1991
MICHIGAN POTATO RESEARCH REPORT

VOLUME 23

Michigan State University
Agricultural Experiment Station

In Cooperation With

The Michigan Potato Industry Commission

THE MICHIGAN POTATO INDUSTRY COMMISSION

February 20, 1992

To All Michigan Potato Growers & Shippers:

The Michigan Potato Industry Commission, Michigan State University's Agricultural Experiment Station and Cooperative Extension Service are pleased to provide you with a copy of the results from the 1991 potato research projects.

This years report is dedicated to the memory of Ronald Allen Andersen, and funded through a donation from the Andersen families. Ron's presence in the potato industry is greatly missed. His interest in the financial responsibility of the potato industry was demonstrated repeatedly in all the projects he became involved in throughout his career.

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

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

Best Wishes for a prosperous '92 season,

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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1991 MSU POTATO RESEARCH REPORT

R.W. Chase, Coordinator

Introduction and Acknowledgements

The 1991 Potato Research Report contains reports of potato research projects conducted by MSU potato researchers at several different locations. The 1991 report is the 23rd report which has been prepared annually since 1969. This volume includes research projects funded by the Special Federal Grant 88-34141-3372, the Michigan Potato Industry Commission and numerous other sources. The principal source of funding for each project has been noted at the beginning of each report.

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

Many other contributions to MSU potato research have been made in the form of fertilizers, pesticides, seed, supplies and monetary grants. We also acknowledge the tremendous cooperation of individual producers who cooperate with the numerous on-farm projects. It is this dedicated support and cooperation that makes for a productive research program for the betterment of the Michigan potato industry.

We further acknowledge the professionalism of the MPIC Research Committee. The Michigan potato industry should be proud of the dedication of this Committee and the keen interest they take in determining the needs and direction of Michigan's potato research.

A special acknowledgement goes to Richard Kitchen who retired from MSU in September of 1991 after completing a career of 39 years. Dick has been a cornerstone of the MSU potato breeding project, the development of the Montcalm Research Farm and the total MSU potato research program. His expertise, experience, assistance and advice has helped many, many faculty, students, colleagues and farmers over the years.

Thanks go to Dick Crawford, for the day-to-day operations at the Research Farm and Dr. Kazimierz Jastrzebski, visiting scientist from Poland. Also, a special thanks to Jodie Schonfelder for the typing and preparation of this report.

Weather

The 1991 growing season can be best characterized as being very "quick". Heat units accumulated much more rapidly than in average years with the season being 2-3 weeks ahead of normal. Monthly average maximum and minimum temperatures were warmer than the 15 year average. There were only two days that the temperature exceeded 90° and night temperatures were generally cool and favorable for good growth and solids.

The rapid growing season was also favorable for hollow heart development and was noted in several varieties. Rainfall was below the 15 year average for August and September which contributed to blackspot injury because of dry soil conditions at harvest.

Soil Tests

Soil tests for the general plot area were:

pH	P_2O_5	K_2O	Ca	Mg	Cation Exchange Capacity
6.1	449	219	800	152	5.3 me/100 g

Previous Crops and Fertilizers

The general plot area was planted to drilled soybeans in 1990 which were disked in the fall and seeded to winter rye at 1½ bushels/A. In November of 1990, Vapam at 50 gpa was knifed into the plot area. Except in the fertilizer trials, where the amounts of fertilizers used are specified in the individual project reports, the following fertilizers were used in the potato trials:

plowdown	0-0-50	300 lbs/A
banded at planting	20-10-10	200 lbs/A
broadcast at emergence	34-0-0	200 lbs/A
sidedress at hilling	46-0-0	100 lbs/A
through irrigation	28-0-0	120 lbs/A
second application on russets	28-0-0	120 lbs/A

Herbicides and Hilling

A tank mix of metolachlor (Dual) at 2 lbs/A plus metrabuzin (Lexone) at ½ lb/A was applied preemergence. Hilling was completed when plants were 10-12" tall.

Irrigation

Irrigation was initiated on June 20 and eight applications were made during the growing season with the last application on September 6, 1991. Approximately 6" of irrigation water were applied. The MSU Irrigation Scheduling program was monitored by Don Smucker, Montcalm County Extension Director and these data were used to determine the timing for irrigation applications.

Insect and Disease Control

Thimet was applied at planting at 11.3 ounces/1,000 ft. of row. Foliar insecticide applications were initiated on May 29 for control of Colorado potato beetles which was the major insect problem throughout the season. Insecticides used were Imidan + PBO, Furadan, Cygon, Rotacide, Monitor and Kryocide. Fungicides used were Mancozeb and Pencozeb. The foliage fungicide application was initiated on July 2 which was determined by the MSU Potato Blight Forecaster Program.

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
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
1990	NA	NA	64	43	77	55	79	58	78	57	72	47	NA	NA
1991	60	40	71	47	82	59	81	60	80	57	69	47	74	52
15-YR. AVG.	55	34	69	43	76	52	82	57	79	55	71	48	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
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
1990	1.87	4.65	3.53	3.76	4.06	3.64	21.51
1991	4.76	3.68	4.03	5.73	1.75	1.50	21.45
15-YR. AVG.	2.70	2.76	3.03	2.70	3.76	4.76	19.71

Funding <u>Federal Grant/MPIC/SFA/NPC</u>

MICHIGAN STATE UNIVERSITY POTATO BREEDING PROGRAM

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Cooperators: K. Jastrzebski, R. Freyre, R.W. Chase, R. Hammerschmidt, D. Maas, J. Cash and G. Bird

To have a successful on-going potato breeding program the efforts must be divided into three integrated directions: 1) breeding and varietal development, 2) germplasm enhancement, and 3) genetics studies to understand the inheritance of key traits. The breeding goals at MSU are based upon current and future needs of the Michigan potato industry. Traits of importance include yield potential, disease resistance (scab and early die), chipping and cooking quality, storability, along with shape, internal quality and appearance.

I. Varietal Development

During the 1991 winter approximately 50 potato varieties and advanced breeding lines were chosen as parents for the greenhouse crossing block to generate new F1 seedling families for variety development. These parents were chosen on the basis of yield potential, specific gravity, disease resistance, processing ability, adaptation, lack of internal and external defects, etc. Over 200 cross combinations were made with the intention of combining traits from different clones to develop improved varieties.

In the fall, approximately 650 single-hill selections were made from a total of 20,000 seedlings grown at the Montcalm Research Farm. Following harvest, specific gravity has been measured and chip-processing (from 45F storage) will be done during winter. These selections will be advanced to 4-hill plots in 1992 for further evaluation. Fifty-five 4-hill, eleven 20-hill, and 19 2x20-hill selections were also selected then post-harvest tested (specific gravity, 50 and 45F chip-processing and dormancy). The best 10 2x20 selections will be tested in a replicated trial at the Montcalm Research Farm in 1992 for more intensive evaluations.

II. Germplasm enhancement

We have also developed a "diploid" breeding program in an effort to simplify the genetic system in potato and exploit more efficient selection of desirable traits. In general, diploid breeding utilizes haploids of cultivated species and diploid wild and cultivated tuber-bearing relatives of the potato. These represent a large source of valuable germplasm, which can broaden the genetic base of the cultivated potato and also provide specific desirable traits such as tuber dry matter content, cold chipping and dormancy, along with resistance to disease, insects, and virus. Even though these potatoes have only half the chromosomes of the varieties in the U.S., we can cross these potatoes to transfer the desirable genes by exploiting 2n pollen. The diploid breeding program at MSU is a synthesis of five species: <u>S</u>. <u>tuberosum</u> (adaptation, tuber appearance), <u>S</u>. <u>phureja</u> (cold-chipping, specific gravity), <u>S</u>. <u>tarijense</u> and berthaultii (tuber appearance, insect resistance) and S. chaconese (specific gravity, low sugars, dormancy).

