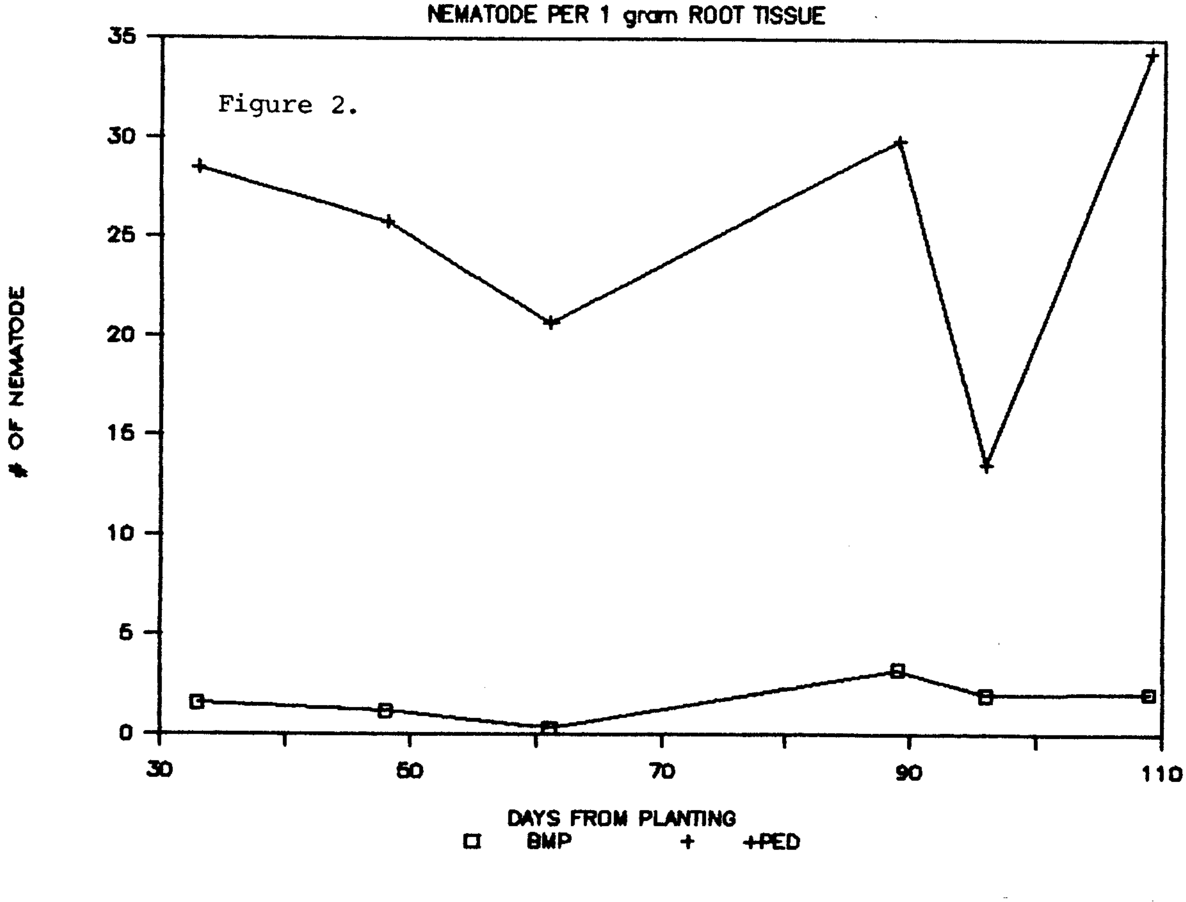

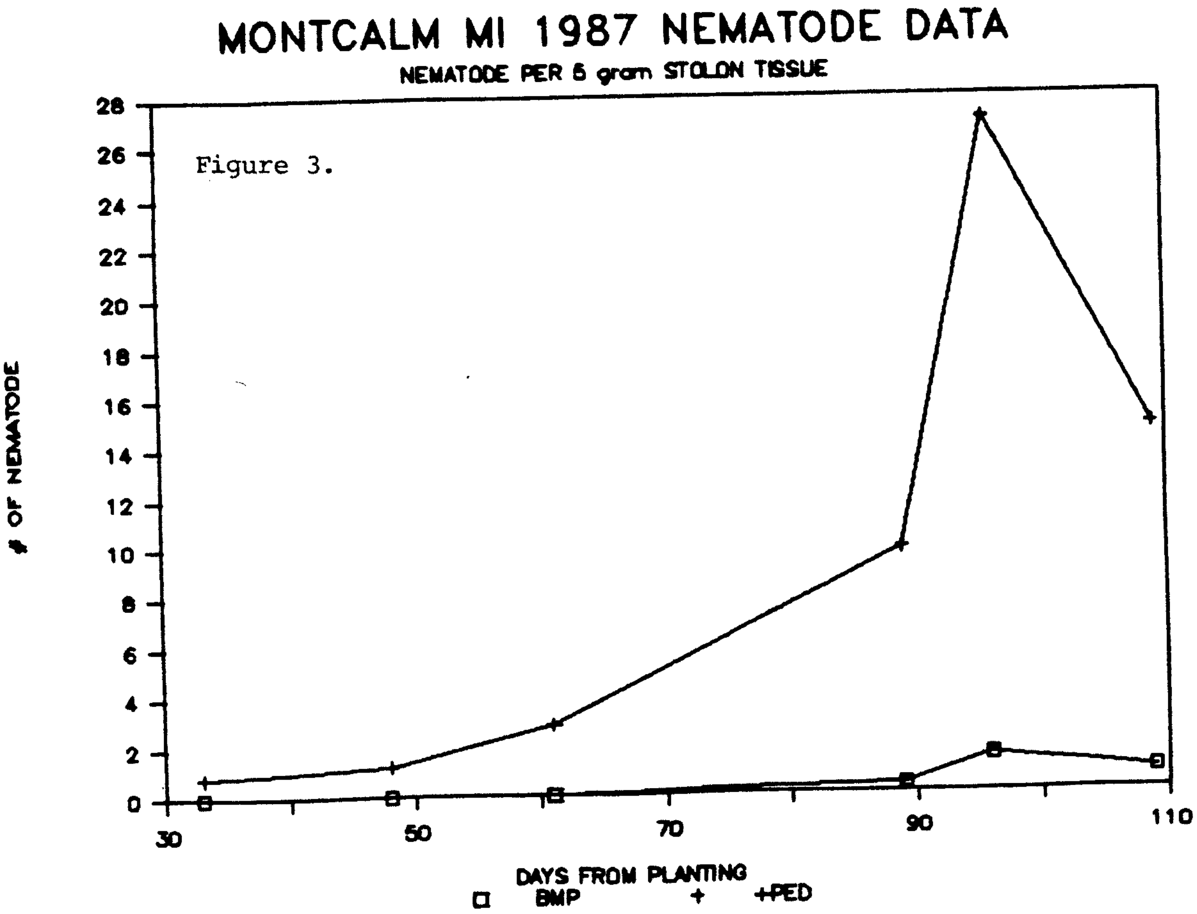
MONTCALM MI 1987 NEMATODE DATA
NEMATODE PER 5 gram STOLON TISSUE
Figure 3.
OF NEMATODE
0
2
4
6
8
10
12
14
16
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22
24
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28
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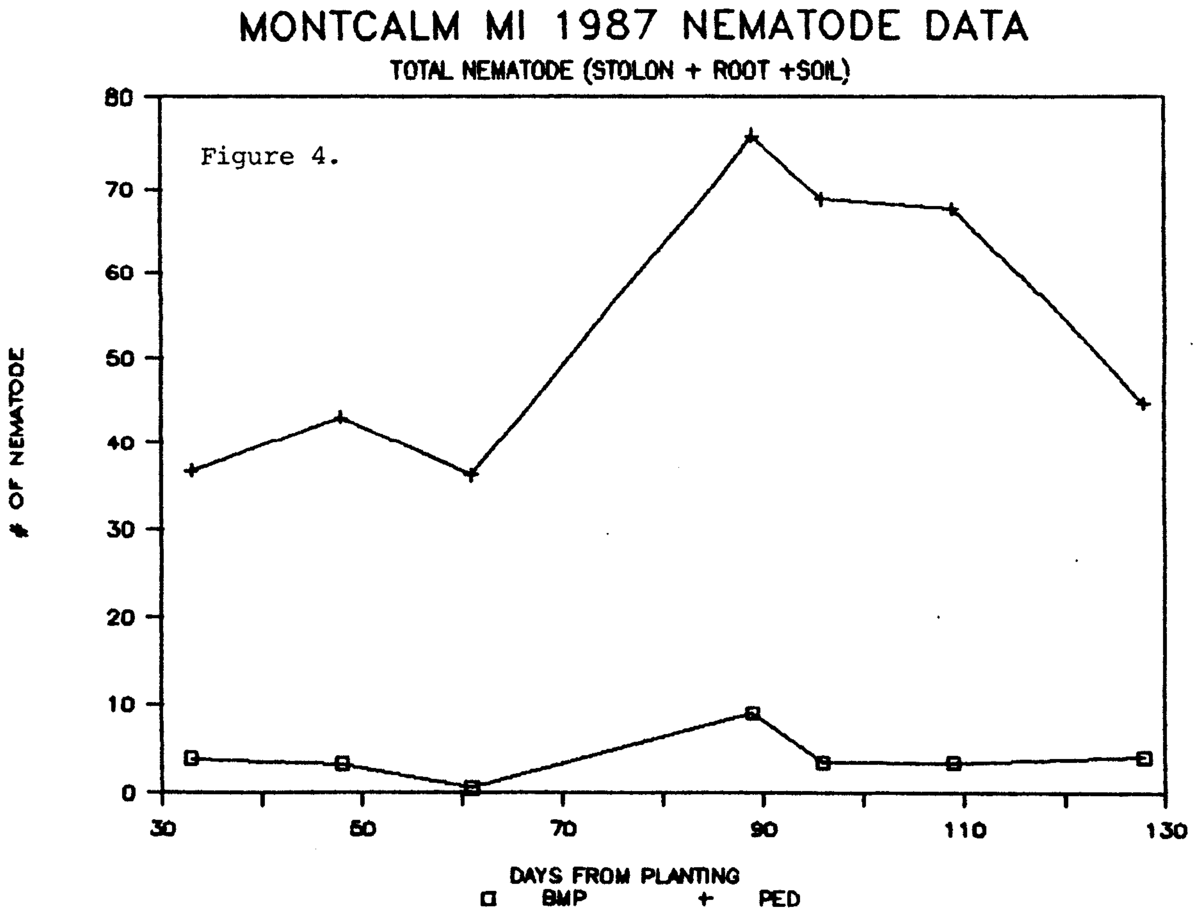
50
70
90
110
DAYS FROM PLANTING
BMP
+PED


MONTCALM MI 1987 NEMATODE DATA
TOTAL NEMATODE (STOLON + ROOT +SOIL)
Figure 4.
OF NEMATODE
0
10
20
30
40
50
60
70
80
30
50
70
90
110
130
DAYS FROM PLANTING
BMP
PED

Funding: MPIC

WEED CONTROL ON MUCK SOILS AND VARIETY RESPONSE TO HERBICIDE APPLICATION AND TIME OF HILLING

1987 Report to the Michigan Potato Industry Commission

K. A. Renner and R. W. Chase, Department of Crop and Soil Sciences

Summary Report (year 2 of 2 year study)

Research in 1987 was conducted to:

1. Establish herbicide efficacy on muck soils.

2. Evaluate the interactions between hilling, potato variety response, and time of herbicide application on mineral soils.

SUMMARY REPORT

Weed Control on Muck Soils: Ten percent of Michigan's potatoes are grown on muck soils, totaling approximately 5000 acres. Weed control trials were conducted in 1986 and 1987 at the M.S.U. muck research farm in Clinton County (58% organic matter in 1986, 92% in 1987), and at the Wes Leep farm in Allegan County (37% organic matter in 1986, 53% in 1987). Twenty-eight herbicide treatments were applied either preemergence, (immediately after planting), delayed preemergence (at ground cracking, 2 weeks after planting), or postemergence (four weeks after planting). Fields were hilled 1 to 2 weeks after the postemergence applications. Potato plots were evaluated for crop injury, weed control, and potato yield. The 'Atlantic' variety was planted at both locations in 1987, and in 1986 the 'Atlantic' variety was planted in Clinton County, and a 'Frito Lay' variety was planted in Allegan County. There were three objectives of this research. The first was to determine annual grass control with metolachlor (Dual), dimethazone (Command), cinmethylin (Cinch), CGA-180937, and SAN-582 on muck soils, and potato tolerance to these herbicides when applied either preemergence or delayed preemergence (at ground cracking). Two additional treatments evaluated for annual grass control were metribuzin (Sencor or Lexone) applied preemergence followed by sethoxydim (Poast) plus crop oil concentrate applied postemergence, and metribuzin (Sencor or Lexone) applied preemergence followed by a postemergence application of metribuzin (Sencor or Lexone) plus sethoxydim (Poast) plus crop oil concentrate. All herbicide treatments provided barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) control equal to or greater than metolachlor at Clinton County in 1987 (Table 1). In Allegan County barnyardgrass control was evaluated in June only, and at that time control with these treatments was excellent. In Clinton County in 1986, barnyardgrass control was poor with SAN-582 (Table 2). Barnyardgrass was not present in Allegan County in 1986. There was no potato injury in 1987 from any treatment except where metribuzin preemergence was followed by metribuzin plus sethoxydim plus crop oil concentrate. Thirty percent of the potato leaf edges were brown and plants remained yellow for 2 weeks after treatment. Potato yield was reduced significantly (at the 10% level according to Duncan's multiple range test). Injury in 1986 occurred at Allegan County from Command applications to the 'Frito Lay' variety. Increased injury occurred from delayed preemergence applications (data not presented).

