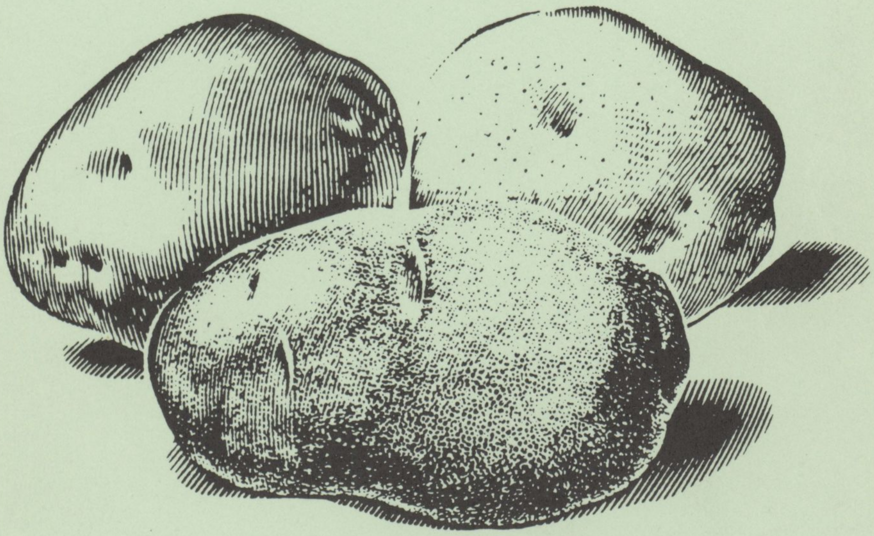
1989
MICHIGAN POTATO
RESEARCH REPORT

VOLUME 21



Michigan State University
Agricultural Experiment Station

In Cooperation With

The Michigan Potato Industry Commission

THE MICHIGAN POTATO INDUSTRY COMMISSION

March 20, 1990

To All Michigan Potato Growers and Shippers

The Michigan Potato Industry Commission, MSU's Agricultural Experiment Station and Cooperative Extension Service are happy to provide you with a copy of the results of 1989 potato research projects.

This years report includes research projects funded by the MPIC as well as projects funded through the USDA.

Providing research funding and direction to principal investigators at MSU is a function of the MPIC Research Committee, on behalf of the Michigan Potato Industry Commission and potato growers of Michigan.

Best wishes for a prosperous year,

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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1989 POTATO RESEARCH REPORT

R.W. Chase, Coordinator

INTRODUCTION AND ACKNOWLEDGEMENTS

The 1989 Potato Research Report includes reports of potato research projects conducted by MSU potato researchers at several different locations. This volume includes research projects funded by the Special Federal Grants (USDA 85-CRSR-2-2562 and 88-34141-3372), the Michigan Potato Industry Commission and other sources. The principal source of funding for each project has been noted at the beginning of each report.

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

Many other contributions to MSU potato research have been made in the form of fertilizers, pesticides, seed, supplies and monetary grants. We gratefully acknowledge all of these supporters. It is this type of support and cooperation that makes for a productive research program.

We also want to acknowledge the professionalism of the MPIC Research Committee. The Michigan potato industry should be proud of the dedication of this committee and the keen interest they take in the needs and directions of Michigan potato research.

A special thanks to Dick Kitchen for his excellent coordination of the production management and the day-to-day operations of the Montcalm Research Farm. A special thanks also to Dr. George Silva who has played a significant role in the Special Federal Grant program, the computerized weather station at the Montcalm Research Farm and the preparation of this report. Also a special thanks to Jodie Schonfelder for the typing and preparation of this report.

WEATHER

The 1989 weather data for the Montcalm Research Station as compared to the average of the 15 previous years are presented in Tables 1 and 2. The weather conditions during the growing season were somewhat normal except for the drought conditions in July and excess rainfall in August. The dry September allowed most of the harvesting to be completed by the end of the month.

SOIL TESTS

Soil test results for the general plot area were:

		lbs/a				
pH	P	K	Ca	Mg	% Organic Matter	Cation Exchange Capacity
5.6	480	185	533	62	1.5	5 me/100g

FERTILIZERS USED

The previous crops in most of the plot areas were dry beans plowdown in fall 1988 and rye plowdown in spring 1989. Except in fertilizer trials, where the amounts of fertilizers used are specified in the project report, the following fertilizers were used in the potato trials.

Banded at planting	15-10-15 + 4% Mg	-	500 lbs/a
Plowdown	0-0-60	-	100 lbs/a
Sidedress with irrigation	28% Liquid N (twice)	-	90 lbs N/a

HERBICIDES AND HILLING

Most of the hilling was completed by the end of May, when the soil started to crack. The potatoes were hilled, building a wide and flattened hill and placing a thin layer of soil over the top of the ridge. Immediately after hilling, a tank mix of metolachlor (Dual) 2 lbs/a plus metribuzin (Lexon 4L) 1/2 lb/a were applied on May 25. No further tillage was done until harvest. Several hand weedings were done during the season. Potato vines were killed with Diquat + X77 on September 10.

IRRIGATION

During the growing season, the potato crop received 7 inches of irrigation water in 10 separate irrigations. Irrigation scheduling was done according to the Michigan State University irrigation scheduling program. The minimum soil profile moisture level maintained throughout the growing season was 50-60%. The amount of water applied ranged from 0.5 to 1.0 inch per application. Nitrogen at 28% was incorporated into irrigation water twice during the season. The heavy rains in late May and early June combined with those in early August did deplete soil N for tuber sizing of several late maturing long type varieties. The drier than normal soil conditions during September harvests did increase the incidence of blackspot. Hollow heart was much more prevalent in 1989.

INSECTS AND DISEASE CONTROL

Aldicarb (Temik 15G) was applied at planting at 20 lbs/a. The foliar fungicide application was initiated on June 28 and 11 separate applications were made during the season. Fungicides used were Dithane M45 (seven applications) and Bravo 720 (four applications). Fungicides were generally used alternatively and were sprayed at 7-10 day intervals. Canopy temperature and humidity levels were monitored and used with the blight forecaster as a guide to commence funigicide spraying for early blight. Foliar insecticides used were Imidan + PBO (six applications) and Cygon (two applications). Although no serious insect problems were encountered during the season, early blight appeared to be high in August and contributed to foliage loss, particularly in early varieties.

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
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
1988	52	31	74	46	82	53	88	60	84	61	71	49	75	50
1989	56	32	72	34	81	53	83	59	79	55	71	44	74	46
15-YR. AVG.	54	34	69	42	75	52	82	56	79	55	70	49	72	48

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

Year	April	May	June	July	August	September	Total
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
1988	1.82	0.52	0.56	2.44	3.44	5.36	14.14
1989	2.43	2.68	4.85	0.82	5.52	1.33	17.62
15-YR. AVG.	2.68	2.60	3.10	2.34	4.22	4.69	19.63

Funding Federal Grant

1989 POTATO VARIETY EVALUATIONS

R.W. Chase, G.H. Silva, D.S. Douches and R.B. Kitchen

The objective of the potato variety evaluation and management program at Michigan State University is to identify improved cultivars for Michigan's fresh market and processing industry. Round whites, russets, reds and yellow fleshed varieties were tested in separate trials for their adaptability potential for specific markets.

Round whites and russets were harvested at two dates to evaluate their marketable and physiological maturity. Varieties selected for their exceptional qualities were then subjected to more intensive tests to determine their strengths and weaknesses. Management profiles were established with some selected varieties that optimized production inputs for improved quality and marketability.

Special emphasis was given to tuber quality parameters of all new varieties. The focus was on overall appearance, external and internal defects, specific gravity, chip color, storability and culinary properties. Of significant interest to Michigan is resistance to common scab and bruising. For chip color and storability studies, potential chipping varieties were stored at two temperatures (45° and 52°F). Blackspot bruising was evaluated with tubers stored at 40°F.

A. DATES OF HARVEST TRIAL FOR ROUND VARIETIES

Eight named and four advanced selections were tested at two harvest dates (98 and 138 days). Onaway, Atlantic and Norchip were included as check varieties. Four replications of a randomized complete block design were harvested at each harvest date. Plots were 23 ft. x 34 inches and plants were spaced 12 inches. The trials were planted in the first week of May. Trials were located at the Montcalm Research Farm in Entrican.

The previous crop was dry beans plowdown in fall 1988 and rye plowdown in spring 1989. Basal fertilizer and aldicarb (Temik 15G) were applied as described in the previous chapter. The hilling and herbicide application was completed by May 25. The crop was irrigated 10 times based on Michigan State University potato irrigation schedule. The amount of water applied ranged from 0.5 to 1.0 inch per irrigation, totalling to 7 inches for the season. An early and late blight forecasting program from Wisconsin was used as a guide to commence fungicide spraying. Relative humidity and temperature at canopy levels were monitored for this purpose. Fungicide spraying started on June 28 and sprayed every 7-10 day intervals. Fungicides Dithane M45 and Bravo 720 were alternated for early blight control. Weather data at the Montcalm Research Farm was collected using a Campbell's CR10 micrologger.

In the culinary tests, chip color was measured for chips made from 20 tubers. A single slice was taken from each tuber. Frying temperature was 350-360°F. An Agtron E-10 colorimeter was used for color measurements. Chip defects such as stem end and vascular discolorations, off colors and bruises were also noted. Samples were stored at 45° and 50°F for chipping out of storage. For after cooking darkening, peeled halves of three tubers were steam cooked and evaluated at 0 and 1 hour after cooking.

Blackspot bruising was evaluated for both check and artificially bruised potatoes. Artificial bruising was carried out by taking samples out of 40°F storage. Twenty tubers were placed in a wooden drum and manually turned 10 revolutions at a moderate speed. These tubers were kept for 48 hours at room temperature prior to peeling. In the check treatments, no artificial bruising was done, so any blackspot observed occurred during harvest and handling. A Hobart peeler was used for peeling the tubers. Both the number of tubers with blackspot and the number of blackspots per tuber were recorded for each sample.

Results

The data for the round varieties at the two harvest dates are presented in Tables 1 and 2. At 98 days, Onaway and Eramosa were the earliest in maturity. Eramosa matured in about 80 days and produced smooth oblong tubers with good general appearance. Although it produced only average yields, Eramosa has potential for early tablestock market.

Most of the medium to medium-late maturing varieties performed well in 1989. Kanona, Spartan Pearl, Somerset, Snowden, Saginaw Gold and AF875-16 produced a high percent of U.S. No. 1 tubers, minimal internal defects and excellent chip color. The tuber yield was above average in Kanona and Spartan Pearl. MS716-15 and AF875-16 had higher specific gravities than Atlantic. Kanona, Spartan Pearl and Saginaw Gold had lower specific gravities compared to Atlantic. Snowden appears to have an excellent potential for chip processing in Michigan. Somerset has slightly lower solids compared to Snowden and the tubers are cylindrical in shape. It also has a good potential in Michigan for processing and fresh market.

Among the late maturing varieties, Steuben, Allegany, MS700-70 and Norwis (FL657) produced very high yields and excellent chip color. There was a high percent of oversized tubers in Steuben and Allegany. MS700-70 had higher solids than Steuben and Allegany. Norwis (FL657) had excellent chip color but its specific gravity was lower than desired for processing. MS716-15 produced average yields but its specific gravity and chip color were excellent.

In the boiling tests (Table 11), undesirable levels of after cooking darkening were observed in Steuben, Allegany and Spartan Pearl. Some sloughing was observed in Kanona, MS716-15, W855 and Atlantic. MS700-70 and Norwis (FL657) had excellent flesh appearance after cooking.

In the blackspot evaluations (Table 11), varieties that showed greater than 25% blackspot in the check treatments were Allegany, Kanona, Atlantic and AF875-16. Most varieties showed a higher incidence of blackspot when they were artificially bruised. Varieties with greater than 75% blackspot were Allegany, Kanona, W855, Atlantic and AF875-16. The drier than normal soil conditions during the 1989 harvest may have contributed to the increased incidence of blackspot compared to previous years.

Variety Characteristics

Spartan Pearl (MS700-83) - To be named and released in 1990 from Michigan State University. Mid-season maturity and above average yields with medium gravity. Good size distribution and skin appearance. Excellent potential for fresh market and chipping. Susceptible to scab, some susceptibility to growth cracks, air checks and after cooking darkening. It has minimal internal defects.

MS716-15 - Medium-late maturity, tubers well shaped and smooth general appearance. It has average yields, high gravity, excellent chip color and no internal defects. It is susceptible to scab.

MS700-70 - Late season maturity with prolific yields. It has high gravity and excellent chip color out of field. Tubers are somewhat rough in appearance with medium deep eyes. Tends to produce a high percent of oversized tubers at 12 inch spacing.

Saginaw Gold - Round to oblong tubers with light yellow flesh and mid-season maturity. It has an excellent chip color but the specific gravity is medium. Good appearance after cooking. Susceptible to early blight in the field and storage. It is susceptible to scab.

Steuben (NY81) - Very late maturity with above average yields and medium gravity. Tends to produce a high percent of oversized tubers at 12 inch spacing. Some hollow heart in 1989. Chip color is excellent.

Kanona (NY71) - Medium to medium-late maturity with above average yields. Excellent chip color but the gravity was average. It is susceptible to scab and has minimal internal defects.

Allegany (NY72) - Very late maturity, above average yields with medium gravity. Tendency to produce oversized tubers at wider spacings but has minimal internal defects. Chip color out of field is excellent.

Somerset - Medium to late maturity, with average yields. Tubers are oblong in shape with medium gravity. Chip color is excellent. Susceptible to greening in the field, scab, hollow heart and growth cracks. Chip color out of cold storage (45°F) was acceptable.

Snowden (W855) - Late maturity with average yields. It has high specific gravity and excellent chip color. Sets heavy and tends to produce undersized tubers if spaced too close. Some reports of increased Colorado beetle attack to its foliage. Has excellent potential for chipping in Michigan. Has minimal internal defects. Chip color out of cold storage (45°F) was excellent. With rough handling, blackspot can be a problem. Higher response to nitrogen than Atlantic.

Norwis (FL657) - A variety to be named and released from Frito-Lay, Inc. Late maturing with high yields. It has light yellow flesh and a rough appearance on the larger tubers. It has excellent chip color but the gravity is too low for processing. Internal defects were minimal.

AF875-16 - Excellent gravity and chip color but yields were below average. Minimal internal defects. Tubers are somewhat small in size.

Eramosa - Very early maturity (80 days) with smooth, round to oblong and slightly flattened tubers with good general appearance. It had no internal defects. Tuber yield and gravity lower than Onaway. Has potential for first-early market. Susceptible to scab.

Atlantic - Major chipping variety in Michigan. Mid- to late-season maturity. High gravity, excellent chip color. It is susceptible to internal brown spot, hollow heart, scab and white knot. Does not store well.

Norchip - Mid-season maturity with below average yields. It has medium gravity but excellent chip color. Tubers vary in size and shape and the appearance is rough. Not widely used in Michigan at present due to poor yields.

Onaway - Early maturity with above average yields. Tubers are round to oblong. Minimal internal defects but vascular discoloration can be a problem. It has a tendency to produce oversized tubers with a rough appearance. It is susceptible to growth cracks and early blight. Does not store well.

B. DATES OF HARVEST TRIAL FOR RUSSET AND LONG VARIETIES

Fourteen varieties were tested for the count-pack and processing potential at two harvest dates, 112 and 142 days (Tables 3 and 4). The production practices used in this trial were similar to those described for the round varieties. Russet Burbank was used as the check variety. Poor sizing was a general problem in this trial and is due in part to heavy rains in early June and early August which apparently depleted the available nitrogen for sizing.

Early to medium maturing varieties were Russet Norkotah, HiLite Russet, ND671-4R and Cal-Ore. They were characterized by lower specific gravities compared to Russet Burbank. All four varieties had smooth external appearance. ND671-4R and Cal-Ore performed poorly in tuber yield with poor sizing. Based on external appearance and freedom from internal defects, Russet Norkotah and HiLite Russet had excellent potential for the count-pack market.

Most of the other varieties in the trial were late to very late maturing. Those with high gravity and potential for processing were A7411-2, Frontier Russet (A74114-4) and A78242-5. A78242-5 is a blocky russet and although the solids were not very high, its shape and appearance were ideal for the French fry market. B7592-1 is a medium-long white with high yields, but the tuber shape appeared to be variable from oblong to long. It had good solids and minimal internal defects. A76147-2 produced high yields with medium gravity and its use may only be for fresh market. A79341-3 and A79357-17 were deleted from future tests due to their susceptibility to hollow heart. MN10874 is a russet with a smooth external appearance and minimal internal defects. It requires further testing. Russet Nugget was very late maturing and produced a very low yield. It had high solids, but was susceptible to hollow heart, blackspot and after cooking darkening.

In artificially bruised tests, varieties having greater than 75% blackspot were B7592-1, A76147-2, A74114-4, A7411-2, Russet Nugget and Russet Burbank. A74114-4, A7411-2 and Russet Nugget showed some sloughing after boiling. Varieties with good to excellent appearance after cooking were A79341-3, B7592-1, A76147-2, A78242-5, Russet Burbank, ND671-4R and Cal-Ore.

Variety Characteristics

A76147-2 - Long, very light russet, late maturity with high yields and medium gravity. It has good external appearance and minimal internal defects. Has potential for fresh market. Sometimes susceptible to heat sprouting. Does not perform well in dry conditions.

A78242-5 - Good early growth and vigor. Blocky russet, maturity is late with above average yields. Has excellent shape and external appearance. Although gravity is not very high, it has potential for French fry industry.

A79341-3 - Late maturing russet, with high yields and solids. Good external appearance and quality. It will be deleted from future trials because of high hollow heart.

A79357-17 - Good early growth and vigor. Produced above average yields and high gravity. Maturity is considered very late. Russet with good external appearance but deleted from future trials because of high hollow heart.

Frontier Russet (A74114-4) - Late season maturity with above average yields and high gravity. Russet with good cooking qualities. Has excellent external appearance, quality and potential for processing and count-pack market. Internal defects are minimal. Rough handling produced blackspot.

A7411-2 - Mid- to late-maturity, average yields with very high gravity. Tubers have good external appearance. Excellent potential for processing with few internal defects. Should be handled carefully because of potential for blackspot. Poor sizing can be a problem.

B7592-1 - Medium to late maturity with high yields. Oblong to long white tubers but shape can be variable. Has a tendency to oversize. Minimal internal defects. Medium to high specific gravity but has potential for processing.

MN10874 - Russet with average yields and specific gravity. Medium to late maturity. Good external appearance for count-pack market. Poor sizing can be a problem.

HiLite Russet - A patented variety, mid-season maturity with below average yields and low gravity, somewhat similar to Russet Norkotah. Has good cooking qualities and moderate resistance to blackspot. Has good external quality, appearance and potential for count-pack market. Minimal internal defects. Poor sizing can be a problem.

Russet Nugget - Very late maturing russet with very low U.S. No. 1 yields. Poor sizing was a major problem. High solids. Susceptible to hollow heart, blackspot and after cooking darkening.

Cal-Ore - Mid-season maturing russet introduced by Plant Genetics, Inc. Produced very low tuber yields. Poor sizing was a major problem. Low gravity but good external appearance. Moderate resistance to blackspot and good appearance after boiling.

ND671-4R - Mid-season maturity. Russet with smooth external appearance but below average yields and gravity. Produced a high percent of undersized tubers. Minimal internal defects with moderate resistance to blackspot. Good appearance after boiling.

Russet Norkotah - Oblong to long russet, early to mid-season maturity. Tubers have a smooth external appearance. Specific gravity lower than Russet Burbank or Shepody. Produced average yields but poor sizing can be a problem. Very susceptible to Verticillium wilt. Excellent potential for fresh market with moderate resistance to blackspot. Some tubers had pink eye at harvest. Some darkening after boiling.

Russet Burbank - Used as a check variety. Late maturity with below average yields. Good specific gravity for processing but produced a high percent of undersized tubers and pick outs. Moderate resistance to blackspot. Excellent appearance after boiling.

C. RED SKINNED VARIETY TRIAL

Red skinned varieties have generated an ongoing interest among Michigan growers. The emphasis was on fresh market potential with uniform size, shape and color retention during storage. In 1989, 11 varieties were tested in a randomized block design with four replications. The trial was harvested after 118 days.

The varieties that performed well and showed the best appearance and color at harvest were ND2224-5R, NDT9-1068-11R and Dark Red Norland. NDT9-1068-11R had the highest tuber yield but its use appears to be limited because of susceptibility to skinning, air checks and soft rot during storage. W949-R, W948-R and Red LaSoda showed severe skinning during harvest. Dark Red Norland and Norland were very similar in growth and maturity but the skin color was darker in Dark Red Norland. All varieties, except Reddale, had minimal internal defects. Reddale was susceptible to hollow heart. There was a high percent of undersized tubers in Red Gold.

In cooking tests, varieties that showed after cooking darkening were Reddale, W949-R, ND2224-5R and Red Gold.

Variety Characteristics

Red LaSoda - Late maturity with high yields. Low specific gravity. Severe skinning at harvest, color not appealing, deep eyes and difficult to peel mechanically.

W949-R - Late maturity with average yields. Some tendency for after cooking darkening. Shape is not uniform.

NDT9-1068-11R - Late maturity with excellent yields. Good appearance and red color at harvest. Has a tendency to oversize. Susceptible to air checks, skinning and soft rot. Poor storability. Minimal internal defects.

Sangre - Mid-season maturing with average yields. Has excellent color at harvest. Very slow early establishment and pre-cutting of seed is recommended. Looks good after peeling and cooking.

W948-R - Late maturing with below average yields. Showed a higher percent of blackspot in artificially bruised treatments. Severe skinning at harvest and tubers have deep eyes.

Red Gold - Mid-season maturing with below average yields. Has a pink skin and yellow flesh. Had a tendency for poor sizing and after cooking darkening.

Reddale - Late maturity with above average yields. Susceptible to growth cracks and skinning. Has a tendency to oversize and susceptible to hollow heart.

ND2224-5R - Early to medium maturity with average yields. Excellent color and appearance at harvest. Some tendency for after cooking darkening. Retains red color and stores well. Poor sizing can be a problem.

Viking - Medium to late maturity with excellent yields. Good external appearance. Minimal internal defects. Good appearance after boiling.

Norland - Used as a check variety. Below average yields. Light red skin color at harvest. Poor color retention after harvest and tendency to sprout early in storage.

Dark Red Norland - A mutant selected from Norland. Below average yields. Plants very similar to Norland in growth and maturity. Skin color darker than Norland but variable and streaky. Tubers somewhat smaller than Norland with a high percent of undersized tubers.

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. One MSU line, MS700-70 was included in the 1989 trial. Sixteen varieties (seven round whites, four russets and five reds). MN13420 is a purple fleshed variety tested for fresh market.

The results are presented in Tables 6 and 7. On a general merit rating based on external appearance and overall worth as a variety, the five top varieties selected were W1005, MS700-70, W855, ND1538-1Russ and ND2224-5R. W1005 is a light russet with medium size and high solids. ND1538-1Russ is a moderate russet with variable shape. It is reported to be resistant to hollow heart. W855 had high solids and excellent chip color. MS700-70 produced very high yields and several other participating states have consistently given it high merit ratings. ND2224-5R had excellent red skin and shape.

In culinary tests, after cooking darkening was undesirable in W1005 and ND2224-5R. Chip color was excellent in MN13451, MN13545, NEA219.70-3 and W855.

Poor sizing was a problem in many varieties and consequently the percent of U.S. No. 1 tubers was low. A summary of general notes, percent external and internal defects are found in Tables 6 and 7.

E. MSU SEEDLING TRIAL

Six new MSU lines were tested at two harvest dates, 96 and 130 days. At each harvest date, four replications of a randomized complete block design were harvested. The lines included four from the 401 series (Atlantic x Yukon Gold) and two from the 402 series (Atlantic and Onaway). Three lines from the 401 series (401-1, 401-2 and 401-8) were yellow fleshed. The results are summarized in Tables 8 and 9. Cultivars Onaway, Atlantic, Michigold and Yukon Gold were included as checks.

Varieties having excellent potential for chip processing with high specific gravity and Agtron chip color were MS401-2, MS401-7 and MS401-1. These varieties have performed consistently well at Montcalm during four years of testing. The two varieties tested for the fresh market, 402-7 and 402-8, had smooth external appearance and a high percent of U.S. No. 1 tubers. Onaway had the highest yield with minimal internal defects. Atlantic was susceptible to hollow heart. Michigold produced a high percent of undersized tubers. Yukon Gold produced below average tuber yield. MS401-8 will be dropped because of susceptibility to internal brown spot.

All MSU lines showed no after cooking darkening but MS401-2 and MS401-7 showed some sloughing.

F. ADVANCED ADAPTATION TRIAL

Entries into this trial consisted of advanced lines released from other states with potential for chipping in Michigan. Nine varieties were tested in a randomized complete block with four replications at one harvest date. Three cultivars, Onaway, Atlantic and Norchip were included as checks.

The results are summarized in Table 10. Trent had high yields and specific gravity. The varieties having excellent Agtron chip color were Trent, B9792-157, B9792-158, Conestoga, CS7232-4 and B9792-61. Trent and B9792-157 were susceptible to hollow heart. CS7232-4 is reported to have an ability to chip out of cold storage. However, its below average yields and gravity are limitations.

In post harvest evaluations, all varieties except Trent, had moderate resistance to blackspot. In boiling tests, only B9792-158 had an undesirable level of after cooking darkening. Some of the promising varieties from this trial will be tested more intensively in 1990, depending on the availability of seed.

Table 1. First Date of Harvest Yield Data - Round White Varieties
August 8, 1989 (98 days)

	Yield cwt/a		Percent Size Distribution						Agtron Chip	Defects*		
Variety	US#1	Total	#1	<2	2-3	>31/4	PO	Sp.Gr.	Color	HH	VD	IN
Onaway	413	465	89	1	76	12	1	1.066	30	0	12	0/34
Saginaw Gold	368	448	82	15	81	1	3	1.076	71	0	0	0/3
Kanona	366	409	90	10	88	2	0	1.075	66	0	4	0/8
Spartan Pearl	357	429	83	16	80	3	1	1.076	63	0	0	0/11
Steuben	351	381	92	7	73	19	1	1.073	61	0	7	0/40
Norwis (FL657)	340	376	90	9	81	9	1	1.067	65	0	0	2/27
AF875-16	318	372	85	14	82	3	1	1.086	62	0	1	0/9
Eramosa	316	367	86	13	85	1	1	1.065	33	0	1	0/10
MS716-15	315	379	83	16	83	1	1	1.084	63	0	0	0/3
MS700-70	308	355	87	12	83	4	1	1.082	60	1	0	0/12
Atlantic	306	349	88	11	76	12	1	1.083	61	5	1	2/27
Somerset	301	334	90	9	88	2	1	1.076	69	0	0	0/5
Allegany	281	313	90	10	85	5	0	1.074	54	1	0	1/13
Norchip	273	352	78	17	75	3	5	1.075	58	0	2	0/8
Snowden(W855)	253	344	74	26	72	2	0	1.081	64	0	0	0/5
Average	324	378	86					1.076				

* Internal defects/Number of oversized (>3 1/4") tubers cut

Table 2. Second Date of Harvest Yield Data - Round White Varieties
September 18, 1989 (138 days)

Variety	Yield cwt/a US#1	Yield cwt/a Total	#1	Percent Size Distribution <2	2-3	>31/4	PO	Sp.Gr.	Agtron Chip Color	Maturity	Defects* HH	VD	IN
Steuben	579	601	95	4	60	35	0	1.077	65	4.5	6	9	0 /40
Allegany	512	540	95	4	70	25	1	1.078	67	5.0	1	1	0 /40
Kanona	485	518	94	5	86	8	0	1.076	69	3.5	1	4	0 /33
MS700-70	483	529	91	7	79	12	1	1.083	60	5.0	3	2	7 /37
Norwis (FL657)	470	522	90	4	82	8	6	1.065	71	4.0	0	0	2 /38
Onaway	466	518	89	6	75	14	4	1.064	27	2.5	0	2	0 /32
Spartan Pearl	439	513	86	12	82	4	2	1.075	63	4.0	1	3	1 /16
MS716-15	419	474	88	11	82	6	0	1.088	66	5.0	0	0	0 /11
Somerset	407	469	87	12	73	14	2	1.079	68	4.0	3	3	1 /38
Snowden(W855)	385	464	84	15	81	3	1	1.084	76	4.0	1	3	0 /9
Atlantic	379	434	87	7	69	18	5	1.085	70	4.0	7	11	9 /38
Saginaw Gold	370	428	86	11	83	3	3	1.076	73	3.0	0	3	0 /14
AF875-16	325	370	88	10	85	3	2	1.088	71	3.5	0	0	1 /13
Eramosa	324	383	85	13	84	1	2	1.062	35	1.5	0	2	0 /5
Norchip	262	359	73	15	71	2	12	1.073	61	3.5	0	3	0 /7
Average	420	475	88					1.077					

* Internal defects per number of oversized (>31/4 ") tubers cut

Maturity: 1 = early; 5 = late maturity

Planting Date 5.2.89
Harvest Date 9.18.89

Observations:
Eramosa had smooth skin at harvest. MS700-83 and Somerset had some shatter bruise. Somerset, Allegany and Steuben showed some greening. Allegany had some stolons still attached to tubers after harvest.

Table 3. First Date of Harvest Yield Data - Count Pack Varieties
August 23, 1989 (112 days)

Variety	Yield cwt/a US#1	Yield cwt/a Total	Percent Size Distribution #1	<4	4-12	>12	PO	Sp.Gr.	Int. Defects* HH	VD	IN
A76147-2	461	597	77	19	68	9	3	1.076	8	0	0/35
A79341-3	447	533	84	13	64	20	3	1.085	29	0	0/40
B7592-1	401	506	79	17	57	22	4	1.077	3	0	0/40
A79357-17	371	530	70	23	55	15	7	1.078	11	0	0/39
A78242-5	283	424	67	27	57	10	6	1.075	2	0	0/30
MN10874	277	406	68	30	62	6	2	1.070	2	0	0/23
R. Norkotah	271	385	70	27	61	9	2	1.068	1	2	0/25
A7411-2	251	404	62	32	57	5	6	1.088	1	0	0/13
H.Russet	248	382	65	33	56	9	2	1.064	0	0	0/24
Frontier Rus.	242	402	60	33	57	3	7	1.085	0	0	0/11
R.Burbank	191	371	51	38	51	0	11	1.079	-	-	-
ND671-4R	170	387	44	55	43	1	1	1.061	0	0	0/1
Cal-Ore	87	246	35	60	35	0	4	1.070	1	0	0/1
R. Nugget	74	219	34	63	34	0	3	1.087	-	-	-
Average	259	413	63					1.075			

* Internal defects/Number of oversized (>10oz)tubers cut

Table 4. Second Date of Harvest Data- Count Pack Varieties

Montcalm Research Farm 1989
(142 days)

Variety	Yield(cwt/a) US#1	Total	% #1	Size Distribution <4	4-10	>10oz	P.O.	SP.GR.	Maturity	Int. Defects HH	VD	IBS/cut
A79341-3	501	594	84	12	70	14	4	1.083	4.5	26	0	0/40
B7592-1	482	608	80	14	61	19	7	1.078	4.0	0	2	0/40
A76147-2	478	597	81	15	69	12	4	1.075	5.0	7	0	0/39
A79357-17	416	562	75	18	57	18	7	1.081	5.0	20	0	0/40
A78242-5	332	477	70	26	60	10	3	1.075	4.5	3	0	0/31
Frontier Russet	313	446	70	19	56	14	10	1.088	4.5	6	0	0/36
A7411-2	304	428	71	24	61	10	5	1.090	4.5	2	0	0/33
MN10874	265	404	65	30	63	2	5	1.074	4.0	0	0	0/9
Russet Norkotah	264	377	70	36	61	9	3	1.068	3.0	1	1	0/21
Russet Burbank	221	420	53	35	49	4	12	1.080	5.0	5	0	0/16
Hilite Russet	198	339	58	38	55	3	4	1.064	3.5	1	0	0/10
ND671-4R	180	390	47	52	45	2	1	1.063	3.5	0	0	0/3
Russet Nugget	122	260	48	51	46	2	1	1.089	5.0	2	0	0/4
Cal-Ore	93	239	39	59	39	0	2	1.071	3.5	-	-	-
Average	298	438	68					1.077				

Internal defects / # oversized (>10oz) tubers cut

Planting Date 5.2.89
Harvest Date 9.22.89

Maturity: 1 = early; 5 = late maturity.