From an initial population of 3,500 seedlings from 62 crosses, 80 diploid selections have been made. Selection criteria was based upon tuber appearance, size, dormancy, and internal quality, along with maturity, specific gravity, and chip quality. These selections will be further crossed to improve their agronomic characteristics.

III. Assessment of Potato Breeding Progress in the U.S.

Replicated field trials were conducted at Montcalm, Michigan in 1990 and 1991 to compare 21 potato varieties that have or have had importance over the past century. The varieties were evaluated for total yield, marketable yield, maturity, internal defects, specific gravity, chip-processing quality, visual merit, tuber dormancy and scab resistance. A number of trends were observed over the two years. The many of the older varieties have a greater yield potential; however, the more recent varieties have improved appearance. The round white varieties have been improved for chip-processing ability and specific gravity. The long type varieties have shown an increase in the percent U.S. #1 yield. This study will help us develop breeding strategies to improve potatoes for Michigan.

IV. Use of Molecular Markers for the Study and Analyses of Quantitative Trait Loci in Diploid Potato

The objective of this study is to identify associations between molecular markers (isozymes and RFLPs) and quantitative trait variation for specific gravity and tuber dormancy in diploid potatoes. The identification of these linkages will make it more efficient to breed in the traits from the diploid breeding program. The populations used, named TRP132 and TRP133, are derived from two (*tbr-chc x phu*) crosses, have the female parent in common, and have 143 and 110 individuals respectively.

In 1990 the two populations were planted with three locations at two locations in Michigan. After harvest, they were evaluated for the tuber traits and characterized with 11 isozyme loci. Single factor ANOVAs were conducted for each pairwise combination of quantitative trait and isozyme locus. For specific gravity, significant differences were found for *6-Pgdh-3*, *Got-2* and *Pgm-1* for TRP133, and results were consistent in both locations. For dormancy, differences were found for *6-Pgdh-3*, *Got-1*, *Got-2* and *Prx-3*. In TRP132, differences were found for specific gravity for *6-Pgdh-3* and *Got-2* over both locations, and for *Pgm-1* and *Dia-2* on only one location.

In 1991 the populations were planted in one location with two replications, and then evaluated for specific gravity. Results have been analyzed for TRP133, showing high correlation with data from the previous year. Confirming previous results, significant association for this trait was found with *6-Pgdh-3* and *Got-2*.

Concurrently, RFLP analysis was initiated in the population TRP133. Up to date, thirty six tomato probes have been used, finding backcross, F_2 and triallelic-type segregation patterns. Twenty of these probes have been scored, and analyzed for a total of 27 loci. Two probes have shown significant association with specific gravity, but their chromosomal location can still not be identified. Other four probes have shown significant association with dormancy. Linkage analysis indicates putative QTLs for this trait in chromosomes 2, 5, 7 and 8.

Future plans include further survey of the genome with other probes to identify more QTLs and also fine-map those already identified. Also, progenies derived from 4x-2x crosses and segregating for some of the markers that show significant association with the QTLs will be studied.

V. Evaluation of 4x progeny in a 2x x 4x cross.

A 2x x 4x cross was made between NDD277-2 (4x breeding line) and T4182, a haploid from W231 that has been identified to produce mixed modes of 2n eggs. Using an electrophoretic marker that is closely linked to the centromere, half-tetrad analysis was applied to discriminate between FDR- and SDR-derived 4x progeny. A field study was conducted in Montcalm, Michigan to compare the field performance of the parents and the two subsets of the progeny. Based upon family means, there was no difference between the total tuber yield in the FDR and SDR progeny, however, the 4x parent had a significantly higher yield than either 4x progeny subset. Meanwhile, the haploid parent had significantly lower yield than the 4x progeny and the 4x parent. No differences were seen between the FDR- and SDR-subpopulations for the distribution of specific gravity and total tuber yield (on a single hill basis). The level of inbreeding in the haploid parent may have nullified any differences we expected between the FDR- and SDR-derived progeny.

Funding Fed. Grant/MPIC

1991 POTATO VARIETY EVALUATIONS

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The objectives of the evaluation and the management studies are to identify superior varieties for fresh market or for processing and to develop recommendations for the growers of those varieties. The varieties were compared in groups according to the tuber type and skin color and to the advancement in selection. The most promising varieties are tested in management profile studies for their reaction to the spacing and nitrogen fertilization. Total and marketable yields, specific gravity, tuber appearance, incidence of external and internal defects, chip color, consistency and after cooking darkening as well as susceptibilities to common scab and bruising were determined. Before testing for chip color, the varieties were stored at 45 and 50°F.

The field experiments were conducted at the Montcalm Research Farm in Entrican. They were planted in randomized complete block design, in four replications. The plots were 23 feet long and spacing between plants was 12 inches. Inter-row spacing was 34 inches.

Both round and long variety groups were harvested at two dates. The yield was graded into four size classes, incidence of external and internal defects was recorded, and samples for specific gravity, chipping, bruising and cooking tests were taken. Chip quality was assessed on 20-tuber samples, taking two slices from each tuber. Chips were fried at 365°F. The color was measured with an M-35 Agron colorimeter and visually with the SFA 1-5 color chart. Prior to chipping, the tubers were stored at 45 and 50°F. Texture and after cooking darkening were assessed on five tuber samples.

Results

A. Round white varieties

Nine varieties and 10 breeding lines were included in the trial. Atlantic, Eramosa, Onaway and Superior were used as checks. The average yield was higher than in 1989 and 1990. The results are summarized in Tables 1 and 2.

NY87 at first date of harvest yielded significantly more U.S. No. 1 tubers than any other variety. However, 31 out of 39 over 3¼" tubers checked were hollow. At the second harvest date, NY87 yielded on the level of Atlantic and Onaway. NYE55-44 yielded on the level of Atlantic and Onaway at first harvest, being inferior to both at second harvest. It can be classified as an early variety with very attractive tubers. The performance of NYE55-35 confirmed its high potential as chipping variety. At the second harvest, its yield and specific gravity were comparable to those of Atlantic but it has a better internal quality than Atlantic. Two Wisconsin lines W856 and W870 were also in this class, while W887 yielded less than Atlantic, but had higher specific gravity (1.10). Calchip was a good yielder and had very high specific gravity, but has a very late maturity, rather small tubers and a high incidence of hollow heart this season. Eramosa, Superior, and Mainechip yielded much below the best varieties. Mainechip, however, had high specific gravity, good internal quality and has excellent chipping color.

Variety Characteristics

Eramosa - very early variety with smooth, round to oval tubers of good appearance. Yield potential and specific gravity very low. Has few internal defects. Susceptibility to silver scurf was noted. Has potential as a early fresh-market variety.

Onaway - medium-early fresh market variety with excellent yield potential and a low specific gravity. Tubers are round to oblong, large, deep eyes, susceptible to growth cracks and early blight. Very good internal quality, storability poor.

Atlantic - medium-late, chipping variety of high specific gravity and good yield potential. Susceptible to scab, soft rot, white knot, and to internal defects (hollow heart, vascular discoloration, internal brown spot).

Superior - medium-early, fresh market variety. Tubers well-shaped, medium size, specific gravity medium. Resistant to scab but susceptible to *Verticillium* wilt.

Calchip - very late, high yielding, high specific gravity, chipping variety. Tubers well shaped, but rather small and have a tendency to hollow.