Weed control efficacy for single applications of linuron (Lorox) or metribuzin (Sencor or Lexone) as a single preemergence or delayed preemergence treatment were investigated. Delayed preemergence applications of either of these herbicides provided better barnyardgrass, redroot pigweed (Amaranthus retroflexus L.), and common purslane (Portulaca oleracea L.) control preemergence applications in Clinton County in 1987 (Table 3). However, in Allegan County In 1987 (Table 4) dry weather and emerged weeds at the time of delayed preemergence applications gave different results. Metribuzin (Sencor or Lexone) provided significantly better barnyardgrass control than linuron (Lorox) when applied preemergence. Control of redroot pigweed was very poor with both herbicides when applied preemergence due to dry weather. Delayed preemergence applications of linuron (Lorox) provided better redroot pigweed control than metribuzin because the pigweed had emerged at the time of application, and linuron provided better control postemergence of the emerged pigweeds. In 1986 in Clinton County (Table 5) delayed preemergence treatments of either metribuzin (Sencor or Lexone) or linuron (Lorox) gave better weed control than preemergence applications. Metribuzin preemergence applications provided better weed control than Lorox preemergence applications. The untreated check plot yielded 65% less than any herbicide plot. 1986 weed control evaluations in Allegan County were made only in June because of flooding.

The optimum timing for metribuzin in combination with a grass herbicide was examined in a four by four factorial design. Cinmethylin (Cinch) at 1.0 and 2.0 lb a.i./acre, dimethazone (Command) at 1.0 lb a.i./acre, and metolachlor (Dual) at 2.5 lb a.i./acre were applied in a tankmix with metribuzin. The treatments were applied preemergence and also delayed preemergence (a total of 8 treatments). The metribuzin was also applied as a split application (0.5 lb a.i./acre preemergence followed by 0.5 lb a.i./acre delayed preemergence) with the four grass herbicide treatments applied either preemergence or delayed preemergence (a total of 8 treatments).

Weed control results varied with year, location, and weed species. In Clinton County (Table 6) the metribuzin timing was significant in 1986 only. Barnyardgrass control was only fair by September 1986, when metribuzin was applied preemergence with a grass herbicide. Common purslane control in June, 1986, was poorer from preemergence applications of Cinch (1.0 lb a.i./A) plus metribuzin (data not presented). There was no significant difference in yield in 1987 and all treatments provided excellent season-long control of barnyardgrass and redroot pigweed in 1987. In Allegan County (Table 7) in 1986 and 1987, metribuzin timing was not significant, but the grass herbicide factor was significant. Common purslane and redroot pigweed control were significantly reduced from cinmethylin (Cinch) at 1.0 lb plus metribuzin treatments, regardless of the metribuzin timing. Cinmethylin and dimethazone do not provide suppression of redroot pigweed, while metolachlor assists in controlling this weed species.

Swamp Smartweed Control: Sencor (Lexone) at 1.0 lb a.i./acre provided the best suppression of swamp smartweed of the four soil-applied treatments (Table 8). Roundup and Banvel were applied at various rates and combinations in June, August, and September in 1986 and 1987 (Table 9). Evaluations were not made for 1986 treatments in the spring of 1987. On September 25, 1986, Roundup at 3 or 4 qt/acre applied in either June or August provided 85% or greater swamp smartweed control. Banvel applied at 1 qt/acre in June provided 87% control, and an August treatment 100% control when evaluated on September 25, 1986. When

Roundup was tankmixed with Banvel in both June and August treatments, control was excellent when evaluated on September 25, 1986.

In 1987, the same treatments were applied to a muck field in Clinton County for swamp smartweed control. June treatments of Roundup provided only 53% control of swamp smartweed when evaluated September 11, 1987. June applications of Banvel and combinations of Banvel plus Roundup gave 70-75% control when evaluated in September. The addition of ammonium sulfate to June Roundup treatments (Treatments 19, 20) increased control to 85-87%. August applications of Roundup at 3 qt (88%) or 4 qt (93%) and Banvel at .1 qt/acre (100%) provided excellent swamp smartweed control. September applications were made, but were not evaluated in October because of frost. The 1987 field will be evaluated for swamp smartweed regrowth in the spring of 1988.

Table 1: Grass herbicide efficacy and potato tolerance and yield in 1987.

		1987 Clinton County				1987 Allegan County	
Herbicide Treatment*	Rate (lb ai/A)	Visual Injury (4 WAP) June	June (4 WAP) ECHCG**	Sept. ECHCG	Yield (cw/A)	Visual Injury (4 WAP)	June (5 WAP) ECHCG
		% injury	--(% control)--			% injury	(% control)
Dual + metribuzin	2.5 + 1.0	0 b	100 a	95 a	489 a-c	0 b	100 a
Command + metribuzin	1.0 + 1.0	0 b	100 a	100 a	500 a-c	0 b	100 a
Cinch + metribuzin	1.0 + 1.0	0 b	100 a	99 a	470 a-c	0 b	100 a
Cinch + metribuzin	2.0 + 1.0	0 b	100 a	100 a	520 a-c	0 b	100 a
CGA-180937 + metribuzin	3.0 + 1.0	0 b	93 a	97 a	508 a-c	0 b	100 a
SAN-582 + metribuzin	1.0 + 1.0	0 b	100 a	100 a	515 a-c	0 b	100 a
metribuzin + (Poast + COC)	1.0 + (.2 + 1 qt)	0 b	100 a	100 a	472 a-c	0 b	100 a
metribuzin + (metribuzin + Poast + COC)	.5 + (.5 + .2 + 1 qt)	27 a	100 a	99 a	416 c	23 a	100 a
untreated	-	0 b	0 c	48 b	292 d	0 b	0 b

*All herbicides applied PRE. ( ) denotes POST application. COC denotes crop oil concentrate.
**ECHCG pressure was moderate. ECHCG is barnyardgrass.
Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 2: Grass herbicide efficacy and potato tolerance and yield in 1986.

			1986 Clinton Co.			1986 Allegan Co.
Herbicide Treatment*	Rate (lb ai/A)	Visual Injury June (4 WAP)	June (4 WAP) ECHCG**	Sept. ECHCG	Yield (cwt/A)	Visual Injury June (4 WAP)
		% injury	--(% control)--			% injury
Dual + metribuzin	2.5 + 1.0	0 c	97 ab	77 abc	248 a-f	0 d
Command + metribuzin	1.0 + 1.0	0 c	90 ab	80 ab	254 a-h	17 b
Cinch + metribuzin	1.0 + 1.0	10 ab	93 ab	77 abc	209 f-i	0 d
Cinch + metribuzin	2.0 + 1.0	3 bc	93 ab	70 abc	266 a-f	0 d
CGA-180937 + metribuzin	3.0 + 1.0	0 c	90 abc	83 ab	318 ab	0 d
SAN-582 + metribuzin	1.5 + 1.0	2 c	83 bc	63 bc	283 a-e	0 d
metribuzin + (Poast + COC)	1.0 + .2 + 1 qt)	3 bc	97 ab	90 ab	290 a-e	-
metribuzin + (metribuzin + Poast + COC)	.5 + (.5 + .2 + 1 qt)	7 bc	90 abc	87 ab	247 c-h	-
untreated	-	0 c	0 e	27 de	75 i	0 d

*All herbicides applied PRE. ( ) denotes POST application. COC denotes crop oil concentrate.
**ECHCG pressure was high. ECHCG is barnyardgrass.
Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 3: Weed control and potato yield for applications of metribuzin and linuron in 1987.

Herbicide Treatment	Rate (lb ai/A)	Application Time	1987 Clinton County					
			June (4 WAP)			Sept.		Yield
			ECHCG*	AMARE	POROL	ECHCG	AMARE	(cwt/A)
			------------------(% control)---------------					
metribuzin	1.0	PRE	80 a	87 b	70 b	95 a	99 a	430 c
Lorox	1.5	PRE	60 b	70 c	43 c	83 a	88 b	477 a-c
metribuzin	1.0	DPRE	100 a	100 a	100 a	98 a	100 a	424 c
Lorox	1.5	DPRE	100 a	100 a	100 a	100 a	100 a	481 a-c
untreated	-	-	0 c	0 d	0 d	48 b	70 c	292 d

*ECHCG pressure was moderate. ECHCG = barnyardgrass. AMARE = redroot pigweed. POROL = common purslane.

Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 4: Weed control and potato yield for applications of metribuzin and linuron in 1987.

Herbicide Treatment	Rate (lb ai/A)	Application Time	1987 Allegan County			
			June 4 (WAP)			Sept.
			ECHCG*	AMARE	POROL	AMARE
			-------------(% control)-------------			
metribuzin	1.0	PRE	97 a	37 cd	100 a	27 cde
Lorox	1.5	PRE	60 b	23 de	90 a	17 de
metribuzin	1.0	DPRE	100 a	63 c	100 a	55 bcd
Lorox	1.5	DPRE	100 a	87 ab	100 a	88 ab
untreated	-	-	0 c	0 e	0 b	0 e

*ECHCG pressure was low. AMARE pressure was high. ECHCG = barnyardgrass. AMARE = redroot pigweed. POROL = common purslane.

Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 5: Weed control and potato yield for applications of metribuzin and linuron in 1986.

			1986 Clinton County					
	Rate	Application	June (4 WAP)			Sept.		Yield
Herbicide Treatment	(lb ai/A)	Time	ECHCG*	AMARE	POROL	ECHCG	AMARE	(cwt/A)
			(% control)					
metribuzin	1.0	PRE	77 c	93 a	77 c	47 cd	90 a	198 c-e
Lorox	1.5	PRE	50 d	77 b	50 d	23 de	63 b	193 de
metribuzin	1.0	DPRE	100 a	100 a	98 ab	83 ab	97 a	246 a-d
Lorox	1.5	DPRE	93 ab	100 a	100 a	62 bc	93 a	228 b-e
untreated	-	-	0 e	0 c	0 e	27 de	0 c	75 e

*ECHCG pressure was high. ECHCG = barnyardgrass. AMARE = redroot pigweed. POROL = common purslane.

Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 6: Optimum timing for metribuzin and 'grass' herbicide in 1986 and 1987.

		1986 Clinton County				1987 Clinton County				
Application Rate	Application	June (4 WAP)			Sept.	June (4 WAP)		Sept.		Yield
(lb ai/A)	Time	ECHCG*	AMARE	POROL	ECHCG	ECHCG**	AMARE	ECHCG	AMARE	(cwt/A)
		(% control)								
G* + 1.0	PRE	93 b	97 b	86 b	76 b	100	99	99	99	438
G* + 1.0	DPRE	100 a	100 a	100 a	93 a	99	99	99	99	409
G* + 0.5 + (0.5)	PRE + DPRE	100 a	100 a	100 a	83 ab	100	100	97	100	433
0.5 + (G* + 0.5)	PRE + DPRE	100 a	100 a	99 a	86 ab	100	99	98	99	429
DMRT						N.S.	N.S.	N.S.	N.S.	N.S.

G* = Grass herbicide.

*ECHCG pressure was high. ECHCG = barnyardgrass. AMARE = redroot pigweed. POROL = common purslane.

**ECHCG pressure was moderate.

Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 7: Optimum timing for metribuzin and 'grass' herbicide in 1986 and 1987.

Metribuzin + 'Grass Herbicide'	Grass Herbicide Rate (lb ai/A)	1986 Allegan County June (4 WAP) AMARE	1986 Allegan County June (4 WAP) POROL	1986 Allegan County Sept. AMARE	1987 Allegan County June (4 WAP) ECHCG*	1987 Allegan County June (4 WAP) AMARE	1987 Allegan County June (4 WAP) POROL	1987 Allegan County Sept. AMARE
		(% control)						
metribuzin + Cinch	1.0	88 b	95 b	80	96	43 b	74 b	55
metribuzin + Cinch	2.2	88 b	99 a	74	100	48 b	86 ab	51
metribuzin + Dual	2.5	100 a	100 a	87	97	64 a	96 a	63
metribuzin + Command	1.0	100 a	100 a	84	93	53 ab	98 a	40
DMRT				N.S.	N.S.			N.S.

*ECHCG pressure was low. ECHCG = barnyardgrass. POROL = common purslane. AMARE = redroot pigweed.

Values followed by the same letter are not significant at the 5% level according to Duncan's multiple range test. Comparisons are valid only within columns.

Table 8: Suppression of swamp smartweed on fallow ground.

Treat*- Number	Pesticide Name	Rate (lb/A)	Application Timing	1986 7/23/86 SWSM	1986 8/11/86 SWSM	1986 9/25/86 SWSM	1987 7/2/87 SWSM	1987 7/27/87 SWSM	1987 8/13/87 SWSM	1987 9/11/87 SWSM
				(% control)						
01	Lorox DF	1.50	May	0.0	4.0	3.3	NT	-	-	-
02	Lexone DF	1.00	May	3.3	7.0	6.7	NT	-	-	-
03	Command	1.00	May	0.0	3.0	1.7	NT	-	-	-
04	Cinch	2.00	May	0.0	0.7	0.8	NT	-	-	-
05	Roundup	3 QT	June	6.8	9.5	8.5	7.0	6.7	8.7	5.2
06	Roundup	4 QT	June	8.1	9.7	9.0	6.7	7.0	8.7	5.3
07	Roundup	2 QT	June	8.0	9.7	8.8	NT	-	-	-
08	Banvel	1 QT	June	10.0	9.5	8.7	8.8	8.0	8.3	7.3
09*	Roundup	1 QT	June	9.3	9.7	9.7	9.0	9.0	9.2	7.0
09	Banvel	1 QT	June							
09	X-77	1/2%	June							

Table 8: Suppression of swamp smartweed on fallow ground continued:

Treat*-Number	Pesticide Name	Rate (lb/A)	Application Timing	1986			1987			
				7/23/86 SWSM	8/11/86 SWSM	9/25/86 SWSM	7/2/87 SWSM	7/27/87 SWSM	8/13/87 SWSM	9/11/87 SWSM
				(% control)						
10*	Roundup	2 QT	June	10.0	9.7	9.2	9.8	9.3	9.0	7.5
10	Banvel	1 QT	June							
10	X-77	1/2%	June							
11	Roundup	3 QT	August	-	-	8.8	-	-	3.0	8.8
12	Roundup	4 QT	August	-	-	9.3	-	-	3.3	8.8
13	Roundup	2 QT	August	-	-	7.8	NT	-	-	-
14	Banvel	1 QT	August	-	-	10.0	-	-	8.0	8.7
15*	Roundup	1 QT	August	-	-	10.0	-	-	6.5	8.5
15	Banvel	1 QT	August							
15	X-77	1/2%	August							
16*	Roundup	2 QT	August	-	-	9.8	-	-	6.7	9.0
16	Banvel	1 QT	August							
16	X-77	1/2%	August							
17	No treatment	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	Roundup	2 QT	June	NT	-	-	6.0	7.3	9.3	7.0
18	Roundup	2 QT	Sept.							
19	Roundup	2 QT	June	NT	-	-	7.0	9.0	9.5	8.7
19	AMS**	2.5 LB	June							
20	Roundup	3 QT	June	NT	-	-	7.3	9.3	9.5	8.5
20	AMS**	2.5 LB	June							
21	Roundup	2 QT	August	NT	-	-	-	-	3.7	8.8
21	AMS**	2.5 LB	August							
22	Roundup	2 QT	August	NT	-	-	-	-	3.0	8.5
22	Roundup	2 QT	Sept.							
23	Roundup	3 QT	Sept.	NT	-	-	-	-	-	NR
24	Roundup	4 QT	Sept.	NT	-	-	-	-	-	NR
25	Banvel	1 QT	Sept.	NT	-	-	-	-	-	NR
26	Banvel	0.5 QT	Sept.	NT	-	-	-	-	-	NR
27	Roundup	2 QT	Sept.	NT	-	-	-	-	-	NR
28*	Roundup	1 QT	Sept.	NT	-	-	-	-	-	NR
28	Banvel	1 QT	Sept.							
28	X-77	1/2%	Sept.							