Observations:
Russet Norkotah and ND671-4R had some pink eye at harvest
A79341-3 and A79357-17 had severe hollow heart
B7592-1 variable tuber shape

Table 5. Yield of Red Potato Varieties 1989

Montcalm Research Farm - August 29, 1989 (118 days)

Variety	Yield cwt/a US#1	Yield cwt/a Total	Percent Size Distribution #1	<4	4-12	>12	PO	Maturity	Sp.Gr.	Int. Defects* HH	VD	IN
NDT9-1068-11R	598	634	93	5	68	25	2	4.5	1.060	0	0	0/4
Viking	570	640	89	6	74	15	5	4.0	1.066	0	0	0/4
Red Lasoda	475	537	88	9	80	8	3	4.5	1.057	3	0	0/3
Reddale	467	503	93	5	66	27	2	4.5	1.056	8	0	0/4
Sangre	457	504	91	8	77	14	1	4.0	1.060	3	0	0/3
W948-R	452	518	87	13	80	7	0	5.0	1.072	0	3	0/3
W949-R	402	440	91	8	81	10	1	5.0	1.063	0	1	0/3
ND2224-5R	372	452	82	19	79	3	0	3.5	1.056	0	2	0/8
Norland	341	420	82	18	81	1	0	3.0	1.063	1	0	0/2
D.Red Norland	306	377	80	20	80	0	1	3.0	1.062	-	-	-
Red Gold	283	419	68	32	67	1	0	3.5	1.070	0	0	0/2
Average	429	495	86						1.063			

* Internal defects/Number of oversized (3 1/4")tubers cut

Notes: ND2224-5R, NDT9-1068-11R and Dark Red Norland had good skin color and appearance
W949-R late variety, shape not uniform
W948-R deep eye and skinning
Red Lasoda Skinning

1989 NORTH CENTRAL REGIONAL POTATO TRIALS

Location: Montcalm Research Farm, Michigan State University

Soil Type: Sandy Loam - McBride

Fertilizer Treatment: Stated below

Date Planted: May 3, 1989

Date Harvested: September 19, 1989

Size of Plots: 25'

Spacing - Between Hills: 12"

Spacing - Between Rows: 34"

Replications: 23

Number of Replications: 4

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

Month	Total RF	Average Max. T°(c)	Average Min. T (c)	Average Radiation (cal/cm^2)
May	2.68	22.2	0.6	NA
June	4.85	26.9	11.5	398.6
July	0.82	28.4	15.2	502.8
August	5.52	25.9	13.0	442.0
September	1.33	21.6	6.5	354.8
October	0.68	17.3	3.0	216.8

Crop received 6.0" of irrigation water in 9 separate irrigations.

Sprays Applied:

HERBICIDES:	Dual + Lexone	-	1 application (5/25)
FUNGICIDES:	Dithane M45	-	7 applications (6/28,7/6,8/3,8/13,8/16,8/29,9/8)
	Bravo 720	-	3 applications (7/25,8/10,8/23)
INSECTICIDES:	Imidan + PBO	-	6 applications (6/28,7/6,7/13,8/3,8/16,9/8)
	Cygon	-	2 applications (8/10,8/16)

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

Vine killing date 9/8/89 (Diquat + X77)

Specific gravity measured by weight in air and weight in water method.

BN9826-1 seed was not received and therefore not tested in the trial.

Fertilizers:	500 lbs/A	15-10-15 + 4% Mg at planting
	100 lbs/A	0-0-60 plowdown
	90 lbs/A	N applied as 28% liquid through irrigation (2 - 45 lb/A applications)

Previous crop: soybeans plowdown in fall 1988 and rye plowdown in spring 1989.

Table 6. North Central Regional Trial - 1989. **SUMMARY SHEET**

Selection Number or Variety	Aver. (1) Mat.	Most (2) Representive Scab Area-Type (A-T)	CWT/A Aver. Yield	CWT/A Yield US #1	Aver. Percent US #1	Aver. (3) % Total Solids	Gen (4) Merit Rating	Chip (5) Color	Early (6) Blight Reading	Comments and General Notes
EARLY TO MEDIUM MATURITY										
Norland	1.5	0	348	287	82	15.4		55	2.5	Good red color, growth crack, skinning, rough.
Norgold Russet	2.5	0	352	222	63	16.7		33	3.5	Medium russet, high % undersized tubers.
Norchip	3.0	0	390	295	75	19.0		59	3.5	Poor overall shape, medium deep eye.
ND1196-2R	3.0	0	384	286	74	15.8		53	3.0	Considerable skinning, small size, good red color.
MEDIUM LATE TO LATE MATURITY										
MN13420	3.5	0	409	262	64	15.0		56	2.5	High % below 2" diameter, pigmented stem, purple flesh, skinning, shallow eyes.
MN13451	3.5	0	361	232	64	16.9		61	2.5	Virus in foliage, poor type, deep eyes, oval shape.
MN13545	3.5	0	324	195	60	17.1		64	3.0	Smooth shallow eyes, high % below 2" diameter.
MS700-70	4.5	0	559	497	89	21.6	2	56	4.0	Medium deep eye, some scurf.
NEA219.70-3	3.5	0	425	364	86	18.2		60	3.0	Deep eyes, small size, bright skin, some scurf.
NEA22.75-1	4.0	0	483	443	92	17.3		38	4.0	Bright skin.
BN9826-1	-	-	-	-	-	-		-	-	Seed not received.
ND2224-5R	3.5	0	389	318	82	15.4	5	55	3.5	Good red color, some skinning.
ND1538-1Russ	3.5	0	420	304	72	17.3	4	55	3.0	Moderate russet, variable shape.
W855	4.0	T-1	423	349	82	20.7	3	63	4.0	Indented stem end, variable size.
W1005	4.0	0	461	351	76	20.3	1	54	4.5	Light russet, moderate size.
Red Pontiac	4.5	0	598	541	90	16.0		37	4.0	Deep eyes, growth cracks, size variable.
Russet Burbank	5.0	0	520	312	60	19.9		57	4.5	Small size, medium russet.
AVERAGE*	3.6		405	329	82			54	3.5	

* Please Average

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) Percent total solids, 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 - PCII Color Chart or Agtron. Indicate what Agtron you are using. Model E10 calibrated at factory.

Table 7. North Central Regional Trial - 1989. **SUMMARY OF GRADE DEFECTS**

Selection Number or Variety	Percent External Defects (1)					Total (3) Tubers Free of External Defects	Percent Internal Defects (1)			
	Scab (2)	Growth Cracks	Off Shape and Second Growth	Sun Green	Tuber Rot		Hollow Heart	Internal Necrosis	Vascular Discolor-ation	Normal Tubers (4)
EARLY TO MEDIUM MATURITY										
Norland	0	2	8	2	0	88	12	2	2	84
Norgold Russet	0	4	6	2	0	88	0	0	10 (slight)	90
Norchip	0	2	2	0	0	96	0	0	4	96
ND1196-2R	0	0	0	0	0	100	0	0	0	100
MEDIUM LATE TO LATE MATURITY										
MN13420	0	0	2	2	0	96	0	0	0	100
MN13451	0	4	0	2	0	98	0	0	0	100
MN13545	0	0	0	0	0	100	0	0	0	100
MS700-70	0	0	0	4	2	94	8	12	4	76
NEA219.70-3	0	0	0	0	0	100	4	0	2	94
NEA22.75-1	0	0	4	0	0	96	0	0	8	92
BN9826-1	-	-	-	-	-	-	-	-	-	-
ND2224-5R	0	0	0	0	0	100	2	0	4	94
ND1538-1Russ	0	0	2	0	0	98	0	0	0	100
W855	4	0	0	2	2	92	0	0	20 (slight)	80
W1005	0	0	0	0	0	100	0	2	0	98
Red Pontiac	0	4	0	0	0	96	8	0	4	88
Russet Burbank	0	2	2	0	0	96	4	0	0	96
AVERAGE*										

*** Please average**

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

(2) 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.

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

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

Table 8. First Date of Harvest Yield Data - MSU lines
August 8, 1989 (96 days)

Variety	Yield cwt/a Total	#1	Percent Size Distribution #1	<2	2-3	>31/4	PO	Sp.Gr.	Agtron Chip Color	Defects* HH	VD	IN
Onaway	402	470	86	9	83	3	5	1.067	32	0	0	0/12
MS401-7	367	412	89	7	88	1	4	1.086	65	0	0	0/8
MS401-2(y)	345	382	90	8	82	8	2	1.084	60	1	1	0/27
MS401-1(y)	318	379	84	15	82	2	1	1.082	64	3	0	1/7
MS401-8(y)	298	335	89	8	81	8	3	1.083	53	6	0	10/20
Atlantic	295	336	88	9	80	8	3	1.084	60	5	1	1/19
MS402-7	281	320	88	9	72	16	3	1.069	55	5	0	3/30
MS402-8	276	294	94	5	85	9	1	1.066	58	1	1	1/20
Yukon Gold	265	295	90	9	85	5	1	1.078	57	5	0	0/12
Michigold	247	346	71	29	71	0	0	1.083	55	0	0	0
Average	309	356	87					1.078				

* Internal defects/Number of oversized (3 1/4")tubers cut

Table 9. Second Date of Harvest - MSU lines 1989

Montcalm Research Farm, MSU
(130 days)

Variety	Yield(cwt/a) No.1	Total	% Size Distribution #1	<2	2-31/4	>31/4	PO	Sp.Gr.	Agtron Chip Color	Int.Defects* HH	VD	IBS
Onaway	466	551	85	8	80	5	7	1.065	27	0	0	0/19
MS401-2	411	440	93	6	88	5	1	1.085	64	0	0	2/19
MS401-7	392	449	87	8	87	0	5	1.087	66	-	-	-
Atlantic	386	438	88	8	78	10	4	1.088	65	9	0	4/29
MS402-7	342	380	90	6	77	13	4	1.070	-	4	0	1/28
Michigold	333	421	79	21	78	1	0	1.083	58	1	0	0/4
MS401-8	328	370	89	8	79	10	3	1.081	59	3	0	7/20
MS402-8	326	347	94	5	79	15	1	1.068	-	3	0	0/30
MS401-1	315	398	79	19	77	2	2	1.081	69	4	0	0/6
Yukon Gold	295	335	88	9	85	3	3	1.077	49	3	0	0/7
	359	413	87					1.079				

* Internal defects per number of oversized (3 1/4") tubers cut

Table 10. Yield of Potential Chipping Varieties in the Advanced Adaptation Trial.
Montcalm Research Farm, MSU
(128 days)

	Yield(cwt/a)		% Size Distribution						Agtron Chip	Int.Defects*		
Variety	No.1	Total	#1	<2	2-31/4	>31/4	PO	Sp.Gr.	Color	HH	VD	IBS
Onaway	503	580	87	5	75	12	8	1.060	27	0	0	2/33
Trent	463	507	91	4	79	12	5	1.091	63	13	0	4/39
ND1859-34	449	499	90	10	82	8	0	1.077	56	3	0	1/15
F72004	435	471	92	6	83	9	2	1.075	50	0	0	0/32
B9792-157	417	468	89	9	80	9	2	1.073	65	10	0	2/30
Atlantic	392	441	89	27	74	15	4	1.083	67	11	0	6/36
B9792-158	359	432	83	13	81	2	4	1.079	61	2	0	0/11
Conestoga	346	407	85	12	81	4	3	1.074	60	2	0	0/15
AF330-1	330	380	87	11	82	5	2	1.077	-	1	0	0/13
Norchip	326	453	72	23	72	0	5	1.074	60	0	0	0/4
CS7232-4	315	349	90	9	87	3	1	1.072	68	2	0	0/9
B9792-61	312	363	86	12	83	3	2	1.077	63	2	0	0/14
	387	446	87					1.076				

* Internal defects per number of oversized (>3 1/4") tubers cut

Table 11. Post Harvest Quality Evaluations of Potato Varieties Tested in 1989.

Variety	Percent Blackspot		After Cooking Darkening		Remarks
	Check	Bruised	0	1 Hour	
Round Varieties - Dates-of-Harvest					
Steuben	20	60	2	2.5	all 3 dark ends
Allegany	30	100	1	2	all 3 have slightly dark ends
Kanona	35	95	1	1	some sloughing
MS700-70	10	60	1	1	excellent appearance
Norwis (FL657)	10	25	1	1	excellent appearance
Onaway	0	25	1	1.5	
Spartan Pearl (MS700-83)	0	45	1	2	all 3 dark ends but not severe
MS716-15	10	35	1	1	some sloughing
Somerset	10	70	1.5	1.5	1 dark end
Snowden (W855)	15	95	1	1	some sloughing
Atlantic	30	75	1	1	some sloughing
Saginaw Gold	10	40	1	1.5	1 slightly dark
AF875-16	40	85	1	1.5	
Eramosa	10	35	1	1.5	2 slightly dark
Norchip	15	35			
Advanced Adaptation					
Onaway	0	25	1	1.5	
Trent	20	75	1	1	all 3 sloughed
ND1859-34	10	25	1	1.5	yellow flesh but slightly dark
F12004	5	15	1	1.5	
Coastal Chip (B9792-157)	5	20	1	1	good
Atlantic	15	40	1	1.5	
B9792-158	10	50	1.5	2	all 3 slightly dark
Conestoga	0	15	1	1.5	
AF330-1	0	10	1	1	
Norchip	0	25	1	1	
CS7232-1	0	20	1	1.5	1 slightly dark
B9792-61	0	15	1	1.5	1 slightly dark
MSU Lines					
Onaway	10	45	1	2	all 3 discolored
MS401-2	0	35	1	1	some sloughing
MS401-7	10	70	1	1	excellent appearance, some sloughed
Atlantic	5	55	1	1	some sloughing
MS402-7	5	70	1	1	
Michigold	10	40	1	1.5	deep eyes for peeling
MS401-8	-	-	-	-	
MS402-8	0	45	1	1.5	
MS401-1	0	15	1	1.5	all 3 mildly discolored
Yukon Gold	10	40	1	1	

Table 11. (continued)

Variety	Percent Blackspot		After Cooking Darkening		Remarks
	Check	Bruised	0	1 Hour	
North Central					
MN13420	0	30	-	-	
MN13451	20	55	-	-	
MN13545	0	10	1	1	excellent
NEA219.70-3	15	60	-	-	
NEA22.75-1	0	45	1	1.5	
Long Types					
A79341-3	5	30	1	1	excellent appearance
B7592-1	25	85	1	1	good
A76147-2	35	85	1	1	excellent appearance
A79357-17	5	70	1	1	
A78242-5	15	45	1	1	good
Frontier Russet (A74114-4)	20	100	1	1	some sloughing
A7411-2	20	85	1	2	severe sloughing
MN10874	25	75	1	2	2 dark ends
Russet Norkotah	15	35	1	2	2 dark ends
Russet Burbank	10	40	1	1	excellent
HiLite Russet	0	55	1	1.5	
ND671-4R	0	25	1	1.5	good
Russet Nugget	20	95	1	2	2 dark ends, some sloughing
Cal-Ore	5	15	1	1.5	good
ND1538-1Russ	0	30	1	1.5	
W1005	25	60	1.5	2	all 3 slightly dark
Norgold Russet	0	55	-	-	
Reds					
NDT1068-11R	0	45	1	1.5	1 dark
Viking	10	45	1	1.5	good
Red LaSoda	0	10	1	1.5	deep eyes, difficult to peel
Reddale	5	45	1.5	3	3 dark ends
Sangre	0	20	1	1.5	good
W948-R	15	80	1	1	good
W949-R	0	30	1	2	2 dark ends
ND2224-5R	10	40	1.5	2	
Norland	0	0	1.5	1.5	
Dark Red Norland	5	5	1.5	1.5	good appearance
Red Gold	0	80	1	2	2 dark ends
ND1196-2R	0	30	-	-	
Red Pontiac	0	10	-	-	

Funding Federal Grant

THE RESPONSE OF SPARTAN PEARL AND NORCHIP TO THE RATES AND SOURCE OF POTASSIUM FERTILIZER

G.H. Silva, R.W. Chase and R.B. Kitchen

Introduction

Spartan Pearl (MS700-83) and Norchip are possible chipping varieties for Michigan but their marginal specific gravities are frequently a major limitation for processing. The objective of this study was to determine if the specific gravity could be increased by manipulating the potassium rate or source without adversely effecting other desirable quality characteristics.

Potassium (K) is required by plants for translocation of sugars and synthesis of starch. Since potato tubers are high in starch, potatoes have a high requirement for K. It is estimated that 500 hundredweight (cwt) of potatoes will remove approximately 300 lbs of K_20 per acre. In Michigan, most potatoes are grown on sandy soils that do not hold large amounts of K. Therefore a great deal of attention must be given to K fertilization. Previous research has demonstrated that high rates of K fertilizers will lower specific gravity (percent dry matter). It has also been speculated that it is the increased chloride levels, rather than the K, that is most detrimental in lowering the dry matter content of tubers.

Procedure

In 1989, the effects of two sources (muriate of potash and potassium sulphate) and four levels (0, 100, 200 and 300 lbs K_20/a) were tested in a randomized complete block design with four replications. All K was applied broadcast with a gandy applicator before planting. The initial soil test showed 303 lbs/a K and a soil pH of 5.5. For a yield goal of 550 cwt/a (for Spartan Pearl) the Michigan recommendation calls for an additional 150 lbs K_20/a.

For Norchip, yield goal of 450 cwt/a, the addition of 100 lbs K_20/a is recommended. Both varieties received at planting 175 lbs N and 50 lbs P_20_5. The trial was planted on May 5 and harvested on September 12. Petioles for nutrient analysis were taken on August 6. Following harvest, freeze dried tuber samples were taken for cation and anion analysis.

Results

The results are summarized in Tables 1 and 2. In Spartan Pearl, the highest specific gravity (1.082) was obtained where no K was applied whereas in Norchip the highest specific gravity (1.079) was at 100 lbs K_20 as sulphate. In both varieties, specific gravity decreased with increasing rates of K, but the decrease with muriate source was more profound compared to the sulphate source. It is apparent therefore that the chloride component is a major contributing factor for lowering the specific gravity. The lowest specific gravity in Spartan Pearl (1.072) and Norchip (1.071) was produced in the 300 lbs K_20/a as muriate treatment. No significant increases in U.S. No. 1 yields resulted from higher K rates. There was an increased uptake of K in the petioles in the K treated plots compared to the untreated.

Post harvest evaluations indicated that the Agtron chip color of Spartan Pearl was slightly lower with the sulphate compared to the chloride source (Table 1). This was not true in Norchip. Potassium rate or source produced no substantial differences in the after cooking darkening (Tables 3 and 4). However, there was a tendency for an increased susceptibility to blackspot at lower K levels. This increased susceptibility was more evident in the potatoes that were artificially bruised following storage at 40°F, compared to the check treatment where bruising occurred during harvest and handling.

This study indicated that the dry matter content of potatoes could be influenced by manipulating the K source and rate. It appears that by using reduced K levels and preferably sulphate source, an opportunity exists to optimize the desired dry matter levels of varieties such as Spartan Pearl and Norchip. With 303 lbs K in the soil before the test, further increments of K only resulted in decreased specific gravity with no response in tuber yield.

Increased susceptibility to blackspot at low K levels must also be considered in the decision regarding potash needs. The drier than normal soil conditions during the 1989 harvest contributed to the increased amount of blackspot. Potatoes for chip processing are usually stored at about 50°F and not at 40°F as in this blackspot evaluation. Therefore blackspot incidence can be expected to be lower than those shown for the artificially bruised samples. The use of the sulphate source will incur an increased cost that must be considered. To apply 150 lbs K_2O/a, it would cost approximately $20.00 more per acre with the sulphate source compared to the muriate.

It should be emphasized that soil testing is the key to potassium fertilizer use for potatoes. In Michigan, the common source of K fertilizer is muriate of potash. Using more than the recommended rate of this source is therefore detrimental to specific gravity of Spartan Pearl and Norchip.

Table 1. Effects of Potassium Rate and Source on Spartan Pearl

Montcalm Research Farm 1989
(134 days)

Source/K2O (lbs)	Yield(cwt/a) US#1	Total	Percent size distribution #1	<2	2-31/4	>31/4	PO	SP.GR.	Chip Color	% Petiole K	N
Check	457	539ab	86	13	80	6	1	1.082a	66	6.56b	3.20a
KCl/100	442	506 b	87	12	82	6	0	1.080ab	66	7.84ab	3.08ab
KCL/200	480	562a	85	14	75	10	0	1.075bc	64	7.79ab	2.67ab
KCL/300	492	562a	88	11	77	11	1	1.072c	67	9.97a	2.55b
K2SO4/100	473	540ab	88	12	79	9	0	1.081a	62	7.60ab	3.16ab
K2SO4/200	499	589a	85	13	78	7	2	1.080ab	63	7.65ab	3.06ab
K2SO4/300	502	576a	87	10	78	9	3	1.078ab	60	8.48ab	3.06ab
Average	478	553	87					1.078			
Check vs K											
Check	457	539	86	13	80	6	1	1.082a	66	6.59b	3.20
+K	481	556	87	12	78	9	1	1.078b	64	8.22a	2.93
Check vs K source											
Check	457	539	86	13	80	6	1	1.082a	66	6.59b	3.20
KCl	471	543	87	12	78	9	0	1.076b	65	8.54a	2.76
K2SO4	491	568	87	12	78	8	2	1.080ab	62	7.91ab	3.09
Check vs K amount											
Check	457	539	86	13	80	6	1	1.082a	66	6.59b	3.20
K (100)	458	523	88	12	81	8	0	1.081ab	64	7.71ab	3.12
K (200)	490	576	85	14	76	9	1	1.078bc	64	7.72ab	2.86
K (300)	496	569	88	10	78	10	2	1.075c	64	9.22a	2.81

Previous crop: Rye
Initial soil test K: 303 lbs/a
All K applied broadcast before planting

Planting date: 5.5.89
Harvest date: 9.12.89

Table 2. Effects of Potassium Rate and Source on Norchip

Montcalm Research Farm 1989
(134 days)

Source/K2O (lbs)	Yield(cwt/a) US#1	Yield(cwt/a) Total	Percent size distribution #1	<2	2-31/4	>31/4	PO	SP.GR.	Chip Color	% Petiole K	% Petiole N
Check	283	355	80	11	77	3	9	1.078a	65	5.61b	3.49a
KCl/100	258	340	76	16	74	2	8	1.078ab	60	8.08a	3.40a
KCL/200	271	364	74	14	68	6	12	1.072bc	63	8.94a	2.70b
KCL/300	271	351	77	14	74	3	9	1.071c	62	8.87a	2.70b
K2SO4/100	285	377	76	15	73	3	9	1.079a	64	9.09a	3.64a
K2SO4/200	268	357	75	15	72	3	9	1.078a	63	8.70a	3.13ab
K2SO4/300	280	379	74	16	72	2	10	1.075ab	66	8.61a	3.43a
Average	274	360	76					1.076	63	8.26	
Check vs K											
Check	283	355	80	11	77	3	9	1.078a	65	5.61b	3.49
+K	272	361	75	15	72	3	10	1.074b	62	8.70a	3.17
Check vs K source											
Check	283	355	80	11	77	3	9	1.078a	65	5.61b	3.49
KCl	267	352	75	15	72	4	10	1.074b	62	8.60a	2.93
K_2SO_4	278	371	75	15	72	3	10	1.077ab	64	8.80a	3.40
Check vs K amount											
Check	283	355	80	11	77	3	9	1.078ab	65	5.61c	3.49
K (100)	272	359	76	16	74	5	9	1.079a	62	8.60ab	3.52
K (200)	270	360	75	14	70	5	11	1.075bc	63	8.82a	2.92
K (300)	275	365	75	15	72	3	10	1.073c	64	8.69ab	3.07

Previous crop: Rye
Initial soil test K: 303 lbs/a
All K applied broadcast before planting

Planting date: 5.5.89
Harvest date: 9.12.89

Table 3. Post Harvest Evaluations - Spartan Pearl.

	After Cooking[y] Darkening			Percent Blackspot	
Source/K_2O (lbs)	11/28/89	12/4/89	Remarks	Check	Bruised[z]
Check	1.3	1.5	sloughed on boiling	20	85
Kcl/100	2.1	1.5	some sloughing	15	65
Kcl/200	1.7	2.0	no sloughing	0	50
Kcl/300	1.8	1.5	no sloughing	0	40
K_2SO_4/100	1.8	1.8	some sloughing	10	70
K_2SO_4/200	1.4	1.3	good	10	65
K_2SO_4/300	1.4	1.8	good	5	55

[y]Rating based on a scale of 1-5; 1 = no color, 5 = severe darkening (black overall) one hour after boiling.

[z]Tubers removed from 40°F storage and bruised artificially in a manually driven wooden drum and peeled after 48 hours.

Table 4. Post Harvest Evaluations - Norchip.

Source/K_2O (lbs)	After Cooking[y] Darkening	Percent Blackspot	
		Check	Bruised[z]
Check	1.0	15	95
Kcl/100	1.0	10	70
Kcl/200	1.0	15	45
Kcl/300	1.3	5	45
K_2SO_4/100	1.0	5	75
K_2SO_4/200	1.2	0	45
K_2SO_4/300	1.2	0	50

[y]Rating based on a scale of 1-5; 1 = no color, 5 = severe darkening (black overall) one hour after boiling.

[z]Tubers removed from 40°F storage and bruised artificially in a manually driven wooden drum and peeled after 48 hours.

Funding Federal Grant

MANAGEMENT PROFILES OF RUSSET NORKOTAH, SNOWDEN (W855) AND SAGINAW GOLD

G.H. Silva, R.W. Chase and R.B. Kitchen

Introduction

In 1989, three promising varieties for Michigan, Russet Norkotah, Snowden (W855) and Saginaw Gold were selected to study the optimum nitrogen and spacing requirements for optimum yield and quality. Russet Norkotah has excellent potential for the count-pack market because of its smooth appearance. In some years, under standard cultural practices, it has a tendency for poor sizing resulting in a higher percent of tubers less than 4 oz. Snowden (W855) and Saginaw Gold have exceptional chipping qualities and a potential for expansion in acreage in Michigan. Snowden possesses high solids, minimal internal defects and most importantly, the capacity to chip out of 45°F storage. In Michigan, it has experienced problems of small sizing and below average yields. Saginaw Gold is a yellow fleshed potato with exceptional chip color and good tuber yield, however, its marginal processing dry matter could restrict its chip marketability in a year of excess potato production.

The management practices currently used for new releases are generally based on standard practices adapted for more traditional cultivars.

Procedure

In 1989, three levels of nitrogen (100, 150 and 200 lbs/a) and three within row spacings (6, 9 and 12 inches for Russet Norkotah and Saginaw Gold; 9, 12 and 15 inches for Snowden) were investigated. Rows were spaced 34 inches apart. The treatments were studied in a split-plot design with four replications. A cost/revenue analysis for each treatment combination was used to further establish the optimum nitrogen and spacing requirements in relation to tuber yield and quality.

The trials were planted on May 8. The previous crops were dry beans plowdown in fall 1988 and rye plowdown in spring 1989. The fertilizer application with the planter was 500 lbs/a 15-10-15 + 4% Mg. A sidedressing of urea providing 25 lbs N/a (for treatments receiving 100 lbs N) and 75 lbs N/a (for treatments receiving 150 and 200 lbs N) were applied on June 18. Another sidedressing of urea providing 50 lbs N was applied on July 5 to the treatment receiving 200 lbs N. Petioles for nitrogen analysis were taken on August 7. Saginaw Gold was harvested on August 30, Russet Norkotah September 11 and Snowden September 15.

Results

Russet Norkotah: The results are summarized in Tables 1, 2, 3 and 4. Nitrogen effects were significant for U.S. No. 1 yield and spacing effects were significant for total yield (Table 1). The highest U.S. No. 1 tuber yield was obtained at 200 lbs N and 9 inch spacing. The highest total yield was obtained at 200 lbs N and 6 inch spacing. Size distribution of potatoes indicated that the highest percent of tubers under 4 oz. was produced at 100 lbs N and 6 inch spacing. The percent of tubers over 10 oz. tended to increase with increments of spacing and nitrogen. Although not significantly different, specific gravity was higher at lower nitrogen and closer spacings. Petiole N content was significantly higher at higher nitrogen levels. The U.S. No. 1 yields for the nine treatment combinations (Figure 1) clearly illustrated that in 1989 Russet Norkotah performed well at intermediate to high nitrogen levels and at intermediate spacings. The total number of tubers set per plant (Table 2) was not influenced by the level of nitrogen but were influenced by spacing. Average total tuber weight increased with increments of nitrogen and spacing, but the range was higher among spacing treatments. Post harvest evaluations indicated that nitrogen and spacing treatments had no significant effects on after cooking darkening and blackspot incidence (Table 3). Nitrogen and seed costs/revenue analysis (Table 4) showed that the highest average net revenues were obtained at 150 lbs N and 9 inch spacings.

Snowden (W855): The data from Snowden is summarized in Tables 5, 6, 7 and 8. Both nitrogen and spacing effects were significant for U.S. No. 1 yield (Table 5). Only nitrogen effects were significant for total yield. The highest U.S. No. 1 tuber yield was obtained at 200 lbs N and 15 inch spacing. Size distribution of potatoes indicated that the highest percent of tubers below 2 inch diameter was produced at 100 lbs N and 9 inch spacing. The percent of tubers over 3¼ inch diameter increased from 100 to 150 lbs N and from 9 to 12 inch spacing, but the increment from 150 to 200 lbs N and 12 to 15 inch spacing was small. Specific gravity was significantly higher at 12 and 15 inches compared to 9 inches. These results indicate that Snowden has a favorable response to higher N levels than the variety Atlantic. As expected, petiole N content was significantly higher at higher N levels. The U.S. No. 1 yields for the nine treatment combinations (Figure 2) clearly illustrated the preference of Snowden for higher nitrogen and spacing levels. The total number of tubers set per plant and the average tuber weight (Table 6) indicated Snowden to be a heavy setter (about 12 tubers per plant). Under these conditions, adequate nitrogen and space between plants should be provided for proper sizing of tubers. Post harvest evaluations indicated that nitrogen and spacing treatments produced no substantial differences in chip color, after cooking darkening and blackspot. The percent blackspot in the artificially bruised tubers was high compared to Russet Norkotah. Nitrogen and seed costs/revenue analysis (Table 8) showed that the highest average net revenues were derived from 200 lbs N and 15 inch spacings. The tubers from this experiment are being stored at 45° and 50°F for further chip evaluations.