Gemchip - late, high yielding, fresh market and chipping variety. Tubers large, round to oblong, of good appearance. Specific gravity low. Some tendency towards hollow heart was noted.

Mainechip - medium-late variety of excellent chipping quality. Comparable to Atlantic in specific gravity, lower yield potential, but better internal quality. Tubers are rather small.

Norwis - medium-late, high yielding variety. Tubers are large, yet do not hollow. Excellent internal quality. Specific gravity too low for chipping industry.

Spartan Pearl - medium-early, fresh market variety. Yield potential above average. Tubers well-shaped, uniform in size, and attractive. Specific gravity medium, good internal quality, but shows some tendency for after-cooking darkening. Susceptible to scab and growth crack.

MS401-1 - yellow-flesh variety with outstanding chipping quality. Tubers well-shaped, but rather small. Specific gravity below that of Atlantic. Yield potential below average. Its major drawbacks are strong tendency to hollow heart and susceptibility to scab.

MS402-8 - early, fresh market variety. Yield potential is low, slow emergence, but has long dormancy. Plan to delete from program.

B9792-61 - early variety from USDA-Beltsville breeding program. Yield potential too low.

NY87 - late variety, but sets tubers early. It was top yielder at both harvest dates. Tubers are large, but have a strong tendency to hollow heart and specific gravity is low for chip processing.

NYE55-35 - late, medium to high yielding with high specific gravity and good chipping quality. Tubers well-shaped, medium large and uniform in size. Few internal defects and reported to have scab tolerance. Has a good potential in Michigan.

NYE55-44 - medium-early, fresh market variety. Chipping quality is good but specific gravity rather low. Tubers are medium large, uniform, well-shaped and good general appearance. Good potential in Michigan.

W856 - very late, fresh market and chipping variety with a high yield potential. Specific gravity slightly below that of Atlantic. Tubers large, eyes are deep, few internal defects,

W870 - medium-late, chipping variety. Yield potential and specific gravity high. Tubers are medium-large and slightly flat. Few internal defects. Has a good potential in Michigan. Wisconsin plans to name this seedling.

W877 - medium late, chipping variety. Average yield potential with high specific gravity. Tubers uniform in size, well-shaped and few internal defects.

W887 - very late, high yielding and high specific gravity chipping variety. Tubers large, a little flattened, eyes rather deep. Average internal quality. Tendency to shatter wounds and short dormancy were noted.

B. Long Varieties

Seven varieties and three breeding lines were tested. The harvest was done 96 and 143 days after planting. The data are summarized in Tables 3 and 4.

Castile has confirmed its outstanding yield potential. It is very late, but sets tubers early. It was the top yielder at both harvest dates. Of the breeding lines, W1005 was the best yielder at both harvest dates. All other varieties and breeding lines yielded below the level of Russet Burbank. Two breeding lines A78242-5 and MN12171 were at the very low end with respect to yield.

W1005 and ND1538-1 (tested in North Central Region trial) are the only russet lines of some potential in Michigan. Incidence of hollow heart was generally high among long varieties. However, no hollow heart, despite its large tubers, was noted in Castile.

Variety Characteristics

Castile - very late variety of very high yield potential. Tubers are very large oblong, and well-shaped, yet do not hollow. White skin and good appearance. Specific gravity is medium, and internal defects are few. Susceptible to blackspot and some incidence of *Altenaria solani*. Early blight was noted on tubers during storage.

W1005 - late, high yielding variety. Tubers are long and rather thin. Specific gravity high. Resistant to scab, susceptible to blackspot.

Ranger Russet (A7411-2) - late, medium yielding, high specific gravity variety. Tubers are large and have good appearance. Few internal defects. Excellent potential for processing. Susceptible to blackspot.

Frontier Russet medium-late variety with average yields. Specific gravity medium. Tuber appearance and cooking quality good. Shows some resistance to scab and some tendency to hollow heart.

Russet Burbank - used as a standard in the trial. Late maturity, average yields. Specific gravity good for processing. Has a tendency to form off-shape and undersize tubers. Excellent appearance after boiling. Resistant to scab.

Hilite - medium maturity with average yield and specific gravity. Has a tendency towards hollow heart.

Russet Norkotah - early to mid-season variety. Yield potential and specific gravity rather low. Tubers oblong to long, well shaped. Resistant to scab. Some after cooking darkening was recorded in some years as well as susceptibility to *Verticilium* wilt.

Eide Russet (MN10874) - medium-late, medium yield potential, low specific gravity. Tubers well shaped and have few internal defects. Resistant to scab. Susceptible to blackspot.

A78242-5 - medium-late, average yield potential, medium specific gravity. Tubers well-shaped, blocky and attractive. Tendency for hollow heart and brown centers was recorded in 1991. Leaves may display mosaic at early stage which is not due to virus infection.

MN12171 - medium early, low yield potential, with specific gravity comparable to Russet Burbank. Few internal defects.

C. Adaptation

Twenty-one advanced breeding lines from various states were compared to eleven varieties in the Michigan adaptation trial (Table 5). This experiment serves as a screen for the more intensive dates of harvest evaluations in the following years. Castile and Steuben confirmed their excellent yield potential. Five breeding lines - B0172-15, AC80545-1 (Chipeta). B0202-4, B0257-12, and S438 were comparable to Castile and Steuben in yield. The most promising lines for fresh market are AC80545-1 and B0257-12. Both have well-shaped tubers, but their specific gravity is too low for chipping. B0172-15 had a strong tendency for hollow heart. B0202-4 had irregular tuber shape, was heavily infected with pitted scab, and showed tendency to form hollow heart. S438 was very late and had strong stolons. B0405-4, W887, and W842 yielded less than Castile and Steuben, but had very high specific gravity, an acceptable tuber shape, and good chipping quality. Should be further tested for chipping industry. W952, S440, and E57-13 had excellent chipping quality, but their yield potential was low. S440 had small tubers. E55-27, the top yielder in 1990, had an average yield in 1991. Since it is medium-late and a good chipper, it will be tested further.

D. North Central Regional Trial

The North Central Trial is conducted in 14 states and provinces, in a wide range of environments, to provide adaptability data for the release of new varieties. Twelve breeding lines of various tuber-type were compared in the 1991 trial. Red Pontiac, Russet Burbank, Norchip, Norland, and Norgold Russet were planted as check varieties. Two MSU lines, MS401-1 and MS402-8 were included in the trial in 1991. The results are presented in Table 6.

Most of the new lines performed well and should be further tested. MN12567 is late, high yielding, fresh-market variety, however, the tubers were severely infected with *Altenaria solani* in storage. Two red-skin varieties, ND1871-3 and LA12-59 also produced very high yields-similar to Red Pontiac. LA12-59 was severely infected with *Altenaria solani* in tubers.

Three Wisconsin lines W856, W870, and W877 yielded a little less, but had high (W856) to very high (W877) specific gravity. The chipping quality of W870 and W877 was excellent and W856 was acceptable. ND1538-1 confirmed its good potential in Michigan as fresh market and processing variety of russet type. MS402-8 yielded too low and should be discarded while MS401-1 produced acceptable yield of excellent chipping quality. However, its tendency to hollow heart, smaller size, and susceptibility to scab may render it unacceptable for commercial growing.