Table 8: Suppression of swamp smartweed on fallow ground continued:

Treat*- Number	Pesticide Name	Rate (lb/A)	Application Timing	1986 7/23/86 SWSM	1986 8/11/86 SWSM	1986 9/25/86 SWSM	1987 7/2/87 SWSM	1987 7/27/87 SWSM	1987 8/13/87 SWSM	1987 9/11/87 SWSM
				(% control)						
29*	Roundup	2 QT	Sept.	NT	-	-	-	-	-	NR
29	Banvel	1 QT	Sept.							
29	X-77	1/2%								
30*	Roundup	1 QT	Sept.	NT	-	-	-	-	-	NR
30	Banvel	1 QT	Sept.							
30	X-77	1/2%	Sept.							

1986 treatment dates May 15; June 17; August 11.
1987 treatment dates June 16; August 3; September 10.

*Treatment 1-8, 11-14, 18-27 - - 23 gpa, 30 psi.
Treatment 9-10, 15-16, 28-30 - 11.5 gpa, 30 psi.
NS = not a treatment in that year.
**AMS = ammonium sulfate.
NR = not evaluated due to frost on 9/20/87.

<u>Variety Responses to Herbicide Application and Time of Hilling:</u> This research was conducted to evaluate the interaction between the time of hilling and the time of herbicide application on potato tolerance, weed control throughout the growing season, and potato yield. The research was conducted in 1986 and 1987 on a sandy clay loam at the Montcalm Potato Research Farm. The study was a 3 factor factorial split-split plot design. The factors were; 1. hilling time, Early hill (EH), approximately 2 weeks after planting at ground cracking, and late hill (LH) - a conventional hilling time 5-6 weeks after planting; 2. potato variety (Atlantic and Russet Burbank); and 3. herbicide treatments (8 treatments in 1986 and 9 in 1987). Treatments included Eptam (EPTC) incorporated prior to potato planting, followed by delayed preemergence (at ground cracking) treatments of either Lorox, metribuzin, or Cobra; Dual plus Lorox applied preemergence, and Dual plus Lorox applied delayed preemergence; Dual plus metribuzin applied either preemergence or delayed preemergence; a postemergence treatment of Poast plus metribuzin plus crop oil concentrate, and an untreated check. Each potato treatment was 4 rows wide and 50 feet long (2 rows of Atlantic & 2 rows of Russet Burbank). Visual evaluations of potato tolerance and weed control were taken monthly throughout the growing season and the middle 2 rows of each plot were harvested and graded and yield converted to a per acre basis. All herbicides used in this research are registered for application to potatoes, with the exception of Cobra (lactofen) and Poast (sethoxydim).

From May 1 through July 11, 1986, all herbicide treatments provided 87% or greater control of barnyardgrass (Table 1), redroot pigweed (Table 2), and common lambsquarters (Table 3) without regard to the time of hilling. By August 14 however, there was a significant difference in weed control between various herbicide treatments, and an interaction between herbicide treatments and the time of hilling. When Eptam treatments were early hilled (EH) and then followed by delayed preemergence (DPRE) applications of either Lorox or Cobra, barnyardgrass control was poor. All other herbicide treatments gave excellent control of barnyardgrass throughout the growing season, regardless of the time of hilling. Broadleaf weed control also varied with herbicide treatment and time of hilling. Eptam followed by Cobra provided very poor control of common lambsquarters when early hilled by August 14. Eptam followed by Sencor (Lexone) provided excellent control of all weeds, regardless of hilling time. Dual plus Lorox applied preemergence gave poor control of all broadleaf weeds when early hilled. Weed control was excellent from the Dual plus Lorox delayed preemergence application for both early and late hilled treatments. The split application of Dual plus Sencor (Lexone), or the postemergence treatment of Poast plus Sencor (Lexone) plus crop oil concentrate (COC) provided excellent season long weed control, regardless of the time of hilling.

Visual potato injury to the Atlantic variety was noted on June 2 from Eptam applications (Table 4). Potatoes treated with Eptam followed by either Lorox or Sencor (Lexone) had 10% injury, and 20% injury when treated with Eptam followed by Cobra. This injury did not reduce potato yield. There was no significant effect of hilling time treatment on the yield of potatoes for each variety and herbicide treatment (Table 5). There was a trend however, for higher yields in the late hilled treatments. There was no significant difference in the yield of the Atlantic variety across all herbicide treatments, and it appeared that a 2X application of Sencor (Lexone) or an application of Sencor (Lexone) POST did not reduce the yield of this variety in 1986. All Atlantic plots treated with herbicides yielded 10 to 15% more than the 'hill only' check. Russet Burbank plots treated with herbicides yielded 30% more than the 'hill only' check. Russet Burbank potato plots treated with Eptam followed by Cobra or the preemergence treatment of Dual plus Lorox yielded less than other herbicide treated plots.

In 1987 poor weed control was noted with various treatments on June 22, seven weeks earlier than in 1986. By June 22, 1987, poor barnyardgrass control was noted for early and late hill treatments of Eptam followed by either Lorox or Cobra (same results as 1986, but occurring 7 weeks earlier), and early hill plots of Dual plus Lorox and Dual plus metribuzin applied preemergence (Table 6). The preemergence application of Dual + Lorox in 1986 had provided good control all season, regardless of hilling time. By July 13, 1987, the late hilled plot of the preemergence treatments of Dual plus Lorox and Dual + metribuzin had significantly poorer barnyardgrass control. This trend continued for the remainder of the growing season. Treatments of Poast + metribuzin + COC, Dual + metribuzin (delayed preemergence), Dual + Lorox (delayed preemergence) and Eptam (PPI) followed by metribuzin (delayed preemergence) gave excellent season long barnyardgrass control, regardless of hilling time.

Redroot pigweed and common lambsquarters control by June 22, 1987, was poor in the Dual plus metribuzin (preemergence) and Dual plus Lorox (preemergence) treatments when early hilled (Tables 7 & 8). These results are similar to 1986, except the poor weed control occurred seven weeks earlier in 1987. By July 13, the late hilled plots of these two treatments had decreased redroot pigweed and common lambsquarters control, and continued to be poor the remainder of the growing season. All other treatments, which included only delayed preemergence or postemergence combinations, provided excellent redroot pigweed and common lambsquarters control throughout the season, regardless of hilling time. Poor control of common lambsquarters in 1986 from the Eptam followed by Cobra treatment was not noted in 1987.

Potato injury was evaluated in 1987 on May 31 and June 22 (Table 9). There was a significant interaction between herbicide treatment and the time of hilling. Eptam followed by metribuzin or Lorox had significantly smaller plants at the May 31 rating, with more severe stunting appearing where the plants had not yet been hilled. Both varieties responded similarly in 1987. Eptam followed by Cobra had 30 to 36% visual injury on May 31. By the June 22 evaluation the Eptam treated potatoes no longer appeared stunted. The only significant injury evident on June 22 was on the potato plants treated with Poast plus metribuzin + COC, three weeks previously. Both varieties showed some leaf bronzing and a delay in flowering.

There were significant interactions for herbicide treatment with time of hilling, herbicide treatment with variety, and variety with herbicide treatment when potato yield was analyzed in 1987 (Table 10). Atlantic had a higher yield than Russet Burbank for early hilled (26%) and late hilled (27%) potatoes, when averaged across all herbicide treatments. Atlantic potatoes had significantly higher yields than Russet Burbank potatoes for each herbicide treatment across both hilling times. Untreated Atlantic plots had a 70% lower yield than the Dual plus Lorox delayed preemergence plots, while Russet Burbank yielded 80% less than this herbicide treated plot. Significantly lower yields were noted for both varieties for the preemergence only treatments, which appeared to be a reflection of the poor weed control noted in these plots in 1987. A significantly lower yield was noted for these two treatments when early hilled plots were compared to the late hill plot treatments. Significantly lower yields were also noted with both varieties for Eptam followed by either Lorox or Cobra. This appeared to be a reflection of poor weed control, as again, significantly lower yield occurred in the early hilled plots where poorer weed control was noted, and/or possible injury from the Cobra application. Potatoes (both varieties) treated with Poast plus metribuzin + coc had significantly lower yields than the delayed preemergence treatments of Dual plus metribuzin, Dual plus Lorox, and Eptam followed by metribuzin. These treatments had excellent weed control throughout 1987, and the lower yield from the postemergence treatment may be a reflection of the crop injury noted on June 22, 1987.

Therefore, in 1987, hilling time had a significant influence on potato yield. Increased weed growth evident in some of the herbicide treatments on June 22, that were early hilled on May 14, resulted in lower potato yield. In 1986, a difference in weed control with the various herbicide treatments due to hilling time was not noted until August 14, 1986, and the poorer weed control noted in the August, 1986 evaluation was not reflected in lower yields. If weeds were controlled for 10 weeks (May 1 until at least July 15) in 1986, potato yield was not reduced. Poor weed control 7 weeks after planting in 1987 significantly reduced potato yield. Therefore, potato fields must have excellent weed control for more than 7 weeks for yield not be be reduced and weeds that emerged in late July or August do not appear to reduce potato yield.

Early hilling (at ground cracking) is an effective hilling time only if herbicides are applied immediately after hilling (delayed preemergence) or postemergence. This practice results in optimum weed control in August and September, but no difference in yields were noted if conventional hilling had been practiced. Delayed preemergence herbicide treatments provided the best weed control, regardless of hilling time.

Sensitivity of both the Atlantic and Russet Burbank varieties to the postemergence application of Poast plus metribuzin + COC was noted. If Poast were to receive a label for potatoes, the application of Poast plus COC would have to be made separately from a postemergence metribuzin treatment. Potatoes appear to have low tolerance for Cobra application, and no recommendation will be made to pursue labeling.

The Atlantic potato variety appears to be more competitive with weeds than the Russet Burbank variety. This information is useful in the future, as competitive weed thresholds are established for various potato varieties.

Table 1: Barnyardgrass control during the growing season - 1986.

Herbicide	Rate (lb ai/A)	Appl Time	% Control 7/11/86 EHLH	8/14/86 EH	8/14/86 LH	9/9/86 EH	9/9/86 LH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	97 a	98 a	97 a	85 ab	92 a
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	93 a	73 b	95 a	62 b	93 a
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	90 a	47 c	87 ab	20 cd	78 ab
Dual + Sen/Lex + (Dual + Sen/Lex)	2.0 + 0.5 + (2.0 + 0.5)	PRE + (DPRE)	100 a	100 a	100 a	100 a	100 a
Dual + Lorox	2.0 + 1.0	PRE	100 a	87 ab	97 a	87 a	90 a
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	100 a	93 a	95 a	92 a	75 ab
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	97 a	93 a	100 a	95 a	99 a
Hill only	-	-	12 b	17 d	33 cd	0 d	27 c

*COC = crop oil concentrate.
Statistical comparisons are valid only between columns 2 and 3, and columns 4 and 5.

Table 2: Redroot pigweed control during the growing season - 1986.

Herbicide	Rate (lb ai/A)	Appl Time	% Control 7/11/86 EHLH	8/14/86 EH	8/14/86 LH	9/9/86 EHLH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	100 a	100 a	100 a	93 a
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	100 a	95 a	100 a	86 a
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	100 a	97 a	100 a	96 a
Dual + Sen/Lex + (Dual + Sen/Lex)	2.0 + 0.5 + (2.0 + 0.5)	PRE + (DPRE)	100 a	100 a	100 a	98 a
Dual + Lorox	2.0 + 1.0	PRE	93 a	50 b	87 a	68 b
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	100 a	100 a	100 a	94 a
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	100 a	97 a	100 a	92 a
Hill only	-	-	23 b	17 d	33 c	13 c

*COC = crop oil concentrate.
Statistical comparisons are valid only between columns 2 and 3.

Table 3: Common lambsquarters control during the growing season - 1986.

Herbicide	Rate (lb ai/A)	Appl Time	% Control 7/11/86 EHLH	8/14/86 EH	8/14/86 LH	9/9/86 EH	9/9/86 LH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	100 a	100 a	100 a	100 a	98 a
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	100 a	100 a	100 a	100 a	100 a
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	100 a	57 bc	100 a	60 bc	98 a
Dual + Sen/Lex + (Dual + Sen/Lex)	2.0 + 0.5 + (2.0 + 0.5)	PRE + (DPRE)	100 a	100 a	97 a	100 a	100 a
Dual + Lorox	2.0 + 1.0	PRE	87 b	37 cd	77 ab	43 cd	78 ab
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	100 a	100 a	100 a	100 a	98 a
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	100 a	100 a	100 a	100 a	99 a
Hill only	-	-	11 c	17 d	33 d	0 e	27 d

*COC = Crop oil concentrate.
Statistical comparisons are valid only between columns 2 and 3, and columns 4 and 5.

Table 4: Injury evaluation and potato yield - 1986.