Saginaw Gold: Significant differences in U.S. No. 1 yield were obtained for both nitrogen and spacing effects (Table 9). Size distribution of potatoes indicated that the highest percent of tubers under 2 inch diameter was produced at 100 lb N and 6 inch spacing. The percent of tubers over 3¼ inches was low in all treatments. Specific gravity was highest at the lowest N and spacing, but not significantly different from other treatments. The U.S. No. 1 yields (Figure 3) produced by the treatment combinations indicated that Saginaw Gold performed well at intermediate to high nitrogen and at intermediate spacing levels. The total number of tubers set per plant (Table 10) was not influenced by the level of nitrogen but was affected by the spacing. The average set was lower than Snowden but higher than Russet Norkotah. Average tuber weight increased with increments of nitrogen and spacing. Nitrogen and seed costs/revenue analysis (Table 11) showed that the highest average net revenues were obtained at 200 lbs N and 9 inch spacing.

Table 1. RUSSET NORKOTAH : Management Profile

Montcalm Research Farm, Michigan State University 1989
(134 days)

rogen s/a)	Spacing (inches)	Yield(cwt/a) US#1	Total	Percent size distribution #1	<4	4-10	>10	PO	SP.GR.	Petiole N %
00	9	380a	475ab	80	16	66	14	2	1.068	3.68a
50	9	375ab	492a	76	22	61	15	1	1.067	2.80 bc
50	12	365ab	461abc	79	20	60	19	1	1.068	2.73 bc
00	6	364ab	505a	72	27	63	9	1	1.068	3.67 a
50	6	345abc	495a	70	30	62	8	0	1.070	2.92 b
00	12	341abc	418 c	82	16	59	23	1	1.067	3.67a
00	12	339abc	432 bc	78	20	65	13	2	1.069	2.35 cd
00	9	326bc	459abc	71	27	63	8	1	1.070	2.37 cd
00	6	313c	466abc	67	32	62	5	1	1.071	2.16 d
	Average	345	467	75					1.069	2.93
rogen effects - Significant for US#1 Yield										
00		326 b	452	72	26	63	9	1	1.070	2.29 c
50		362a	482	75	24	61	14	0	1.068	2.82 b
00		361a	466	78	19	63	15	1	1.067	3.65a
cing effects - Significant for total yields										
	6	341	488a	69	30	63	7	0	1.070	2.89
	9	361	475a	76	22	63	13	1	1.069	2.95
	12	348	437 b	80	18	61	19	1	1.067	2.92

Table 2. RUSSET NORKOTAH : MANAGEMENT PROFILE 1989

Tuber Number and Size

Treatment	Marketable		Total	
	# tubers/plant	Av.Tuber Weight(gm)	# tubers/plant	Av.Tuber weight(gm)
Nitrogen (lbs/a)				
100	4.0	176	7.5	133
150	4.0	181	7.6	131
200	4.0	193	6.8	147
Spacing (inches)				
6	3.0	172	6.3	119
9	4.5	188	7.8	144
12	5.3	191	8.3	151

Table 3. Post Harvest Evaluations - Russet Norkotah

Nitrogen	Spacing	After Cooking[y] Darkening	Percent Blackspot Check	Percent Blackspot Bruised[z]
100	6	1.0	10	25
100	9	1.0	5	15
100	12	1.5	15	20
150	6	1.0	10	55
150	9	1.0	5	25
150	12	1.5	5	55
200	6	1.0	10	45
200	9	1.0	15	55
200	12	1.5	10	40

[y]Rating based on a scale of 1-5; 1 = no color, 5 = severe darkening (black overall) one hour after boiling.

[z]Tubers removed from 40°F storage and bruised artificially in a manually driven wooden drum and peeled after 48 hours.

Table 4. Management Profile : RUSSET NORKOTAH 1989

Nitrogen and Spacing Costs/Acre

N Applied (lbs/ac)	N +Appl'n cost($) [a]	Spacing (inches)	Seed Cost($) [b]	N + Seed Cost($)	Yield (cwt/ac)	Revenue ($) [c]	Net ($)
	A		B	A+B		C	C-(A+B)
200	52	9	174	226	380	2510	2284
150	38	9	174	212	375	2484	2272
150	38	12	131	169	365	2430	2261
200	52	6	261	313	364	2392	2079
150	38	6	261	299	345	2265	1966
200	52	12	131	183	341	2276	2093
100	24	12	131	155	339	2238	2083
100	24	9	174	198	326	2140	1942
100	24	6	261	285	313	2041	1756

Nitrogen 100, 150, and 200 lbs applied in 2,3 and 4 applications.

[a] Nitrogen cost = $ 0.20 /lb. Cost per application = $ 3.00/ac.

[b] Seed cost = $7.00/cwt

[c] Revenue on the basis of $ 6.50/cwt (4-10 oz) and $ 7.00/cwt (>10 Oz)

Table 5. SNOWDEN(W855) : Management Profile

Montcalm Research Farm, Michigan State University 1989
(140 days)

itrogen	Spacing	Yield(cwt/a)		Percent size distribution						Petiole
lbs/a)	(inches)	US#1	Total	#1	<2	2-31/4	>31/4	PO	SP.GR.	N %
200	15	445a	493ab	91	6	79	12	2	1.083abd	3.4 a
200	12	428ab	480abc	89	10	78	10	2	1.086ab	3.3 a
200	9	425ab	501a	85	13	82	4	2	1.086a	3.4 a
150	15	425ab	460bcd	92	8	84	8	0	1.085ab	2.6 b
150	12	388bc	441d	88	12	81	7	0	1.085ab	2.3 bc
150	9	360cb	446cd	81	18	76	5	1	1.085ab	2.3 bc
100	15	343cb	396e	87	11	80	7	2	1.083abc	2.0 d
100	12	323de	402e	80	19	77	3	0	1.083 bc	2.1 cd
100	9	295e	403e	73	25	73	0	1	1.082 c	2.0 d
	Average	381	447	85					1.084	2.6

itrogen effects - Significant for US#1 and Total Yield

100		320c	400c	80	18	77	3	1	1.082b	2.0c
150		392b	449b	87	13	80	7	0	1.085 a	2.4b
200		432 a	491 a	88	10	79	9	2	1.085 a	3.4 a

pacing effects - Significant for US#1 Yield

	9	360b	450	79	19	77	3	1	1.084	2.6
	12	379ab	442	86	14	78	8	1	1.085	2.5
	15	406a	453	90	8	81	9	2	1.084	2.6

Table 6. SNOWDEN : MANAGEMENT PROFILE 1989

Tuber Number and Size

Treatment	Marketable		Total	
	# tubers/plant	Av.Tuber Weight(gm)	# tubers/plant	Av.Tuber weight(gm)
Nitrogen (lbs/a)				
100	6.6	120	11.6	89
150	8.3	130	11.3	111
200	10.5	138	12.9	121
Spacing (inches)				
9	6.9	117	11.1	91
12	8.6	130	11.5	112
15	10.8	145	13.9	123

Table 7. Post Harvest Evaluations - Snowden (W855).

Nitrogen	Spacing	After Cooking[y] Darkening	Percent Blackspot	
			Check	Bruised[z]
100	9	1.0	5	45
100	12	1.0	15	80
100	15	1.5	5	70
150	9	1.0	20	55
150	12	1.5	5	80
150	15	1.5	10	55
200	9	1.0	5	75
200	12	1.5	10	60
200	15	1.5	10	65

[y]Rating based on a scale of 1-5; 1 = no color, 5 = severe darkening (black overall) one hour after boiling.

[z]Tubers removed from 40°F storage and bruised artificially in a manually driven wooden drum and peeled after 48 hours.

Table 8. Management Profile : SNOWDEN(W855)

Nitrogen and Spacing Costs/Acre

N Applied (lbs/ac)	N +Appl'n cost($)[a] A	Spacing (inches)	Seed Cost($)[b] B	N + Seed Cost($) A+B	Yield (cwt/ac)	Revenue ($)[c] C	Net ($) C-(A+B)
200	52	15	104	156	445	2927	2771
200	52	12	131	183	428	2810	2627
200	52	9	174	226	425	2773	2547
150	38	15	104	142	425	2776	2634
150	38	12	131	169	388	2539	2370
150	38	9	174	212	360	2352	2140
100	24	15	104	128	343	2238	2110
100	24	12	131	155	323	2106	1951
100	24	9	174	198	295	1917	1719

Nitrogen 100, 150, and 200 lbs applied in 2,3 and 4 applications.

[a] Nitrogen cost = $ 0.20 /lb. Cost per application = $ 3.00/ac.

[b] Seed cost = $7.00/cwt

[c] Revenue on the basis of $ 6.50/cwt (2-31/4") and $ 7.00/cwt (>31/4")

Table 9. SAGINAW GOLD : Management Profile

Montcalm Research Farm, Michigan State University 1989
(130 days)

trogen bs/a)	Spacing (inches)	Yield(cwt/a) US#1	Total	Percent size distribution #1	<2	2-31/4	>31/4	PO	SP.GR.	Petiole N %
200	6	361a	446a	81	17	80	1	2	1.077	2.60bc
150	6	357ab	443a	81	17	81	0	3	1.077	2.20d
200	9	352ab	415bc	85	13	85	0	2	1.076	2.87a
150	9	343ab	416bc	83	13	82	1	4	1.076	2.55c
150	12	340ab	392c	87	9	83	4	5	1.075	2.45c
200	12	330ab	391c	84	13	79	6	1	1.075	2.83ab
100	9	329ab	397bc	83	13	83	0	4	1.079	1.86 e
100	6	322bc	423a	76	23	76	0	2	1.079	1.87 e
100	12	289c	361d	80	16	79	2	4	1.076	1.86 e
	Average	335	409	82					1.077	2.34
trogen effects - Significant for US#1 Yield										
100		313 b	393	80	17	79	0	3	1.078	1.86 c
150		347a	417	84	13	82	2	4	1.076	2.40 b
200		348a	417	83	13	81	3	2	1.076	2.77a
acing - Significant for Yield effects										
	6	347a	437a	79	19	79	0	2	1.078	2.22 b
	9	341a	409 b	84	13	83	1	3	1.077	2.43a
	12	320 b	381 c	84	12	80	4	4	1.076	2.38a

Table 10. SAGINAW GOLD : MANAGEMENT PROFILE 1989

Tuber Number and Size

Treatment	Marketable		Total	
	# tubers/plant	Av.Tuber Weight(gm)	# tubers/plant	Av.Tuber weight(gm)
Nitrogen (lbs/a)				
100	5.9	120	8.2	102
150	6.0	129	8.2	111
200	6.1	136	8.5	116
Spacing (inches)				
6	4.8	121	7.3	96
9	7.2	122	9.4	109
12	7.0	140	9.6	121

Table 11. Management Profile : Saginaw Gold 1989

Nitrogen and Spacing Costs/Acre

Applied lbs/ac)	N +Appl'n cost($)[a] A	Spacing (inches)	Seed Cost($)[b] B	N + Seed Cost($) A+B	Yield (cwt/ac)	Revenue ($)[c] C	Net ($) C-(A+B)
200	52	6	261	313	361	2349	2033
150	38	6	261	357	357	2321	2022
200	52	9	174	352	352	2288	2062
150	38	9	174	343	343	2252	2040
150	38	12	131	340	340	2216	2047
200	52	12	131	330	330	2240	2057
100	24	9	174	329	329	2139	1941
100	24	6	261	322	322	2093	1832
100	24	12	131	289	289	1881	1624

Nitrogen 100, 150, and 200 lbs applied in 2,3 and 4 applications.

[a] Nitrogen cost = $ 0.20 /lb. Cost per application = $ 3.00/ac.

[b] Seed cost = $7.00/cwt

[c] Revenue on the basis of $ 6.50/cwt (2-31/4") and $ 7.00/cwt (>31/4")

Figure 1. Russet Norkotah - Management Profile 1989.

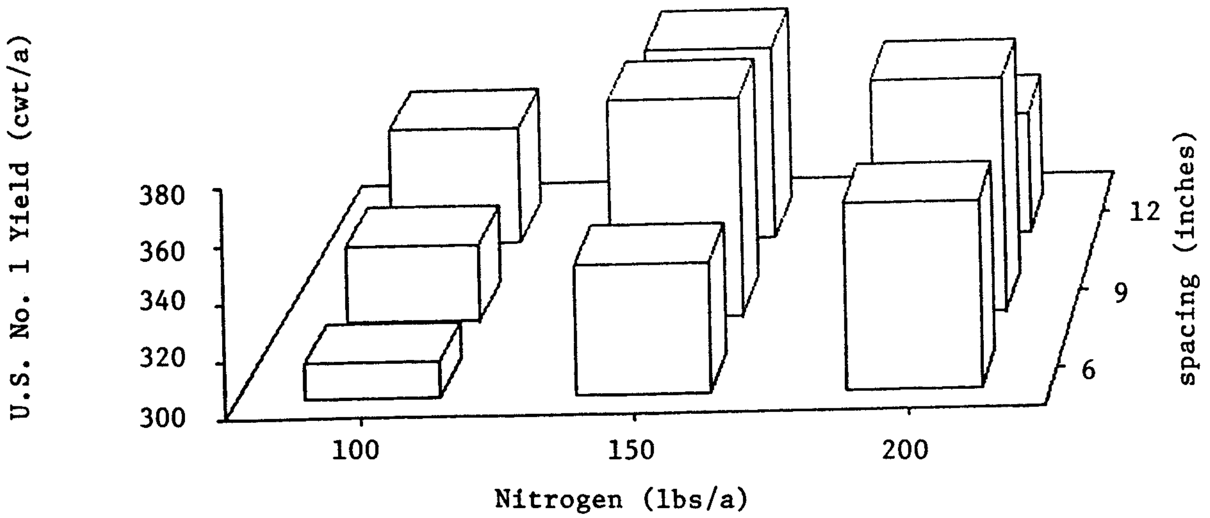


Figure 2. Snowden (W855) - Management Profile 1989.

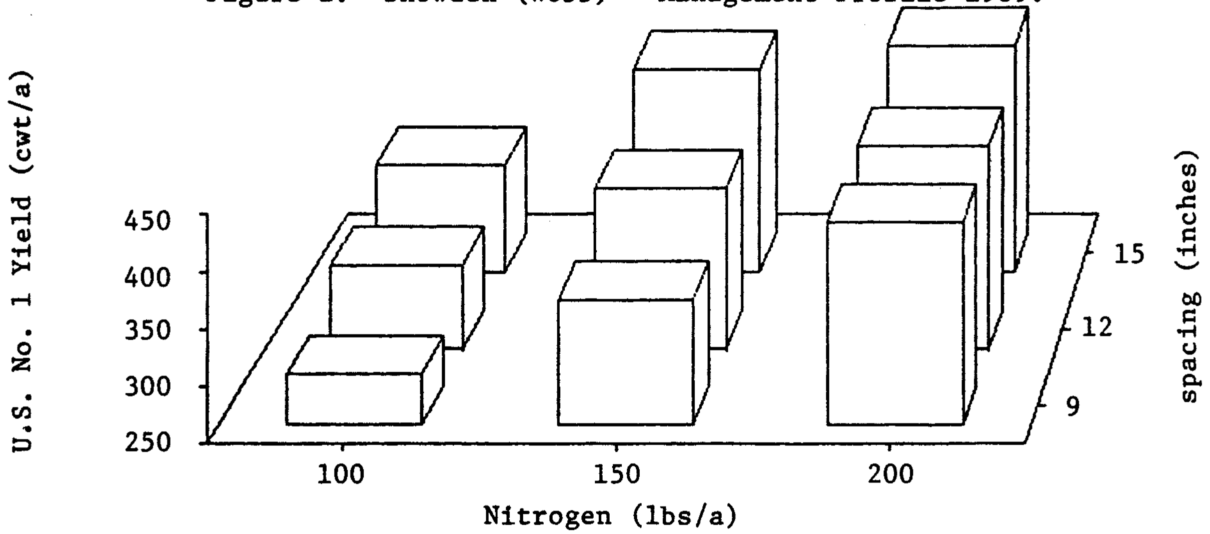
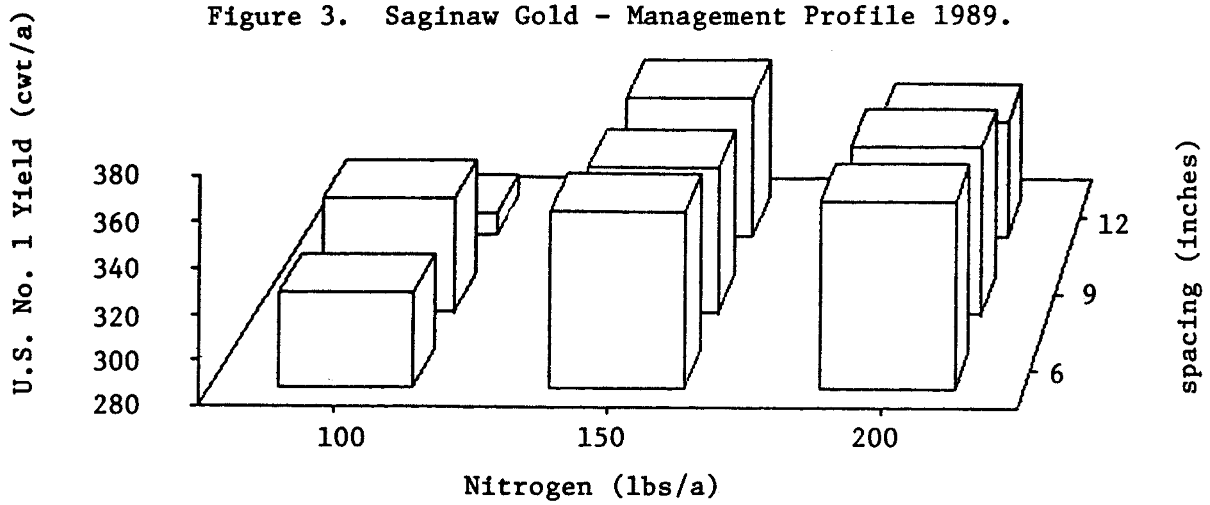


Figure 3. Saginaw Gold - Management Profile 1989.



Funding Federal Grant

IRRIGATION, NITROGEN AND SUPPLEMENTARY CALCIUM IN RELATION TO SPECIFIC GRAVITY, TUBER YIELD AND INTERNAL DEFECTS OF ATLANTIC AND RUSSET BURBANK

G.H. Silva, R.W. Chase and R.B. Kitchen

Introduction

Quality parameters such as specific gravity and internal defects are of crucial importance particularly to processing potatoes. A study initiated in 1987 was continued in 1989 to investigate the role of irrigation and nitrogen management and supplementary calcium on specific gravity and internal defects of Atlantic and Russet Burbank.

Procedure

A split-plot design with four replications was used to evaluate three irrigation levels and four calcium treatments in Atlantic, and three irrigation levels and two nitrogen levels in Russet Burbank. Irrigation was used as the main plot treatment and was applied through a drip irrigation system. The three irrigation treatments included (a) irrigation scheduling, based on Michigan State University potato irrigation scheduling program, (b) over-irrigation, where the plots received an excess of 5 inches of water more than the irrigation schedule, applied in five separate irrigations during the month prior to harvest and (c) irrigation water was withheld after August 1. In 1989 the irrigation schedule recommended the application of 8.5 inches of water throughout the growing season. The total rainfall during the season was 14.5 inches.

Supplementary calcium tested for only Atlantic was specifically directed towards controlling internal brown spot (IBS). Treatments included 750 lbs gypsum/a applied (a) at planting, (b) at hilling, (c) split at planting and hilling and (d) untreated. Most of the literature suggests that localized calcium deficiency in the tubers as the primary cause of this disorder, with environmental factors modifying the expression of the disease. In light of the relative immobility of calcium within the plant, the intention was to place the gypsum in close proximity to the stolons and developing tubers. It has been reported that only very little calcium absorbed by the root system is able to reach the developing tubers. For Russet Burbank, in a separate experiment, the two levels of nitrogen tested were 150 and 225 lbs/a.

The trials were planted on May 8 and the previous crops were rye and dry beans. Initial soil tests showed a pH of 5.4 and a calcium level of 480 lbs/a. The fertilizers applied were 500 lbs/a of 15-10-15 + 4% Mg with the planter and a sidedressing of 75 lbs N/a on June 15. A second sidedressing of 75 lbs N/a was applied to Russet Burbank on July 6.

Petiole samples for nutrient analysis were taken on August 5 and the trial was harvested on September 22. Following harvest, 100 tubers (25 from each replication) were cut to determine the frequency of IBS and hollow heart in Atlantic. Tuber peel samples were sent to MSU Soil Testing Laboratory for calcium analysis.

Results

The results obtained with Atlantic and Russet Burbank are summarized in Tables 1 and 2, respectively. In both varieties, over-irrigation resulted in a significant decrease in specific gravity. Although over-irrigation produced slightly higher tuber yields, it was also associated with the highest frequency of hollow heart.

In Atlantic, gypsum treated plots showed a slight decrease in the frequency of IBS from 7.8% for untreated to an average of 4.4% for the three gypsum treatments. The gypsum treatments produced no significant effects on tuber yield, specific gravity and hollow heart. In Russet Burbank, 225 lbs N/a produced significantly higher U.S. No. 1 tuber yield compared with 150 lbs N. However, higher nitrogen levels were associated with a decrease in specific gravity, and an increased hollow heart. Petiole nitrogen content was significantly higher at 225 lbs/a N.

It is evident that gypsum application was only partially effective in reducing the incidence of IBS. Based on studies at the Montcalm Research Farm, gypsum has not eliminated the problem of IBS nor has it consistently reduced IBS to an acceptable level.

Petiole and peel calcium levels in the gypsum treated plants showed only slight increases in the uptake of calcium compared to the untreated (Table 1). This may account for the lack of a significant response to applied gypsum in controlling IBS.

Soil samples collected from the tuber zone in the row following harvest indicated that the gypsum application had no influence on the soil pH. Soil calcium levels were higher in the gypsum treated plots compared to the untreated.

Post harvest quality evaluations showed that irrigation, calcium and nitrogen levels tested in the trial had no significant effects on after cooking darkening and blackspot susceptibility (Tables 3 and 4).

The results from irrigation treatments substantiate the importance of irrigation management as a tool to increase specific gravity of Atlantic and Russet Burbank. Traditionally, Michigan receives excessive amounts of rainfall late in the growing season and it is not uncommon for this rain to occur when the crop was irrigated on the same or previous day. It appears that reducing irrigation, particularly during the month prior to harvest, would lead to optimizing dry matter and reduced hollow heart. Any increased tuber yields achieved by an over supply of water at this stage appears to be insignificant. Harvest management, which avoids long delays after the crop has matured and the vines have senescenced is desired, particularly if the soils are wet.

In view of the fact that gypsum has failed to produce the desired results, particularly for the control of IBS and that only slight increases in the uptake of Ca was achieved by the gypsum treated plants, a preliminary trial was conducted using alternate calcium sources to evaluate their effectiveness for controlling IBS. In addition to Atlantic, MS401-6 seedling was used in this trial because of its high susceptibility to IBS. Gypsum was applied at two rates, 750 and 1500 lbs/a. All calcium treatments were applied to the furrow at planting, except for the wet emulsion treatment which was used as a seed piece treatment.

Results indicated that none of the calcium sources produced acceptable IBS control in the susceptible seedling MS401-6 (Table 5). Although anhydrous $CaSO_4$ produced the lowest level of IBS in Atlantic, the results did not establish any one superior calcium source for IBS control. None of the calcium sources applied at planting produced adverse effects on plant stands. The chloride source resulted in the lowest specific gravity with both varieties.

Table 1. Dry Matter and Internal Defects : Atlantic

Montcalm Research Farm 1989
(138 days)

Treatment		Tuber Yield (cwt/a) US#1	Total	SpGr	Chip Color	Pet-iole Ca %	Peel Ca (g/kg)	HH %	IBS %	Soil pH	CA (lb/a
Zero-Irrigation		418 b	463 b	1.088a	60	1.06	7.6	15	4.4	5.0	57
Irrigation Schedulin		441a	484a	1.086a	64	1.05	7.8	18	6.1	5.0	58
Over-irrigation		447a	496a	1.083 b	62	0.99	7.5	24	5.3	5.1	57
Gypsum:	(1) 0	432	480	1.086	61	0.94 b	7.5	21	7.8	5.0	53
	(2) 750(P)	438	478	1.086	62	1.07a	7.9	17	4.1	5.1	59
	(3) 375P+375H	435	483	1.087	63	1.10a	7.8	20	3.6	5.0	57
	(4) 750(H)	440	483	1.085	64	1.04a	7.6	19	5.4	5.0	61

Planting date: May 8, 1989
Harvest date: Sep 22, 1989

Previous crop: Rye
Initial soil test Ca: 480 lbs/a

Table 2. Dry Matter and Internal Defects : Russet Burbank

Montcalm Research Farm 1989
(136 days)

reatment	Tuber Yield (cwt/a) US#1	Total	% US#1	Sp. Gr.	* HH %	Petiole N %
ero-Irrigation	302	465	65	1.082a	15	3.0
rrigation Scheduling	324	477	68	1.082a	23	3.3
ver-irrigation	331	493	68	1.078 b	30	2.7
itrogen: 150 lbs	303a	469	64	1.082a	21	2.7 b
225 "	338 b	488	70	1.079 b	26	3.3a

Hollow heart in oversized (10oz) tubers

Planting date: May 8, 1989
Harvest date: Sep 22, 1989

Previous crop: rye
First top dressing: 6/15/89 urea (75 lbs N/a)
Second top dressing: 7/6/89 urea (75 lbs N/a)

Table 3. Post Harvest Quality Evaluation - Atlantic.

Treatment	After Cooking Darkening [y]	Percent Blackspot	
		Check	Bruised [z]
Zero irrigation	1.1	23	38
Irrigation Scheduling	1.1	18	41
Over irrigation	1.3	15	39
Gypsum (1) 0	1.0	20	43
(2) 750 (P)	1.2	13	45
(3) 375 (P) + 375 (H)	1.2	18	35
(4) 750 (H)	1.3	20	33

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

[z]Tubers removed from 40°F storage and bruised artificially in a manually driven wooden drum for 10 revolutions and peeled after 48 hours.

Table 4. Post Harvest Quality Evaluation - Russet Burbank.

Treatment	After Cooking[y] Darkening	Percent Blackspot	
		Check	Bruised[z]
Zero irrigation	1	20	62
Irrigation scheduling	1	13	65
Over irrigation	1.5	18	65
Nitrogen 150 lbs	1	19	65
225 lbs	1.5	13	63

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

[z]Tubers removed from 40°F storage and bruised artificially in a manually driven wooden drum for 10 revolutions and peeled after 48 hours.

Table 5. EFFECTS OF CALCIUM SOURCE ON YIELD AND INTERNAL QUALITY OF ATLANTIC AND MS401-6

MONTCALM RESEARCH FARM MICHIGAN STATE UNIVERSITY 1989

Source	Dose (lbs/a)	Cultivar	Plant Stand (%)	US#1* (cwt/a)	Total (cwt/a)	%#1	IBS* (%)	SPGR	pH	CA
US GYPSUM	750	Atlantic	93	314	389	81	6	1.090	5.4	800
		MS401-6	90	231	276	84	13	1.076	5.6	800
US GYPSUM	1500	Atlantic	90	311	369	84	5	1.087	5.4	838
		MS401-6	93	246	276	89	8	1.080	5.3	824
AGRICO CaS04	750	Atlantic	90	341	368	93	6	1.089	5.4	762
		MS401-6	97	257	277	92	10	1.075	5.3	686
Anhydrous CaS04	750	Atlantic	93	307	352	87	3	1.090	5.6	800
		MS401-6	97	266	282	94	14	1.079	5.4	762
Wet Emulsion(US Gypsum)		Atlantic	93	320	360	88	8	1.090	5.5	724
		MS401-6	90	239	259	92	13	1.078	5.5	762
Calcium Chloride	750	Atlantic	93	358	401	89	4	1.080	5.6	762
		MS401-6	97	289	302	95	11	1.073	5.5	724
Control	0	Atlantic	97	326	371	88	10	1.087	5.4	648
		MS401-6	97	224	258	87	15	1.076	5.4	648

* LSD (0.05) for US#1 yield = 12.8
LSD (0.05) for IBS = 5.4

Wet emulsion from US Gypsum was applied as a seed piece treatment

Variety MS401-6 was used because of its high susceptibility to IBS in previous trials. However, during the 1989 season the overall IBS observed in both Atlantic and MS401-6 was much lower than in 1988. For this reason, the test did not establish any one superior CA source for IBS control. None of the CA sources adversely affected the plant stand.

Funding Federal Grant

MICHIGAN STATE UNIVERSITY POTATO BREEDING PROGRAM

David S. Douches
Department of Crop and Soil Sciences

Cooperators: R.W. Chase, R. Hammerschmidt, G. Silva, J. Cash

I. Varietal Development

In 1989, 20,000 single hills were evaluated at the Clarksville Horticultural Experiment Station (CHES). These plants represented 150 different crosses between advanced lines and/or varieties. Thirty-five of the crosses were between russet/long white types, 114 crosses were between round white/yellow flesh types, and 1 cross for red types. Visual selection for tuber set, internal quality, external appearance was made. Approximately 300 single hills (1.5% selection rate) were selected and advanced for further testing in 1990. In the subsequent years, advancement of these seedlings will be based upon scab resistance, specific gravity, cold chipping, storability, internal/external quality and yield.

II. Advanced Selections

In 1989, 35 advanced selections from USDA Idaho (3), Maine (5), USDA Beltsville (12), Wisconsin (4), New York (1), Minnesota (7) and North Dakota (3) were grown and evaluated at the Montcalm Potato Research Farm. Each line was planted in two replications (23 hills/replication) except F100-1 and A80559-2 (1 replication each). Atlantic and Russet Norkotah were used as standards in the trial. The field was planted May 18 and harvested September 12 (127 days). The plots were mechanically harvested then graded for size distribution, internal defects, external defects, specific gravity. Table 1 summarizes the data from all the lines tested. Tables 2 and 3 list the best 10 lines for US#1 yield and specific gravity, respectively. In November, most of the round types were chipped and fried. This data are reported in Agtron values (model E-10) in Table 1. Additional tubers of these lines were placed in 45°F and 50°F long-term storage (120 days) for further evaluation.

These advanced selection were also placed in the replicated scab trial at the Soils Farm, East Lansing (see Potato Scab Research Report). Thirty tubers of each line were classified into 5 categories for percent scab coverage (0, 1, 5, 10, and 25%) and then averaged. Lines with less than 2% scab coverage were considered resistant in the trial.

TABLE 1. ADVANCED SELECTION TRIAL 1989.