E. Processing and Quality Evaluation of Fresh-Peeled and Canned Potatoes From the MSU Variety Trials

Tubers from approximately 6-8 cultivars and/or selections grown in Michigan and the MSU variety trials were used for processing as fresh-peeled and canned. Tubers from each processing lot were assessed for specific gravity and black spot. Samples were abrasion-peeled to approximately 10-12% peel loss and divided into lots for holding as fresh-peeled or diced for canning. Fresh peeled samples were held at 38°F after treating with 0.5% citric + 0.5% ascorbic + 0.1% $NaCl_2$ or after dipping in water (control). These samples were evaluated at 0, 3, 5, 7 and 10 days for color (visual rating and Hunter CDM) and texture (shear press or Instron). Canned samples were diced and canned under commercial conditions. These samples will be removed from storage and evaluated at 0, 3, 6 and 9 months for drained weight, color (visual and Hunter CDM), and texture (shear press or Instron). Processing for fresh-peeled and canned product were done at harvest and will be done again after 6 months storage.

Results of the 10 day storage regime for fresh-peeled potatoes are shown in Table 7. Changes in color and overall acceptability took place slowly during the first 3 days of refrigerated storage and there were no significant differences between the control and ascorbic acid treated samples. By day 5 the only control samples that had acceptable quality were Kanona, Superior and Viking but all of the ascorbic acid-treated samples except Eramosa were still acceptable. By day 7 only the ascorbic acid-treated sample of Onaway still had acceptable color and by the tenth day of storage none of the samples was acceptable.

Table 8 shows the results of evaluation of the canned samples after 3 months. As expected, all samples gained weight in the can, with Superior and Russet Burbank showing the greatest gains. Viking, Eramosa, Superior and Onaway all had excellent color while Stueben and Atlantic exhibited very poor color. Visual assessment of texture was related to the wholeness and integrity of the diced potato pieces. Atlantic and Stueben scored lowest but all of the samples had very acceptable attributes in this category. The Kramer Shear data indicates that the samples were very similar in their shear characteristics. Shear values relate to the force necessary to move one or more shear cell blades through a given volume of sample inside a cell of defined size. Compression values were highest for Russet Burbank, Kanona, Atlantic and Stueben. It is likely that this is an indirect reflection of the starch content of these tubers and the changes which the starch granules have undergone during processing.

F. Fusarium Dry Rot Evaluation

As part of the postharvest evaluation, resistance to *Fusarium sambucinum* (fusarium dry rot) was assessed by inoculating whole tubers with a syringe and needle to a depth of 1 cm. The tubers were held at 20°C for three weeks and then scored for disease by measuring the depth and diameter of the decayed tissue. No absolute resistance was detected in the two groups of varieties that were screened (Table 9). Some varieties did, however, exhibit a lesser degree of rot than others. We will continue to conduct studies to determine if this lesser degree of rot is a valuable mechanism of reducing fusarium dry rot infection in storage.

G. Upper Peninsula Variety Trial

A potato variety trial was conducted by Dr. Rich Leep on the farm of Tim Barron in Rock. The plots were planted on June 7 and harvested on September 28. Overall yields were very good, however, specific gravity values were lower than normal. MS401-1, W1005 and Ranger Russet had the highest values.

Two sources of Frontier Russet were compared. Frontier Russet (LC) was obtained from the breeder, Dr. Joe Pavek, in 1990 and Frontier Russet (JP) was obtained in 1991. There was no essential difference in the performance between the two seed sources. Frontier Russet appears to respond to light by developing a purple color on the stems and vine and also on the tuber surface.

Table 1.

ROUND WHITES DATES OF HARVEST
MSU MONTCALM RESEARCH FARM
AUGUST 11, 1991 (93 DAYS)

	YIELD(CWT/AC)		PERCENT SIZE DISTRIBUTION						DEFECTS*		3-YEAR AVE.
VARIETY	US #1	TOTAL	US#1	<2"	2-31/4"	>31/4"	PO	SP.GR.	HH	VD	US#1
NY87	475	510	93	6	77	16	1	1.077	31	0/39	---
W870	409	463	88	11	81	7	1	1.098	4	0/26	---
NYE55-44	406	428	95	5	90	6	0	1.077	1	0/10	---
ATLANTIC	394	432	91	9	78	13	0	1.095	16	0/33	325
ONAWAY	389	450	86	7	69	18	7	1.071	0	0/37	399
MS401-1	387	457	85	15	82	3	0	1.085	7	0/11	341**
NORWIS	378	403	94	5	64	31	1	1.072	1	0/33	359**
GEMCHIP	374	420	89	10	81	8	1	1.076	6	0/27	330**
SPARTAN PEARL	366	444	82	16	78	5	1	1.081	0	0/19	362**
W856	365	395	93	5	82	11	2	1.082	4	0/22	---
W887	355	375	95	5	80	15	1	1.096	3	1/33	---
NYE55-35	334	391	85	14	77	8	1	1.089	4	0/20	---
SUPERIOR	334	372	90	8	88	1	3	1.074	0	1/4	322**
ERAMOSA	321	351	91	6	75	16	2	1.064	1	0/29	319
MAINECHIP	313	362	86	12	86	0	2	1.093	0	0/0	302
W877	275	347	79	21	78	1	0	1.101	1	0/3	---
CALCHIP	251	327	77	23	77	0	0	1.107	0	0/0	---
MS402-8	225	255	88	9	80	8	3	1.069	2	0/16	---
B9792-61	188	243	77	18	77	0	4	1.073	1	0/1	---
AVERAGE	344	391	88					1.083			
LSD (.05)	65	67						0.003			

*NUMBER OF DEFECTS/NUMBER OF OVERSIZE TUBERS CUT

**TWO-YEAR AVERAGE
PLANTED MAY 10, 1991

Table 2.

1991 ROUND WHITES-SECOND DATE OF HARVEST
MSU MONTCALM RESEARCH FARM
SEPTEMBER 16, 1991 (129 DAYS)

	YIELD(CWT/AC)		PERCENT SIZE DISTRIBUTION						DEFECTS *				3-YEAR AVE.
VARIETY	US#1	TOTAL	US#1	<2"	2-31/4"	>31/4"	PO	SP.GR.	HH	BC	IBS	VD	US#1
NY87	593	617	96	4	66	31	0	1.075	26	0	0	0/40	---
ATLANTIC	592	615	96	3	72	24	1	1.092	10	1	1	0/40	418
ONAWAY	566	603	94	4	70	24	2	1.072	0	0	0	0/40	478
W856	543	572	95	3	68	27	2	1.085	3	0	0	4/40	512**
NYE55-35	528	571	92	8	77	16	0	1.091	5	0	3	0/39	460**
CALCHIP	527	595	89	11	84	5	0	1.112	10	0	0	3/19	---
NORWIS	526	544	97	3	51	46	0	1.068	8	1	0	0/40	498**
W870	518	558	93	6	80	13	1	1.095	4	1	1	0/39	460**
GEMCHIP	517	567	91	8	75	16	1	1.071	5	0	0	0/40	499**
W887	485	515	95	3	55	40	3	1.100	5	1	1	4/40	---
NYE55-44	444	473	94	6	86	8	0	1.075	4	0	0	0/26	435**
SPARTAN PEARL	420	489	86	14	82	4	1	1.079	0	0	1	0/15	430
W877	402	464	86	13	81	5	0	1.099	2	0	1	0/19	386**
MAINECHIP	379	432	88	11	85	3	1	1.089	0	0	0	0/10	347
MS401-1	377	454	83	16	77	6	1	1.082	20	0	0	0/24	362
SUPERIOR	358	407	88	11	84	4	1	1.071	1	0	0	0/15	391**
ERAMOSA	320	362	88	8	75	13	3	1.060	0	0	0	1/27	324
MS402-8	292	316	92	5	77	16	3	1.067	4	0	0	0/27	276
B9792-61	220	263	84	15	80	3	1	1.071	3	1	1	0/17	---
AVERAGE	453	495	91					1.082					
LSD (.05)	82	84						0.004					

*NUMBER OF DEFECTS/NUMBER OF OVERSIZE TUBERS CUT

**TWO-YEAR AVERAGE

PLANTED MAY 10, 1991

Table 3.