Herbicide	Rate (lb ai/A)	Appl. Time	% Visual Injury 6/2/86 ATL	% Visual Injury 6/2/86 RB	Yield (CWT/A) 10/3/86 ATL	Yield (CWT/A) 10/3/86 RB
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	10 b	0 c	515 ab	523 ab
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	12 b	0 c	513 ab	505 ab
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	20 a	2 c	527 a	453 cd
Dual + Sen/Lex + (Dual + Sen/Lex)	2.0 + 0.5 + (2.0 + 0.5)	PRE + (DPRE)	3 c	3 c	494 abc	496 abc
Dual + Lorox	2.0 + 1.0	PRE	0 c	o c	495 abc	474 bcd
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	8 c	0 c	513 ab	528 a
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	0 c	0 c	525 ab	487 abcd
Hill only	-	-	0 c	0 c	444 d	339 e

*COC = Crop oil concentrate.
Statistical comparisons are valid between columns 1 and 2, and between columns 3 and 4.

Table 5: Timing of hilling had no significant effect on potato yield - 1986.

Herbicide	Rate (lb ai/A)	Appl. Time	Yield (cwt/A) Atlantic EH	Atlantic LH	Russet B EH	Russet B LH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	501	528	501	544
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	494	532	512	497
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	495	559	435	472
Dual + Sen/Lex + (Dual + Sen/Lex)	2.0 + 0.5 + (2.0 + 0.5)	PRE + (DPRE)	487	502	493	498
Dual + Lorox	2.0 + 1.0	PRE	474	516	469	478
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	542	483	525	532
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	521	529	487	488
Hill only	-	-	433	456	307	372

*COC = Crop oil concentrate.
Statistical comparisons are valid between columns 1 and 2, and between columns 3 and 4.

Table 6: Barnyardgrass control during the growing season - 1987.

Herbicide	Rate (lb/ai/A)	Appl. Time	% Control 6/22/87 EH	6/22/87 LH	7/13/87 EH	7/13/87 LH	8/19/87 EH	8/19/87 LH	9/11/87 EH	9/11/87 LH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	94 a	95 a	92 abc	97 ab	87 a	94 a	75 abc	82 ab
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	55 c	73 b	50 e	83 bcd	25 de	78 ab	20 ef	62 bc
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	37 d	65 bc	20 f	70 d	7 ef	58 bc	0 f	25 ef
Dual + Sen/Lex	2.0 + 0.5	PRE	52 c	92 a	47 e	80 cd	47 cd	82 a	37 de	74 abc
Dual + Lorox	2.0 + 1.0	PRE	63 bc	93 a	43 e	83 bcd	23 ef	82 a	53 cd	73 abc
(Dual + Lorox)	(2.0 + 0.5)	(DPRE)	100 a	100 a	100 a	100 a	99 a	100 a	96 a	96 a
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	100 a	92 a	100 a	100 a	100 a	100 a	100 a	95 a
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	100 a	92 a	100 a	95 abc	99 a	93 a	98 a	85 ab
Hill only	-	-	0 e	0 e	0 g	0 g	0 f	0 f	23 ef	0 f

*COC = Crop oil concentrate.
Statistical comparisons are valid between columns for the same evaluation date only.

Table 7: Redroot pigweed control during the growing season - 1987.

Herbicide	Rate (lb/ai/A)	Appl. Time	% Control 6/22/87 EH	6/22/87 LH	7/13/87 EH	7/13/87 LH	8/19/87 EH	8/19/87 LH	9/11/87 EH	9/11/87 LH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	100 a	97 a	100 a	100 a	100 a	99 a	98 a	92 a
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	90 a	97 a	100 a	95 ab	100 a	90 ab	88 a	89 a
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	100 a	98 a	100 a	100 a	100 a	100 a	99 a	98 a
Dual + Sen/Lex	2.0 + 0.5	PRE	30 b	92 a	58 c	87 b	43 c	92 ab	10 c	80 a
Dual + Lorox	2.0 + 1.0	PRE	27 b	90 a	42 d	87 b	23 d	77 b	10 c	45 b
(Dual + Sen/Lex)	(2.0 + 0.5)	(DPRE)	100 a	98 a	100 a	100 a	100 a	99 a	100 a	90 a
(Dual + Lorox)	(2.0 + 1.0)	(PRE)	100 a	100 a	100 a	100 a	98 a	100 a	94 a	97 a
[Poast + Sen/Lex + COC]	[0.2 + 0.5 + 1 pt]	[POST]	100 a	100 a	100 a	100 a	99 a	99 a	100 a	88 a
Hill only	-	-	0 c	0 c	0 e	0 e	0 e	0 e	0 c	0 c

*COC = Crop oil concentrate.
Statistical comparisons are valid between columns for the same evaluation date only.

Table 8: Common lambsquarters control during the growing season - 1987.

Herbicide	Rate (lb/ai/A)	Appl. Time	% Control 6/22/87 EH	6/22/87 LH	7/13/87 EH	7/13/87 LH	8/19/87 EHLH**	9/11/87 EHLH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	100 a	98 a	100 a	100 a	100 a	100 a
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	100 a	98 a	100 a	100 a	98 a	98 a
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	100 a	90 a	100 a	100 a	95 a	92 a
Dual + Sen/Lex	2.0 + 0.5	PRE	40 b	90 a	60 b	87 a	55 b	60 b
Dual + Lorox	2.0 + 1.0	PRE	43 b	88 a	48 b	88 a	41 b	41 c
(Dual + Lorox)	(2.0 + 0.5)	(DPRE)	100 a	100 a	100 a	100 a	100 a	100 a
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	100 a	100 a	100 a	100 a	100 a	100 a
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	100 a	100 a	100 a	100 a	100 a	100 a
Hill only	-	-	0 c	0 c	0 c	0 c	0 c	0 c

*COC = Crop oil concentrate. EHLH = No significant difference between hilling times.
Statistical comparisons are valid between columns for the same evaluation date only.

Table 9: Potato injury evaluations in 1987.

Herbicide	Rate (lb/ai/A)	Appl. Time	% Visual Injury 5/31/87** EH	% Visual Injury 5/31/87** LH	% Visual Injury 6/22/87 EHLH
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	10 cd	17 bc	2 b
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	7 d	20 b	0 b
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	30 a	36 a	3 b
Dual + Sen/Lex	2.0 + 0.5	PRE	0 d	0 d	2 b
Dual + Lorox	2.0 + 1.0	PRE	0 d	0 d	1 b
(Dual + Sen/Lex)	(2.0 + 0.5)	(DPRE)	0 d	7 cd	1 b
(Dual + Lorox)	(2.0 + 1.0)	(DPRE)	0 d	0 d	0 b
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	0 d	0 d	18 a
Hill only	-	-	0 d	0 d	0 b

*COC = Crop oil concentrate.
**On 5/31/87 there was no significant difference between potato varieties.
Statistical comparisons are valid between columns under the same date only.

Table 10: Interactions of herbicide treatment with hilling time and variety on yield in 1987.

Herbicide	Rate (lb/ai/A)	Appl. Time	Yield (cwt/A) EH	Yield (cwt/A) LH	Yield (cwt/A) ATL	Yield (cwt/A) RB
Eptam + (Sen/Lex)	3.0 + (0.5)	PPI + (DPRE)	385 ad	400 a-d	457 a	328 ef
Eptam + (Lorox)	3.0 + (1.0)	PPI + (DPRE)	261 f-g	366 b-d	365 cd	262 g
Eptam + (Cobra)	3.0 + (0.25)	PPI + (DPRE)	165 h	306 ef	322 ef	149 i
Dual + Sen/Lex	2.0 + 0.5	PRE	194 h	356 de	315 f	235 h
Dual + Lorox	2.0 + 1.0	PRE	213 gh	375 bcd	349 de	239 gh
(Dual + Sen/Lex)	(2.0 + 0.5)	(DPRE)	420 abc	428 ab	465 a	382 bc
(Dual + Lorox)	(0.2 + 1.0)	(DPRE)	408 a-d	447 a	476 a	379 bc
[Poast + Sen/Lex + COC*]	[0.2 + 0.5 + 1 pt]	[POST]	381 b-d	362 cde	394 b	349 de
Hill only	-	-	107 i	100 i	135 i	73 j
Atlantic	-	-	324 b	405 a		
Russett Burbank	-	-	239 d	294 c		

*COC = Crop oil concentrate.
Statistical comparisons are valid between columns 1 and 2, and between columns 3 and 4.

Funding: MPIC and Ortho

APPLICATION OPTIMIZATION OF DIQUAT 2 FOR VINE KILL

1987 Report to the Michigan Potato Industry Commission

K. A. Renner, G. VanEe, D. Ledebuhr & D. Chase

Preliminary Report (year 1 of 2 year study)

Summary of Results

Research was conducted in 1987 on 'Onaway' potatoes (vine killed in July) in Bay County, and on 'Russet Burbank' potatoes (vine killed in September) in Montcalm County. Twenty-four vine kill treatments were applied to potatoes at both locations. Application optimization of Diquat 2 was evaluated at the Montcalm location only. A summary of the preliminary results is given below.

'Onaway' vine kill study: 'Onaway' potatoes were vine killed on July 9, 1987 at Johnson Brother's Farms in Bay County. Plots consisted of three rows of potatoes, each row forty feet in length. Twenty-four vine kill treatments were applied. Goal and Stampede were applied as experimental treatments to evaluate the possibility of their use as potato vine killers. They are not labeled by EPA for this use. H-273 was applied instead of Des-i-cate, because Des-i-cate was not available at the time of treatment (Des-i-cate and H-273 are two different formulated salts of the active ingredient endothall). Each treatment was replicated four times. All treatments were applied at 29 gpa and 50 psi with flat fan nozzles. A light drizzle fell within one hour of the last treatment. Treatments were made from 11:00 a.m. to 1:00 p.m. on July 9, 1987, when humidity was high and the air temperature was 90^{O}F.

Visual evaluations of the degree of vine kill were made 4, 7, and 14 days after treatment. The percentage of moisture remaining in the vines 7 and 14 days after vine kill applications were calculated by measuring fresh weight of two vines per plot, drying these vines in an oven, and then measuring dry weights. Potatoes were harvested on July 23, 1987, fourteen days after vine kill treatment. Potatoes were dug from the middle row of the plot and windrowed. Twenty feet of row from the center of each plot were graded and the total yield per plot calculated and then converted to tuber yield on a per acre basis. Specific gravities were determined for potatoes from each plot. Twenty potatoes from each plot were evaluated using catachol for the degree of skin set (as measured by the percentage of total tuber area that was skinned). Stem end tuber discoloration was measured from a sample of 20 potatoes from each plot. All data were subjected to a statistical analyses of variance to determine if there were any statistical differences between the various vine kill treatments for the various parameters measured.

The results of the vine kill experiment are presented in Table 1. Goal and Stampede are not currently labeled as potato vine desiccants and should not be applied to potatoes in Michigan. All treatments were applied at 50 psi, which appeared to be adequate pressure for vine kill on 'Onaways'. Spray pressures above 50 psi are not recommended when vine killing because of the increased risk of spray drift.

The average yield for the plots harvested on a per acre basis were 296 cwt/A. A 55 cwt/A yield difference was needed for there to be a significant difference in yield between plots due to vine kill treatment effects. The variability in the field resulted in this 55 cwt/A difference being necessary for a true statistical difference to occur between vine kill treatments. There was no significant difference in yield between the untreated plots (314 cwt/A) (Treatment 1) and the hand-clipped vine plots (291 cwt/A) (Treatment 2). The vines were left untreated in one plot to show the degree of skin set on potatoes that were not vine killed, and also to determine how much additional weight the tubers gained between July 9 (day of the vine kill applications) and July 23 (harvest date). The hand-clipped vine treatment determined the potato yield on July 9, and this yield was compared to the potato yield on July 23 in the untreated plots. the hand-clipped vine plot was also used to determine if a quick kill (i.e. clipping of the vines) would cause poor skin set and/or stem end discoloration. Potatoes that were not vine killed had the greatest degree of skinning. If these potatoes had been mechanically harvested after windrowing and then evaluated for skin set, the degree of skinning would probably have been much greater.

There were no statistical difference in stem end discoloration between any of the treatments. Since 2.5 tubers out of 20 in the untreated plots had some stem end discoloration, it appeared that none of the vine killers increased stem end discoloration on the 'Onaway' potatoes. The stem end discoloration noted was slight, and may have been caused by Verticillium wilt, particularly when noted in tubers from the untreated plot.

There were no significant differences in the specific gravities between any of the vine killed potato plots and the check plots. Therefore, potato vine killers did not appear to increase or decrease specific gravity in this study.

Potato yield varied across treatments, but there was little correlation between the degree or quickness of vine kill and potato yield. There was a trend for a lower yield with a rapid kill, but this difference was not significant. In other words, the slower or poorer vine kill treatments did not have significantly higher yields even through the vines remained green longer and were still capable of photosynthesis.

There were marked visual differences in the quickness of the vine kill and the thoroughness of the vine kill from the different treatments. The visual evaluations had a high negative correlation with the amount of moisture remaining in the potato vines (the poorer the visual kill, the greater the moisture content of the vines). On July 13, the untreated plots had 5% visual dieback. By July 23 the 'Onaway' potatoes had started to diedown naturally and the untreated plots (Treatment 1) were evaluated as having 58% visual dieback. Therefore, visual evaluations on July 23, 1987 of 58% dieback $\pm$ 16% (LSD .05 = 16% on this data set) would reflect no difference between a chemical vine kill treatment and natural diedown from the untreated check.

All Goal + Ag-98 ¼nonionic surfactant (NIS) treatments (Treatments 3, 4, 5) gave poor vine kill. Goal reduced the efficacy of Diquat, when applied in combination with Diquat and a nonionic surfactant (Treatments 6, 7, 8). Evik gave an excellent kill of potato vines. The kill was slower with Evik than Diquat (Treatments 9 & 10) or Gramoxone Super (paraquat) (Treatments 19, 20). Evik 80W at 2.5 lb/A (Treatment 18) gave a faster kill and had a lower yield than the 1.5 lb/A rate applied either with or without a nonionic surfactant (Treatments 16 & 17). Evik has herbicidal activity in the soil. After potato harvest, rye should not be planted for at least three weeks to allow time for the Evik to dissipate in the soil.