Clone	Total	%US#1	%A's	%>3.25"	%<2"	PO	HH[2]	IBS[2]	VD[2]	SPGR[3]	AGTRON	SCAB [4] % Coverage
A79141-3	327.7	63	63	0	35	01	6	0	0	1.080	-	2.2
AF465-2	269.6	45	45	0	54	00	0	0	0	1.071	-	3.0
AF845-11	348-1	88	81	06	07	04	1	1	7	1.067	-	7.3
AF875-15	363.4	88	87	01	09	01	0	0	1	1.080	63	11
AF875-17	374.6	81	79	01	16	02	0	0	1	1.080	65	5.1
AF879-3	288.6	84	84	0	14	00	0	0	2	1.082	73	12
ATD63-2	347.1	73	73	0	24	01	10	0	0	1.086	46	0.9
Atlantic	363.8	87	75	11	09	02	7	0	1	1.081	61	3.6
B0034-10	208.7	68	68	0	28	03	0	7	3	1.077	77	6.5
B0172-15	511.3	92	77	15	03	03	2	0	0	1.078	68	13
b0178-16	314.1	80	72	08	14	04	3	7	1	1.083	73	7.5
B0178034	352.9	90	74	15	08	01	7	3	1	1.081	67	2.8
B0202-4	336.6	84	84	0	14	01	1	0	0	1.080	56	5.6
B0234-4	392.3	82	81	00	13	03	10	0	0	1.074	65	5.0
B0257-3	293.4	69	69	0	29	00	0	1	3	1.086	58	4.2
B9792-2B	298.1	84	75	09	11	03	2	0	8	1.083	62	6.4
B9922-11	247.1	67	57	09	28	03	4	1	1	1.075	-	0.5
B9955-11	335.5	88	74	13	05	05	1	0	2	1.078	61	9.6
B9955-33	242.4	91	76	15	05	02	0	0	1	1.076	63	20
B9972-2B	294.1	78	75	02	18	02	2	0	2	1.081	63	7.5
D43	376.7	79	79	00	18	02	1	0	3	1.064	48	1.9
J8	457.9	72	68	04	16	10	0	0	0	1.062	59	6.4
MN12823	377.0	84	76	08	10	05	3	2	1	1.071	65	3.2
MN12828	291.0	67	67	0	21	10	0	0	0	1.070	60	10
MN12966	294.4	80	79	00	15	04	0	0	0	1.064	-	-
MN13540	303.6	64	64	0	32	02	0	3	2	1.067	62	-
MN13653	277.4	70	70	0	29	00	0	0	0	1.063	64	0.4
MN13740	331.8	82	80	01	16	00	2	0	4	1.070	69	7.1
MN9632	284.9	69	69	0	30	0	0	0	1	1.069	62	6.5
NDA2031-2	309.0	58	57	00	40	00	1	1	0	1.069	63	10
NDA2126-6	415.4	88	75	12	08	03	0	0	6	1.065	57	-
R. Nork	216.5	56	56	0	43	0	0	0	0	1.062	-	4.1
S465	312.4	84	84	0	12	02	0	0	0	1.075	70	2.2
TND22-2	306	84	84	0	14	01	0	0	2	1.074	63	5.0
W231	259.7	66	66	0	33	0	0	0	0	1.076	64	5.7
F100-1	344.8	86	82	4	12	2	2	2	0	1.080	-	4.6
A80559-2	374	91	73	17	7	3	2	0	0	1.079	70	9.3

1 - cwt/acre
2 - 20 tuber sample
3 - average of 2-3 Kg samples
4 - range of scab coverage: 0.4 (resistant) - 20 (susceptible)

ADVANCED SELECTION TRIAL 1989
MONTCALM RESEARCH FARM

TABLE 2.

TEN BEST FOR US #1 YIELD

Family	US #1 Yield	Total Yield	Spec Grav	HH	IBS	VD	Type
B0172-15	475	511	1.079	2	0	0	RND
NDA2126-6	366	415	1.065	0	0	6	RND
J8	333	458	1.062	2	0	0	RND
B0234-4	322	392	1.075	6	0	0	RND
AF875-15	322	363	1.080	0	0	1	RND
MN12823	319	363	1.072	1	2	1	RND
B0178-34	319	353	1.081	4	3	1	RND
ATLANTIC	318	364	1.082	1	0	1	RND
AF845-11	308	348	1.068	1	1	7	RND
AF875-17	307	375	1.080	0	0	1	RND

TABLE 3.

TEN BEST FOR SPECIFIC GRAVITY

Family	Spec Grav	Total Yield	US #1 Yield	HH	IBS	VD	Type
B0257-3	1.087	293	205	2	1	3	RND
ATD63-2	1.086	347	256	9	0	0	RND
B9792-2B	1.083	298	253	2	0	8	RND
B0178-16	1.083	314	253	5	7	1	RND
AF879-3	1.082	288	244	7	0	2	RND
ATLANTIC	1.082	364	318	1	0	1	RND
B9972-2B	1.082	294	231	2	0	2	RND
B0178-34	1.081	353	319	4	3	1	RND
AF875-17	1.081	339	268	0	0	2	RND
A79141-3	1.081	328	208	6	0	0	RUSS

Funding Federal Grant

POTATO SCAB RESEARCH

R. Hammerschmidt, D. Douches, M.L. Lacy, K. Ludlam, C. Wallace, L. Hanson and F. Spooner

Research has been carried out with the following objectives:

1. Evaluation of varieties and advanced selections for resistance to scab.

2. Identification of the factors responsible for scab resistance and characterization of the heritability of scab resistance.

3. Evaluation of selected cover crops for influence on scab expression and examination of soils for presence of antagonists.

4. Further characterization of the mode of pathogenicity by the scab pathogen.

Disease Resistance Research

During the Summer of 1989, named varieties and advanced selections were screened for scab resistance at the MSU soils farm. All seed pieces were inoculated with a *Streptomyces scabies* spore suspension prior to planting and each hill was amended with *S. scabies* infected vermiculite. Several lines were shown to have some resistance. We also evaluated several 2x and 4x populations that were segragating for scab resistance. Several of these families exhibited resistance. The results of these evaluations are presented in Tables 1-3.

A green house screen for both advanced selections and for seedlings was used to enhance the breeding efforts. Pot tests, using plants grown from seed pieces, were used to augment field evaluations. Based on these results, we have been able to categorize the varieties and selections into resistant or susceptible (Tables 4). We have also used this test to examine the interaction of several varieties with different isolates of *S. scabies* (Table 5). This work is being carried out to determine tha variability of plant response to different isolates of *S. scabies* that we have collected in Michigan. Table 6 lists the diploids and tetraploids that will be investigated by this method.

A seedling screen was also developed in order to facilitate determining the resistance of individual progeny. In brief, individual seedlings were transplanted to seedling trays containing soil infested with *S. scabies*. The results of this evaluation is shown in Table 7. This type of evaluation will be very useful in characterizing resistance as well as providing for an early evaluation step in variety development.

We have also continued to look at biochemical factors that are possibly involved in scab resistance. Although we have found that there is a rough correlation between chlorogenic acid levels in the young periderms of 4x varieties (Table 3), we have not seen this relationship in the 2n populations. We have incorporated into our work an evaluation of another plant compound that appears to be in the resistant, but at very low levels (if present at all) in susceptibles. We are currently characterizing this material. The young periderm tissue is also being analyzed for the presence of any unique suberization-related peroxidases. Thus far, resistant varieties that have been examined have an additional acidic isozyme that is not in the susceptibles. This isozyme could prove useful in determining how periderm formation is regulated in resistant varieties as well as provide a new isozyme marker for reisistance.

Influence of selected cover crops on scab expression

Last year we reported that certain cover crops strongly influenced the expression of scab in the Atlantic variety. We have repeated this work this past Summer. In brief, green manure crops were planted 4 May (the field was in potatoes the previous year and left fallow overwinter). The cover crops were rototilled in on 7 June. Atlantic potatoes were planted on 12 June.

Evaluation of the potatoes for scab is presented in Table 9. There were no significant differences between the fallow treatment and any of the cover crops. However, corn, soybean and red clover prior to potatoes resulted in the highest amount of scab. Oriental mustard had the greatest effect in reducing scab. None of the treatments, however, resulted in reduction of disease to 100% marketable level.

Soil samples were collected from the red clover and oriental mustard plots to determine if the differences in disease between these two cover crops could be the result of soil borne antogonists of S. scabies. On two dates, antagonists were identified by ability to inhibit growth of the pathogen (Table 10). Two actinomycetes and one bacillus, that still were antagonistic to S. scabies following isolation are being further tested for disease suppression and for characterization of possible antibiotics produced by the antagonists.

Pathogenicity characteristics of S. scabies

Further study of the ability of S. scabies to produce extracellular enzymes that may be of importance in pathogenesis was cerried out. The pathogen appears to be very good at producing certain types of pectin degrading enzymes. Pathogenic variability does appear to correlate with production of these enzymes. However, the sole importance of these enzymes in infection is doubtful since at least one saprophyte is a more competent enzyme producer. The ability of these organisms (including pathogenic types) to survive as saprophytes may be related to the production of the enzymes.

TABLE 1
1989 SCAB TRIAL: RUSSETS

Soils Farm
East Lansing, Michigan

Michigan State University

VARIETY	% Scab Coverage
RUSSET NUGGET	0.5
B9922-11	0.5
HILITE RUSSET	0.6
A79239-8	1.2
A79141-3	2.2
LEMHI RUSSET	2.8
AF465-2	3.0
RED LASODA	3.3
A74114-4	3.6
REDDALE	3.6
ATLANTIC	3.6
RUSSET NORKOTAH	4.1
B7592-1	4.2
RIDEAU	4.4
SUPERIOR	5.7
A78242-5	7.5
A79357-17	7.8
MS700-83	8.1
ONAWAY	8.3
A76147-2	10.
A7411-2	12.
B9955-33	20.

Scab rating is based upon a 30 tuber average

TABLE 2

1989 SCAB TRIAL: ROUND & RED TYPES

Michigan State University

VARIETY	% Scab Coverage
ND791-5R	0.3
B0178-34	2.8
LEMHI RUSSET	2.8
ND2224-5R	3.1
MN12823	3.2
RED LASODA	3.3
REDDALE	3.6
ATLANTIC	3.6
NDA2126-6	4.0
B0257-3	4.2
RIDEAU	4.4
W949-R	4.5
NTD9-1068-11R	4.5
F100-1	4.6
W948-R	4.7
TND22-2	5.0
B0234-4	5.0
AF875-17	5.1
ROSE GOLD	5.3
LA01-38	5.5
B0202-4	5.6
SUPERIOR	5.7
W231	5.7
B9792-2B	6.4
B0034-10	6.5
MN13740	7.1
MS402-7	7.2
AF845-11	7.3
B9972-2B	7.5
B0178-16	7.5
STUEBEN	7.7
KANONA	8.0
MN10874	8.0
MS700-83	8.1
ONAWAY	8.3
ND860-2	8.3
SOMERSET	8.3
A80559-2	9.3
MN13540	9.5
ERAMOSA	9.5
B9955-11	9.6
MN12828	10.
AF875-15	11.
MS401-2	11.
MS402-8	11.
SAG GOLD	11.
AF879-3	12.
B0172-15	13.
MS401-1	19.
B9955-33	20.

TABLE 3

1989 SCAB TRIAL
SOILS FARM, EAST LANSING, MI
PROGENY DISTRIBUTIONS

Family	Overall Scab Rating 1	2	3	4	5	Progeny Tested	Parents
A120	2	4	6	2	1	15	Onaway selfed
A073	9	10	12	3	1	35	Superior selfed
A048	3	10	9	4	3	29	Atlantic selfed
A109	2	1	2	0	0	5	ND860-2 selfed
A102	2	9	5	4	2	22	700-83 selfed
A063	2	8	7	2	2	21	Lemhi R selfed
A060	5	10	9	3	1	28	Sag Gold X Superior
SD19	4	22	5	5	2	38	Y245.7 X 84SD22
A115	1	8	2	2	2	15	Atlantic X Onaway
A067	3	9	7	5	3	27	ND860-2 X Lemhi R
A054	0	11	7	6	5	29	Atlantic X 700-83
A119	0	6	12	17	4	39	Onaway X ND860-2
A112	0	1	3	7	0	11	Superior X Onaway
A055	0	7	8	2	1	18	Atlantic X ND860-2
A104	0	4	8	11	2	25	ND860-2 X 700-83
A057	1	15	16	2	0	34	Sag Gold X Lemhi R
A065	3	18	25	1	1	48	Superior X Lemhi R
A114	0	3	19	13	2	37	Sag Gold X Onaway
A117	4	10	17	6	0	37	Onaway X Lemhi R
A049	3	2	7	9	2	23	Sag Gold X Atlantic
A113	0	1	9	3	1	14	700-83 X Onaway
A050	2	10	7	1	0	20	Superior X 700-83
A099	0	12	8	4	0	24	Superior X 700-83
A191	5	6	2	1	0	14	P100-2 X 84S10
A192	16	5	0	0	0	21	84S11 X 84S10
A156	7	11	4	0	0	22	P100-2 x 84SD20
A162	6	5	0	0	0	11	84SD20 X 106-2-1
A187	8	5	0	0	0	13	84S10 X 84S11
A193	7	3	2	0	0	12	P100 X P168-1
A169	0	6	4	0	0	10	85SD56 X 84S11
A155	8	3	1	0	0	12	106-2-1 X W5337.3
A185	0	10	0	0	0	10	85SD55 X P100-2
A153	4	0	0	0	0	4	106-2-1 X 84S11
A146	1	1	0	0	0	2	106-2-1 X 84SD22
A152	2	1	0	0	0	3	106-2-1 X 84S10
A149	0	4	1	0	0	5	P133-5 X 106-2-1

based upon 5-10 tubers/seedling

TABLE 4

1989 GREENHOUSE SCAB TEST - SUMMER/FALL

CLONE	RATING*
NOOKSACK	1
BURBANK	1
LEMHI RUSSET	1
SUPERIOR	1.1
133-72	1.3
84S10	1.3
ONTARIO	1.5
133-128	1.5
133-9	1.6
W5295.2	2
133-124	2
133-67	2
133-197	2
R. BURBANK	2
84SD22	2
ATLANTIC	2.3
133-151	2.3
133-26	2.3
133-208	2.5
ONAWAY	2.5
133-16	2.6
133-227	2.6
133-158	2.6
133-47	2.6
DM56-4	3
133-293	3
133-250	3
MS716-15	3
133-30	3
85SD55	3
MONONA	3.1
MICHIGOLD	3.1
KATAHDIN	3.3
SAGINAW GOLD	3.3
PIOO-2	3.5
MS700-83	3.8
NDD277-2	4
133-87	4
Y245.7	4
133-273	4
ND860-2	4.5

* Based on three replications

TABLE 5

Strains	Onaway	Atlantic	R. Burbank
DP (Z)	deep	deep	common
Onaway 9/25	common	common	---
830103	common	common	---
F945	common	deep	common
RP	deep	deep,comm.	---
RP(F)	common	common	---

TABLE 6

Variety x strain analysis

Varieties

4x	2x
Superior	84S10
Lemhi Russet	84SD22
Onaway	W5295.7(I)
Atlantic	DM56.4
Saginaw Gold	W5337.3
MS700-83	P100-2
ND860-2	

TABLE 7

GREENHOUSE SEEDLING SCAB TEST 1989

FAMILY	FEMALE	MALE	Progeny Distribution 1	2	3	4	5	PROGENY TESTED
246	Lemhi R	Lemhi R	18	18	55	9	0	11
245	Superior	Superior	17	22	22	29	11	18
247	ND860-2	ND860-2	0	15	23	54	8	13
248	Monona	Monona	33	22	45	0	0	27
244	Superior	Lemhi R	78	17	5	0	0	18
251	ND860-2	Lemhi R	5	19	33	38	5	21
250	Superior	Monona	16	6	44	28	6	32
360	NDD277-2	Lemhi R	80	11	4.5	4.5	0	44
249	Lemhi R	Monona	0	0	27	36	36	11
254	84SD22	84S10	58	35	7	0	0	31
253	84SD22	84S11	7	23	30	30	10	30
364	84S11	84S10	71	19	7	3	0	42
366	31-75	84SD22	80	8	8	4	0	25
363	31-75	84S10	74	18	8	0	0	40
357	NDD277-2	84S10	24	36	10	20	10	42
358	NDD277-2	84SD22	58	20	8	13	2	48
356	NDD277-2	31-75	33	18	20	24	5	45
362	NDD277-2	84S11	9	11	17	28	35	46

1 = 0% scab coverage; 5 = > 25% scab coverage

TABLE 8

Mean levels of chlorogenic acid

Resistant	CGA	Susceptible	CGA
Hindenburg	1.863	Saginaw Gold	0.556
Onaway	1.654	Michigold	0.584
Nooksack	1.508	MS700-83	0.608
Superior	1.428	NDD277-2	0.637
Lemhi R.	0.972	Atlantic	1.155
		ND860-2	1.654

TABLE 9

Effect of pre-planted green manure/soil ammendment crops on scab incidence in field-grown Atlantic potatoes, summer, 1989

Cover crop[1]	Scab rating[2]	Marketable Yield (CWT/A)[3]
alfalfa (7 lbs/A)	10.5 BC[5]	102 ABC
corn (7 lbs/A)	14.5 A	53 C
fallow control	11.9 ABC	118 AB
oat (20 lbs/A)	10.6 BC	109 ABC
oriental mustard[4] (20 lbs/A)	9.5 C	140 A
red clover (7 lbs/A)	12.7 AB	73 BC
rye (20 lbs/A)	10.2 BC	141 A
soybean (20 lbs/A)	12.4 AB	87 ABC

[1] all plots had been left fallow through the winter

[2] based on a rating scale where 0= no scab, 1=1-4% scab, 5=5-9% scab, 10= 10-20% scab, and 25=20-25% or more scab

[3] estimated weight per acre of marketable potatoes with less than 5% scab

[4] *Brassica juncea*

[5] numbers with different letters indicate are significantly different by Duncan's Multiple Range test at =0.05

TABLE 10

Antagonists from soil amendment field trials.

date	avg. number of plaques red clover	mustard
6/16	1 on 10^{-4}	4 on 10^{-4}, 1 on 10^{-5}
6/30	0	0
7/14	1 on 10^{-4}	2 on 10^{-4}
7/28	0	0
8/11	0	0
8/25	0	0

[2] did not show antagonism when isolated

[3] 2 of these (both Actinomycetes) showed antagonism to 5 pathogenic *Streptomyces* when isolated

[4] 1 of these (a *Bacillus*) showed antagonism to 5 pathogenic *Streptomyces* when isolated

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CONTROL OF INTERNAL BROWN SPOT (IBS) IN ATLANTIC

R. Hammerschmidt, R.W. Chase, Paul Marks, and G. Silva

Heat necrosis/internal brown spot has been reported as a significant concern in the Atlantic variety in many areas throughout the U.S. It has occurred in various potato regions of Michigan but has had the greatest frequency in Southeastern Michigan.

In 1988 a field study was initiated at the W.J. Lennard Farm in Monroe County to evaluate the effect of banded applications of 750 lbs/A of agricultural gypsum to the soil at planting, at hilling and as a split application of 375 lbs/A at planting and at hilling. The use of an anti-transpirant (Vaporgard) was applied as the main plot treatment. The experiment was duplicated with two planting dates of April 15 and May 15. Application of gypsum did significantly reduce the amount of IBS but not to an acceptable level. There was no effect from the anti-transpirant.

Procedure:

In 1989 a similar plot was established at the Lennard Farm with a single planting on May 3, 1989. Individual plots were 4 rows x 25' and the 2 center rows were harvested for yields and quality evaluations. The gypsum applications of 750 lbs/A and the split application of 375 lbs/A were applied to the soil surface (1 ft. x 25 ft.) just prior to planting. The mechanical action of the planter shoe and covering disc thoroughly incorporated the gypsum. Prior to hilling, the gypsum was applied in a similar matter. The experimental design was a randomized complete block with four replications.

A main plot treatment of maleic hydrazide at 2 gal/A in 23 gpa of water was applied to one-half of the area on July 28. The plots were harvested on October 19.

Results:

There were no emergence or plant growth effects observed as a result of the gypsum treatments. Following the application of the maleic hydrazide, there was a light yellowing of the foliage. Table 1 summarizes the yields, specific gravity and internal defects of the harvested tubers. There was no significant effect on yields and specific gravity from any of the treatments. Tuber samples were also evaluated for the incidence of common scab with no treatment differences.

There was a significant reduction in the incidence of IBS on the plot treated with MH30 regardless of the gypsum treatment. There was a reduction in the incidence of IBS where gypsum was applied, however it was not at an acceptable level, similar to the 1988 results. There was an increase in the incidence of vascular discoloration resulting from the MH30. Interaction effects between gypsum and maleic hydrazide were not significant.

Following harvest, soil samples were collected from the untreated and the gypsum treated plots and were analyzed. Table 2 shows that there were no increased levels of calcium resulting from the addition of gypsum. The magnesium levels on the check plots were lower than where gypsum was applied.

A pre-plant soil test showed phosphorus at 627, potassium at 96, calcium at 436 and magnesium at 50 lbs/A, respectively. The pH was 5.3.

TABLE 1. YIELDS, SPECIFIC GRAVITY AND INTERNAL DEFECTS OF ATLANTIC POTATOES TREATED WITH MALEIC HYDRAZIDE AND GYPSUM (LENNARD FARM, MONROE COUNTY, 1989).

Treatment No.	MH	Gypsum (lbs/A)	Yields (cwt/A) U.S. No. 1	Yields (cwt/A) Total	Specific Gravity	% No. 1	% HH*	% IBS*	% VD*
1	-	0	187	247	1.084	76	5	58	1
2	-	750 P	175	237	1.082	74	0	45	7
3	-	750 H	191	251	1.083	76	11	40	3
4	-	750 (P+H)	204	261	1.084	78	9	37	0
5	+	0	176	231	1.082	76	8	11	4
6	+	750 P	197	248	1.082	79	8	9	8
7	+	750 H	188	236	1.082	80	4	7	16
8	+	750 (P+H)	180	226	1.080	80	3	11	17
Significance Level			ns	ns	ns		ns	* 5%	* 10%

*Data from cutting 25 tubers/plot.

TABLE 2. SOIL TEST RESULTS OF POST-HARVEST SAMPLES.

		pH	Pounds/Acre P	Pounds/Acre K	Pounds/Acre Ca	Pounds/Acre Mg
750 lbs/A	A	5.5	644	112	509	192
Gypsum	B	5.3	593	112	436	110
	C	5.3	610	96	436	80
	D	5.3	576	88	436	70
	Ave.	5.4	606	102	454	113
					1%	
Zero	A	5.3	681	88	436	60
Gypsum	B	5.3	610	96	364	50
	C	5.3	627	96	436	50
	D	5.3	610	89	436	60
	Ave.	5.3	632	92	418	55

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Nitrogen Management Strategies to Maximize Profit and Minimize Nitrate Leaching: 1989 Results

J.T. Ritchie, B.S. Johnson, and P.R. Grace

This study represents a continuing effort to evaluate the impact of contrasting nitrogen management strategies on crop yields and nitrate leaching. In 1988 we demonstrated that the nitrogen (N) application rate could be reduced without affecting yield and quality of Russet Burbank potatoes. Leaching loss of nitrate-N, as measured in permanently installed drainage lysimeters, was about 15 lb/A lower by the end of October where the N rate was reduced. Two important questions were left unanswered by our 1988 results. First, due to the drought in 1988, we were unable to evaluate the impact of a large rain on nitrate leaching when the concentration of soil N is high (e.g., after application of fertilizer N). Second, it was impossible to determine whether nitrate appearing in the drainage water originated from fertilizer additions or from other sources such as mineralization of soil organic matter. The experiment conducted at the lysimeter site in 1989 was modified as follows to address these issues: (1) Tracer techniques were used to determine the fate of the fertilizer N applied to the lysimeter areas; and (2) The plots were irrigated excessively at midseason to simulate the occurrence of a large rain. The latter objective was in response to the MPIC Research Committee's request to study how much N is lost during a summer storm through leaching. This report contains the 1989 results and a summary of the soil water drainage and nitrate leaching data collected from the drainage lysimeters during the last two years.

Methods

It was necessary to plant the lysimeter site to corn in 1989 due to problems with Potato Early Die Complex during the previous year. Two plots, 16 rows X 50 ft in length, were planted to corn hybrid Pioneer 3585 on May 24. The row spacing and seed spacing within the row were 23 inches and 9 inches, respectively giving a population of 30,300 plants/A. A treatment consisting of conventional nitrogen management (CON) was applied to one plot and a "Better Management System" (BMS), involving reduced input of fertilizer N, was applied to the second.

Permanently installed drainage lysimeters, one in each plot, were used to monitor soil water drainage and nitrate leaching. The lysimeters (48" X 68" X 6 ft deep) consist of steel boxes that are open at the top and closed at the bottom except for an opening used to collect water that drains through the lysimeter profile. The lysimeters intercept water at the 7½ ft soil depth, the sum of the distance from the soil surface to the top of each lysimeter (1½ ft) and their depth (6 ft). The 68" dimension accommodates three rows of corn, each containing 5 plants over the 48" length for a total of 15 plants over each lysimeter. Drainage depths and nitrate leaching were determined by measuring the volume of water collected and sampling it each time for nitrate concentrations using traditional autoanalyzer techniques. Sampling frequency was dictated by drainage rates during the season.

Each plot received N as ammonium sulfate at a rate of 13 lb/A at planting and one additional application of ammonium sulfate on June 21. The second application involved an N rate of 187 lb/A (200 lb/A total) for the CON treatment and 116 lb/A (130 lb/A total) for BMS. The ammonium sulfate applied to each lysimeter area on June 21 was labeled with the stable isotope ^{15}N. Four microplots (46" X 29") were established adjacent to the lysimeters in each treatment to provide replication of the soil and plant ^{15}N measurements. They also received the ^{15}N labeled ammonium sulfate at the prescribed rates (187 lb/A for CON and 116 lb/A for BMS) on June 21. The 46" dimension of each microplot was chosen as an exact multiple of the 23 inch row spacing. Each row, 29 inches in length, accommodated 3 plants for a total of 6 plants in each microplot.

Soil samples for NH_4 and NO_3 measurements were collected prior to planting, at midseason, and after fall harvest. Samples were collected in 4 inch increments to a depth of 1 ft on each occasion. Samples collected after application of the labeled material will be analyzed for ^{15}N concentrations. Plant leaf disks for ^{15}N analysis were collected during the season and whole plant samples were collected at harvest for ^{15}N uptake measurements. Drainage water samples collected after the June 21 application of the labeled fertilizer were also analyzed for ^{15}N concentrations. Results of the soil, plant, and lysimeter ^{15}N measurements will enable us to calculate the total N balance in terms of the amount of fertilizer N taken up by plants (corn in 1989, potato in 1990), the amount of fertilizer N remaining in the soil at the end of each season, and the leaching loss of N from the lysimeter profiles. Results of these measurements will be included in a future report except for preliminary findings from the drainage water ^{15}N concentrations.

Both plots were irrigated as needed during the season using similar irrigation schedules for each treatment. The simulated "storm" consisted of irrigating 3.9 inches over a 3-day period, 2.4 inches on July 24 and 1.3 inches on June 26. Constraints of the irrigation system existing at the lysimeter site precluded the possibility of applying this quantity of water during a shorter time period (e.g., 4 hours).

Results

1989

Yields and yield components for the contrasting N management strategies are given in Table 1. Plant growth was similar for both treatments as grain yield for CON exceeded the yield for BMS by only 8.0 Bu/A. Total above ground biomass production for the CON treatment was 7.66 tons/A compared to 7.53 tons/A for BMS, a difference of 0.15 tons/A (300 lb/A). The dry weight of grain produced was about 45 % of the biomass for both treatments.

The plant responses reported in Table 1 are consistent with the premise that N rates applied to many crops can be reduced without diminishing yields appreciably. This should result in lower residual N in the soil at the end of each season and therefore a lower potential for nitrate leaching. Figures 1 to 3 illustrate the extent to which BMS reduced nitrate leaching. The time scale in each Figure represents a 8 month period from May 15, 1989 through January 5, 1990. A significant "pulse" of soil water drainage is evident shortly after the simulated storm as drainage amounts increased sharply from 5 inches to about 11 inches over a two-week period (Fig. 1). Very little drainage occurred during the remainder of the season totalling 12.1 inches for the BMS compared to 10.8

inches for the CON treatment. A large natural rainfall of 3.5 inches on August 4 added to the observed response.

Nitrate concentration in the drainage water was consistently greater where the CON treatment existed than where the BMS was applied (Fig. 2). For both treatments, nitrate concentrations decreased from about 80 ppm at planting to 30 ppm by the beginning of September. Cumulative nitrate loss from each lysimeter is illustrated in Fig. 3. As expected, most of the nitrate leaching occurred prior to September when the drainage rates and nitrate concentrations in the drainage water were greatest. The total amount of nitrate lost from the profile during the 8-month period was 121 lb/A for the CON treatment and 107 lb/A for BMS.

The results given in Fig. 3 show that treatment differences are small compared to the difference between fertilizer N rates for CON and BMS (70 lb/A). Because the fertilizer applied to each lysimeter was labeled with ^{15}N, the nitrogen (mostly nitrate) appearing in the drainage water should eventually exhibit this label. As of the last measurement date (January 5, 1990), less than 1 percent of the ^{15}N applied to each lysimeter as ammonium sulfate was recovered in the drainage water. This result suggests that there is a substantial time lag between the application of fertilizer N and its appearance in drainage water intercepted at the 7½ ft depth. Most of the ^{15}N not taken up by the 1989 crop remained in the soil by the end of 1989, some of which will be used by the subsequent crop. However, continued movement of water through the lysimeter profile will gradually transport some of the residual ^{15}N to greater depths until it exits the lysimeter into the collection device.

1988 and 1989 Combined Results

The 1988 report considered the April to October time period. The measurement period for data included in Fig. 1 to 3 begins at May 15, 1990 leaving a 6-month "gap" in data obtained from the lysimeters. Fig. 4 to 6 summarize the results of our lysimeter measurements from June 1, 1988 through January 5, 1990. Soil water drainage was negligible prior to fall harvest in 1988 due to the drought that year. Above normal rainfall during October and November caused a substantial amount of drainage during the last part of 1988. Cumulative soil water drainage totalled about 10.0 inches for both treatments over the 6-month post harvest period. Drainage after planting in 1989 equalled drainage that occurred during the previous 6-month period. Drainage for the entire 19-month period totalled 20.3 inches for the CON treatment and 20.9 inches for the BMS.

Fig. 5 shows the seasonal changes in nitrate concentrations of the drainage water. Three distinct patterns are evident corresponding to time periods when crops were variously present or absent. Nitrate concentrations increased gradually prior to harvest in 1988, they were relatively constant after harvest, and decreased with time after planting in 1989. Fig. 6 shows the combined effects of the dynamically changing drainage rates and nitrate concentrations on nitrate leaching. Though nitrate concentrations in the drainage water were high during the 1988 growing season, nitrate leaching was negligible due to insignificant drainage amounts during the same time period. By the time of planting in 1989 however, nitrate leaching totalled 177 lb/A for CON compared to 163 lb/A for BMS. The final nitrate leaching values of 272 lb/A for CON and 245 lb/A for BMS are obtained by "adding" the cumulative curves in Fig. 3.

Plans for the 1990 Experiment

The lysimeter site will be planted to potatoes and treatments similar to those existing in 1989 will be established. This will allow us to build a long term record of the impact of reduced N application rates on crop yields and nitrate leaching. All fertilizer inputs will be unlabeled (i.e., no ^{15}N) in 1990 so that the following objectives can be addressed: (1) Determine how much of the ^{15}N remaining in the soil from 1989 is taken up by the subsequent crop; and (2) Determine how much of the labeled N appears in the drainage water. The second objective is particularly important because it will finally allow us to determine the contribution of fertilizer N (applied the previous year in this case) to nitrate leaching.

Table 1. Corn grain yield and yield components for the Conventional nitrogen management treatment (CON) and the Better Management System (BMS) during 1989.

Treatment	Grain Yield[1]	Yield Components[2]			
		Grain	Cob	Stover	Biomass
	Bu/A	------------ lb/A ------------			tons/A
CON	149	7047	1255	7009	7.66
BMS	141	6669	1189	7211	7.53

[1] Reported at a grain moisture content of 15.5 percent.
[2] All yield components are reported on a dry weight basis.