FIRST DATE OF HARVEST
LONG VARIETIES
MSU MONTCALM RESEARCH FARM
AUGUST 14, 1991 (96 DAYS)

VARIETY	YIELD(CWT/AC) US #1	YIELD(CWT/AC) TOTAL	PERCENT SIZE DISTRIBUTION US #1	<4OZ	4-10OZ	>10OZ	PO	SP.GR.	HH *	3-YEAR AVE. US#1
CASTILE	409	496	82	17	61	22	1	1.0833	0/40	409
W1005	346	484	71	27	66	6	2	1.0908	4/21	362**
R. NORKOTAH	337	427	79	18	61	18	3	1.0737	4/40	287
FRONTIER(LC)	319	394	81	18	58	23	1	1.0768	11/38	276
FRONTIER(PAVEK)	307	406	75	21	56	20	4	1.0771	20/36	276
A78242-5	303	360	84	16	66	18	0	1.0783	5/34	290
R. BURBANK	295	449	65	28	58	7	7	1.0838	11/25	241
EIDE RUSSET	293	391	75	24	63	12	0	1.0793	5/32	278
RANGER RUSSET	269	377	71	25	66	5	3	1.0888	3/13	283
HILITE RUSSET	267	347	77	21	57	20	2	1.0685	14/40	257**
MN12171	167	279	59	34	51	8	7	1.0873	5/16	---
AVERAGE	301	401	74					1.0807		
LSD (.05)	65	72						0.004		

* NUMBER OF DEFECTS/NUMBER OF OVERSIZE TUBERS CUT

**TWO-YEAR AVERAGE

PLANTED MAY 10,1991

Table 4.

SECOND DATE OF HARVEST
LONG VARIETIES
MSU MONTCALM RESEARCH FARM
SEPTEMBER 30, 1991 (143 DAYS)

VARIETY	YIELD(CWT/AC) US #1	YIELD(CWT/AC) TOTAL	PERCENT SIZE DISTRIBUTION US #1	<4OZ	4-10OZ	>10OZ	PO	SP.GR.	DEFECTS* HH	VD	BC	IBS	GE	3-YEAR AVE. US#1
CASTILE	612	686	88	12	66	23	0	1.0816	0	0	0	0	0/40	543
W1005	528	631	83	13	61	23	4	1.0873	9	0	0	1	0/40	445
RUS. BURBANK	461	585	79	16	56	23	4	1.0823	21	1	1	1	0/40	330
HILITE RUSSET	446	515	85	14	59	26	1	1.0738	19	0	0	0	0/40	322
FRONTIER(LC)	414	496	83	14	57	26	3	1.0756	18	3	0	0	0/40	339
RUS. NORKOTAH	407	513	80	16	55	25	4	1.0811	6	2	0	0	4/39	313
RANGER RUS	384	466	82	17	64	18	1	1.0890	8	1	0	0	0/40	372
FRONTIER(PAV)	333	419	80	17	59	21	3	1.0740	15	1	0	4	0/38	339
EIDE RUSSET	331	394	84	14	62	22	2	1.0725	8	2	0	1	0/39	312
A78242-5	329	397	82	14	57	25	4	1.0804	17	0	0	14	0/40	336
MN12171	273	369	72	23	57	15	5	1.0811	5	2	0	4	0/23	---
AVERAGE	411	497	82					1.0799						
LSD (.05)	176	187						0.010						

*NUMBER OF DEFECTS/NUMBER OF OVERSIZE TUBERS CUT

PLANTED MAY 10, 1991

Table 5.

ADAPTATION TRIAL
MSU MONTCALM RESEARCH FARM
SEPTEMBER 25, 1991 (138 DAYS)

VARIETY	YIELD(CWT/AC) US #1	YIELD(CWT/AC) TOTAL	PERCENT SIZE DISTRIBUTION US #1	<2"	2-31/4"	>31/4"	PO	SP.GR.	DEFECTS* HH	VD	IBS	BC
B0172-15	643	694	93	1	19	74	6	1.084	25	0	1	0/40
CASTILE	642	684	94	5	48	45	2	1.078	4	0	0	0/40
AC80545-1	620	690	90	4	45	45	6	1.075	8	2	0	0/40
STEUBEN	602	619	97	1	53	45	2	1.080	4	0	0	0/40
B0202-4	584	630	93	6	74	18	1	1.078	11	0	0	0/28
B0257-12	556	582	96	4	64	31	1	1.078	9	0	0	0/40
S438	549	594	92	5	87	6	2	1.087	1	0	0	1/28
CHIEFTAIN	546	567	96	4	82	14	0	1.059	0	0	1	2/33
B0405-4	535	581	92	8	77	14	0	1.093	6	0	5	1/36
W887	491	509	96	2	60	36	1	1.093	3	0	1	0/40
SAGINAW GOLD	488	527	93	6	75	17	2	1.074	0	0	0	0/36
W842	469	514	91	8	80	11	0	1.093	5	0	1	4/36
NISKA	468	517	91	5	47	44	5	1.074	7	2	0	0/40
VIKING	435	461	95	2	60	35	3	1.066	0	0	0	0/40
W936	429	471	91	7	76	15	2	1.079	2	2	1	0/37
MS716-15	423	475	89	9	77	12	2	1.089	9	0	0	0/39
TRENT	400	437	91	7	85	7	1	1.100	2	0	1	1/27
MS401-7	388	431	89	8	82	7	3	1.086	6	0	0	0/15
NYE55-27	386	446	86	11	67	19	3	1.082	2	0	1	0/40
W760	378	406	93	4	76	17	2	1.096	2	0	0	0/39
MS401-2	377	412	91	5	60	32	3	1.082	4	0	0	0/39
B0257-3	375	423	88	12	83	5	0	1.082	9	0	0	0/40
SNOWDEN	363	439	82	17	79	3	1	1.082	0	0	0	0/11
W952	363	410	89	8	80	9	3	1.078	2	0	1	1/27
S440	363	428	84	15	81	3	1	1.094	4	0	0	0/11
MS402-7	323	341	95	5	69	26	0	1.071	2	0	1	0/40
KANONA	310	333	93	7	78	15	0	1.070	3	0	0	0/29
W845	291	390	74	26	70	4	0	1.091	2	0	0	0/11
B0175-21	288	394	71	7	63	8	21	1.084	2	0	0	0/18
DK RED NORLAND	288	335	86	12	86	0	2	1.054	0	0	0	0/ 0
NYE57-13	284	363	78	22	71	7	0	1.068	4	0	0	0/20
AVERAGE	441	487	90					1.081				
LSD (.05)	94	90						0.004				

*NUMBER OF DEFECTS/NUMBER OF OVERSIZE TUBERS CUT

PLANTED MAY 10, 1991

Table 6.