Two pints of Diquat plus a nonionic surfactant (Treatment 10) gave a quicker kill than 1 pint of Diquat plus a nonionic surfactant (Treatment 9), but this was not statistically significant. The addition of a drift retardant (Chemtrol) (Treatment 11) did not change the degree of vine kill. The addition of ammonium sulfate or copper sulfate to Diquat plus a nonionic surfactant (Treatments 12 & 13) appeared to slow the rate of vine kill and also resulted in a less thorough kill. The addition of ammonium sulfate or copper sulfate plus surfactant plus a drift retardant (Treatments 14 & 15) also gave a slower and less thorough kill. However, this change in the visual efficacy of Diquat was not reflected in tuber yield or the degree of skin set. Compatibility problems in the spray tank occurred with copper sulfate. If adding copper sulfate, the sprayer should have an excellent agitation system. Stampede + Sevin + COC (crop oil concentrate) gave a slow but thorough vine kill (Treatments 23 & 24). Tubers were taken from the Stampede and Goal plots and will be analyzed by Rohm and Haas Company to determine if the chemicals entered the tuber, and the potential use of these chemicals as potato vine killers. H-273 performed poorly as a vine killer (Treatments 21 & 22). H-273 is the dipotassium salt of endothall and is not labeled for use in potatoes. Des-i-cate is the mono N, N-dimethylalkylamine salt of endothall and is labeled as a potato vine killer. Des-i-cate may perform better than H-273 as a vine killer since formulations of postemergence chemicals can affect their efficacy. However, Des-i-cate was not compared to H-273 in this study.

Gramoxone Super (paraquat) (Treatments 19 & 20) gave a very rapid kill. The 2 1/2 pt/A rate of Gramoxone Super plus a nonionic surfactant (Treatment 20) gave a quicker and more thorough kill than the 1 1/2 pint/A application (Treatment 19). The potato leaves in the Diquat and Gramoxone Super treatments were very brown four days after application, but the potato stems remained green. The Gramoxone Super treatments were two of the lowest yielding treatments in the study. There was no increase in stem end discoloration or a poorer skin set from the Gramoxone Super treatments.

Vine killing of 'Onaway' summer potatoes resulted in a better skin set and a better quality potato for fresh market. In this study, vine kill did not change the specific gravity of the potato or cause increased stem end discoloration. Tuber yield varied between treatments, but did not have a high correlation with the quickness or thoroughness of the vine kill. There was a trend for a lower yield with a very rapid kill, but this was not statistically significant. Evik 80W at 1.5 lb/A with or without nonionic surfactant, Diquat at 1 to 2 pt/A with nonionic surfactant, and Gramoxone Super at 2 1/2 pt/A with a nonionic surfactant gave an adequate vine kill. The addition of a drift retardant to the Diquat treatment did not affect the rate or thoroughness of the vine kill. The addition of copper sulfate or ammonium sulfate to Diquat plus nonionic surfactant and with or without a drift retardant were antagonistic to Diquat and slowed the rate of vine kill. Copper sulfate settled out in the spray tank, and adequate agitation or a formulated product containing copper sulfate, would be necessary if a grower wished to add copper sulfate when vine killing with Diquat. Excellent vine kill of 'Onaway' potatoes was achieved with the labeled chemical options available in Michigan.

Russet Burbank' Vine Kill Study: Russet Burbank potatoes were vine killed on September 9, 1987 at Crawford Farms in Montcalm County. Plots consisted of 4 rows of potatoes, 30 foot in length. Twenty-four vine kill treatments were applied at 29 gpa and 50 psi. Each treatment was replicated four times. Visual evaluations were made 2, 6, and 14 days after treatment. Potatoes were harvested September 24, 1987, and dug from the center 2 rows of the plots. Twenty feet of the center 2 rows were graded and yield per acre calculated. Stem end discoloration was measured for certain treatments.

The results for this vine kill study are presented in Table 2. The yield of the non-vine killed plot was 496 cwt/Acre, while hand-clipped yielded 408 cwt/Acre. There was no significant difference in stem end discoloration between these two treatments. Evik gave a slower vine kill than Desicate, Diquat, or Gramoxone Super, but 14 days after treatment visual vine dieback had reached 89-93%. The addition of ammonium sulfate or copper sulfate did not enhance the degree of kill by Diquat, and there was no difference in the degree of visual dieback 6 days after treatment between treatments of Diquat + X-77 and Diquat plus various additives. There was no difference in the degree of vine kill from the 3 application rates of Desicate tested, and no difference in the degree of kill when crop oil concentrate was added. Gramoxone Super did not provide as rapid a vine kill as Diquat in this study. There was a trend for increased stem end discoloration from Gramoxone Super applications. All treatments gave excellent potato vine kill. However, 14 days after herbicide application the untreated plot had 81% dieback. Therefore, the '6 day after treatment' is the best date in this study to evaluate the quickness of vine kill. Evik and the lower application rate of Desicate provided slower vine dieback than other treatments.

'Application Optimization Study': 'Russet Burbank' potatoes were vine killed on September 9, 1987 at Crawford Farms in Montcalm County. Plots consisted of 6 rows of potatoes, 30 foot in length. Seven vine kill methods were used to apply Diquat + X-77 (1 pt/A + 1/2% v/v). Each treatment was replicated four times. Visual evaluations of the degree of vine kill were made 2, 6, and 14 days after treatment. The percentage of moisture remaining in the vines 6 and 14 days after vine kill was determined by measuring fresh weight of two vines per plot, drying these vines in an oven, and measuring dry weights. Plots were dug on September 24, 1987 and grade and yield calculated from 15 foot of row of each of the center two plot rows. All yield data was converted to a per acre basis.

The results of this vine kill study are presented in Table 3. Handclipped plots had the lowest yield. All plots had 59 to 64% of total weight harvested graded as A's. Incorrect adjustment of the air curtain sprayer resulted in only 2/3's of the plot area receiving the Diquat application, and the application rate in the treated area was greater than 1 pt/A. The roller followed by a flat fan application at 50 gpa and 50 psi had a faster and more thorough kill than the other application methods.

Trt. No.	Treatment	Rate[a]	% Visual dieback July 13	% Visual dieback July 16	% Moisture in vines July 16	% Visual dieback July 23	% Moisture in vines July 23	Yield (cwt/A)	Specific Gravity	% of Tuber surface with skinning	% of Tubers in 20 showing stem end discoloration
1	untreated	-	5	11	89	58	73	314	1.067	17.00	2.50
2	hand-clipped	-	100	100	77	98	56	291	1.060	8.50	4.50
3	Goal + Ag-98	0.6 pt + 1/2%	14	24	88	60	80	344	1.067	11.75	5.75
4	Goal + Ag-98	1.25 pt + 1/2%	29	33	89	69	66	265	1.061	10.00	2.25
5	Goal + Ag-98	2.5 pt + 1/2%	34	40	90	74	81	254	1.064	10.25	3.00
6	Goal + Diquat + Ag-98	0.6 pt + 0.5 pt + 1/2%	21	25	91	68	80	268	1.067	13.25	2.25
7	Goal + Diquat + Ag-98	0.6 pt + 1.0 pt + 1/2%	31	35	90	71	80	319	1.069	15.75	4.50
8	Goal + Diquat + Ag-98	1.25 pt + 1.0 pt + 1/2%	31	40	91	74	75	299	1.067	11.00	2.25
9	Diquat + Ag-98	1 pt + 1/2%	75	85	86	88	53	321	1.062	9.75	3.25
10	Diquat + Ag-98	2 pt + 1/2%	88	94	87	97	36	311	1.061	9.00	2.00
11	Diquat + Ag-98 + Chemtrol[c]	1 pt + 1/2% + 1/8%	80	85	83	90	40	304	1.063	8.00	3.75
12	Diquat + AMS[e] + X-77[b]	1 pt + 5 lb + 1/2%	58	58	87	86	72	312	1.064	6.75	2.50
13	Diquat + $CuSO_4$[e] + X-77	1 pt + 5 lb + 1/2%	76	68	86	83	53	318	1.061	7.75	3.00
14	Diquat + AMS + X-77 + Chemtrol	1 pt + 5 lb + 1/2% + 1/8%	36	50	92	66	81	291	1.067	5.25	1.50
15	Diquat + $CuSO_4$ + X-77 + Chemtrol	1 pt + 5 lb + 1/2% + 1/8%	58	58	88	80	66	319	1.063	12.00	2.00
16	Evik 80W	1.5 lb	69	79	87	98	51	312	1.061	10.50	4.00
17	Evik 80W + X-77	1.5 lb + 1/2%	65	74	89	96	49	289	1.058	8.00	3.50
18	Evik 80W	2.5 lb	69	85	87	99	36	260	1.063	6.50	3.75
19	Gramoxone Super + X-77	1.3 pt + 1/2%	50	59	89	68	65	278	1.064	13.75	4.25
20	Gramoxone Super + X-77	2.6 pt + 1/2%	71	76	86	87	46	275	1.063	8.50	2.75
21	H-273	2 pt	35	31	89	59	82	315	1.062	12.50	1.75
22	H-273 + COC[d]	2 pt + 1 qt	48	39	89	68	81	291	1.064	8.00	3.25
23	Stampede + Sevin + COC	5.3 pt + 3/4 pt + 1 qt	53	68	88	93	55	277	1.062	8.75	3.00
24	Stampede + Sevin + COC	10.6 pt + 1 1/2 pt + 1 qt	66	79	79	99	36	270	1.063	11.50	3.00
Least significant difference LSD (0.5) =			13	14	7	16	25	55	NS	NS	NS

[a]Rates are given in amount of formulated product applied per acre. Surfactant rates are given in a % of volume of surfactant/volume of spray mixtures.

[b]Ag-98 and X-77 are nonionic surfactants.

[c]Chemtrol is a drift retardant.

[d]COC is crop oil concentrate.

[e]AMS = ammonium sulfate, $CuSO_4$ = copper sulfate.

Table 2: Results of vine kill of 'Russett Burbank' potatoes in Sept, 1987.

Treat-Number	Treatment	Rate lb/A	% Visual Die Back: 2 Days After Treatment	% Visual Die Back: 6 Days After Treatment	% Visual Die Back: 14 Days After Treatment	Yield: A's	Yield: B's	Yield: OVER	Yield: KNOB	Yield: CWT/A	Yield: % A's	% of Tubers in 10 Showing Stem End Discoloration
												------(%)------
01	Desicate	1 Gal	4.8	8.8	9.7	221	93	27	22	362	46	-
02	Desicate	1 1/2 Gal	5.5	9.1	9.8	214	91	22	25	351	46	-
03	Deiscate	2 Gal	5.8	9.1	9.7	219	82	25	15	340	48	23
04	Untreated	-	0	2.4	8.1	337	107	16	36	496	66	20
05	Evik 80W	1.5 Lb	0	4.3	9.3	276	84	44	34	438	63	-
06	Evik 80W	2.5 Lb	0	4.4	9.0	277	95	33	31	436	63	-
07	Evik 80W X-77	1.5 Lb 1/2%	0	4.5	8.9	265	93	23	46	426	61	15
08	Hand clipped	-	-	-	-	250	86	20	52	408	61	18
09	Diquat X-77	1 Pt 1/2%	7.5	9.6	9.9	270	109	28	50	456	59	-
10	Diquat X-77	2 Pt 1/2%	8.3	9.7	9.9	297	95	30	25	447	66	-
11	Diquat AG-98 Orthotrol	1 Pt 1/2% 1/8%	7.3	9.4	9.9	270	108	22	46	439	62	-
12	Diquat AMS X-77	1 Pt 5 Lb 1/2%	5.3	8.75	9.7	300	93	46	52	491	61	-
13	Diquat CUSO4 X-77	1 Pt 5 Lb 1/2%	7.0	9.3	9.9	285	80	23	45	433	66	-

Table 2: Results of vine kill of 'Russett Burbank' potatoes in September, 1987 Continued:

Treat- Number	Treatment	Rate lb/A	% Visual Die Back: 2 Days After Treatment	% Visual Die Back: 6 Days After Treatment	% Visual Die Back: 14 Days After Treatment	Yield: A's	Yield: B's	Yield: OVER	Yield: KNOB	Yield: CWT/A	Yield: % A's	% of Tubers in 10 Showing Stem End Discoloration
												-----(%)------
14	Desicate COC	1 Gal 1 Qt	3.3	7.8	9.3	291	108	26	39	464	62	-
15	Desicate COC	1 1/2 Gal 1 Qt	3.8	8.2	9.4	196	81	30	37	344	42	-
16	Diquat AG-98 Stay-Put	1 Pt 1/2% 1/8%	6.4	9.4	9.9	257	89	24	58	428	60	-
17	Stampede Sevin 80W COC	5.3 Pt 3/4 Pt 1 Pt	0.4	5.9	8.9	301	87	24	59	471	64	-
18	Stampede Sevin 80W COC	10.6 Pt 3/4 Pt 1 Qt	0.8	7.1	9.1	295	107	37	54	492	59	18
19	Desicate	1 1/2 Gal	3.8	9.0	9.5	314	120	25	55	515	61	18
20	Desicate COC	1 1/2 Gal 1 Qt	3.4	8.7	9.4	323	109	44	38	515	62	10
21	Gramoxone Super X-77	1.3 Pt 1/2%	5.5	9.4	9.7	310	120	31	38	498	62	40
22	Gramoxone Super X-77	2.6 Pt 1/2%	7.4	9.7	10.0	321	108	22	30	481	67	27
23	Diquat AMS X-77 Orthotrol	1 Pt 5 Lb 1/2% 1/8%	4.1	8.9	9.8	323	120	34	22	498	64	27
24	Diquat CUSO4 X-77 Orthotrol	1 Pt 5 Lb 1/2% 1/8%	5.3	9.1	9.5	303	110	50	16	479	63	23

Table 3: Vine Kill Application Optimization of 'Russett Burbank' potatoes (Montcalm County), MI - 1987*.