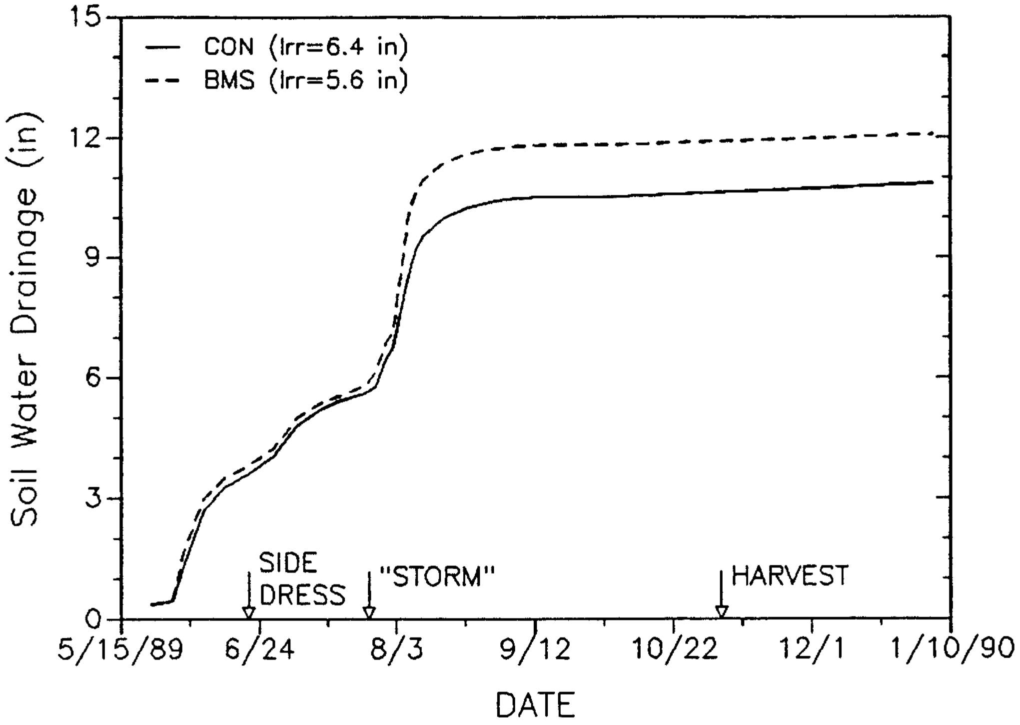

Figure 1. Cumulative soil water drainage during 1989.

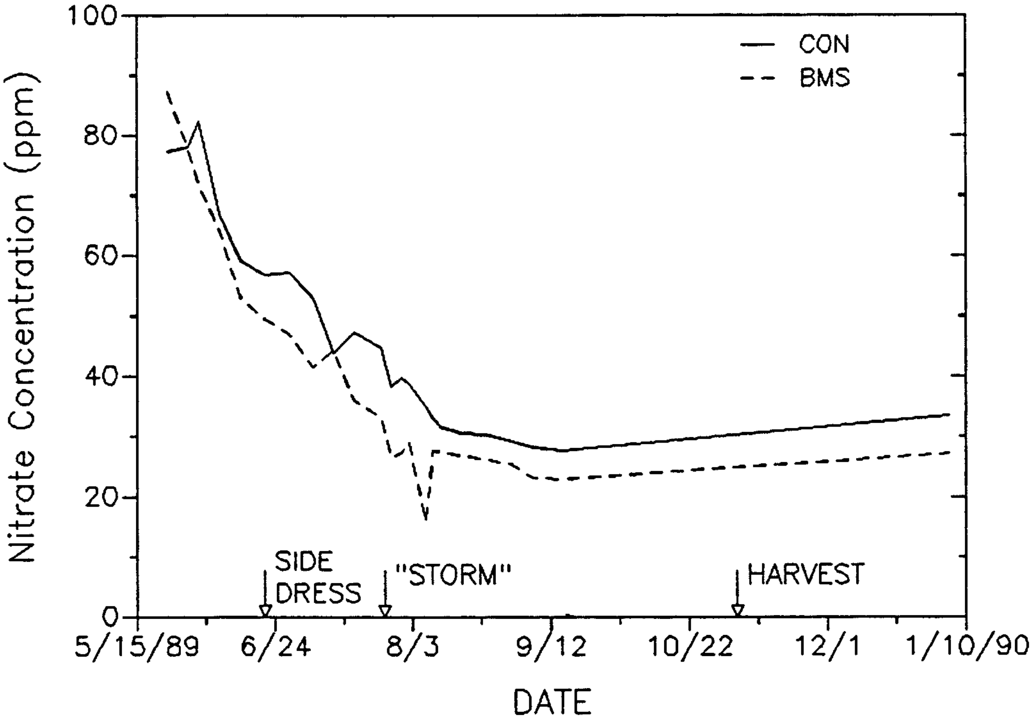

Figure 2. Nitrate concentration of drainage water collected during 1989.

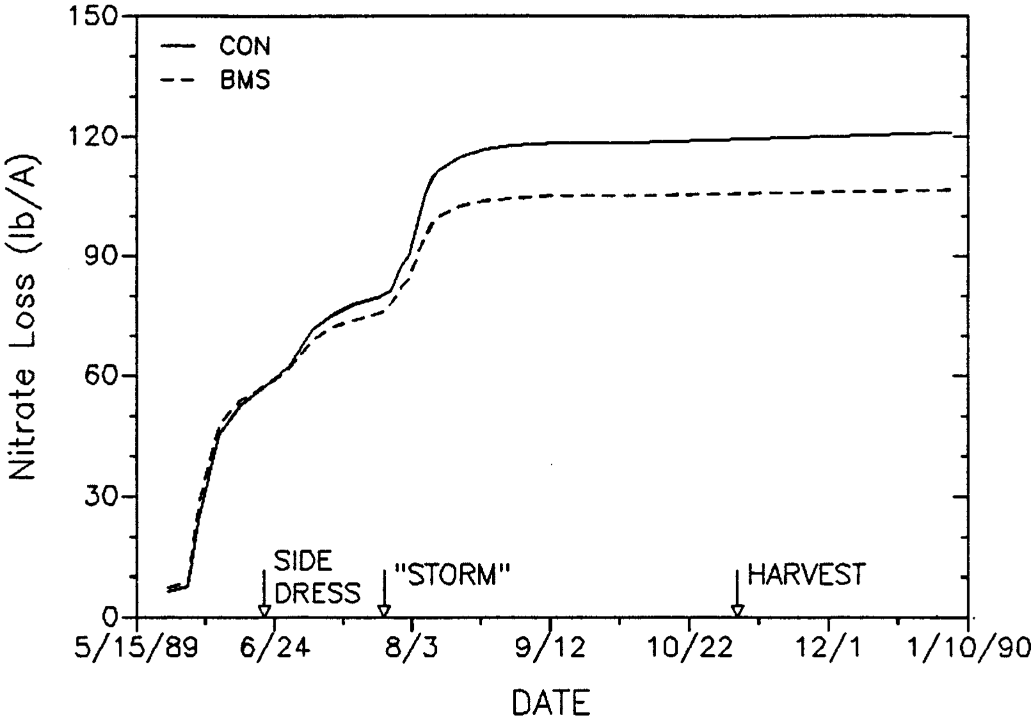

Figure 3. Cumulative nitrate leaching during 1989.

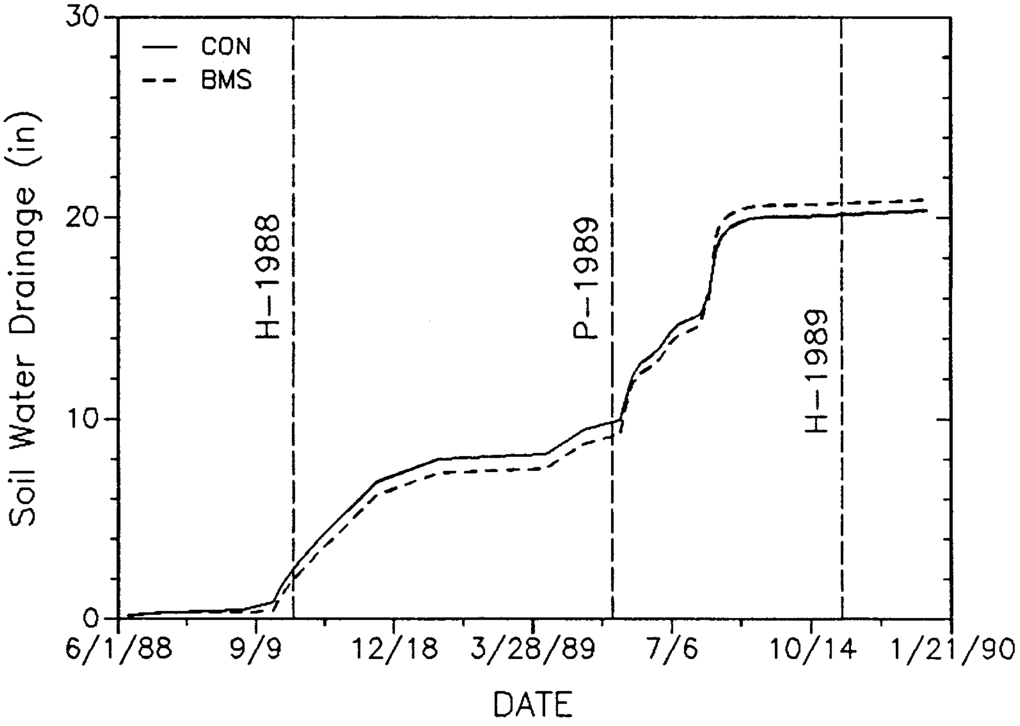

Figure 4. Cumulative soil water drainage from June 1, 1988 through January 5, 1990.

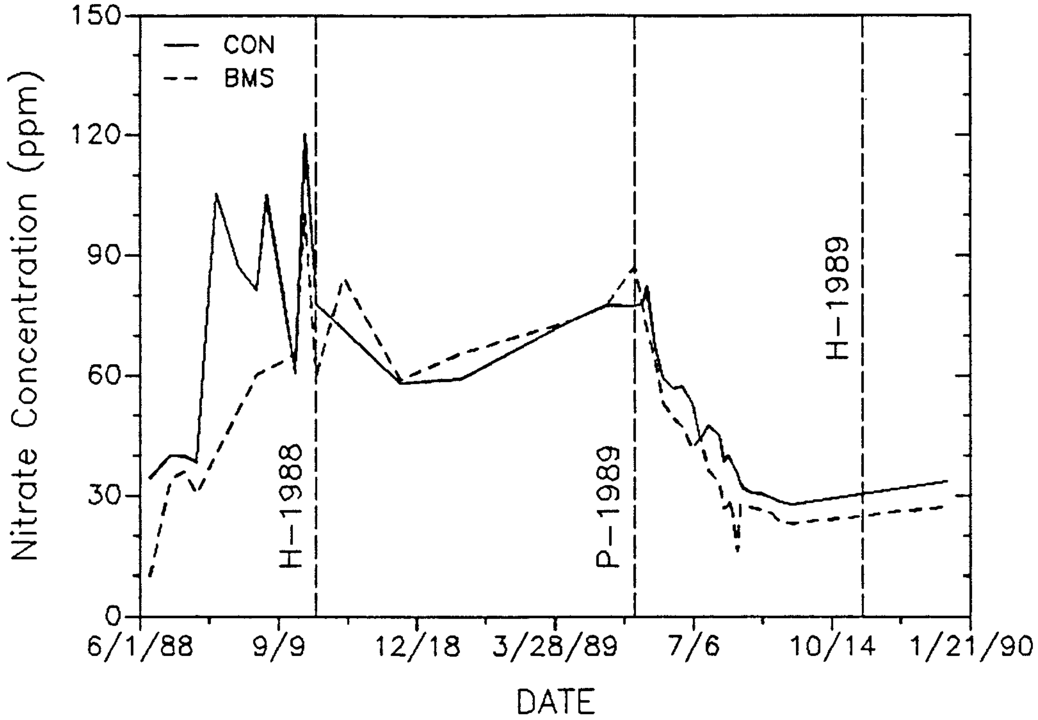

Figure 5. Nitrate concentration of drainage water collected during 1988 and 1989.

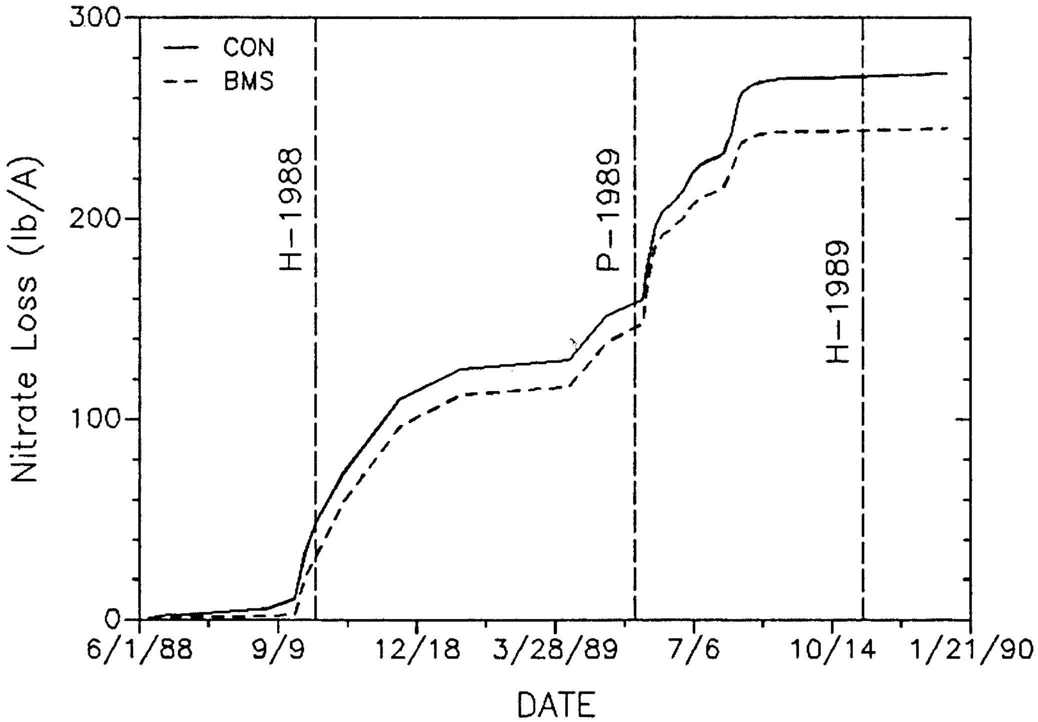

Figure 6. Cumulative nitrate leaching during the June 1, 1988 to January 5, 1990 period.

Funding MPIC

NITROGEN MANAGEMENT STRATEGIES FOR RUSSET BURBANK POTATOES

B.C. Joern and M.L. Vitosh

Introduction

Nitrate contamination of groundwater from non-point sources has developed into a serious and well publicized environmental issue. The present potato production system is quite susceptible to nitrate leaching because potatoes are a shallow rooted crop grown mainly on coarse-textured soils under irrigation. The relatively high economic value of the crop has historically led to an excessive use of fertilizer nitrogen (N) and irrigation water, which further contributes to the nitrate leaching potential of the potato production system. There is a need to develop N management strategies for potatoes that will improve their N use efficiency and reduce their nitrate leaching potential. With groundwater protection acts already legislated in several states, public support is building for comprehensive federal groundwater legislation. It is imperative that good local research data is available to demonstrate the high efficiency and minimal groundwater contamination risk of improved N management strategies for the potato production system.

Procedure

The 1989 potato studies were conducted at the Montcalm Research farm on a Montcalm-McBride sandy loam soil (location 1) and at the Michigan State University soils farm located on Hagadorn road on a Spinks-Riddles sandy loam soil (location 2). The experimental design selected for this study was a randomized complete block with four replications. Six N management practices (combinations of N rates and application times) were used as treatments for this investigation. Russet Burbank was the potato cultivar used and ammonium sulfate, $(NH_4)_2SO_4$, was the fertilizer N source applied to the crop. ^{15}N depleted ammonium sulfate was applied to each plot for fertilizer N uptake and N use efficiency determinations. Soil samples were taken to a depth of four feet four times during the growing season in the potato experiment. These soil samples will be analyzed for nitrate and ammonium to monitor N movement through the profile during the growing season.

The major objectives of this investigation were to evaluate the selected N management strategies for their ability to:

1. maximize tuber yield and quality
2. maximize fertilizer N uptake
3. minimize residual N in profile after harvest.

1989 Results

The potato yield data for locations 1 and 2 are shown in Tables 1 and 2, respectively. Tuber yields at location 1 were significantly influenced by the N management treatments. Both U.S. number 1 yields and total yields were maximized at 120 to 180 pounds N per acre as long as the N was applied by the onset of flowering. Nitrogen applied after flowering (treatment 6) did not appear to increase yields. A slight increase in large tuber yields (greater than 10 ounces) was detected at the highest fertilizer N rate (180 pounds per acre). Tuber yields at location 2 also indicated that yields were maximized at N application rates of 120 to 180 pounds per acre. At this location, the 180 pound N per acre treatment had a significant yield response of both the U.S. number 1 and total yield compared to 120 pounds of N per acre applied at planting. No significant yield increases were detected between the 180 pound N per acre treatment and the 120 pound N per acre treatment when the N applications were split. From the results of the 1989 experiments, it appears that 120-180 pounds of N applied by the end of tuber set (late June to early July) was sufficient for maximum tuber yields. The effects of splitting the N applications on tuber yields was mixed in 1989. Potato tuber quality, as indicated by specific gravity, was not significantly affected by the N treatments at either location. Fertilizer N uptake by the tubers at harvest for the 1988 (Year 1) and 1989 (Year 2) growing season is presented in Table 3. From the data, it appears that the percent recovery of the fertilizer N by the tubers was maximized at the 120 pounds N per acre rate, but these results are based on preliminary data and are highly variable.

Data for percent N in petiole samples taken throughout the growing season are presented in Tables 4 and 5 for locations 1 and 2, respectively. The petiole samples were taken just prior to each fertilizer sidedress application so that each petiole sample collected would reflect the previous fertilizer application. The percent N in the petioles generally reflected the most recent fertilizer application prior to petiole sample collection dates at both locations. The percent N in the petioles was generally maximized in the treatment which received the highest sidedress N application prior to sample collection.

To determine if the increase in percent N in the petioles was due directly to the fertilizer N, the fertilizer N in the petioles was also evaluated. These results are presented in Tables 6 and 7 for locations 1 and 2, respectively. The percent N from fertilizer in the petioles was directly correlated to the total percent N in the petioles, indicating that total N in the petioles may be a good indicator of fertilizer N uptake. This does not mean that percent N in the petioles is necessarily a good indicator of yield potential, as it appears that N applied after the onset of flowering (late June to Early July) may be taken up by the crop, but not translocated to the tubers for increased yields.

Conclusions

From the results of the 1989 (and 1988) investigation, it appears that 120 to 180 pounds of N per acre applied by the onset of flowering was sufficient for obtaining maximum yields of Russet Burbank potatoes. The effects of splitting the N applications was variable although there is some indication that N uptake efficiency may be increased by splitting the N applications. For this reason and the flexibility of yield goal modifications due to other environmental factors, the use of split N applications (planting and hilling) is recommended.

Table 1. The effect of N rate and application time on yield of Russet Burbank potatoes. Location 1.

--N fertilization rate---					--Yield--						
						--Tuber size distribution--					
-N application date-				Total	Off	Under	4-10	Over	U.S.	Total	Specific
5-09	6-23	7-07	7-20	N	type	4 oz.	oz.	10 oz.	no.1	yield	gravity
-----lb N per acre-------					--cwt per acre--						--g/cc--
--	--	--	--	0	7a	77 bc	93 c	2 d	95 c	179 c	1.079a
60	--	--	--	60	11a	94a	150 b	1 d	151 b	256 b	1.080a
120	--	--	--	120	15a	77 bc	232a	7 cd	239a	331a	1.081a
60	60	--	--	120	19a	61 d	224a	14ab	238a	318a	1.079a
60	60	60	--	180	19a	68 cd	220a	18a	238a	325a	1.077a
30	30	30	30	120	16a	86ab	157 b	9 bc	166 b	268 b	1.079a

Values followed by the same letter were not statistically different at the .05 level of probability.

Table 2. The effect of N rate and application time on yield of Russet Burbank potatoes. Location 2.

--N fertilization rate---					---Yield---						
-N application date-				Total	---Tuber size distribution---						
5-04	6-18	7-03	7-17	N	Off type	Under 4 oz.	4-10 oz.	Over 10 oz.	U.S. no.1	Total yield	Specific gravity
------lb N per acre------					---cwt per acre---						--g/cc--
--	--	--	--	0	21a	34a	161 c	2 d	163 d	218 d	1.081a
60	--	--	--	60	49a	41a	241 b	14 c	255 c	364 c	1.083a
120	--	--	--	120	39a	44a	289ab	17 c	306 bc	389 bc	1.083a
60	60	--	--	120	49a	40a	329a	31 b	360ab	449ab	1.084a
60	60	60	--	180	51a	41a	332a	42a	374a	466a	1.083a
30	30	30	30	120	34a	32a	287ab	24 bc	311 bc	377 bc	1.085a

Values followed by the same letter were not statistically different at the .05 level of probability.

Table 3. The effect of N rate and application time on the percentage of the applied fertilizer N found in potato tubers at harvest. Years 1 and 2.

---N fertilization rate---					---% Fertilizer N found in tubers----			
-N application date-					------Year 1------		------Year 2------	
				Total	-----Location-----		-----Location-----	
PTG	T.I.	F.F.	M.S.*	N	1	2	1	2**
-----lb N per acre------					---% N---			
--	--	--	--	0	0.0 b	0.0 c	0.0 c	0.0
60	--	--	--	60	35.0a	42.7ab	37.5 b	40.0
120	--	--	--	120	29.8a	51.5a	36.6 b	47.3
60	60	--	--	120	30.2a	44.7ab	42.8a	40.6
60	60	60	--	180	25.6a	32.7 b	40.5a	35.6
30	30	30	30	120	28.8a	47.3ab	40.2a	36.1

* PTG = at planting, T.I. = tuber initiation, F.F. = first flower, M.S. = mid season.
** Estimated values, so no statistical analyses run.
Values followed by the same letter were not statistically different at the .05 level of probability.

Table 4. The effect of N rate and application time on petiole N concentration of Russet Burbank potatoes. Location 1.

---N fertilization rate---					-------Tissue N concentration-------			
-N application date-				Total	--------Petiole sample date---------			
5-09	6-23	7-07	7-20	N	6-23	7-07	7-20	8-03
------lb N per acre-------					---------------% N-----------------			
--	--	--	--	0	4.16 d	3.57 c	3.43 d	2.89 b
60	--	--	--	60	6.00 b	3.21 c	3.07 e	2.57 c
120	--	--	--	120	7.11a	4.37 b	4.02 c	2.90 b
60	60	--	--	120	6.37 b	4.86a	4.21 c	2.89 b
60	60	60	--	180	6.34 b	5.07a	5.23a	4.06a
30	30	30	30	120	5.29 c	4.25 b	4.58 b	3.99a

Values followed by the same letter were not statistically different at the .05 level of probability.

Table 5. The effect of N rate and application time on petiole N concentration of Russet Burbank potatoes. Location 2.

---N fertilization rate---					--------Tissue N concentration--------			
-N application date-				Total	---------Petiole sample date----------			
5-04	6-18	7-03	7-17	N	6-17	7-03	7-17	8-01
------lb N per acre-------					----------------% N-----------------			
--	--	--	--	0	3.75 d	2.84 c	2.38 e	2.16 d
60	--	--	--	60	5.57 b	3.42 b	2.68 de	2.27 cd
120	--	--	--	120	6.37a	4.14a	3.24 bc	2.61 bc
60	60	--	--	120	5.52 b	3.95ab	3.04 cd	2.64 b
60	60	60	--	180	5.64 b	4.14a	4.40a	3.81a
30	30	30	30	120	4.87 c	3.44 b	3.65 b	3.65a

Values followed by the same letter were not statistically different at the .05 level of probability.

Table 6. The effect of N rate and application time on percent N from fertilizer in petioles of Russet Burbank potatoes. Location 1.

--N fertilization rate---					----------% N from fertilizer----------			
-N application date-				Total	--------Petiole sample date--------			
5-09	6-23	7-07	7-20	N	6-23	7-07	7-20	8-04
-----lb N per acre------					------------------% N------------------			
--	--	--	--	0	0.0 d	0.0 d	0.0 e	0.0 f
60	--	--	--	60	60.3 b	34.9 c	19.3 d	13.5 e
120	--	--	--	120	67.9a	47.7 b	34.9 c	24.2 d
60	60	--	--	120	61.2 b	59.7a	44.9 b	31.2 c
60	60	60	--	180	60.6 b	60.0a	56.3a	49.1a
30	30	30	30	120	45.7 c	44.9 b	42.8 b	42.7 b

Values followed by the same letter were not statistically different at the .05 level of probability.

Table 7. The effect of N rate and application time on percent N from fertilizer in petioles of Russet Burbank potatoes. Location 2.

---N fertilization rate---					---------% N from fertilizer---------			
-N application date-				Total	---------Petiole sample date---------			
5-04	6-18	7-03	7-17	N	6-17	7-03	7-17	8-01
-----lb N per acre-------					----------------% N-----------------			
--	--	--	--	0	0.0 d	0.0 c	0.0 d	0.0 d
60	--	--	--	60	53.1 b	45.2 b	37.1 c	28.1 c
120	--	--	--	120	69.2a	61.7a	51.1 b	41.2 b
60	60	--	--	120	56.5 b	56.0ab	51.4 b	39.3 b
60	60	60	--	180	58.2 b	64.6a	70.0a	58.9a
30	30	30	30	120	45.0 c	50.7ab	57.8 b	60.0a

Values followed by the same letter were not statistically different at the .05 level of probability.

Funding Other Sources

NITROGEN MANAGEMENT STUDIES ON POTATOES
Sandyland Farms, Montcalm County

M.L. Vitosh, D.B. Campbell, D.A. Hyde and B.P. Darling

Objective: To evaluate the use of soil and plant N analysis during the growing season for determining the optimum N fertilizer rate on Atlantic potatoes.

Soil Type: Mancelona loamy sand

Initial soil nitrate level......: 18 lb N/A-2ft. on May 30, 1989

Fertilizer Program :

Planting time N...............: 90 lb/A

Broadcast N June 1............: 46 lb/A

Sidedress Treatments..........: Applied June 13, 1989

#1................	0 lbs N/A
#2................	60 lbs N/A
#3................	90 lbs N/A
#4................	120 lbs N/A

INTRODUCTION:

This study was conduced on small plots located at the end of the growers field. The plots were 3 row plots replicated 4 times. Nitrogen fertilizer was applied at planting time and again on June 1 by the grower for a total of 136 lbs of N per acre. The sidedress N treatments were applied on June 13th. No other N fertilizer was applied to the study area.

RESULTS AND DISCUSSION :

The soil nitrate and ammonium nitrogen data collected during the summer are shown in Table 1, Figures 1 and 2. On June 28, most of the nitrate and ammonium was uniformly distributed between both the surface and subsurface samples. Nitrate levels were generally related to the rate of N fertilizer applied. On July 10, soil nitrate and ammonium levels were considerably lower, however on July 17, both nitrate and ammonium levels were considerably higher. The reason for higher levels of soil nitrate and ammonium levels on July 17 are difficult to explain. We initially suspected that some N fertilizer was applied to the entire field between July 10th and 17th; however, the plant analysis data in Table 2 does not confirm this. We can only speculate that the increased N levels are due to increased soil mineralization during July or improper handling of the soil samples.

Table 1. Soil nitrate and ammonium levels during the growing season as affected by four sidedress N fertilizer rates.[1]

Sidedress Rate	6-28	7-10	7-17	7-25	8-24	9-19
--lb N/A--			lb NO_3-N/A 1st ft.[2]			
0	16^d	9^a	43^a	--	--	--
60	33^b	11^a	31^a	--	--	--
90	28^c	9^a	35^a	--	--	--
120	65^a	23^a	45^a	16	44	30
			lb NO_3-N/A 2nd ft.			
0	17^c	--	22^a	--	--	--
60	30^b	--	34^a	--	--	--
90	29^b	--	33^a	--	--	--
120	48^a	--	57^a	--	--	22
			lb NH_4-N/A 1st ft.			
0	22^b	7^a	51^a	--	--	--
60	21^b	7^a	56^a	--	--	--
90	25^{ab}	7^a	54^a	--	--	--
120	28^a	8^a	36^a	33	50	6
			lb NH_4-N/A 2nd ft.			
0	21^b	--	36^a	--	--	--
60	21^b	--	69^a	--	--	--
90	24^{ab}	--	40^a	--	--	--
120	27^a	--	39^a	--	--	6

[1] Sidedress N applied June 13, 1989
[2] Any means followed by the same letter were not statistically different at the .05 level of probability.

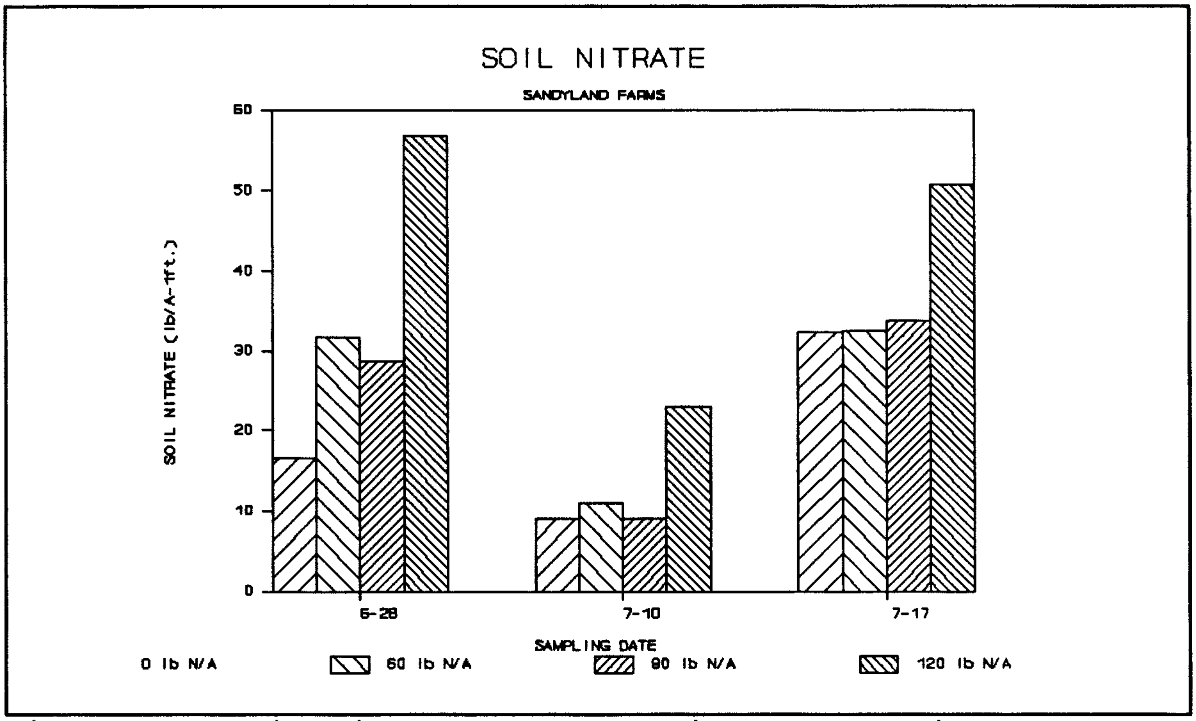

Figure 1. Soil nitrate levels during the growing season as affected by four sidedress N fertilizer rates.