NORTH CENTRAL REGIONAL TRIAL
MSU MONTCALM RESEARCH FARM
SEPTEMBER 25, 1991 (135 DAYS)

	YIELD(CWT/AC)		PERCENT SIZE DISTRIBUTION						DEFECTS *		
VARIETY	US #1	TOTAL	US #1	>2"	2-31/4"	>31/4"	PO	SP.GR.	HH	BC	IBS
MN 12567	576	672	86	14	66	20	0	1.079	0	0	0/40
ND1871-3R	570	625	91	7	74	17	2	1.065	3	1	1/40
RED PONTIAC	568	628	91	3	49	42	6	1.066	8	0	1/40
LA12-59	547	585	93	4	67	26	2	1.078	0	0	0/40
W856	516	534	96	3	63	33	0	1.085	3	2	2/40
ND1538-1	505	576	88	9	54	34	3	1.071	1	0	0/40
NORCHIP	459	508	90	5	77	14	5	1.076	3	1	2/35
W870	452	481	94	5	79	15	1	1.094	8	0	0/36
R. BURBANK	427	595	72	16	53	19	12	1.086	17	0	2/40
W877	396	431	92	8	84	7	0	1.099	2	0	2/24
MN 12966	391	436	90	7	77	12	3	1.071	0	1	1/28
MS401-1	378	430	88	12	78	10	1	1.082	19	0	0/27
MN 13035	360	435	82	12	77	6	5	1.064	0	0	0/16
NORGOLD RUS	346	441	78	19	60	17	3	1.068	17	0	1/40
NORLAND	336	361	93	6	82	11	1	1.055	0	1	0/25
MS402-8	209	231	90	8	81	9	2	1.067	2	0	0/15
AVERAGE	440	498	88					1.075			
LSD (.05)	79	78						0.004			

* NUMBER OF DEFECTS/NUMBER OF OVERSIZE TUBERS CUT

PLANTED MAY 13, 1991

Table 7. - Quality Evaluation of Fresh Peeled Potatoes, 1991.

	Day 1		Day 3		Day 5		Day 7		Day 10	
Cultivar	w/Asc	CK[1]	w/Asc	CK	w/Asc	CK	w/Asc	CK	w/Asc	CK
Russet Burbank	8[2]	8	8	6	5	2	4	-	3	-
Onaway	8	8	8	6	5	4	5	2	2	-
Kanona	8	8	8	7	6	5	4	3	2	-
Superior	9	9	8	8	6	6	3	4	2	-
Viking	8	8	8	7	5	6	2	3	1	-
Eramosa	7	7	6	6	4	4	2	2	1	-
Atlantic	8	8	8	6	6	3	4	-	3	-
Stueben	7	7	6	3	5	0	1	-	0	-

1/ w/Asc = with ascorbic acid; CK = control without ascorbic acid

2/ 1 to 10; 1 = poorest, 10 = best; the scores shown are subjective ratings of a combination of color and overall acceptability.

Table 8. - Quality Evaluation of Canned Potatoes After 3 Months Storage, 1991.

Cultivar	Drained wt (g)[1]	Visual Color[2]	Visual Texture[2]	Force in lbs/100g[3] Shear	Force in lbs/100g[3] Compression
Russet Burbank	438.6	6	7	36	87
Onaway	395.9	9	9	30	63
Kanona	419.2	8	8	33	87
Superior	462.9	9	8	33	76
Viking	405.7	10	7	30	66
Eramosa	370.5	10	8	30	63
Atlantic	433.0	5	6	36	87
Stueben	428.0	4	5	36	81

[1] Fill wt = 341 g (12 ozs)

[2] 1 to 10; 1 = poorest, 10 = best

[3] Kramer Shear Press

Table 9. **Fusarium Dry Rot Resistance Evaluation.**

(Lesion diameter, mm)

<u>TRIAL 1</u>

Atlantic	22.4
Calchip	31.6
B9792-61	5.2
Eramosa	30.4
E55-35	26.6
E55-44	20.4
Gemchip	14.8
Mainechip	15.2
NY87	25.6
Norwis	32.0
Spatan Pearl	15.8
Superior	12.2
401-1	23.6
402-8	13.4
W856	21.0
W870	26.0
W877	27.4
W887	16.6

<u>TRIAL 2</u>

A78242-5	11.8
AC80545-1	10.6
B0202-4	12.2
B0175-21	4.0
B0405-4	9.0
B0172-15	11.0
B0257-3	6.8
B0257-12	4.8
B9792-6	3.0
Chieftain	10.4
Eide	18.0
E57-13	7.2
Frontier	2.4
Hilite	5.0
Kanona	21.2
LA1259	26.6
MN12567	4.8
MN13035	22.4
Mn1266	16.6
Niska	21.8
ND1538-1	3.0
Norgold	15.0
Norland	14.0
NY87	19.0
Onaway	15.2
Ranger	20.4
S440	7.0
S438	24.2
Steuben	24.2
Trent	11.4
W760	3.4
W842	9.6
W845	9.0
W887	15.8
W936	7.0
W952	5.4
Viking	9.8
401-7	10.2
402-7	15.0
716-15	13.8

Table 10. UPPER PENINSULA POTATO VARIETY TRIAL

R. Leep, J. Lempke, B. Buehrly and R. Chase
Farm Cooperator - Tim Barron, Cornell, MI

Variety	Yield cwt/A U.S. No. 1	Total Yield cwt/A	Percent Size Distribution U.S. No. 1	<4 oz	>10 oz 3¼"	Pick Outs	Specific Gravity	Scab*
Saginaw Gold	406	448	90	10	11	0	1.075	+
W1005	372	413	90	10	10	0	1.079	--
Steuben	367	378	97	3	19	0	1.071	+
HiLite	344	424	81	14	21	5	1.072	--
Frontier Russet (JP)	307	385	79	13	21	8	1.074	--
Russet Norkotah	299	347	87	11	19	2	1.069	+
Frontier Russet (LC)	297	337	88	10	34	2	1.077	--
Ranger Russet	295	344	81	19	22	0	1.076	--
A78242-5	290	315	90	9	24	1	1.071	--
Russet Burbank	286	345	83	11	19	6	1.072	--
MS401-1	274	304	90	10	4	0	1.080	+
Eide	271	293	93	6	22	1	1.072	+
ND1538-1	256	302	85	14	11	1	1.068	+
Norwis	255	292	86	14	7	0	1.064	--
Gemchip	249	284	87	13	16	0	1.068	+
Sangre	249	321	75	23	12	2	1.063	+
Kanona	211	233	90	10	7	0	1.069	+
MS402-8	188	210	90	10	6	0	1.066	+
Red Norland	159	200	80	19	1	1	1.060	+
AVERAGE	282	325	86				1.071	

*Scab: + = present, -- = not present

Planted: June 7, 1991
Harvested: September 28, 1991
Seed Spacing: 12"

FundingFederal Grant/NPC

1991 POTATO SCAB RESEARCH

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Each year a replicated field trial is conducted to assess resistance to common and pitted scab. In 1991, 86 varieties and advanced breeding lines were planted in a scab innoculated field at the MSU Soils Farm. These data are summarized in Table 1. The varieties are ranked on a 1-5 scale based upon a combined score for scab coverage and lesion severity. Examining one year's data does not indicate which varieties are resistant but should begin to identify ones that can be classified as susceptible to scab. Our goal is to evaluate important advanced selections and varieties in the study at least three years to obtain a valid estimate of the level of resistance in each line. The varieties that have been tested at least three years out of the last four are summarized in Table 2. In our assessment, certain points can be made at this time. The check varieties (Superior, Norgold Russet, Onaway and Atlantic) have ratings that are well correlated with their past characterizations. In general, few new varieties and advanced selections have high levels of resistance. The round white varieties (tablestock and chip-processing types) have little if any usable resistance. Russet varieties tend to have higher levels of resistance.

The greenhouse pot test was used to compare the level of scab resistance between a series of varieties and their respective russet sports. There was no significant difference for scab resistance between the varieties and its sport suggesting that the russet skin is not a significant factor in determining scab resistance in a clone.