Treat-number	Treatment	% Visual Dieback: 2 Days After Treatment	% Visual Dieback: 6 Days After Treatment	% Visual Dieback: 14 Days After Treatment	Yield: A's	Yield: B's	Yield: OVERS	Yield: KNOBS	Yield: CWT/A	Yield: % A's
01	Untreated	0	1.4	6.3	308	127	37	34	505	61
02	Hand clipped	-	-	-	279	143	20	18	459	61
03	Flat Fan 50 gpa, 50 psi	4.0	7.8	9.0	295	126	42	16	479	62
04	Roller + Flat Fan 50 gpa, 50 psi	7.0	9.6	9.8	295	141	27	20	482	61
05	Hollow Cone 20" spacing 50 gpa, 125 psi	4.0	8.2	8.9	331	125	30	29	520	63
06	Hollow Cone 10" spacing 50 gpa, 125 psi	6.1	8.9	9.3	318	122	33	22	495	64
07	MSU Air Curtain**	4.5/7.3	2.6/9.4	7.6	312	132	43	41	528	59

*All Treatments Sprayed with Diquat: 1 pt/A

X-77: 1/2% (v/v)

**Air curtain adjustment incorrect. 2/3 plot area sprayed, with 1/3 plot area untreated strips.

Funding: Federal Grant

TITLE: Influence of Environmental Factors on Wound Healing of Potato Tubers in Relation to Storage Disorders

INVESTIGATORS: R. Hammerschmidt and A.C. Cameron

OBJECTIVES:

A. Monitor the wound healing process in relation to the development of disease (soft rot) and water vapor loss as a function of CO_2 levels.

B. Evaluate the effect of CO_2 on the development of *Erwinia* soft rot decay of potato tuber tissue.

C. Evaluate selected varieties for resistance to dry rot (*Fusarium sambucinum*), soft rot (*Erwinia carotovora*), and wound healing.

D. Evaluate wound healing rates and disease reactions of tubers at various times in storage.

JUSTIFICATION:

Storage disorders of potato tubers can lead to economic loss due to shrinkage (water loss) and decay caused by pathogens. Much of this type of loss can be traced to wounds that occurred on the tubers during the harvesting and handling of the tubers and conditions that do not promote proper healing (suberization) of wounds. Suberization has been shown in the past to be an effective means to prevent both excessive loss of water and invasion by tuber rotting organisms. A full understanding of the wound healing process, the environmental factors that influence the wound healing process and disease development, and the mode of infection by tuber rotting organisms is needed to help in the reduction of storage losses by improved engineering of the storage. Our current knowledge of these areas is incomplete.

PROCEDURES:

A. Screening methods.

1. Resistance to water loss: For this procedure, 2.1 cm diameter by 1.0 cm thick slices of tuber tissue were prepared from surface sterilized tubers. The slices were placed into chambers (20'C) and humidified air (90-95% RH) passed through the chambers at a constant flow rate. At intervals, the slices were sampled for the development of resistance to water loss by determining the rate of water loss from disks over a specified time period.

2. Suberin deposition: Suberin deposition can be determined by measuring the deposition of the lignin-like component of the polymer via the thioglycolic acid procedure. In this assay, the top mm of tuber slices are excised from the slice and then thoroughly extracted with methanol and chloroform and the tissue residue reacted with thioglycolic acid in HCl. The lignin-reaction product can

then be measured via spectrophotometry. The slices were also evaluated for suberization by direct microscopic examination.

3. Resistance to maceration: Since the major tuber rotting organisms attack the tuber tissues by macerating enzymes, these enzymes were used to determine the effectiveness of the suberin barrier against these enzymes. The top mm slices of healed tuber disks were incubated over night with the enzyme mixture and visually inspected for the amount of degradation. This assay provides good correlation with suberin deposition rates and the development of resistance of the wound to infection.

4. Wound induced antibiotic substances: Wounding of tubers results in the deposition of antimicrobial compounds in the newly formed suberin layer. A primary component is the phenolic compound chlorogenic acid which is readily assayed from the methanol extracts prepared from the tuber slices used in the maceration or lignin assays.

5. Whole tuber disease resistance screens: Whole tubers were inoculated with either spores of Fusarium sambucinum or cells of Erwinia carotovora pv. carotovora by injection to a depth of 1 cm. The tubers were analyzed at four weeks (Fusarium) or 6 days (Erwinia) by slicing the tubers through the inoculation site and measuring the diameter of the lesion.

B. Environmental factors and storage duration:

1. Storage duration: Russet Burbank, Atlantic and Superior tubers were stored at 5C and sampled several times for wound healing ability and disease response over a 10 month period.

2. Effect of CO_2 on wound healing and soft rot development: CO_2 was blended in the humidified air stream to yield final concentrations of 0% added CO_2, 2%, 4%, 6%, and 8% CO_2. Tuber slices for wound healing measurements or whole tuber inoculuated with Erwinia were placed into chambers with one of the above types of atmospheres.

RESULTS AND DISCUSSION:

Variety responses to wound healing and disease:

No major differences were found among 15 varieties for the development of resistance to water loss. Onaway and Sunrise exhibited slightly greater resistance development than the other varieties tested. Analysis of these varieties for degree of lignin developement and resistance to maceration showed that most varieties had initiated good suberization and resistance to maceration by 4 days. A few varieties, most notably Atlantic, required up to 6 days for consistently good suberization. No high degree of resistance to either Erwinia soft rot or Fusarium dry rot was detected in the varieties tested although some differences in the severity of disease was detected.

Effect of storage duration on wound healing and disease:

Over a 10 month period, no effect of time in storage was noted in the ability of wounded tuber tissue to develop resistance to water loss. A gradual decline in the resistance to Erwinia and Fusarium infection as well as the ability to deposit the lignin portion of suberin were noted over the 9 month period. These results are not totally surprising since resistance to water loss and the structural parts of suberin are believed to be produced by different metabolic pathways of the tuber.

Effect of CO_2 levels on wound healing and soft rot decay:

A dramatic decrease in wound healing ability and increase in soft rot decay were noticed between the tuber slices and whole tubers incubated in air vs those in 2%CO_2. A gradual decline in the rate of wound healing (as measured by resitance to water loss, lignin deposition, maceration resistance and chlorogenic acid accumulation) was detected as the levels of added CO_2 increased from 0 to 8%. Increase in soft rot decay followed the same pattern with essentially no rot in air and gradually increasing degrees of decay as the level of CO_2 increased. These results clearly show that increases in CO_2 during the early phases of storage can have a very negative effect on the tubers (even though adequate oxygen was present). Preliminary experiments indicate that developing soft rot lesions can be arrested by decreasing CO_2 levels during the first few days following inoculation.

In conclusion, our research from the last year has demonstrated several aspects of wound healing and pathogen infection as these factors relate to variety, storage atmosphere, time in storage and how all of these factors can potentially influence tuber quality. First of all, we examined the influence of CO_2 on the rate of wound healing and resistance of tubers to soft rot, a major storage disorder. This information indicates that if CO_2 levels are too high, even in the presence of adequate O_2, the quality of the stored tubers can be decreased through shrinkage and/or pathogen decay. We have also shown that there was no high level of disease resistance present in the selections screened. This fact makes the studies on proper environmental conditions for wound healing more important because of the effective barrier against infection that is provided by an complete skin (periderm) of the tuber. The decrease in pathogen resistance during the storage in combination with a gradually decreasing ability to develop effective wound barriers underlies the care that needs to be taken in protecting the tubers as they are being removed from storage.

THE EFFECTS OF PRESTORAGE CHEMICAL TREATMENTS ON THE MARKET QUALITY OF POTATOES 1986-1987

B.F. Cargill, T.D. Forbush, R.C. Brook, R.L. Ledebuhr, G.R. Van Ee
Agricultural Engineering Department
H.S. Potter, Botany and Plant Pathology

While the current potato harvesting and handling equipment has greatly reduced the time required for fall harvest, it also has one large disadvantage--excessive tuber damage. This is the final research report on the influence of prestorage mechanical handling and chemical treatments on the market quality of potatoes out of extended storage.

PROCEDURE

Potato - The MSU Atlantic and Shepody potatoes were grown at the Michigan State University potato research farm, Entrican, MI, and were harvested using the MSU one-row plot harvester.

Chemical Solution/Treatments - All potatoes were treated with the MSU developed air curtain sprayer, which incorporated low volume application technology, mounted on the bin piler. The chemical solution used for all treatments consisted of 0.42 oz of Mertect 340F per ton of potatoes, with a carrier solution which contained 4.2 oz of either water, or soybean oil with 5% Rohm Hass food grade emulsifier. Purigene was added to the total solution to provide 200 ppm of chlorine dioxide.

Sample Preparation - The effect of various degrees of bruising was investigated. A complete list of treatments is presented in Table 1.

Storage Environment - Immediately after treatment, 25 lb samples were collected and placed in controlled environment cubicle storage at MSU. The potatoes in the cubicles were suberized for two weeks; one week at 60F and 95% RH. and one week at 55F and 95% RH. After suberization the potatoes were lowered 5F/week until reaching desired storage temperatures were obtained. The Atlantic potatoes were stored at temperatures of 45F and 50F; the Shepody potatoes were stored at temperatures of 40F and 45F.

EVALUATION METHODS

Analysis of Treatment Bruising - Various lots of 80 lb samples of potatoes from each treatment were collected just prior to placement in the storage bin. These samples were delivered to Ore-Ida Foods, Greenville, MI, where they were held at room temperature for 48 hours before evaluation for bruising (including both shatter bruise and black spot bruise).

Market Quality - Market quality evaluations were done on the stored potato samples after 92 and 187 days of storage. These evaluations involved removal of the respective sample from storage and cutting and examining each individual tuber.

Acceptable Shatter Bruise - Acceptable shatter bruise includes only those potatoes that had suffered a shatter bruise during harvesting and/or handling. A potato that has no shatter bruise may not be affected by the treatment since there is no avenue for the fungus to enter the tuber.

Weight Loss - The samples were weighed after suberization and at the market quality evaluation dates. Weight loss is represented by percent and is determined by total sample weight at harvest and at subsequent evaluations.

RESULTS AND DISCUSSION

Harvest - Rainfall in 1986 prior to potato harvest (14 inches in a 14 hour period in early September) reduced the amount and quality of harvestable potatoes.

Analysis of Treatment Bruising - The results of the bruise-free analysis conducted by Ore-Ida are presented in Table 2. The difference in the bruise free ratings shows that there is a significant increase in the level of bruising of the bruised treatment versus the other treatments.

Market Quality - The results of the market quality evaluations are presented in Tables 3-4. The differences in means were not statistically significant at the 10% level. However, these potatoes were all of high quality. Previous research supports the observation that high market quality potatoes are not as significantly affected by this treatment method as lower market quality potatoes.

Acceptable Shatter Bruise - The results of the acceptable shatter bruise evaluations are presented in Tables 5-6. The differences in means were not statistically significant at the 10% level. However, mean separations indicate an increase of acceptable shatter bruise on potatoes treated with both chemical solutions.

Weight Loss - The results of the weight loss calculations are presented in Tables 7-8. In the majority of the cases, the weight loss from the samples treated with the oil-carrier solution were statistically significant at the 10% level relative to other treatments. Previous research supports this observation that the oil-carrier treatments result in significantly less weight loss during storage than the other treatments investigated.

CONCLUSIONS

1) The low volume application technology has allowed the full advantage of these chemical treatments to be realized. The problem of excessive water in the pile that was apparent with previous application systems has been eliminated, while maintaining the increased market quality exhibited by the chemical treatments.

2) both oil and water carriers were equally effective with respect to maintaining market quality and reducing the effects of shatter bruise.

3) soybean oil decreases weight loss over check and water carrier treatments; this decrease was of sufficient magnitude to recover increased treatment costs for the soybean oil carrier.

Table 1. Treatments Performed in the 1986-1987 MSU Potato Storage Research Project.

Treatment	Mechanical handling	Chemical applied
Check Harvester	MSU plot harvester	--
Check Non-Bruised	MSU plot harvester and bin piler	--
Water Non-Bruised	MSU Plot harvester and bin piler	0.42 fl oz Mertect 340F, 4.2 oz water with 200 ppm chlorine dioxide
Oil Non-Bruised	MSU Plot harvester and bin piler	0.42 fl oz Mertect 340F, 4.2 oz soybean oil with 5% Rohm Hass food grade emulsifier with 200 ppm chlorine dioxide
Check Bruised	MSU plot harvester, bin piler and artificial bruising devices (windrower)	--
Water Bruised	MSU plot harvester, bin piler and artificial bruising devices (windrower)	0.42 fl oz Mertect 340F, 4.2 oz water with 200 ppm chlorine dioxide
Oil Bruised	MSU plot harvester, bin piler and artificial bruising devices (windrower)	0.42 fl oz Mertect 340F, 4.2 oz soybean oil with 5% Rohm Hass food grade emulsifier with 200 ppm chlorine dioxide

Table 2. Bruise Free Percent Evaluated by Ore-Ida Foods, Greenville, MI.

Mechanical handling	Bruise free rating (%)	
	1986 Atlantic	1986 Shepody
MSU plot harvester	55	71
MSU plot harvester and bin piler	56	57
MSU plot harvester, bin piler and windrower	36	49

Table 3. Percent Marketable by Number of MSU Grown and Stored 1986-87 Atlantic Potatoes.

Days in Storage	92 days		187 days	
	45F	50F	45F	50F
Check Harvester	96.5	--	94.5	--
Check Piler	92.3	95.4	94.0	93.5
Water Non-Bruised	92.8	95.8	93.9	87.1
Oil Non-Bruised	96.1	92.1	89.3	88.8
Check Bruised	87.8	88.5	81.8	82.8
Water Bruised	87.9	89.6	85.9	86.3
Oil Bruised	91.0	84.9	83.9	82.2

Table 4. Percent Marketable by Number of MSU Grown and Stored 1986-87 Shepody Potatoes

Days in Storage	92 days		187 days	
	40F	45F	40F	45F
Check Harvester	--	99.0	--	98.2
Check Piler	97.5	95.5	96.4	97.3
Water Non-Bruised	97.9	97.2	97.2	98.3
Oil Non-Bruised	97.5	96.3	96.6	97.6
Check Bruised	94.5	96.3	95.5	92.9
Water Bruised	96.5	96.3	94.1	94.4
Oil Bruised	95.9	96.0	95.4	92.5

Table 5. Percent Acceptable Shatter Bruise by Number of MSU Grown and Stored 1986-87 Atlantic Potatoes.