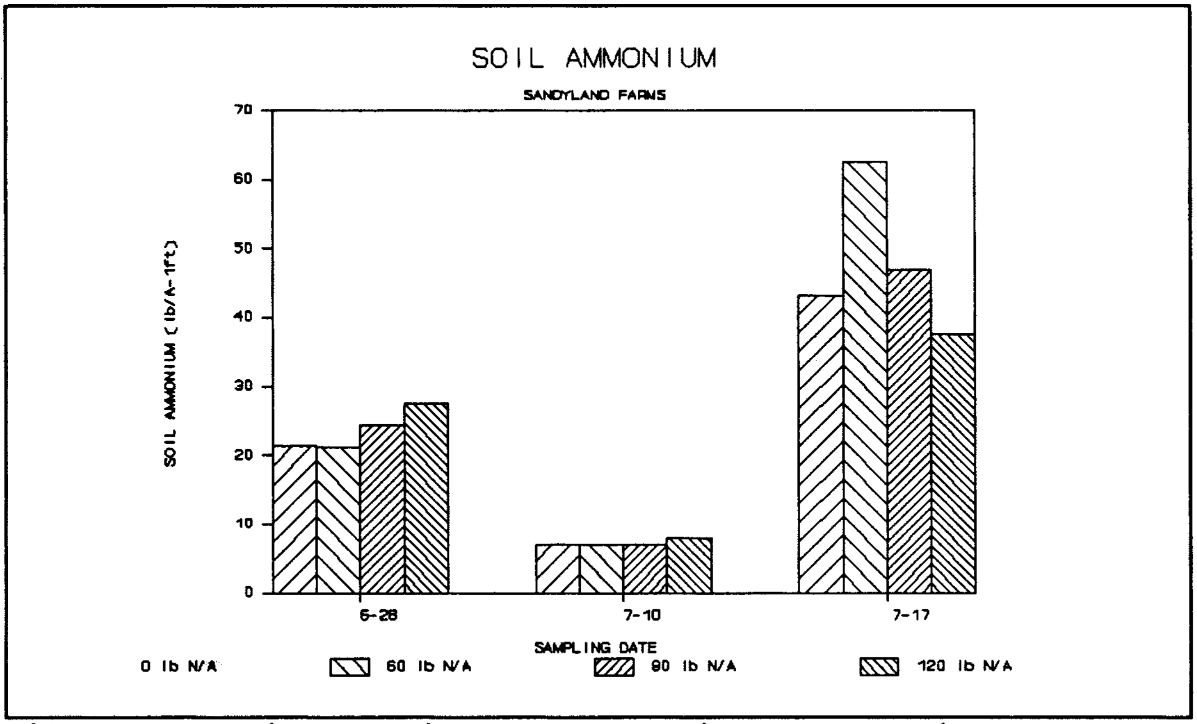

Figure 2. Soil ammonium levels during the growing season as affected by four sidedress N fertilizer rates.

Petiole nitrate levels for the season are shown in Table 2 and Figure 3. Nitrate levels declined throughout June and July. The amount of nitrate in the petioles on June 28 and July 17 were closely related to the rate of N fertilizer applied. However, petiole analysis on July 10 do not appear to be related to the N rates. Samples were not collected from the low N treatments on July 25th. According the MSU guidelines for nitrate levels in potato petioles (Extension Bulletin WQ09), the 90 and 120 lb N treatments exhibited adequate petiole nitrate N on June 28th. However, on July 10, 17 and 25 all levels were inadequate. The 120 lb N rate appeared to maintain between 5,000 and 6,000 ppm of nitrate throughout July. Anything above 6,000 ppm of nitrate this late in the season would be considered adequate.

Table 2. Potato petiole nitrate levels during the growing season as affected by four sidedress N fertilizer rates[1].

Sidedress	Sampling date			
Rate	6-28	7-10	7-17	7-25
---lb N/A--	------------------ lb NO_3-N[2]			
0	14,555[a]	6,322[a]	2,238[b]	--
60	17,917[a]	7,574[a]	3,060[b]	--
90	20,139[a]	6,021[a]	3,084[b]	--
120	21,111[a]	5,078[a]	5,390[a]	5,799

[1] Sidedress N applied May 30, 1989
[2] Any two means followed by the same letter are not statistically different at the .05 level of probability.

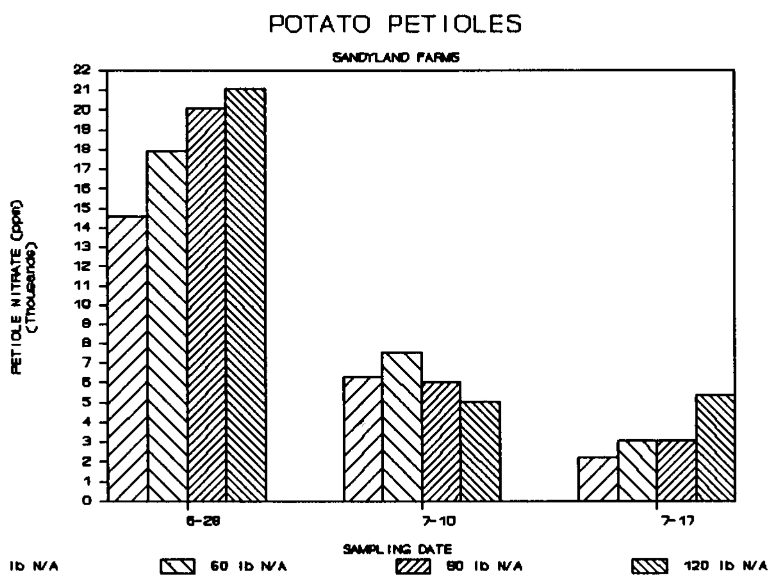

Figure 3. Potato petiole nitrate levels during the growing season as affected by four sidedress N fertilizer rates.

Yields, tuber size distribution and specific gravity are shown in Table 3. Four check samples were collected adjacent to the experiment from the growers field where the growers N practices were slightly different. Yields from these plots, although not part of the randomized complete block experimental design, were analyzed statistically with the other N plots. Total yield and U.S. No. 1 yields were closely related to the rate of N fertilizer applied, although the difference between the 90 and the 120 lb N sidedress treatments are not statically different. The field check out yielded all N treatments, however, total and US No. yields were not statistically greater then the 120 lb N rate. Neither, off-type, small or large tubers, nor specific gravity were affected by any of the N treatments.

Table 3. The effect sidedress nitrogen fertilizer rate on yield, tuber size and specific gravity of Atlantic potatoes.[1]

	Yield						
	- Tuber size distribution -						
Sidedress nitrogen	off type	under 4 oz	4-10 oz	over 10 oz	U.S. no.1	Total yield	Specific gravity
-----lbs/A--	-----------cwt per acre				----------------		--g/cc--
0	0[a]	52[a]	254[b]	16[a]	269[c]	329[c]	1.092[a]
60	0[a]	57[a]	306[a]	19[a]	325[b]	383[b]	1.089[a]
90	0[a]	54[a]	309[a]	25[a]	334[ab]	386[b]	1.092[a]
120	0[a]	69[a]	312[a]	26[a]	338[ab]	406[ab]	1.089[a]
Field check	0[a]	69[a]	335[a]	34[a]	368[a]	436[a]	1.085[a]

[1] Any two means followed by the same letter are not statistically different at the .05 level of probability.

We conclude from this study that plant analysis information is more reliable than soil analysis for determining N adequacy for potatoes during the growing season. Soil nitrate and ammonium levels were highly variable and appear to be greatly affected by environmental conditions (rainfall, irrigation and soil temperature).

Funding Other Sources

NITROGEN MANAGEMENT STUDIES ON POTATOES
Anderson Bros., Montcalm County

M.L. Vitosh, D.B. Campbell, D.A. Hyde and B.P. Darling

Objective: To evaluate the use of soil and plant N analysis during the growing season for determining the optimum N fertilizer rate on Russet Burbank potatoes.

Soil Type: Mancelona loamy sand

Initial Soil Nitrate Level: 50 lbs N/A-2ft. on May 31, 1989

Fertilizer Program :

Planting time N............: 58 lbs N/A

Sidedress Treatments.......: Applied May 30, 1989

#1.................	0 lbs N/A
#2.................	60 lbs N/A
#3.................	120 lbs N/A
#4.................	180 lbs N/A

INTRODUCTION:

This study was conducted on small plots located at the end of the growers field. The plots were 3 row plots replicated 4 times. Fifty eight (58) lbs N fertilizer was applied at planting time by the grower. The sidedress N treatments were applied on May 31st. A heavy rain in excess of 2 inches occurred that evening. An additional application of N was considered due to anticipated loss but was not applied to the plots. The grower applied his N to the surrounding field after this heavy rain.

RESULTS AND DISCUSSION :

The soil nitrate and ammonium nitrogen data taken during June, July and September are shown in Table 1, Figures 1 and 2. On June 13, most of the nitrate and ammonium was found in the surface foot. Nitrate and ammonium levels were directly associated with the rate of N fertilizer applied. Significant amounts of nitrate were also present in the subsurface samples on June 13. A very heavy rain in excess of 2 inches occurred the evening the sidedress N treatments were applied and probably explains the relatively high levels of nitrate and ammonium in the subsoil on June 13. On June 21 the soil nitrate and ammonium levels were considerably lower and continued to decline until

July 14. The reason for higher levels of nitrate and ammonium levels on July 14 can not be easily explained. We initially suspected that some N fertilizer was applied to the entire field between July 7th and 14th; however, we could not confirm this and the plant analysis data shown in Table 2 do not support this idea. We can only conclude that the higher level of nitrate and ammonium is due to increased mineralization of organic matter in July due to warm temperatures or improper handling of the soil samples.

Table 1. Soil nitrate and ammonium levels during the growing season as affected by four sidedress nitrogen rates.[1]

Sidedress Rate	6-13	6-21	6-30	7-7	7-14	9-19
------lb N/A-			lb NO_3-N/A 1st ft.[2]			
0	36[c]	12[a]	14[a]	12[a]	54[a]	--
60	112[b]	36[a]	20[a]	14[a]	64[a]	--
120	180[a]	32[a]	17[a]	11[a]	50[a]	--
180	204[a]	40[a]	20[a]	16[a]	73[a]	50
			lb NO_3-N/A 2nd ft.			
0	40[a]	--	16[a]	--	40[a]	--
60	52[a]	--	19[a]	--	62[a]	--
120	76[a]	--	18[a]	--	84[a]	--
180	92[a]	--	35[a]	--	93[a]	36
			lb NH_4-N/A 1st ft.			
0	20	19	24	14	32	--
60	60	20	19	10	28	--
120	68	20	24	8	29	--
180	63	22	25	15	28	8
			lb NH_4-N/A 2nd ft.			
0	10	--	22	--	27	--
60	12	--	17	--	34	--
120	20	--	21	--	27	--
180	12	--	26	--	29	9

[1] Sidedress N applied May 30, 1989
[2] Any means followed by the same letter or no letter are not significantly different (p=0.05).

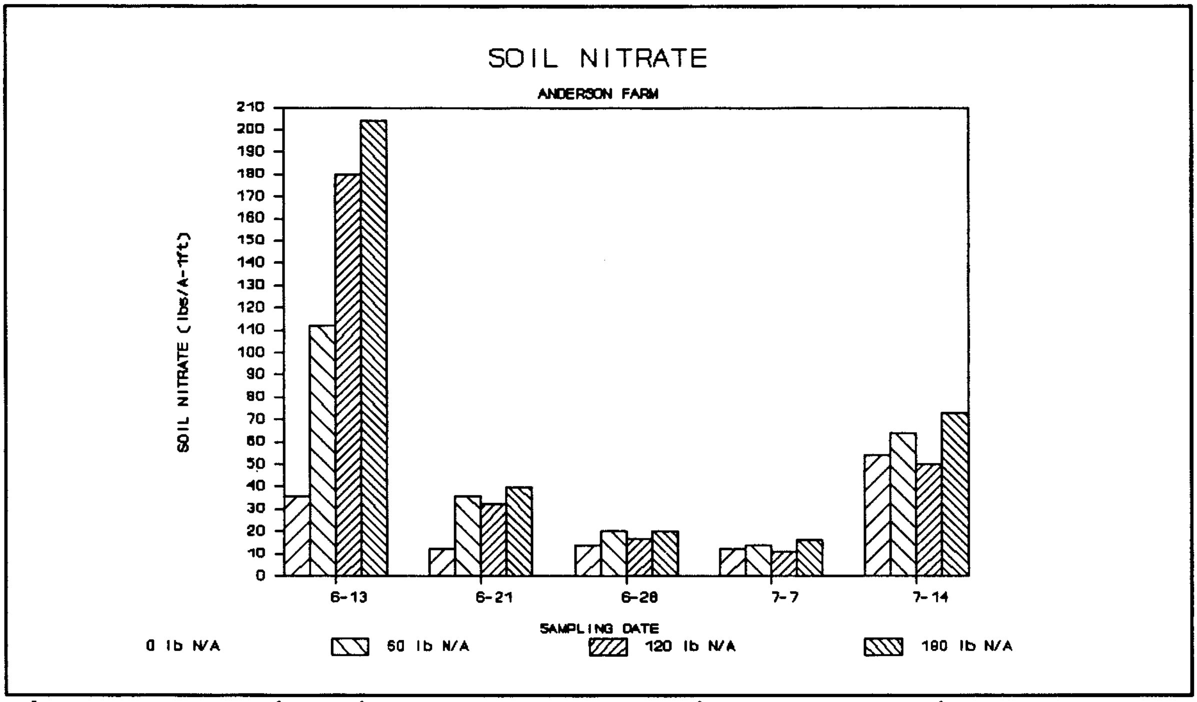

Figure 1. Soil nitrate levels during the growing season as affected by four sidedress N fertilizer rates.

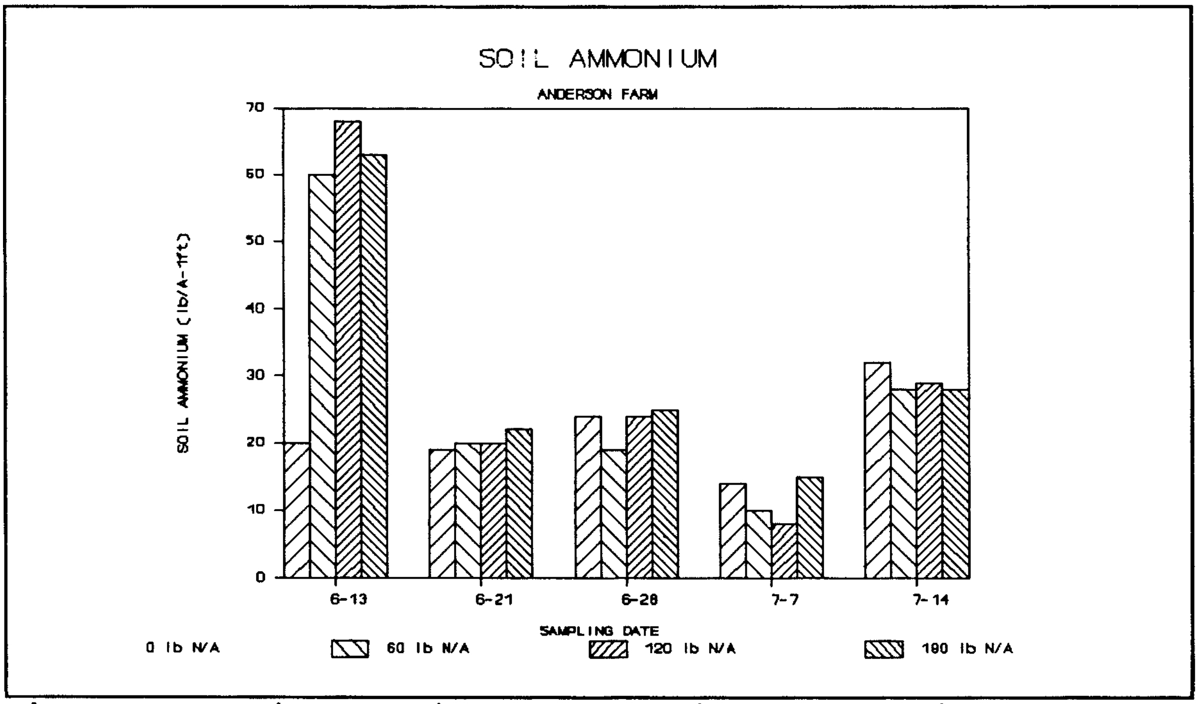

Figure 2. Soil ammonium level during the growing season as affected by four sidedress N fertilizer rates.

Petiole nitrate levels for the season are shown in Table 2 and Figure 3. Nitrate levels declined throughout June and July. The amount of nitrate in the petioles was directly related to the rate of N fertilizer applied. According the the MSU guidelines for nitrate levels in potato petioles (Extension Bulletin WQ09), only the 180 lb N treatment contained an adequate level of nitrate N on June 28, July 7 and July 14th. The level on July 14, however, was approaching the critical level. No samples were taken after this date.

Table 2. Potato petiole nitrate content as affected by four sidedress N fertilizer rates[1].

Sidedress Rate	6-13	6-21	6-28	7-7	7-14
----lbs N/A-	----------------	--------	lb NO_3-N[2]	--------	----------------
0	20,737[a]	22,210[a]	3,275[b]	980[c]	1,476[c]
60	20,602[a]	19,189[a]	5,060[b]	1,935[bc]	2,238[bc]
120	26,045[a]	20,613[a]	10,719[a]	6,606[ab]	3,750[b]
180	24,277[a]	22,674[a]	13,660[a]	11,180[a]	6,484[a]

[1] Sidedress N applied May 30, 1989
[2] Any means followed by the same letter are not statistically different at the .05 level of probability.

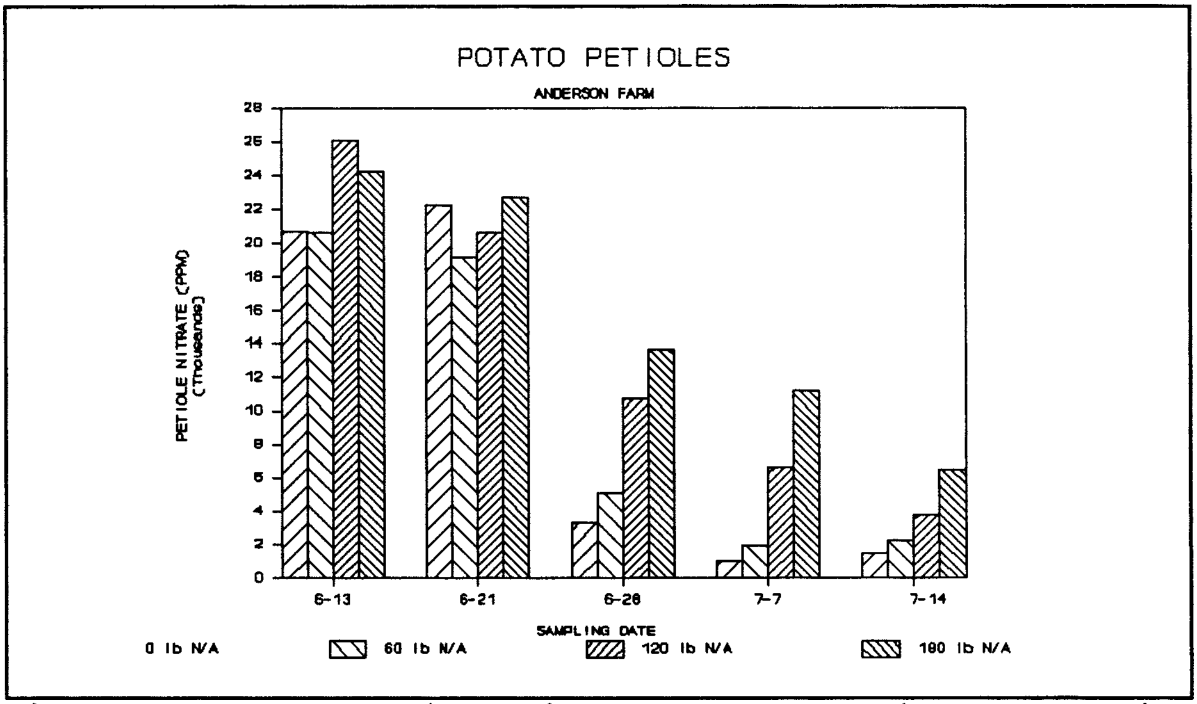

Figure 3. Potato petiole nitrate content during the growing season as affected by four sidedress N fertilizer rates.

Yields, tuber size distribution and specific gravity are shown in Table 3. Four check samples were collected adjacent to the experiment from the growers field where the growers N practices were slightly different. Yields from these plots, although not part of the randomized complete block experimental design, were analyzed statistically with the other N plots. Total yield and U.S. No. 1 yields were directly related to the rate of N fertilizer applied, although the difference between the 120 and the 180 lb N sidedress treatments are not statically different. The field check significantly out yielded all N treatments. Neither, off-type, small or large tubers, nor specific gravity were affected by any of the N treatments.

Table 3. The effect of nitrogen fertilizer rate on yield, tuber size and specific gravity of Russet Burbank potatoes.

	Yield						
	-- Tuber size distribution --						
Sidedress Nitrogen	off type	under 4 oz	4-10 oz	over 10 oz	U.S. no.1	Total yield	Specific gravity
----Lbs/A--	-------------cwt per acre--------------						--g/cc---
0	16[a]	47[a]	257[d]	1[a]	258[d]	320[d]	1.077[a]
60	13[a]	49[a]	289[c]	10[a]	299[c]	360[c]	1.080[a]
120	17[a]	41[a]	328[b]	10[a]	338[ab]	394[b]	1.081[a]
180	22[a]	42[a]	325[b]	7[a]	331[b]	397[b]	1.078[a]
Field check	20[a]	34[a]	365[a]	62[a]	365[a]	480[a]	1.084[a]

[1] Values followed by the same letter were not statistically different at the .05 level of probability.

We conclude from this study that plant analysis information is more reliable than soil analysis for determining N adequacy for potatoes during the growing season. Soil nitrate and ammonium levels were highly variable and appear to be greatly affected by environmental conditions (rainfall, irrigation and soil temperature).

Funding MPIC

1989 Nematology Progress Report

G.W. Bird, Nematologist
Department of Entomology

MPIC funded a 1989 nematology project to develop and test computer software for the diagnosis, risk prediction and recommendations related to the root-lesion nematode in potato production. In addition to reporting the results of this project, the report contains the results of a nematicide trial, 1988 nematicide use survey, and crop rotation observations.

NEMATICIDE EVALUATION

Eleven nematicide treatments were evaluated in 1989 at the MSU Montcalm Potato Research Farm. All treatments provided excellent control of the root-lesion nematode (Table 1). The metham (Vapam or Busan 1020) treatment, however, resulted in the greatest tuber yield.

1988 NEMATICIDE USE SURVEY

The results of the nematicide use survey indicated that 35,547 acres of potato land were treated with nematicides in 1988 (Table 3). Based on seventeen years of nematode research data, Michigan nematicide use resulted in an estimated profit increase of 13% of the crop value (Table 4). Chemigants and non-fumigant nematicides were used more widely than soil fumigants. Large potato farms used more nematicides than small or medium size farms.

ROTATION CROP OBSERVATIONS

As part of a Ph.D. dissertation by Mr. Tim Griffin, under the direction of Dr. Oran Hesterman, observations have been made on the impact of various rotation crops and management procedures on root-lesion nematodes, potato scab and black scurf (Table 5). A research project was initiated in 1989 at the MSU Montcalm Potato Farm to validate these observations. The test will be continued in 1990 and 1991, and the site will be available for observation by Michigan potato growers throughout the 1990 and 1991 growing seasons.

NEMACAST-POTATOES

NEMACAST-POTATOES is a computerized decision-support program designed to assist with diagnosis, predication and management of root-lesion nematodes and Verticillium in Michigan potato production. It is designed with an expert system component, which allows the user to quantify expert opinion. The resulting probabilities and management options can be used with a microcomputer or with a hand-held calculator. It is composed of three sections:

Table 1. Influence of eleven nematicide treatments on Pratylenchus penetrans and potato foliage senescence in 1989.

Treatment	Mid-season nematodes 100 cm^3 soil	1.0 g root	At harvest nematodes 100 cm^3 soil	PEDex (0-3)
Control	260 a	151 a	267 a	2.5 a
Telone II 10 gal/A	97 b	52 a	104 a	1.8 ab
SN 109106 WP 18 lb/A	83 b	122 a	87 a	2.4 a
SN 109106 WP 36 lb/A	73 b	66 a	80 a	2.4 a
Telone II 15 gal/A	50 b	473 a	53 a	1.3 b
Telone C-17 12.7 gal/A	27 b	18 a	32 a	2.3 a
Telone C-17 19 gal/A	17 b	5 a	17 a	1.4 a
Vorlex 12 gal/A	10 b	18 a	11 a	2.2 a
Temik 15 G 20 lb/A	10 b	21 a	13 a	2.3 a
Mocap 10 G 90 lb/A	7 b	1 a	17 a	2.5 a
Vydate 2L 2 gal/A	7 b	1 a	12 a	1.6 ab
Metham 75 gal/A	1 b	1 a	2 a	1.1 b

Table 2. Influence of eleven nematicide treatments on tuber yields.

Treatment	Tuber weight (cwt) a's	b's	j's	k's	Total
Metham 75 gal/A	228 a	25 a	15 a	25 a	290 a
Telone C-17 19 gal/A	197 ab	29 a	11 a	18 ab	250 ab
Vydate 2L 2 gal/A	195 ab	26 a	4 a	11 b	242 b
Telone II 15 gal/A	184 ab	29 a	11 a	3 b	237 b
Telone C-17 12.7 gal/A	183 ab	28 a	6 a	10 b	226 b
Vorlex 2L 12 gal/A	182 ab	27 a	8 a	13 b	235 b
Mocap 15 G 90 lb/A	180 ab	21 a	5 a	12 b	227 b
Temik 15 G	178 ab	32 a	6 a	20 ab	230 b
Telone II 10 gal/A	174 ab	31 a	9 a	11 b	223 b
SN 109106 WP 18 lb/A	166 b	30 a	9 a	13 b	213 b
SN 109106 WP 36 lb/A	162 ab	32 a	10 a	11 b	217 b
Control	151 b	26 a	5 a	11 b	197 b

- PROBLEM DIAGNOSIS: Use to assist growers in the within-season diagnosis of a plant growth or foliage senescence problems.

- RISK PREDICTION: For use by growers to determine the potential risk of a nematode problem for a potato production site. Nematode and fungus sample population information required.

- ECONOMICS OF NEMATODE MANAGEMENT: For use by growers to estimate the benefits of nematode management tactics. Information from "Risk Prediction" required.

An example of the results of a **NEMACAST-POTATOES** Economics of Nematode Management analysis is provided in Table 6. The software indicates that under a specific set of grower-field conditions the potato crop would generate a revenue of $1,238 per acre without use of a nematicide for control of the root-lesion nematode population. Use of a non-fumigant nematicide would increase the projected revenue to $1,439 per acre, and chemigation with metham would further increase the projected revenue to $1,848 per acre.

Nemacast-Potatoes is ready for grower testing. A computer disc containing the program can be obtained by calling (517) 353-8133. A hand calculator version of the program is also available for evaluation by Michigan potato growers. The software is designed to be user friendly, and should require very little instruction prior to use.

Table 3. Nematicide use for three sizes of Michigan potato farms.

Nematicide	Acres Treated[1]		
	< 50 A Farms	50-250 A Farms	>250 A Farms
Chemigants	0 A	54 A	11,554 A
Soil Fumigants	0 A	569 A	5,777 A
Non-Fumigants	225 A	2,846 A	14,522 A

[1]Total treated = 35,547 acres.

Table 4. Total net return increase from nematicide use in Michigan.

Nematicide	Acres Treated[1]		
	< 50 A Farms	50-250 A Farms	>250 A Farms
Chemigants	$0	$14,526	$3,766,604
Soil Fumigants	$0	$128,025	$1,178,508
Non-Fumigants	$47,700	$572,046	$3,035,098
Total	$47,700	$714,597	$7,980,210

[1]Total = $8,742,507 or 13% of a $68,750,000 crop.

Table 5. Potato crop rotation observations related to root-lesion nematodes, potato scab and black scurf.[1]

Management Rank[2]	Potato Production System Rotation Crops[3]						
	Nematode	Potato Scab	Potato Scurf	N/PS	N/BS	PS/BS	N/PS/BS
1	C	SC	AGM	AGM	AGM	AGM	AGM
2	AGM	AGM	BTGM	SC	AH	SC	SC
3	RCH	BTH	AH	BTH	QSC	AH	AH
. . .							
10	AH	BTGM	HV	RCH	RCGM	BTH	BTH
11	BTGM	C	RCGM	BTGM	BTH	RCGM	RCGM
12	HV	RCH	RCH	HV	HV	RCH	RCH

[1]Observations from Mr. Tim Griffin's Ph.D. dissertation under the direction of Dr. Oran Hesterman and Dr. G.W. Bird.

[2]1 = best for potato production, 12 = worst for potato production.

[3]N = nematode, PS = potato scab, BS = black scurf, C = corn, SC = sweet clover, AGM = alfalfa green manure, BTGM = birdsfoot treefoil green manure, AH = alfalfa hay, RCGM = red clover green manure, RCH = red clover hay, BTH = birdsfoot treefoil hay, HV = hairy vetch.

Table 6. Example results of the Economics of Nematode Management section of Nemacast-Potatoes run for the following condition:

Soil Texture	Sandy Loam
Cultivar	Superior
Yield	Low
Root-Lesion Nematode Population	10-24
Verticillium Population	4-9
Expected Yield:	350.00
Selling Price:	6.00

	No Application	Insecticide Application
Revenue	1238.16	1338.66
Cost of Application	0.00	25.00
Yield gain	---	16.75
Net revenue	1238.16	1313.66
Net increase	---	75.50

	Nematicide Application	Soil Fumigant Application
Revenue	1439.40	1649.38
Cost of Application	50.00	150.00
Yield gain	33.54	68.54
Net revenue	1389.40	1499.38
Net Increase	151.24	261.22

	Chemigation Application
Revenue	1848.90
Cost of Application	200.00
Yield gain	101.79
Net revenue	1648.90
Net increase	410.74

Funding MPIC

Control of Insecticide-Resistant Colorado Potato Beetles in Michigan

1989 Research Report

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Summary: Research on Colorado potato beetles (CPB) in 1989 included: Insecticide evaluations; development and distribution of an expanded test kit for monitoring insecticide resistance; research on inheritance and mechanisms of resistance and cross-resistance; and measurement of survival and development of resistant and susceptible CPB larvae on different host plants.

Insecticide evaluation studies indicated that new insect growth regulators, cryolite, Asana, and Asana plus PBO synergist gave good to excelent control. Temik was less effective than in previous years, probably partly due to the very early planting date in relation to plant growth and CPB activity.

The resistance test kit was expanded to include 4 insecticides and 1 insecticide/synergist combination. 296 kits were given to growers, county agents, and consultants and results were reported back from 84 sites. Laboratory and greenhouse studies were conducted to relate test kit results more precisely to insecticide performance under field conditions.

At least six resistance mechanisms have been determined or Michigan CPB; three types of enzymes (two mixed-function oxidases and one esterase), knock-down resistance, penetration resistance, and altered nerve chemistry. Inheritance and cross resistance studies for Furadan and Guthion were completed. However, the Guthion data have not yet been completely analyzed at this time. Studies on Ambush/Pounce resistance and resistance to other pyrethroids are underway.

Survival and development of resistant and susceptible CPB strains indicates that resistant strains are as vigorous or more so than susceptible strains. All larvae did poorly on tomato, but most did well on eggplant and Solanum chacoense (a wild potato species used in potato breeding). Data are being analyzed and will be reported later.

Thanks to the Michigan Potato Industry Committee, Michigan Agricultural Experiment Station, and Michigan Energy Conservation Program for support of this research.