To have a higher probability of breeding scab resistant round white varieties, scab assessment must be initiated early in a breeding program. A greenhouse test was developed to assess scab resistance at the seedling stage (described in previous progress reports). We have conducted a study to determine the correlation between this seedling test and greenhouse pot and field tests and found a high correlation between the seedling and greenhouse pot tests. The 1991 field test had limited levels of infection, therefore it did not correlate well with the greenhouse results. Additional greenhouse and field tests will be conducted to study this relationship. We have incorporated this seedling screen into the breeding program so that we can identify the most susceptible seedlings. These plants are then eliminated from the breeding program before more intensive evaluation of agronomic traits is initiated. This should increase the probability that scab resistant round white varieties can be bred for Michigan.

A genetics study was conducted to evaluate the potential to breed scab resistant varieties from the cultivated germplasm. In greenhouse seedling and pot tests, the most resistant parent (Lemhi Russet) transferred the highest level of resistance to its progeny, and the most susceptible parent (ND860-2) produced the lowest family means for resistance. Surprisingly, Atlantic was a better parent to transmit scab resistance than the more resistant varieties Superior and Onaway.

We are also in the process of identifying scab resistance in the related *Solanum* species. We hope these sources will offer greater levels of resistance than those we currently find in the cultivated potato. At this time we are intensively examining collections of two species, *Solanum phureja* and *S. chacoense*, which show higher levels of scab resistance. We are focusing on these species because some selections have been noted to carry high specific gravity and chip-processing potential.

A study was initiated using a diploid population, in conjunction with a saturated genetic map (based upon RFLPs, RAPDs and isozyme genetic markers) to identify chromosome segments that may contain genes controlling scab resistance. A replicated greenhouse pot test was used to assess scab resistance in the population. Isozyme analysis has been used to characterize the population, while RFLP and RAPD analysis currently is being conducted to characterize the population. Statistical analyses to determine linkage between genetic markers and scab resistance will proceed this phase of the study.

Table 1.

1991 Scab Evaluation
MSU Soils Farm
East Lansing, MI

1*	2	3	4	5
Eide Russet	B9792-61	AC80545-1	A78242-5	B0175-21
Frontier Russet	Early Rose	B0202-6	Atlantic	B0175-21
Hilite Russet	Green Mtn.	B0405-4	B0172-15	Castile
MN12171	Mainechip	Chieftain	B0257-3	Eramosa
MN12567	MN12966	Dk. Rd. Norland	Calchip	Yukon Gold
ND1538-1 Rus.	MS401-7	Gemchip	Kanona	
Norgold R.	MS402-8	I. Cobbler	MS401-2	
Norland	MS716-15	Katahdin	NDD277-2	
NYE57-13	NYE55-27	Kennebec	Niska	
Russet Burbank	NYE55-44	LA12-59	Norwis	
R. Norkotah	Onaway	MN13035	Ranger Russet	
S438	Ontario	MS401-1	Red Lasoda	
Sebago	S440	MS402-7	Red Pontiac	
Superior	Viking	Norchip		
W1005	W842	NY87		
White Rose	W845	NYE55-35		
	W877	Saginaw Gold		
	W936	Shepody		
		Snowden		
		Spartan Pearl		
		Steuben		
		W760		
		W856		
		W870		
		W887		
		W952		

*1 = no incidence of scab
5 = high incidence of scab

Table 2.

Scab Field Test Summary **Variety Ranking**

	1988	1989	1990	1991	Ave.
Lemhi R.	-	1	1	-	1.0*
R. Norkotah	2	1	1	1	1.2
Frontier R.	-	1	2	1	1.3
Norgold R.	3	-	1	1	1.6
Superior	-	2	3	1	2.0
Eide R.	3	3	2	1	2.2
MS402-8	2	4	2	1	2.2
Castile	-	1	2	4	2.3
Rosegold	2	2	3	-	2.3
W231	2	2	3	-	2.3
Ranger R.	2	4	2	2	2.5
Onaway	1	3	4	2	2.5
Mainechip	3	-	3	2	2.6
MS716-15	3	-	4	1	2.6
A78242-5	-	3	3	2	2.6
Spartan Pearl	3	3	3	2	2.7
Saginaw Gold	3	4	3	2	3.0
Snowden	4	-	3	2	3.0
Norchip	5	-	2	2	3.0
Red Lasoda	-	1	4	4	3.0
MS402-7	4	3	4	1	3.0
Steuben	4	3	3	3	3.2
Atlantic	3	1	5	4	3.2
B0257-3	-	1	5	4	3.3
B0172-15	-	4	2	4	3.3
Eramosa	3	4	3	4	3.5
Shepody	3	-	5	3	3.6
MS401-2	3	4	4	4	3.7
MS401-1	5	5	4	2	4.0

*Resistant: <2
Moderately resistant: 2.0-2.5
Susceptible: 2.6-3.0
Very susceptible: >3.0

Funding Federal Grant

MANAGEMENT PROFILE OF STEUBEN

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Introduction

Management profile studies have been conducted on selected varieties and advanced seedlings since 1986 in order to evaluate the effect of plant spacing and nitrogen levels. The Steuben study was initiated in 1991 as interest had been expressed for this variety as a possible fresh market variety. Steuben is a very late maturing variety released by Cornell in 1989. It has a high yield potential but does set and size tubers early.

Procedure

Three levels of nitrogen (100, 150 and 200 lbs/A) and three in-row spacings (6, 9 and 12 inches) were studied. The seed was hand cut to obtain uniform seed size of 1½ to 2 ounces and was hand planted on May 13 in a randomized split plot design. Each plot was 23 feet long with four replications. At plowdown, 300 lbs/A of potassium sulfate (0-0-50) was applied broadcast. At planting, a 20-10-10 fertilizer was banded at 200 lbs/A to all of the plots. Two border rows were established between the main plots of nitrogen levels and the variable nitrogen rates were applied as a sidedress treatment on May 22, 1991. Soybeans were grown as a plowdown crop in 1990 and rye was planted in the fall. The area was treated with 50 gpa of sodium methyl dithocarbamate (Busan 1020) in November of 1990. Thimet was used as the systemic insecticide and foliar insect and disease controls were applied as needed. The study was irrigated using the MSU Irrigation Scheduling Program.

Results

The yields, percent size distribution and specific gravity are shown in Table 1. The results are in descending order based on yields of U.S. No. 1 potatoes. These data show that the closer spacings produced the higher yields of marketable potatoes. There was considerable variability in this study as the stands were less than desired. The overall stand for the 6 inch spacing was 78%, 91% for the 9 inch and 83% for the 12 inch spacing. Fusarium dry rot was present in the seed and did affect the final stand.

Table 2 summarizes the results by spacings and nitrogen levels. These data show that the closer spacings produced the best marketable yields. The percentage of tubers over 3¼ inch increased with the wider spacing and there was no effect on specific gravity. Hollow heart in the larger tubers also increased with the wider spacings. In terms of nitrogen level, the highest yield of marketable potatoes was obtained at 200 lbs N/A. The lowest yield occurred at the 150 lb level and reflects the variability of this study. Specific gravity was higher at the higher nitrogen levels and hollow heart did increase at the 150 and 200 lb/A levels.

The number of tubers were counted in two replications and showed an average of six tubers per hill. At harvest, considerable tuber rot was noted in all plots. It appears that Steuben may be susceptible to bruising which leads to subsequent breakdown. Steuben has a very late maturity which can limit good skin set at harvest.

Table 1. Steuben Management Profile - Montcalm Research Farm.