Days in Storage	92 days		187 days	
	45F	50F	45F	50F
Check Harvester	82.3	--	71.8	--
Check Piler	82.1	88.4	82.3	80.5
Water Non-Bruised	79.9	89.8	82.1	69.6
Oil Non-Bruised	87.1	81.5	75.2	76.7
Check Bruised	72.6	76.4	64.3	66.9
Water Bruised	73.8	79.3	73.1	71.2
Oil Bruised	80.8	73.4	68.7	64.8

Table 6. Percent Acceptable Shatter Bruise by Number of MSU Grown and Stored 1986-87 Shepody Potatoes in Storage.

Days in Storage	92 days		187 days	
	40F	45F	40F	45F
Check Harvester	--	92.9	--	90.6
Check Piler	90.5	85.6	90.2	90.9
Water Non-Bruised	92.4	92.3	83.7	94.4
Oil Non-Bruised	87.8	84.3	86.8	89.7
Check Bruised	85.7	90.1	84.9	82.9
Water Bruised	89.1	91.4	81.5	87.4
Oil Bruised	88.9	89.2	87.0	83.7

Table 7. Weight loss, %, of 1986-1987 MSU Growth and Stored Atlantic Potatoes.

Days in Storage	Suberization	92 Days		187 Days	
		45F	50F	45F	50F
Check Harvester	--	7.13	--	15.78	--
Check Piler	2.20	4.20	4.20	13.40	14.83
Water Non-Bruised	2.04	5.73	4.20	14.60	13.33
Oil Non-Bruised	1.76[b]	4.40	4.43	12.85	14.10
Check Bruised	1.82	4.51	7.33	13.84	14.72
Water Bruised	2.01	4.41	4.33	14.67[a]	15.65
Oil Bruised	1.45[bc]	4.23	4.32	13.48[c]	13.05[c]

a. Water treatment significantly differs from corresponding check treatment ($p<0.10$).
b. Oil treatment significantly differs from corresponding check treatment ($p<0.10$).
c. Oil treatment significantly differs from corresponding water treatment ($p<0.10$).

Table 8. Weight loss, %, of 1986-1987 MSU Growth and Stored Shepody Potatoes.

Days in Storage	Suberization	92 Days		187 Days	
		40F	45F	40F	45F
Check Harvester	--	--	6.47	--	--
Check Piler	3.03	4.15	4.45	8.30	9.07
Water Non-Bruised	3.36	3.99	3.84	12.27	9.97
Oil Non-Bruised	2.91	3.91	5.14	9.85	9.90[b]
Check Bruised	2.85	3.56	3.79	10.51	10.56
Water Bruised	2.88	4.05[a]	3.78	10.31	10.86
Oil Bruised	2.55[bc]	3.18[bc]	3.58	8.92[bc]	9.55[bc]

a. Water treatment significantly differs from corresponding check treatment ($p<0.10$).
b. Oil treatment significantly differs from corresponding check treatment ($p<0.10$).
c. Oil treatment significantly differs from corresponding water treatment ($p<0.10$).

SIMULATED POTATO STORAGE RESEARCH

Roger Brook and Todd Forbush
Agricultural Engineering Department

OBJECTIVE

The overall goal of this project was to develop and validate an improved MSU Simulated Storage system in which the environmental conditions could be controlled, monitored, and replicated to study potatoes over an extended storage season.

METHODS/PROCEDURES

The Simulated Storage was a potato bin measuring 8'X 8'10" X 18' high. Each bin was filled with approximately 370 cwt. of Atlantic potatoes.

Each Simulated Storage was equipped with a ventilation system which was independent of the other storages. The intake air was drawn from the attic of the building. Fresh air was distributed to the three Simulated Storages through a "fresh air manifold" to insure that these bins had access to the same intake air. Air was exhausted via pressure louvers over the top of an adjoining commercial bin. A floor plan of the storage facility is shown in Figure 1.

Three ventilation rates were studied 1.72 (same as adjoining commercial bin), 3.0, and 4.5 cfm/cwt. These ventilation rates were approximately 1X, 2X, and 3X, the commercially recommended rates for storing process potatoes in Michigan. The ventilation specifications are given in Table 1.

The ventilation system was controlled using a 1056 FANCOM environmental control computer. The system was capable of controlling the ventilation rate (variable or fixed speed fan), the fresh air volume, the recirculation air volume, and heating, cooling and humidifying devices.

Data was recorded and control changes made based on feedback from the sensors that were placed as follows: 4 temperature sensors at three foot increments within the pile, 1 temperature and 1 RH sensor in the main air plenum, 1 sensor for fresh air temperature, and 1 carbon dioxide sampling tube (inside each pile eight foot from the floor).

Sample bags (25 lb.) were placed within each of the Simulated Storages at levels of 4 ft, 8 ft, and 12 ft from the floor of the storage (4 bags per level). Upon removal from storage, these samples were evaluated for market quality and weight loss. Samples from each bin were also evaluated by Frito-Lay at the time of removal for chipping quality.

RESULTS AND DISCUSSION

Temperature Control - Excessive static pressure, caused by the ventilation fan running in the commercial bin, prohibited the Simulated Storages from exhausting air via a pressure louver. Therefore, the storages could not obtain fresh air at various times throughout the storage season. The pile temperature fluctuations, which resulted from this lack of fresh air, could not be corrected by the computer because no cooling device was available.

The average pile temperature for the 1986-87 storage season in the four storage bins is given in graphical form in Figure 2.

Potato Quality - The data presented in Table 2 represents weight loss and market quality for the potatoes stored within the Simulated Storages. The overall quality of the potatoes was low due to fresh air starvation; however, some trends were consistent throughout this data.

In bins 1 and 2, there was a significant reduction in weight loss from the 4' to the 12' level within the pile (90% level of significance), see Table 2. This reduction in weight loss was not present in bin 3. Due to the high ventilation rate, uniformly high weight losses were experienced. A market quality gradient was also noted in bins 1 and 2. A significant (90% level) increase in quality was noted from the 4' level to the 12' level. This increase in quality would be expected as the potatoes on the top of the pile were under less stress from potato pile pressures and had also exhibited lower levels of weight loss. Again, the high ventilation rate bin had uniform quality, which was lower on the average than bin 1 and higher than bin 2.

Data generated by Frito-Lay on the chipping quality of the potatoes from the Simulated Storage is presented in Table 3. The criteria for quality in the test performed by Frito-Lay was the appearance number. Any load scoring an appearance higher than 15 is not acceptable.

The loads from bins 1 and 3 had acceptable appearance. However, bin 2 scored an appearance of 25, which was above the acceptable level for chip potatoes. The main factor for rejection of this load was high external discoloration in the Cook Test, see Table 3. The high appearance numbers (above 10) for bins 1 through 3 were a result of the uncontrollable temperature fluctuation, see Figure 2. Bin 2 had the largest temperature fluctuation, and also the lowest average temperature measured (45.5 F) of the season.

CONCLUSIONS

1) The FANCOM 1056 environmental control computer was a useful tool for controlling a commercial potato storage in Michigan. It provides the grower with information and capabilities that were not available with many of the current systems.

2) The control system proved to be well constructed and designed to operate under the adverse environment in the potato storage.

3) Recurring temperature fluctuations of up to 15 F, as noted in the Simulated Storage bins, were detrimental to potato quality.

4) The potatoes within the Simulated Storage responded as would be expected in a commercial storage under equivalent environmental conditions.

5) Further investigation into the effectiveness of the computer running an operable ventilation system with both fixed and variable speed fans was required before this product should be placed onto the market for potato storage operators.

Table 1. Details of Simulated Storage Ventilation Systems.

	Bin #1	Bin #2	Bin #3	Commercial
Capacity (cwt.)	370	370	370	8420
Ventilation Rate (cfm/cwt)	1.72	3.0	4.5	1.72
Slot Height (in.)	0.5	0.85	1.25	0.5
Slot Area (ft^2)	0.69	1.2	1.81	14.27
Slot Velocity (ft/min)	925[1]	925[1]	920[1]	1015[1]
Lateral Size (ft^2)	1.2	1.57	2.45	3.53
Main Size (ft^2)	35.3	35.3	35.3	35.0

[1] Systems designed with equivalent slot velocities.

Table 2 Average weight loss and market quality for potatoes stored in the simulated storage facility.

Level	Bin #1	Bin #2	Bin #3	Commercial
Weight Loss				
4 foot	18	15	15	--
8 foot	10	12	15	--
12 foot	11	11	15	--
Average	13	13	15	11
Market Quality				
4 foot	68	50	63	--
8 foot	76	78	75	--
12 foot	81	78	65	--
Average	75	63	68	83

Table 3 Cook tests for samples from shipments of potatoes to Frito-Lay from simulated storages.

	Bin #1	Bin #2	Bin #3	Commercial
No. of Samples	2	2	2	3
Moisture	1.8	1.9	1.9	1.8
Specific Gravity	1.095	1.098	1.097	1.092
Product	Lays	Ruffle	Lays	Ruffle
Color	61	57	56	53
Green	0	1	0	0
External Discoloration	13	28	11	16
Total External	13	29	11	16
Undesirable Color	2	3	1	0
Internal Discoloration	11	5	12	4
Total Internal	13	8	13	4
Appearance	14	25	12	8

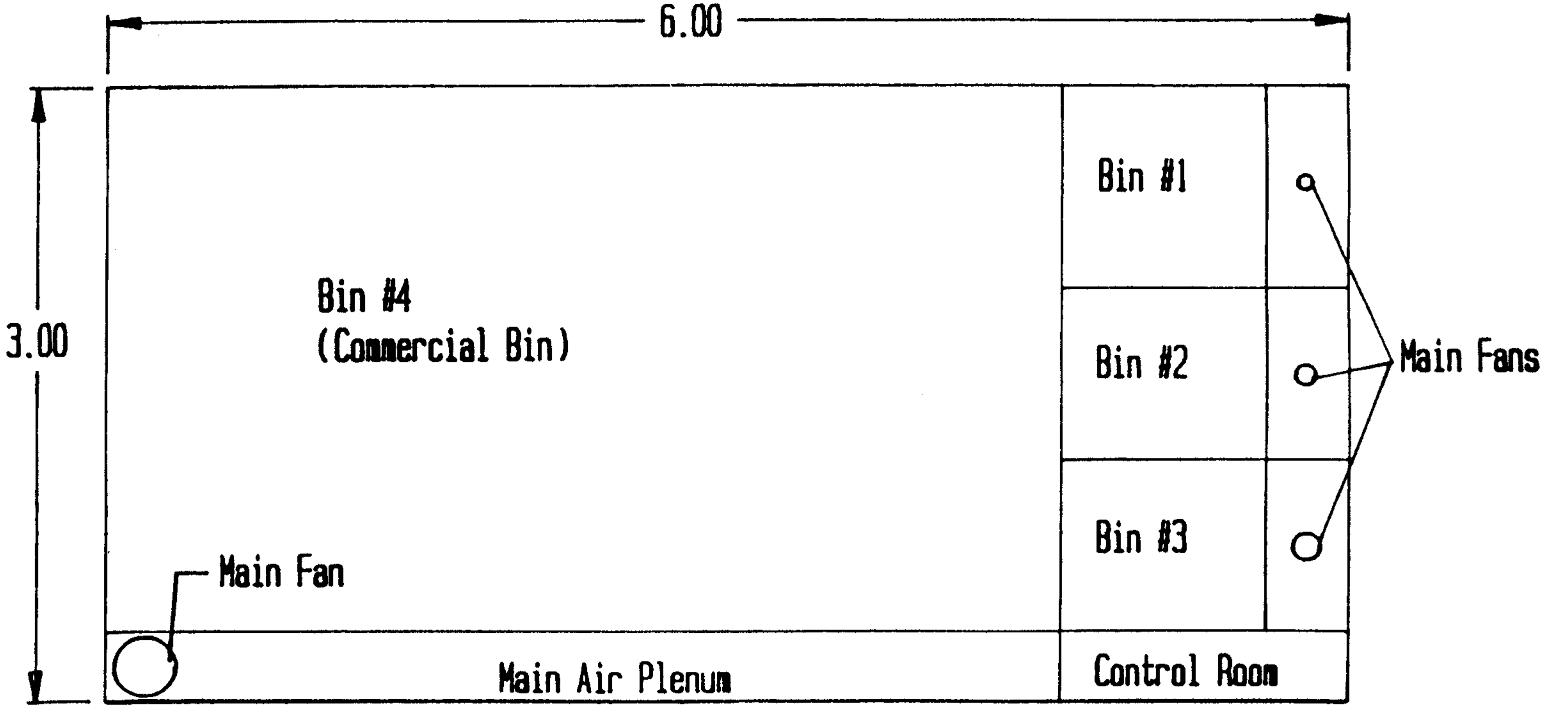
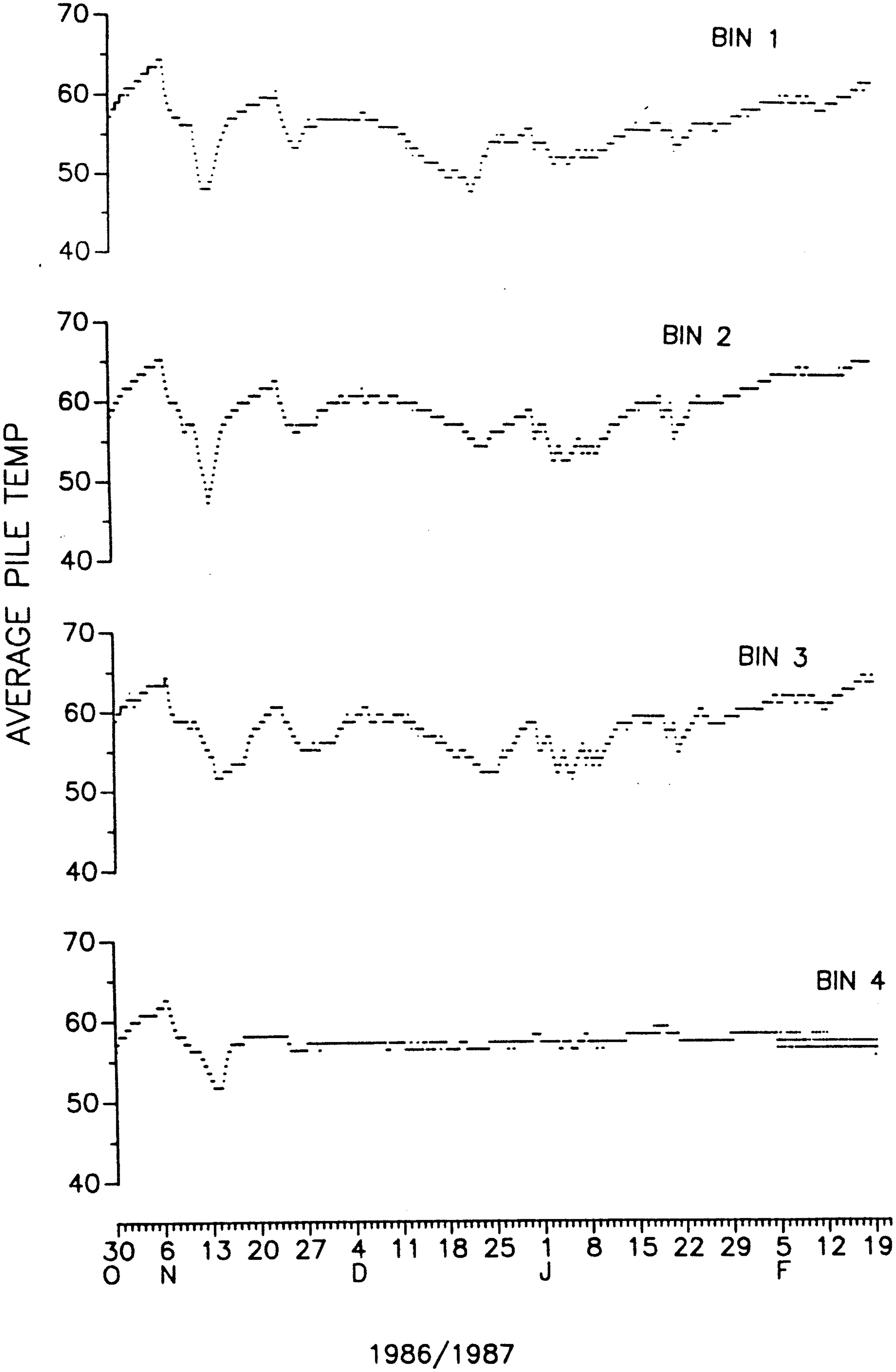