Insecticide Evaluations

Trials were conducted at the MSU Montcalm Potato Research Farm in Entrican, MI. Potatoes were planted on April 28, 1989. Plots were 40 ft long and 3 rows wide (34 in row spacing) and were arranged in a randomized complete block design with 4 replications (=blocks) per treatment. Granular systemic treatments applied at planting were sprinkled in the furrow directly over the seed piece. The Temik sidedressed treatment was applied on May 24, 1989 by placing the insecticide over the row just prior to hilling. Foliar treatments were applied using a tractor-mounted boom sprayer at 30 gpa, 40 psi, with 3 nozzles per row. Foliar sprays were applied at approximately weekly intervals from June 23 to July 28. Insecticide effectiveness was evaluated by counting the number of insects on entire plants randomly selected from the middle row of each plot (2 plants per plot) 1 to 5 days after foliar application. The middle row of each plot was harvested on September 26. Tubers were separated by size and weighed.

Most insecticide treatments (Table 1) effectively controlled Colorado potato beetle adults and larvae (Figure 1). The seasonal totals (sum of the number of beetles per plant on six different sampling dates) for adults and large larvae were significantly higher in untreated plots than in any of the treated plots. In generally, the *Bacillus thuringeinsis* treatments (M-One, Diterra, Trident) gave the poorest control, although the experimental Bt product MYX 1806 resulted in good control. The combination of Temik (at the 1#/A rate) with Asana resulted in season-long control of adults and larvae that was better than Temik alone at the 3#/A rate. Kryocide 96WP (registered in Michigan for the second year under section 18 emergency registration) was found to give excellent control of both adults and larvae

Table 1. Insecticide treatments and rates included in insecticide evaluation studies at MSU Montcalm Potato Research Farm in 1989.

Treatment No.	Treatment	Treatment No.	Treatment
1	Dowco 473 10SC 0.5 oz ai/A	14	EXP 60145A 0.012#ai/A
2	Dowco 473 10SC 1.0 oz ai/A	15	EXP 60145A 0.025#ai/A
3	Dowco 473 10SC(0.5 oz ai/A)	16	EXP 60145A 0.05#ai/A
	& Lorsban 50WP (1# ai/A)		
4	Dowco 473 (10SC)(1.0#ai/A)	17	PP-0321 10WP 0.02#ai/A
	& Lorsban 50WP (1#ai/A)		
5	Lorsban 50WP (1#ai/A)	18	Karate 1EC 0.02# Ai/A
6	Trident 4SC 4 Qt/A	19	AsanaXL 0.66EC (9.6oz/A)
7	Trident II 4SC 2 Qt/A	20	Asana XL 0.66EC (9.6oz/A) &
			Butacide 8E (0.25#ai/A)
8	Kryocide 96WP 12#ai/A	21	Temik 15G (1#ai/A IF@Plant) &
			Asana XL 0.66EC (9.6oz/A)
9	Mycogen M-1 2Qt/A	22	Temik 15G (1#ai/A Side @ Hill)
			& Asana XL 0.66EC (9.6oz/A)
10	MYX 1806 3Qt/A	23	Temik 15G (3#ai/A IF @Plant)
11	Sevin XLR+ 1#ai/A	24	Diterra (1#ai/A)
12	Sevin XLR+ (1#ai/A)		
	& Cygon 4EC (0.25#ai/A)	25	Diterra (2#ai/A)
13	Sevin XLR+ (1#ai/A)	26	Untreated
	& Asana XL 0.66EC (0.025#ai/A)		

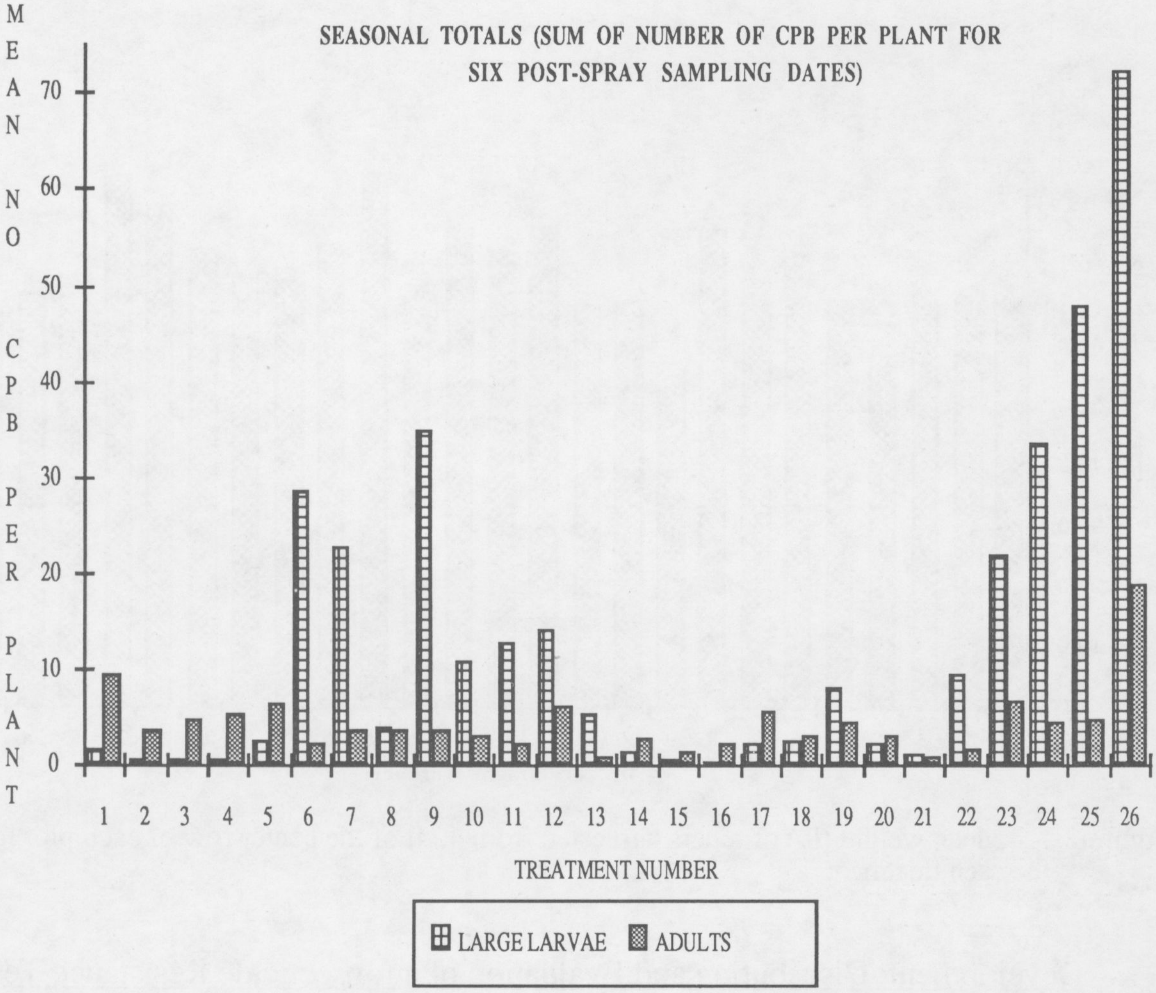

Figure 1. Mean no. Colorado potato beetle adults and large larvae per plant. Seasonal totals for each treatment.

Harvest Weights (total weight of tubers harvested from 40' of the middle row) were significantly lower in untreated plots (36.8 lb) than in any of the treated plots (Figure 2). Harvest weights in treated plots ranged from 57.5 to 89.3 lbs and, in general, did not differ significantly, although the 2 highest harvest weights (treatments 16 and 22) were signigicantly higher than the two lowest weights (treatments 4 and 9).

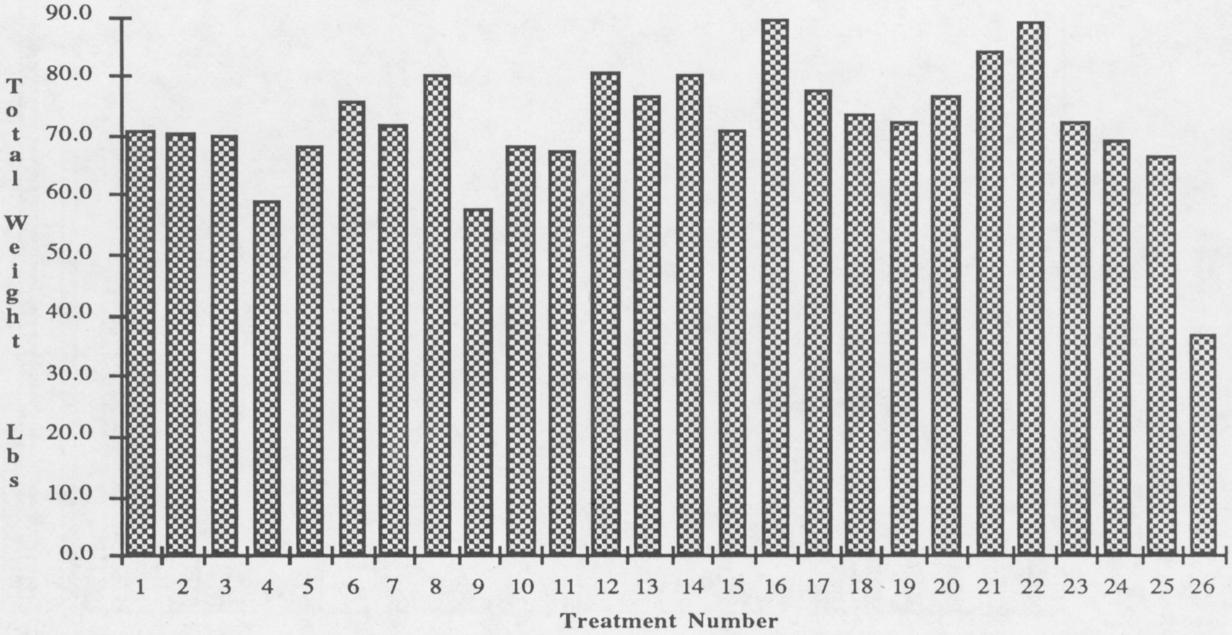

Figure 2. Mean weight (lb) of tubers harvested from 40 ft of the center row of each plot for each treatment

Development, Distribution and Evaluation of an Insecticide Resistance Test Kit

The on-farm petri dish test kit for detecting insecticide resistance in Colorado potato beetles that was first introduced in 1988 was furthur refined. The test for evaluating resistance to Imidan was improved and a test for detecting resistance to Thiodan was added.

Demand for these test kits was very high early in the season. A total of 296 kits was distributed in 1989. Most were distributed to growers, extension agents and pest control consultants in Michigan, although requests from kits were received from and honored from other places, specifically, Ohio and Quebec, Canada.

A total of 84 copies of test results were sent in. In addition, many field-collected populations were tested in our lab. Results are still being analyzed, although preliminary analysis seems to indicate that, compared with 1988 results, the proportion of resistant populations was higher for all insecticides in the test kit.

Demonstrations designed to show the relationship between petri dish resistance test results and field efficacy of an insecticide were conducted during the 1989 growing season. In June, 3 demonstrations were conducted in the Gun Marsh area and in August a demonstration was conducted on the Stan Leep Farm in the Gun Marsh area. Demonstrations consisted of collecting beetles from the field, testing them with the resistance test kit, applying insecticides (those in the test kit) to small plots in the field, doing a pre-application and post-application counts of Colorado potato beetle in the field, and evaluating how well the test kit results predict the effectiveness of the insecticide when applied in the field. Unfortunately, in all cases the beetle populations in the field were very low, and little difference in beetle numbers between small plots in the field could be detected.

Consequently, simulated field applications of 3 insecticides (Furadan 4F, Imidan 50WP, and Thiodan 3EC) were made to 5 beetle populations collected from fields throughout Michigan. Results of the field application (% mortality) were compared to resistance test results (% mortality) and to results of topical application bioassays (LD_{50} and resistance ratios).

Beetles were collected from field populations during late August and early September. Four different beetle strains were tested with each insecticide. Each strain was tested with the resistance test, topicial application bioassay, and field application simulation for that insecticide. Resistance tests were performed by placing 10 to 20 beetles in a resistance test plate and counting mortality 24 hours later. Topical applications were made by applying 2 µl of one of four different concentrations of technical insecticide diluted in acetone to the first abdomenal sternite of a beetle. Mortality at each concentration was evaluated 3 days later. Using probit analysis, LD_{50} values and resistance ratios were calculated.

Field application was simulated by applying commercial grade insecticides at recommended field rate in the greenhouse. Insecticide was applied using a hand-held CO_2 sprayer with a single nozzle at 20 gpa and 40 psi. Both potato foliage (potted potato plants) and beetles contained in screen-covered petri plates were sprayed. Beetles that were sprayed were subsequently fed untreated potato foliage for 3 days. A second group of beetles (unsprayed) were fed sprayed foliage for 3 days. Mortality was evaluated in both groups after 3 days.

Results of the petri dish resistance test for carbofuran (Furadan 4F) showed that 3 of the 4 strains tested were resistant (less than 30% mortality) (Figure 3). The Montcalm strain was found to be a mixed population. The trends revealed by the resistance ratios (= LD_{50} of the strain in question ÷ LD_{50} of a susceptible strain) corresponded well to the resistance test results. Mortality both in beetles that had been sprayed with Furadan 4F and those that had been fed Furadan-treated foliage was significantly correlated with mortality resulting from the petri dish resistance test kit.

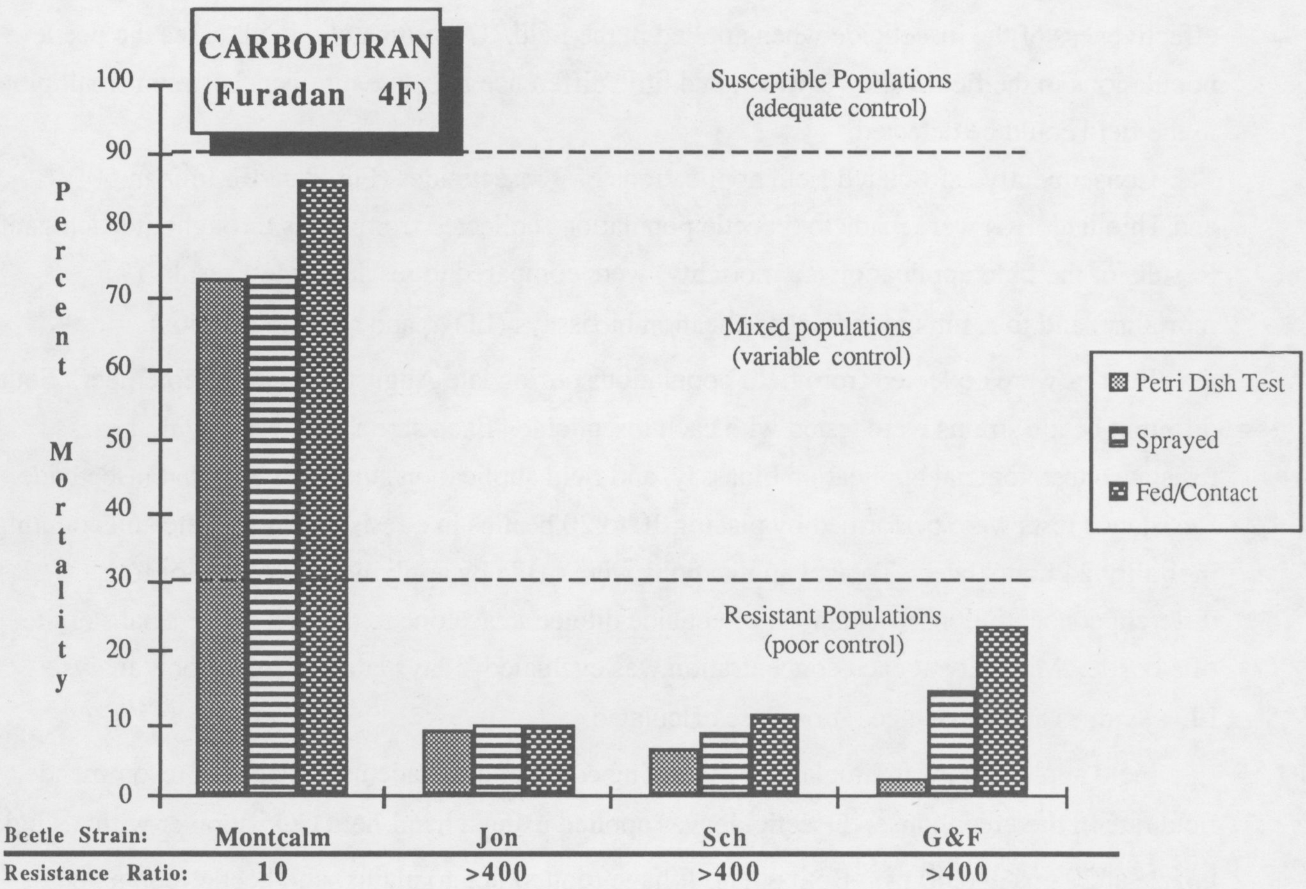

Figure 3. Results of testing 4 strains of Colorado potato beetle with 3 different tests of carbofuran resistance (petri dish resistance test [percent mortality], topical application bioassay [resistance ratio], and a simulated field application of Furadan 4F [percent mortality]). Mortality from simulated field application was evaluated by spraying beetles with Furadan 4F (sprayed group) and by feeding beetles potato foliage that had been sprayed with Furadan 4F (Fed/Contact group).

Results with Imidan (phosmet) were similar, although somewhat more variable (Figure 4). Again, 3 of the 4 beetle strains evaluated with the petri dish resistance test were found to be resistant with the remaining Montcalm strain classed as mixed. Resistance ratios of these four strains confirmed these classifications. Mortality in beetles sprayed with Imidan 50WP was significantly correlated with mortality resulting from the petri dish resistance test. In general, mortality resulting from beetles consuming Imidan-treated foliage was also similar, although in one strain (B.T.) mortality was much greater. This particular strain was 4 generations removed from the field and was undergoing selection for resistance to *Bacillus thuringeinsis*, so it is possible that this may explain the inconsistency.

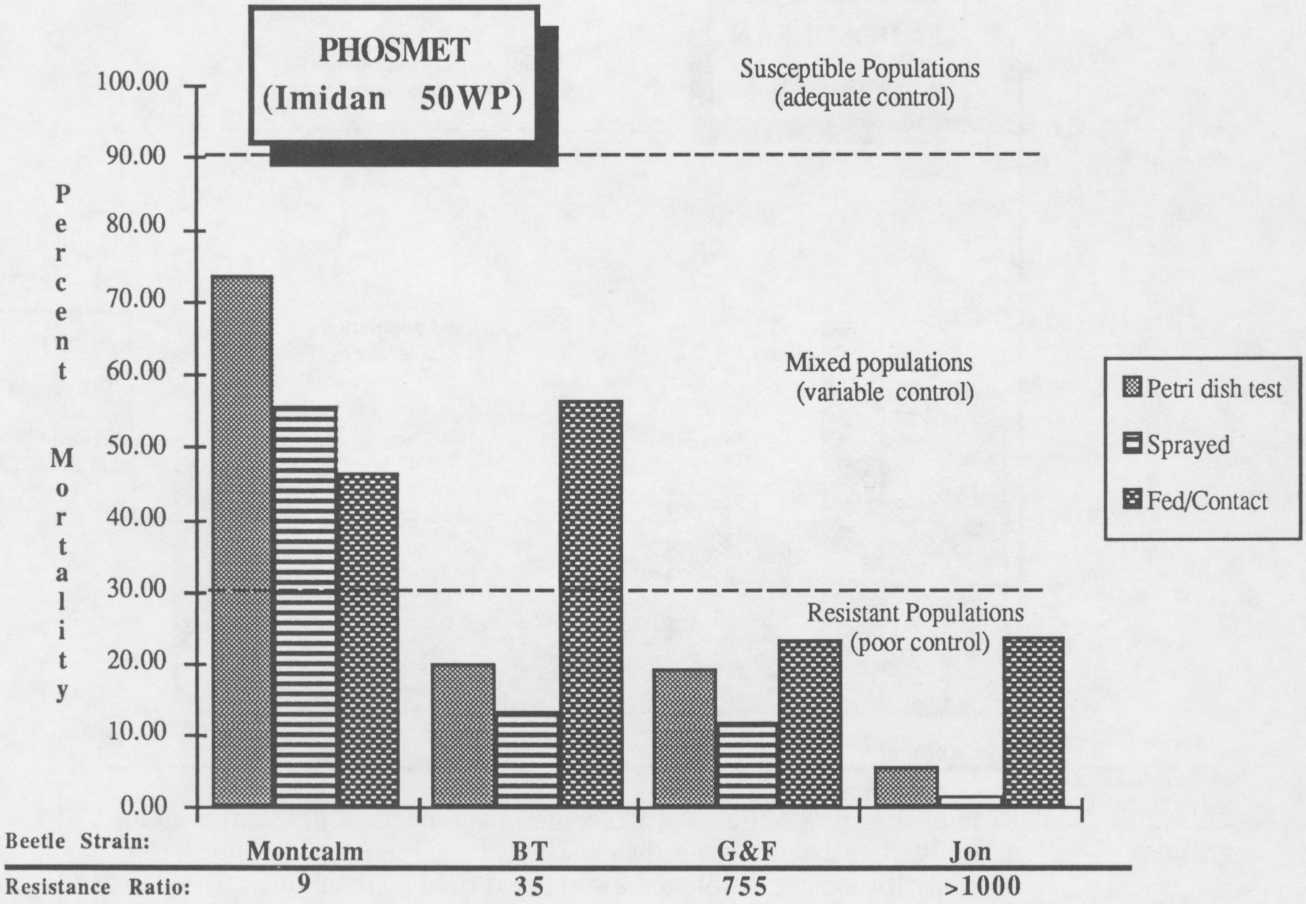

Figure 4. Results of testing 4 strains of Colorado potato beetle with 3 different tests of phosmet resistance (petri dish resistance test [percent mortality], topical application bioassay [resistance ratio], and a simulated field application of Imidan 50WP [percent mortality]). Mortality from simulated field application was evaluated by spraying beetles with Imidan 50WP (sprayed group) and by feeding beetles potato foliage that had been sprayed with Imidan 50WP (Fed/Contact group).

Results with Thiodan (endosulfan) were also similar (Figure 5). Once again, 3 of the 4 strains tested were classified by the petri dish resistance test as resistant. The resistance ratios obtained by topical application bioassay agreed with this classification. Mortality in beetles sprayed with Thiodan 3EC was significantly correlated with petri dish resistance test mortality. Again, mortality in beetles fed Thiodan-treated foliage was somewhat more variable than the other tests, being higher than predicted, in some beetle strains.

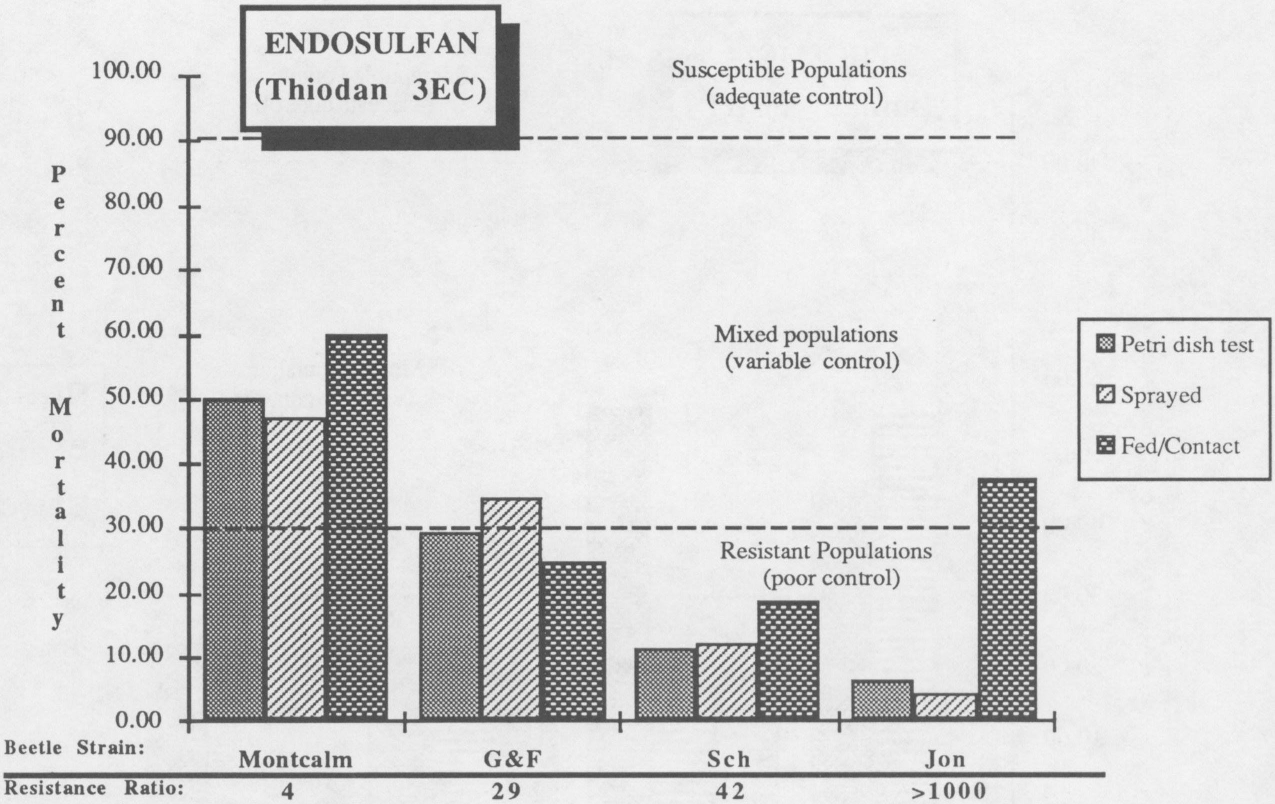

Figure 5. Results of testing 4 strains of Colorado potato beetle with 3 different tests of endosulfan resistance (petri dish resistance test [percent mortality], topical application bioassay [resistance ratio], and a simulated field application of Thiodan 3EC [percent mortality]). Mortality from simulated field application was evaluated by spraying beetles with Thiodan 3EC (sprayed group) and by feeding beetles potato foliage that had been sprayed with Thiodan 3EC (Fed/Contact group).

In general, then, these test results indicate that the petri dish insecticide resistance test for Colorado potato beetle is able to detect the presence of resistance in field populations, and predict when , due to resistance, control achieved by insecticide application will be less than adequate.

Carbofuran Resistance

Carbofuran resistance is rapidly becoming wide-spread in Michigan. A better understanding of the mechanism and inheritance may allow growers to avoid problems with Furadan, if it is still effective. Also, this knowledge may help in managing similar resistance if it occurs to other insecticides. The objectives were to: 1. Select for carbofuran resistance, beginning with large-scale field selection; 2. Characterize resistance in terms of dose-mortality relationships, possible mechanism, and inheritance (number of genes, degree of dominance, sex linkage, etc.); and 3) Compare the selected strain with other resistant populations.

CPB populations. The initial field selection for carbofuran resistance was conducted in 1986 at the Michigan State University Montcalm County Potato Research Farm (Entrican MI). CPB at the research farm were susceptible to carbofuran (LD50 = 0.63 μg/beetle) and organophosphate insecticides (e.g. LD50 for Guthion = 1.43 µg/beetle) and moderately resistant to pyrethroids (e.g. LD50 for permethrin = 6.86 µg/beetle)(unpublished data). Beetles at this site had been exposed to a range of commercial and experimental insecticides in previous years, particularly endosulfan (a chlorinated hydrocarbon), methamidophos (an organophosphate), and the carbamates, carbaryl and aldicarb. To the best of our knowledge, no carbofuran had been sprayed on the research farm prior to the study. Small plot studies of carbofuran as a soil insecticide had been conducted previously, but these never involved more than 0.3% of the potato acreage.

The laboratory culture was started with ca. 300 individuals collected from unsprayed volunteer potatoes next to a commercial farm near Vestaberg MI (Montcalm Co.) in the summer of 1987 and kept in continuous laboratory culture. This was the most susceptible population to carbofuran of 29 field populations tested (unpublished data). The LD50 for Vestaberg to carbofuran was 0.18 µg/beetle and 1.24 µg/beetle to Guthion, with a homozygous response to both compounds. These values are in a agreement with those for susceptible strains reported by Forgash (1985) and Johnson and Sandevol (1986). The Vestaberg strain has been regularly tested to ensure continued susceptibility to carbofuran and shows no loss of vigor due to inbreeding.

Laboratory techniques. Technical grade carbofuran (98% purity, courtesy of FMC Corporation) in acetone was used for all laboratory selections and assays. Adults were immobilized using a 3.3 mm diam. vacuum hose and 2 µl of solution was placed on the underside of the abdomen of each adult. Mortality was assessed 72 h post-treatment. Fresh potato leaves from greenhouse plants were provided to the beetles daily during the testing. For LD50 determinations, at least 4 doses of carbofuran with 16 beetles per dose 2 replications of 8 each), plus an untreated group (acetone only), were used. Results were corrected for mortality in the controls (acetone alone - usually less than 10% mortality) using Abbott's (1925) formula and standard log-probit analyses were performed. All laboratory rearing and experiments were conducted at 25°C±2°C, 16 h light : 8 h dark photophase. Adults were tested ca. 1 week after emergence from pupation.

Field selection. Selection for carbofuran resistance was initiated in the field on 25 July 1987. Carbofuran was applied to a 16 row x 168 m plot of potatoes at 0.55 kg active ingredient per hectare using a commercial ground insecticide sprayer. CPB was in the first generation larval stage at the time of treatment and the pre-treatment density was estimated as 37 ± 10 (mean ± SE) larvae per plant based on data from adjacent untreated plots (unpublished data). The total number of CPB larvae treated in the field was approximately 488,400 (37 x 13,200 plants estimated in the plot). 24 h post-treatment, the plot was searched visually for surviving larvae. All surviving larvae were collected and returned to the laboratory.

Laboratory selection. A sample of the field-collected larvae was tested for carbofuran resistance using a dose of 5 µg/beetle. (All survived.) The rest of the larvae were fed untreated potato foliage and reared to adults in the laboratory. These adults were tested for LD50 for Furadan as described above. The adults that survived the two highest doses (5 and 2.5 µg/beetle) were kept in culture. Progeny were reared to the adult stage and a sample was again tested for LD50 to Furadan. The untested adults were selected with Furadan to cause ca. 80% mortality. This process was repeated on the next 2 generations. These beetles were designated as the "Montcalm-C" strain and maintained in culture and subjected to a dose of 100 μg Furadan/beetle every generation to assure maintenance of resistance.

Resistance mechanism studies. The synergists piperonyl butoxide (PBO) and s,s,s,tributylphosphorothionate (DEF) were used as indicators of possible resistance mechanisms. PBO is a specific inhibitor of mixed-function oxidase enzymes (MFO's). DEF inhibits esterases and MFO's. Synergists were applied at 100 μg/beetle for the Montcalm-C strain and 50 μg for the susceptible strain, 2 h prior to insecticide treatment of the beetles. The 100 μg dose caused no mortality to the Montcalm-C beetles but more than 20% mortality to Vestaberg beetles (hence the use of 50μg).

Resistance ratios with and without synergist were calculated from LD50 values for resistant and susceptible strains. Susceptibility of the Montcalm-C strain to Guthion was also estimated using the standard LD50 method and results were compared to LD50 values for the unselected (field-collected) Montcalm farm population.

Inheritance studies. Adults from the Montcalm-C and the Vestaberg strains were sexed within 48 h after emerging from pupation. Male/female reciprocal crosses were conducted. Pairs were kept together until they began mating (to insure that no male/female errors had been made) and then grouped with other pairs of the same cross in cages and fed potato foliage. Adult offspring (F1 adults) from the crosses were tested with a discriminating dose (3.12 μg/beetle) for Furadan resistance, and the numbers dead and alive were recorded after 72 h, as described above. A subsample of the F_1 adults were treated with the descriminating dose. The survivors (resistant heterozygotes) were back-crossed to the Vestaberg strain and adult progeny tested with the descriminating dose, as before. This process was continued for 3 generations.