Figure 1 Floor plan of the Simulated Storage research facility (scale 1:10)

Figure 2 Average potato pile temperature for the 1986-1987 storage season.



Funding: Federal Grant

TITLE: Potato Processing and Utilization for Improved Marketing

INVESTIGATORS: Jerry N. Cash and Mohamed Kenawi, Food Science & Human Nutrition

OBJECTIVE:

General Objective:

Improve utilization of the total potato crop by developing processed products which can use small, extra large and off-grade potatoes.

Specific Objectives:

1. Develop remanufactured potato products.
2. Define parameters for extrusion processing of remanufactured products.
3. Perform sensory analysis on all products.
4. Define packaging requirements.
5. Assist in marketing operations, where possible.

JUSTIFICATION:

In any given year, a portion of the potato crop will be graded into small, extra large or off-grade classes. Some of these tubers may find acceptance in certain types of processed products but this is usually minimal. Since this segment of the crop represents significant quantities of raw product, economics dictate that these potatoes be utilized in some manner, however, without processing alternatives a majority find their way into fresh market channels. This results in lowering the consumer's perception of Michigan potato quality, with attendant losses in sales and revenue. It is imperative that new processed products be developed which can utilize that portion of the potato crop which is not suited for use in presently established processed products.

METHODS/PROCEDURES

Cylindrical samples of raw potato tissue will be subjected to various time/temperature regimens for use in back extrusion pressure testing. Data from this effort will be used to develop deformation and puncture force curves, which can assist in computer modeling to predict optimum processing parameters for the Baker-Perkins twin screw extruder. Pre-extrusion treatments, including blanch time, blanch temperature, gell binder type and concentration will be determined. Raw potatoes will be extruded into molds for shaping and these products will be subjected to treatments such as case hardening with hot air and/or coating with starches. Cellulose ethers or amylose to form a thin crust to simulate a potato skin. Samples will be frozen and subjected to sensory analysis.

RESULT:

A computer model was developed which could assist in determining the activation energy (time/temperature) required for processing with the Baker-Perkins extruder. Data for this model were generated by conducting studies with raw potato tissue cooled at temperatures of 175°F, 195°F and 205°F with varied cooking times. Viscosity measurements of these samples produced information which could be used to develop an activation energy equation which was used in defining final operating parameters for the twin screw extruder.

Russet Burbank and Atlantic potatoes were the cultivars used for much of the extrusion work. Diced, raw potatoes were steam blanched at atmospheric pressure and a temperature of 210°F for 6 minutes. The samples were cooled and 7% (w/w) of non-fat dry milk was added to act as a proteinaceous binding agent. This mixture was introduced into the Baker-Perkins twin screw extruder with barrel temperature zones set at 69°F, 98°F, 148°F, 188°F, 173°F, 175°F, 175°F, 175°F and a final product extruded temperature of 160°F. Time required for movement of the product through the barrels was 1.0 to 1.25 minute. Samples were extruded into a plastic mold and frozen. Preliminary sensory analysis indicates the extruded product has good texture and flavor quality. Development of a simulated skin is underway.

Funding: MPIC and PPG Industries

The Interaction of Potato Carbohydrates, Sprout Inhibition and CO_2 Exchange on Chipping Quality of Commercially Stored Potatoes

J. N. Cash, Food Science and Human Nutrition
R. Chase, Crop and Soil Sciences
Michigan State University
W.A. Keim, PPG Industries, Inc.

Procedure:

Atlantic and Russet Burbank potatoes from regular and high irrigation plots were harvested at the Montcalm Farm.. Twenty eight, 30 pound samples of each irrigation treatment of Atlantics and twenty eight, 10 pound samples of Russet Burbanks were placed in double mesh bags and buried in a commercial storage bin with 15,000 hundred weights of other potatoes at the Wayne J. Lennard and Sons farm in Monroe county. The samples were placed in storage on October 6th and arranged in the bin to give four replications, with seven bags per rep, for each treatment and cultivar. One set of samples (i.e. one bag of each treatment and cultivar from each rep) was removed for analysis one day before CIPC application. Subsequent samples were/will be taken at 2 day, 30 days, 60 days, 90 days, 120 and 150 days after CIPC application. At each sample time, tubers analysis includes specific gravity, CIPC residue, sucrose, glucose, fructose, chip color and sprout inhibition.

Results:

Tables 1 and 2 show that specific gravity has not change appreciably during the short storage period, thus far. Table shows that CIPC residues ranged from 5 to 7 PPM immediately after application and dropped to approximately 4 to 5 PPM after 30 days storage. Visual examination of tubers stored 60 days showed effective retardation of sprouting by CIPC at these lower levels.

The sucrose, glucose, and fructose content of the Atlantic from regular irrigation increased during storage, thus contributing to an increase in the total sugar content for this treatment. The sucrose and glucose content of the Atlantics from the high irrigation treatments did not change appreciably but the fructose content did increase and contributed to an overall increase in total sugar content (Fig. 2). This same pattern was seen in 1986-87 samples but the present storage times are too short to make predictions regarding the final outcome of this years efforts.

Table 1. Specific Gravity of Regular Potatoes Irrigation, Atlantic Potatoes in Storage, Lennard Farm, 1987.

Days After CIPC	Rep 1	Rep 2	Rep 3	Rep 4	Average
0	1.089	1.084	1.085	1.085	1.086
2	1.088	1.088	1.089	1.084	1.087
30	1.085	1.087	1.087	1.083	1.086
60	1.084	1.086	1.088	1.086	1.086

Table 2. Specific Gravity of High Irrigation, Atlantic Potatoes in Storage, Lennard Farm, 1987.

Days After CIPC	Rep 1	Rep 2	Rep 3	Rep 4	Average
0	1.086	1.084	1.086	1.083	1.084
2	1.082	1.088	1.088	1.085	1.085
30	1.081	1.084	1.080	1.081	1.082
60	1.082	1.080	1.078	1.082	1.081

Table 3. CIPC Residues (PPM) in Russet Burbank and Atlantic Potatoes in Storage, Lennard Farm, 1987.

Days After CIPC	Russet Burbank	Atlantic High Irrigation	Atlantic Regular Irrigation
2	6.8	6.0	5.6
30	5.1	4.6	3.9

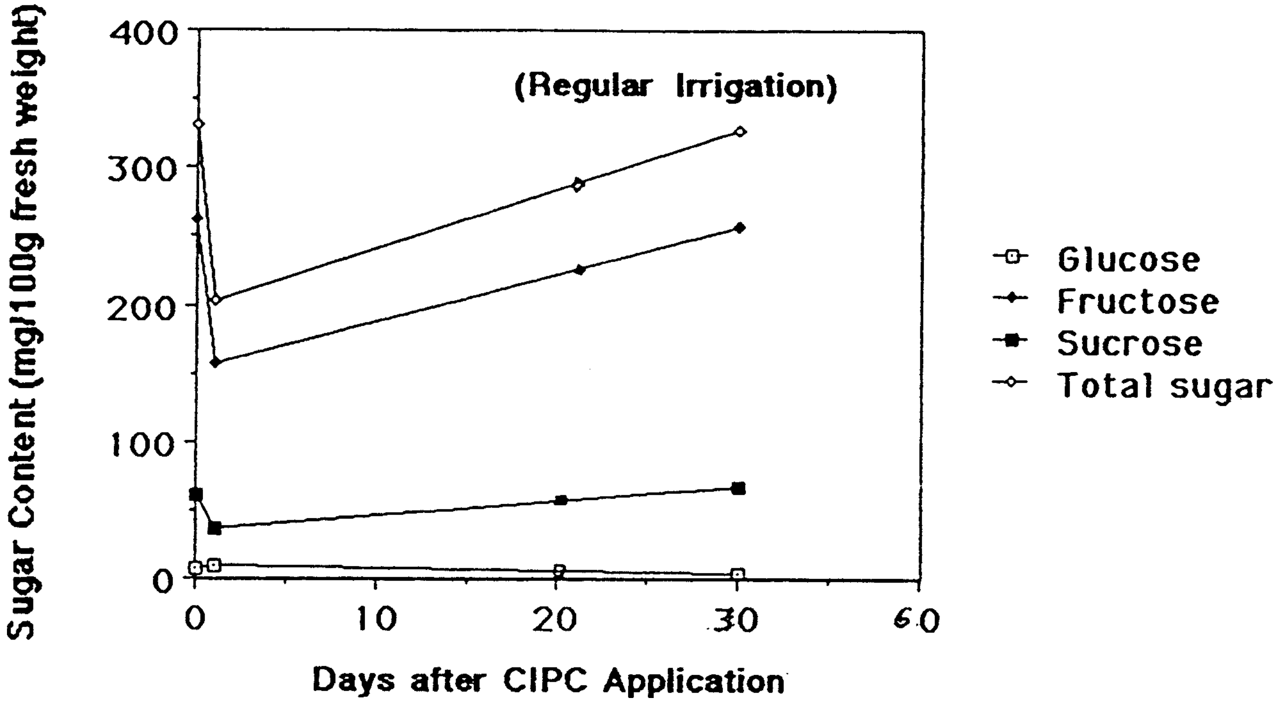


Figure 1. Carbohydrate Content of Atlantic Potatoes in Storage, Lennard Farm, 1987.

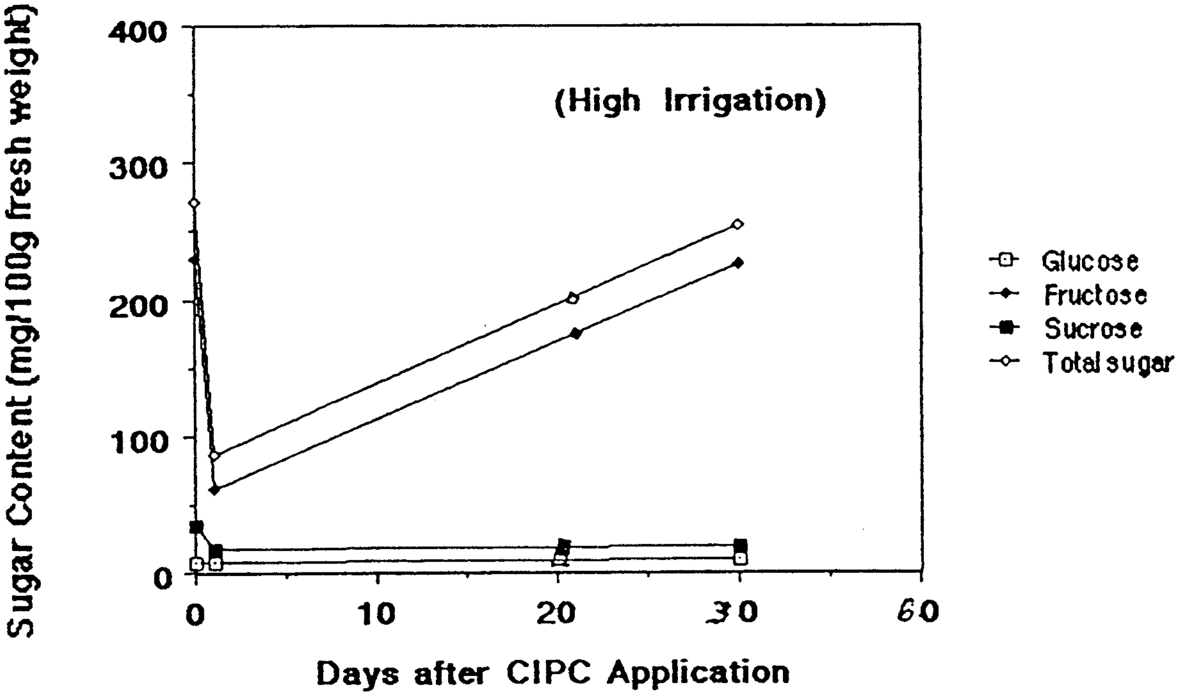


Figure 2. Carbohydrate Content of Atlantic Potatoes in Storage, Lennard Farm, 1987.

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