F2 adults (progeny of F1 x F1 crosses) were also tested for susceptibility to Furadan.

Results

Initial field selection resulted in survival of ca. 80 larvae (>99.98% mortality). Survivors occurred in groups of 5 to 10 larvae on a plant, rather than individual larvae as might have been expected due to random effects of factors such as spray coverage. Analysis of adults developing from the surviving larvae indicated that they were approximately 52 times more resistant to Furadan than the initial population. Subsequent laboratory selection increased the resistance ratio to 175 fold, within 4 generations. Reports from commercial potato fields and on-farm resistance monitoring also support the rapid change from Furadan susceptible to highly resistant, often within one growing season.

Inheritance studies indicated that F1 offspring of resistant x susceptible crosses were uniformly resistant. Resistance levels were nearly as high as parental levels and showed no significant difference between sexes, suggesting near complete dominance and autosomal inheritance (Fig. 6). F1 backcrosses to susceptible beetles and F1 x F1 crosses showed nearly perfect Mendelian segregation, indicating a single gene or closely linked genes (Table 2).

Cross-resistance and synergist experiments showed a moderate cross-resistance to Guthion and almost no synergism for Furadan or Guthion with either PBO or DEF. Lack of synergism and the absence of low and intermediate levels of resistance in the Montcalm-C strain or other populations from commercial fields suggests target site insensitivity. Preliminary data from in vitro studies on the Montcalm-C strain and on another Michigan carbofuran-resistant population shows altered acetyl cholinesterase activity (Weirenga & Hollingworth, unpublished data). This mechanism is also suggested by cross-resistance to Guthion. The extremely rapid mortality of susceptible beetles in response to Furadan treatment (100% mortality in < 2 h) also suggests that detoxification enzymes would be of limited usefulness unless they were present at very high levels.

In contrast to the Michigan populations studied, a population from Long Island NY, selected for Guthion resistance in our laboratory, shows significant synergism of Furadan by PBO and a lower level of resistance, probably indicating detoxification as the primary mechanism of resistance. In vitro studies with this train did not show any altered acetyl cholinesterase activity.

Historically, Furadan was only used very late in the resistance history on Long Island, after failure of numerous organophosphates and carbamates. In Michigan, and specifically at the Montcalm site, Furadan resistance was selected much earlier in the resistance history. We hypothesize that this difference in resistance history explains the different mechanisms that involved. At the time of selection, detoxification enzymes in the Montcalm population were probably not near the very high levels required to detoxify the rapidly-acting Furadan, thus leading to selection for target-site insensitivity.

Management of Furadan resistance in CPB appears to be a difficult proposition. The single gene dominant nature of the inheritance and high selection pressure exerted by Furadan treatment result in exceptionally rapid resistance occurrence. Resistant populations are, for all practical purposes, immune to Furadan treatment. The resistance factor appears to be present at very low frequencies in many or prehaps all Michigan populations, judging from the wide-spread and rapid build-up of resistance in the field. Limited use of Furadan (< once per CPB generation) and alternation of Furadan treatment with non-cross resistant materials (e.g. permethrin, where effective, or aldicarb), along with non-chemical management tactics, may increase the effective life of Furadan in the field.

Table 2. CPB mortality from Furadan: Ratio expected if resistance is inherited by a single gene and observed mortality.

Cross (# tested)	Expected Ratio RR : RS : SS	Observed Mortality (SS individuals)
F1	0 : 1 : 0	0
F1 x F1 (150)	1 : 2 : 1	26.0%
B1 (191)	0 : 1 : 1	49.7%
B2 (323)	0 : 1 : 1	56.0%
B3 (36)	0 : 1 : 1	52.8%

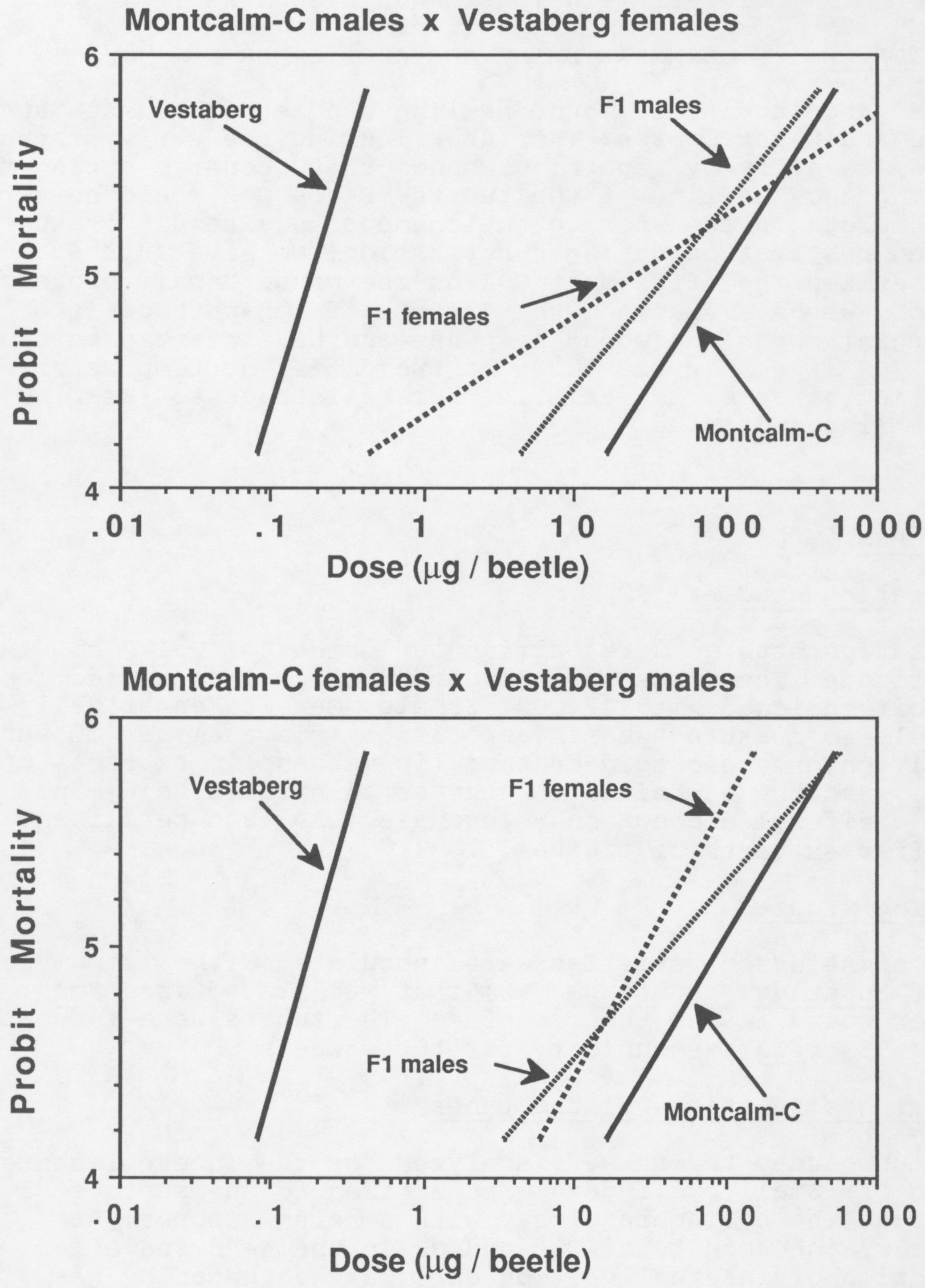

Figure 6. Mortality (probit 5 = 50%, probit 4 = versus dose for Furadan-susceptible (Vestaberg) and resistant (Montcalm-C) strains and offspring of reciprocal male x female crosses.

Funding Federal Grant

INFLUENCE OF ENVIRONMENTAL FACTORS ON WOUND HEALING IN RELATION TO STORAGE DISORDERS

INVESTIGATORS: R. HAMMERSCHMIDT AND A.C. CAMERON

Improper and incomplete wound healing can lead to losses due to disease and water losses. The tuber, during the early stages of storage, is actively repairing wounds that occurred during the harveting and handling of the tubers. Since CO2 would be expected to accumulate in the storage environment as a result of the enhanced respiration during suberization, we have further characterized the effects of CO2 on the wound repair process. In addition, we have examined the effects of non-pathogenic microorganisms on the wound response and have started to study the CO2/O2 levels in the tuber at two different temperatures. Evaluation of selected varieties for resistance to Fusarium dry rot was also initiated.

PROCEDURES

Suberization studies

Suberization studies were carried out using 2.1 X 1.0 cm disks of tuber tissue. The discs were incubated at 20 C in humidified air or in air enriched with 4% CO2. Samples were taken at daily intervals to measure suberin deposition (via analysis of suberin lignin), chlorogenic acid content (in methanolic extracts of tissue), and the suberization enzymes phenylalanine ammonia lyase (PAL), coniferyl alcohol dehydrogenase (CAD) and peroxidase (PO) (in buffer extracts of tissue).

Infection studies

Tubers of selected varieties were inoculated with a 2mm mycelial plug of *Fusarium sambucinum* (FS) that was placed in a 3mm diameter wound in the tuber surface. The tubers were incubated at 18C and 95% relative hunidity for three weeks.

Internal gas relations of the tuber

Whole, unwounded tubers were analyzed for the internal content of CO2 and O2. Small cyclinders were affixed to the surface of tubers and the cylinders closed with a serum stopper. At intervals, the amounts of CO2 and O2 in the head space (a refelection of internal gas content) was evaluated by gas chromatography.

RESULTS AND DISCUSSION

Influence of elevated CO2 on biochemical factors involved in suberization

Introduction of 4% CO2 into the incubation chambers decreased the time of induction and and total amounts of lignin (Fig. 1), chlorogenic acid (Fig. 2), and peroxidase (Fig. 3). PAL was also supressed (data not shown). Most striking were the consistent difference observed between Atlantic and Russet Burbank in relation to timing of induction of all parameters in air and the magnification of these differences in CO2. Isozyme analysis of the tissue demonstrated that the suberization specific peroxidase was induced at only a very low level in the tissue exposed to CO2. These results further demonstrate the wound repair suppressive effects of CO2 as well as the great differences that can be observed between cultivars. Wound induced peroxidase analysis of several cultivars further demonstrate the differences in wound healing induction rates that are found among varieties.

Infection studies

Inoculation of selected varieties with FS demonstrated no clear resistance among the varieties tested (Table 1).

Tuber gas analysis

We have carried out preliminary work to determine if we can monitor the internal gas composition of tubers without wounding. Oxygen and carbon dioxide were measured in Russet Burbank tubers over a 39 day period. The tubers were incubated at 20C for 22 days and then placed in 5C storage on day 23. Internal CO2 levels gradually declined over the first 22 days, possibly as a result of slowing respiration. Oxygen levels remained constant. When the tubers were placed at 5C, there was an immediate drop in CO2, and the level of CO2 remained low. We interpret this as a temperature-related drop in respiration. The transient increase in O2 at the same time was probably a direct reflection of the change in respiratory rate Figure 4). We plan to use this technique to further evaluate the effects of infection and tuber storage environments on the internal gas relations of the tuber. With infected tissues, we may also be able to determine specific metabolic profiles of the tuber under stress by observing changes in volatiles released during infection and disease development.

TABLE 1

FUSARIUM DRY ROT DEVELOPMENT IN TUBER TISSUE

VARIETY	LESION DIMENSIONS*
Atlantic	10.9 X 6.0
Superior	13.0 X 5.4
Saginaw Gold	16.0 X 9.1
Onaway	15.8 X 5.8
Lemhi	12.6 X 6.2
ND 860-2	12.9 X 5.6
700-83	13.9 X 6.5

* Diameter X depth, 10 tubers per variety

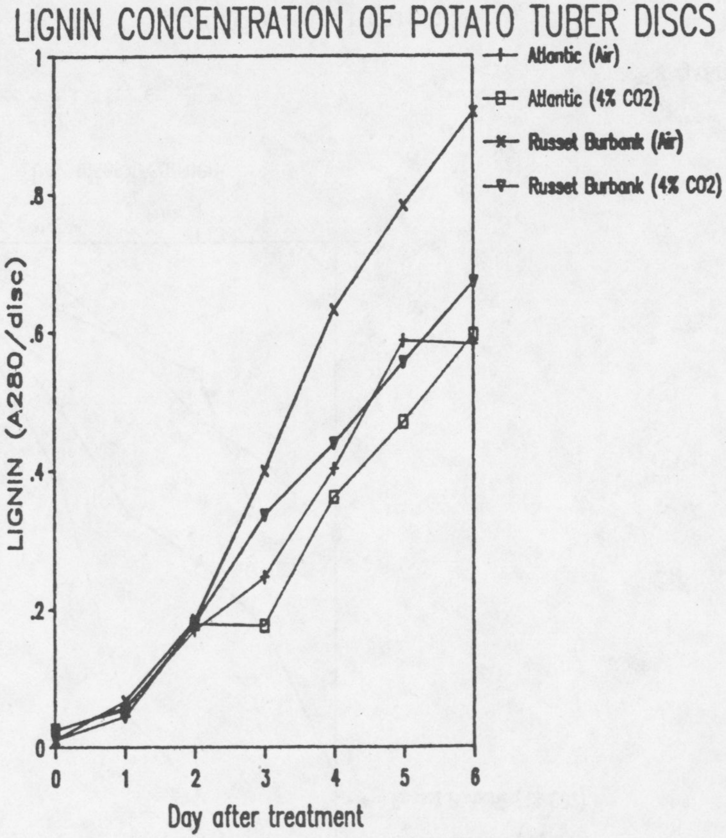

Figure 1.

Effect of CO_2 on lignin portion of suberin

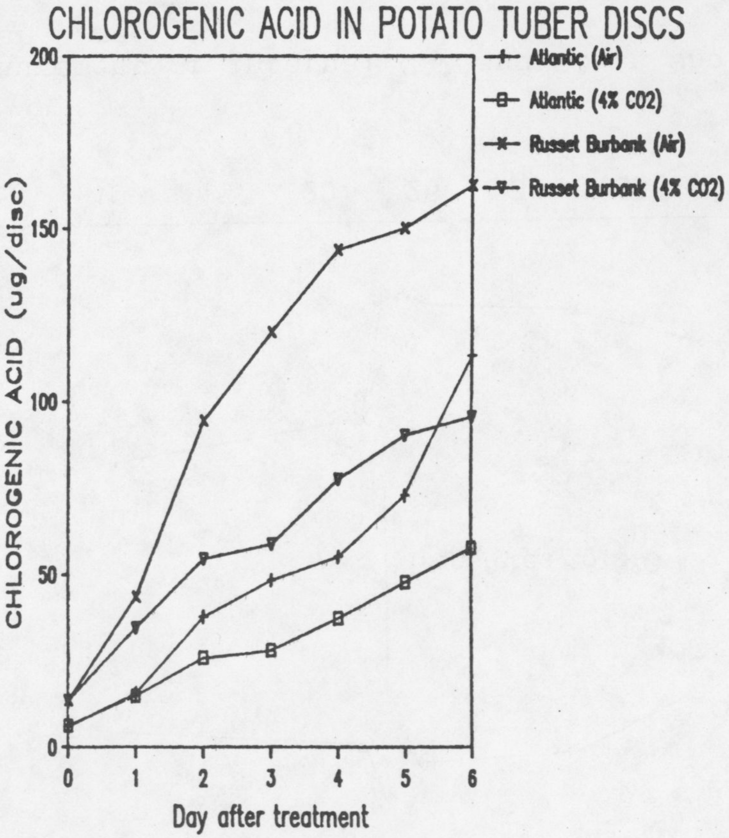

Figure 2.

Effect of CO_2 on chlorogenic acid accumulation

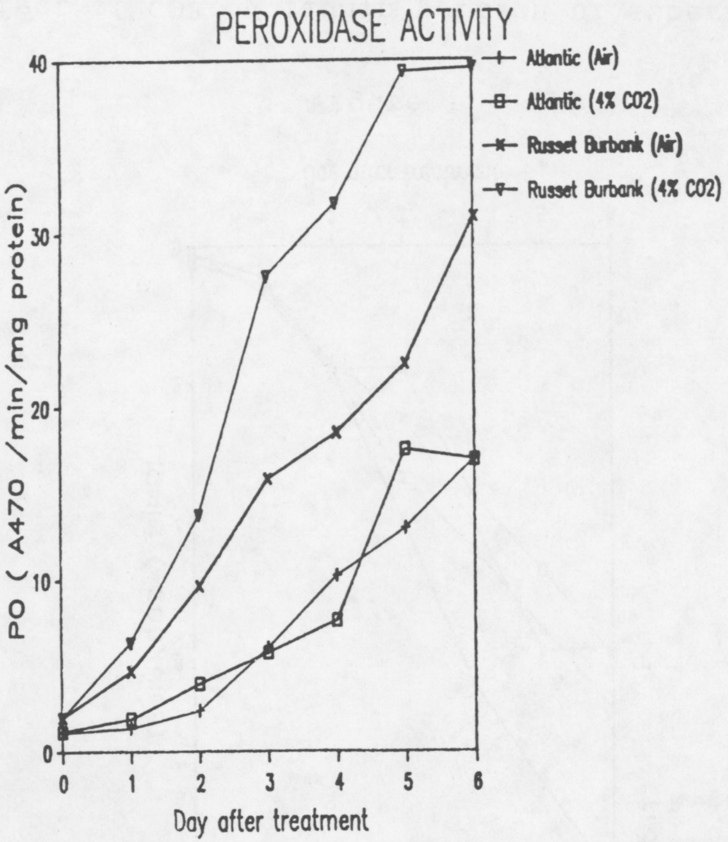

Figure 3.

Effect of CO2 on peroxidase induction

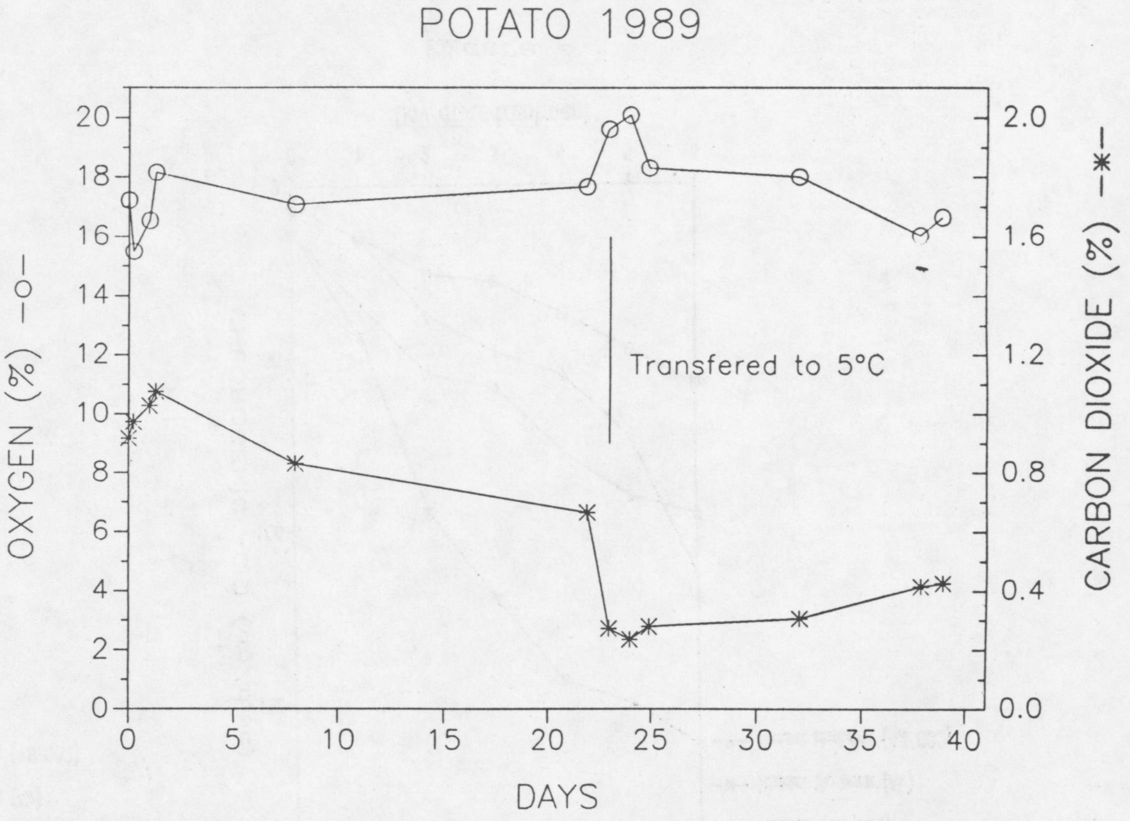

Figure 4. Meaurement of internal CO2 and O2 in whole tubers over time

Funding MPIC

Determination of Bisulfite Residues in Potato Products

Jerry N. Cash

Food Science and Human Nutrition

INTRODUCTION

In fresh, peeled potato products enzymatic browning occurs very rapidly after peeling so the use of an anti-browning agent is essential for obtaining any reasonable degree of shelf life. For many years bisulfites (SO_2) have been used to prevent discoloration and inhibit microbial growth in many plant tissues, including fresh, peeled potatoes. However, bisulfites have recently been implicated as the causative agent for adverse health reactions in certain sulfite-sensitive individuals and FDA has proposed banning sulfite usage in several products, including fresh, peeled potatoes. The potato industry has been requested to supply information regarding the minimum levels of sulfites required to achieve intended effects and the reductions in bisulfite levels during storage and preparation of potato products for consumption. The objective of this study was to assess the residue levels of bisulfites in potato products made from fresh, peeled potatoes.

MATERIALS AND METHODS

Medium size (7 to 9 oz) Russet Burbank potatoes, specific gravity 1.082 and approximately 20% dry matter were used throughout the study. After peeling, potatoes were sulfite treated as: 1) raw, whole tubers; 2) 3/8" french fry slices; or 3) 1/2" diced cuts. Whole potatoes went directly into the treatment tank after peeling. The whole potatoes to be cut into french fry slices and dice cuts were held briefly in a 1% salt (NACl) solution to retard browning before cutting. Based on previous work in our lab and information obtained from Michigan processors it was felt that a residual SO_2 level of approximately 40-75 ppm immediately after dipping is required for 10-12 days shelf life on whole tubers and french fries, while approximately 150-200 ppm is required for the same shelf life on diced cuts because of the larger surface area of this product. Using data developed by Rodriguez and Zaritsky (1986) a 0.5% bisulfite solution was used with dip times of 60 seconds for the medium sized, whole tubers and 30 seconds for french fry and diced cuts. After bisulfite treatment, samples were packaged in plastic bags, refrigerated at 36^{o}F and held for 0, 4, 8 and 12 days before cooking. At each sample time potatoes were removed from refrigeration and boiled in water for 25 minutes (whole and diced) or fried in vegetable oil at 370^{o}F for 2-3 minutes until golden brown (french fries). Residual sulfite concentration was determined on triplicate raw and cooked samples by the AOAC Modified Monier-Williams method.

RESULTS

The changes in bisulfite concentration for all products throughout the study are shown in Table 1. A 12 day shelf life, based on product color, was obtained with all the samples in the study indicating that the sulfite concentrations and dip times chosen were adequate. Microbiological tests were not included in the study but the appearance, texture and overall quality of samples at the end of the storage time seemed to indicate that minimal microbiological deterioration had occurred. It is not known if smaller sulfite residue concentrations can achieve the same results.

As expected, bisulfite levels did decrease greatly during storage and cooking because of the volatile nature of the compound. The rate of decline in the raw products over the 12 day storage period ranged from a 75% loss of SO_2 in the french fries to 80% in the whole tubers and 86% in the diced samples. Cooking further reduced bisulfites in all products. In this study, boiling seemed to be slightly more effective than frying in terms of SO_2 reduction but frying did lower SO_2 levels dramatically. This study indicates that bisulfite residues in fresh, peeled potato products are reduced significantly during storage and preparation for consumption. The data from this work are in close agreement with the work of Finne (1987).

REFERENCE

1. Rodriguez, N. and N.E. Zaritsky. 1986. Modeling of sulfur dioxide uptake in pre-peeled potatoes of different geometrical shapes. J. Food Sci. 51:618.

2. Finne, G. 1987. Effect of treatment conditions on the residual sulfite concentrations and shelf life of fresh raw peeled potatoes.

Table 1. Bisulfite Residues in Raw and Cooked Potato Products Dipped in a 0.5% Bisulfite Solution.

Days of Storage @ 36°F	Product	SO_2 Dip Time (sec)	Residual SO_2 (ppm)[1]	
			Raw	Cooked[3]
0	Whole[2]	60	48	17
	Diced	30	172	50
	French Fries	30	69	25
4	Whole[2]	60	20	12
	Diced	30	135	30
	French Fries	30	43	19
8	Whole[2]	60	15	8[4]
	Diced	30	37	11
	French Fries	30	31	10
12	Whole[2]	60	10	5-7
	Diced	30	24	11
	French Fries	30	17	9

[1] Average of 3 samples
[2] Whole = Medium sized 7-9 oz. tubers.
[3] Cooked = Whole and diced boiled 25 minutes; french fries fried in vegetable oil @ 370°F for 2-3 minutes.
[4] SO_2 analytical method loses sensitivity below 10 ppm.

Funding Federal Grant

PACKAGING ALTERNATIVES FOR LIGHT USERS OF TABLESTOCK (FRESH) POTATOES...A Synthesis of Two Focus Groups

Mary D. Zehner[1]

Focus group interviews were conducted with consumers of fresh potatoes in December, 1989 in Kalamazoo, Michigan. While the overall goal of the study was to suggest how the Michigan potato industry might recover its share of the fresh potato market (especially for round, white potatoes), specific objectives included:

* To learn potato packaging preferences for light users of fresh potatoes (paper, plastic, mesh, from bulk display and unit of purchase).

* To learn present use patterns and selection criteria for light users (potato size, quality, varieties, etc).

* To examine levels of satisfaction/dissatisfaction with fresh potatoes in order to suggest ways in which producers can adjust to better meet the needs of the consumer.

Methodology

Two focus group interviews were held with light users of fresh potatoes. A light user was defined as someone who purchased one to ten pounds of fresh potatoes in an average month. Participants were recruited by random telephoning. Selected participants were adults most responsible for food purchase and preparation for their household. The groups were recruited to include a representation of age, employment patterns, household income and race. The sessions were conducted by Harrington Market Research of Kalamazoo, Michigan and were audiotaped. The sessions began at 5:45 p.m. and 8:00 p.m. and lasted one and one-half hours.

Focus group interviewing consists of bringing together a small group of people, normally 8 to 10 at a time. Then let them talk about a topic, idea, product or concept. The unique advantage of focus group interviewing is the dialogue between participants. Members listen and react to each other. The focus group technique is qualitative, not quantitative in nature. Therefore findings cannot be statistically projected to the general population. This methodology provides the opportunity to gain insights into consumers' decision-making process relative to fresh potatoes. It also offers direction for the follow-up mall intercept interviews with light potato users (a quantitative study) planned for March 1990.

Summary

The project was to determine the potato and potato packaging preferences of light users of potatoes. The focus was on the all-purpose Superior variety which accounts for the majority of round, white potatoes sold during the winter months from Michigan potato storages. The report summarizes the focus group interviews (part one of the two-part project).

The participants were aware of a number of types of fresh potatoes; however, there was some confusion as to variety(ies) and sources of the potatoes (Idaho and Michigan). They were able

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to describe 25 ways of preparing potatoes. Nearly everyone microwaved potatoes because of convenience and speed, but conventionally baked potatoes were preferred by the vast majority.

Factors in the selection of fresh potatoes included price, size of potatoes, quantity per package, physical characteristics (firmness, number of eyes, taste, greening), brand or variety, and packaging. The decision to purchase potatoes was based on the interaction of these factors with the intended use of the potatoes--how and for whom they were to be prepared. Potatoes considered "best" for inclusion in a pot roast for the family might be quite different from those to be baked for a special dinner party.

Everyone wanted inexpensive and uniformly high-quality potatoes. They also wanted the option of buying prepackaged potatoes or selecting individual potatoes from a bulk display. Because there consumers wanted prepackaged potatoes to be visible and well-ventilated, net bags were favored over plastic or paper.

Sizing was also important to the participants. Uses for every size were described, but in addition to mixed size potatoes in a bag (but not very small potatoes in the same bag with large potatoes), these consumers wanted to be able to buy uniformly sized potatoes.

A display box for bulk potatoes (50 lbs) designed to reduce greening from ultraviolet light was not enthusiastically received because the participants imagined having to dig through the box to select potatoes. No one in either group had identified the cause of greening as exposure to florescent light--if they had, the box might have been considered more useful.

The people in the discussions were generally satisfied with the fresh potatoes they purchase. They view potatoes as a versatile, nutritious, economical, low-calorie and good tasting staple. The negative comments concerned packaging (paper and plastic bags) and the lack of quality (dirty, green, soft, nonuniformly sized and spoiled potatoes).

Comparison of the "Idaho" potato to the "Michigan" potato revealed a sharp distinction in images. The Idahos were considered formal, elegant potatoes, suitable for guests, but lacked versatility. They were described as uniform and having a consistent quality that could always be counted on. In contrast, the Michigan were thought to be more like old friends that one is comfortable with on a day-to-day basis. They were thought to lack the consistent quality of Idaho; virtually all the complaints mentioned previously were directed at Michigan-grown potatoes. The participants also seemed to feel that Michigan growers lacked pride in their product.

It must be emphasized that Michigan-grown potatoes were well-liked in terms of taste, texture and versatility. The majority of these participants would support the Michigan potato if quality control were improved. A number of ideas for promoting Michigan-grown potatoes emerged from the discussions including:

- informational displays in the vegetable section of the supermarket
- educational programs in schools
- endorsement by restaurants
- multi-media advertising
- a guarantee of quality
- emphasis on potatoes as a basic, "comfort" food

The clearest message seemed to be that although a promotional campaign might be successful in getting the good word out about Michigan-grown potatoes, the money and the effort would be wasted unless, as several participants reported, the "Michigan potato industry first cleans up its act" by improving quality through better grading and sizing systems. It was felt that although advertising might encourage buyers to try Michigan potatoes once or twice; only a good product will retain those buyers.

Direction For Mall Intercept Study

The focus group findings suggest that there are market opportunities for Michigan potato products which better meet the needs and preferences of light users of fresh potatoes (i.e., ability to see the potatoes in the bags, smaller units of purchase, the option of selecting the number of potatoes needed and/or prebagged potatoes, improved quality, and more closely sized than U.S. No 1 potatoes).

In response, the upcoming mall intercept interviews will address three areas: (1) Identifying the preferences (from a choice of six different displays) for buying fresh potatoes...and the reasons for the decision. Four of the six displays will represent packaging options not currently available in Michigan supermarkets. They include: bulk Superior potatoes 8 to 10 ounces, 3-pound bag sized Superior potatoes, 3-pound bag of Russet Norkotahs (strippers) and Russet Norkotahs in a tray with an overwrap.

(2) If growers move in the direction of more closely sized potatoes, what specific size(s) of the variety(ies) of potatoes would best meet needs of light potato users? Three sizes of three different varieties will be displayed (Russet Burbank, Russet Norkotah and Superior potatoes). Participants will be asked to select their top choices and then indicate how they would likely prepare them. Price would not be a consideration in the decision.

(3) Determine if greening of potatoes is an issue with consumers and how well participants understand what causes this greening to occur. Long a problem for growers and the main reason for packaging round, white potatoes in paper bags, the time has arrived to address the problem, if indeed, consumers are confused about and/or misinformed regarding greening of potatoes.

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