Treatment		Yield (cwt/AC)		Percent Distribution					
#N/AC	Spacing	U.S. No. 1*	Total	U.S. No. 1	<2"	2-3¼"	>3¼"	Pick Outs	Specific Gravity
200	6"	533 a	587	91	6	57	34	3	1.080
100	9"	475 ab	509	93	6	61	33	1	1.076
150	6"	471 ab	519	91	7	65	25	2	1.080
200	9"	463 abc	541	85	6	54	31	9	1.079
100	6"	457 bc	495	92	7	66	27	1	1.076
200	12"	439 bcd	473	93	5	47	46	2	1.079
100	12"	429 bcd	457	94	4	57	36	2	1.076
150	9"	388 cd	431	90	6	51	39	4	1.077
150	12"	373 d	402	92	4	52	40	4	1.079
AVERAGE		448	490	91					1.078

LSD 76

Planted May 13, 1991

Harvested September 30, 1991 (140 days)

*Least significant difference test. Values with the same letters are not significantly different.

Table 2. Steuben Management Profile Summary of Nitrogen and Spacing Levels.

		Yield (cwt/A)		Percent Distribution						Internal Defects*			
Nitrogen (lbs/A)	Space (in.)	No. 1	Total	No. 1	<2"	2-3¼"	>3¼"	Pick Outs	S.G.	HH	VAS DIS	Brown Center	Tubers Cut
	6	487	534	91	7	63	28	2	1.078	3	1.0	1.0	40
	9	442	494	89	6	55	34	5	1.077	4	2.0	1.0	40
	12	414	444	93	4	52	41	3	1.078	6	2.0	1.0	40
100		454	487	93	6	61	32	1	1.076	3	0.3	2.0	40
150		410	451	91	6	56	35	3	1.078	5	3.0	0.7	40
200		478	533	90	6	53	37	5	1.079	5	1.0	0.3	40

*Number of internal defects noted in the sample of oversized tubers cut.

Funding MPIC

Effects of Nitrogen Fertilizer Management on Nitrate Leaching

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The goal of this study is to minimize the loss of nitrate-N out of the root zone but still produce a good economic yield. Increasing public awareness of nitrate contamination of groundwater has caused agriculturalists to focus their attention on nitrogen recommendations and management strategies. This study, which began in 1988, evaluated the impact of nitrogen fertilizer management on the leaching of nitrates out of the root zone. Using two permanently installed drainage lysimeters, the drainage water and nitrate-N leaching were measured. The lysimeters were separated by treatment, one receiving a conventional nitrogen treatment (CON) and the other receiving a more conservation/research nitrogen treatment (RES). Each year, the RES plot has received less nitrogen fertilizer than the CON plot.

METHODOLOGY

The lysimeters used in this study are steel boxes that are 48 in. wide, 68 in. long, and 6 ft. deep, and are open at the top. The open tops of the lysimeters are located about 1.5 ft. below ground surface and drainage samples are taken from the bottom of the lysimeters, at a depth of approximately 7.5 ft. At the bottom of each lysimeter, there is a small opening where drainage water from inside the lysimeter is discharged. From the opening, the amount of drainage water is measured and samples are taken. These samples are then tested for nitrate-N concentration and the amount of nitrogen lost can be calculated.

In 1991, a new automated sampling device was installed in the lysimeters. The auto-sampler measured the water draining from the lysimeters and then automatically pumped a sample from the drainage water for nitrate-N analysis. The sampler is set to pump a sample whenever 0.25 inches of water has drained through the soil profile.

The plots were hand-planted on May 28 with the Saginaw Gold variety. At the time of planting, the RES plot received 500 lbs/A of 5-10-15 (25 lbs N/A), placed at the bottom of the furrow cut, just below the seed. The CON plot received 500 lbs/A of 15-10-15 (75 lbs N/A) that was also placed in the bottom of the furrow. Row spacing was 34 inches and seed spacing was nine inches.

Additional nitrogen was added to the plots throughout the season. On July 27, the CON received 125 lbs N/A as urea and the RES plot received 50 lbs N/A as urea. The urea was worked into the ground. On August 6, an additional 50 lbs N/A was applied to the RES plot. The total amount of nitrogen added to the two plots was 200 lbs N/A for the CON plot and 125 lbs N/A for the RES plot. Irrigation for the two plots basically followed the same schedule as the rest of the Montcalm Research Farm.

The plant leaves in the RES plot were mostly senesced by August 22. The plants in the CON plot began to lose green leaf area on August 27, and were completely senesced by September 9.

The tubers in both plots showed no signs of disease or rot and were generally in excellent condition. The plants in the lysimeter areas were hand harvested. The plants in the plot areas were mechanically dug up, and then hand harvested. Four samples, in addition to the lysimeter samples, were taken from each plot. The samples were 20 feet of a single row. The potatoes were separated according to size and condition, and weighed. Sub-samples were taken from each harvest sample for specific gravity measurements.

RESULTS

The results for this study will be split into two sections: first, the 1991 results will be reviewed and then the cumulative results for the past four years will be discussed.

Results: 1991

As in 1990, the tuber yields in the RES treatment were less than those measured in the CON treatment. Overall, the RES treatment yielded 78 cwt/A less than the CON treatment. As Table 1 shows, the RES treatment yielded more small tubers, less than 2 inches, whereas the CON treatment yielded more pick-outs. The distribution of size was 18%, 72%, 0%, and 10% for the CON treatment and 46%, 50%, 0%, and 4% for the RES treatment, for the four sizes given in Table 1.

The lysimeter drainage data for 1991 are shown in Figs. 1-3. Figure 1 shows the cumulative drainage that occurred during the past year. Throughout most of the year, the two lysimeters drainage was approximately the same. However, toward the end of the season, the lysimeter drainage on the RES plot increased. This may be due to the early leaf senescence that occurred in that plot and would cause less water to be taken up, allowing more drainage to occur.

The nitrate leaching data are shown in Figs. 2 and 3. Figure 2 shows the nitrate-N concentrations for the drainage water from the two lysimeters. The CON lysimeter consistently had a higher nitrate-N concentration. Nitrate-N concentrations dropped in both lysimeters as the season began with some spikes of increase occurring during the growing season.

Table 1. Tuber yield and quality in term of size distribution, pick outs, and specific gravity, for Montcalm Research Farm Lysimeter plots, 1991.

Yield (cwt/A)			Size Distribution				
TRMT	Sample*	Total	< 2"	2"-2.75"	> 3.25"	Pick Outs	Specific Gravity
CON	CON1	254	35	205	0	15	1.079
	CON2	201	28	142	0	31	1.090
	CON3	248	42	176	5	25	1.077
	CON4	209	42	131	0	36	1.077
	CON LYS	254	61	179	0	13	1.083
	AVE	**233**	**42**	**167**	**1**	**24**	**1.081**
RES	RES1	164	76	85	0	4	1.072
	RES2	164	80	81	0	3	1.067
	RES3	151	58	78	0	15	1.069
	RES4	111	48	57	0	6	1.067
	RES LYS	183	98	83	0	10	1.080
	AVE	**155**	**72**	**77**	**0**	**7**	**1.071**

* Samples consisted of 20 feet of a single row (samples 1-4) and of the lysimeter area (LYS).

The nitrate-N loss for the season is shown in Fig. 3. This shows that the CON treatment continues to lose more nitrogen as the year progresses. The measurements show that by the end of 1991, 15 lbs N/A more leached from the CON lysimeters than from the RES lysimeter. This low difference is probably due to the early senescence of the plant leaves in the RES treatment. Of the 125 lbs N/A applied to the RES treatment, about 51 lbs N/A was removed by the tubers, but some would be contained in the plant tops and roots.

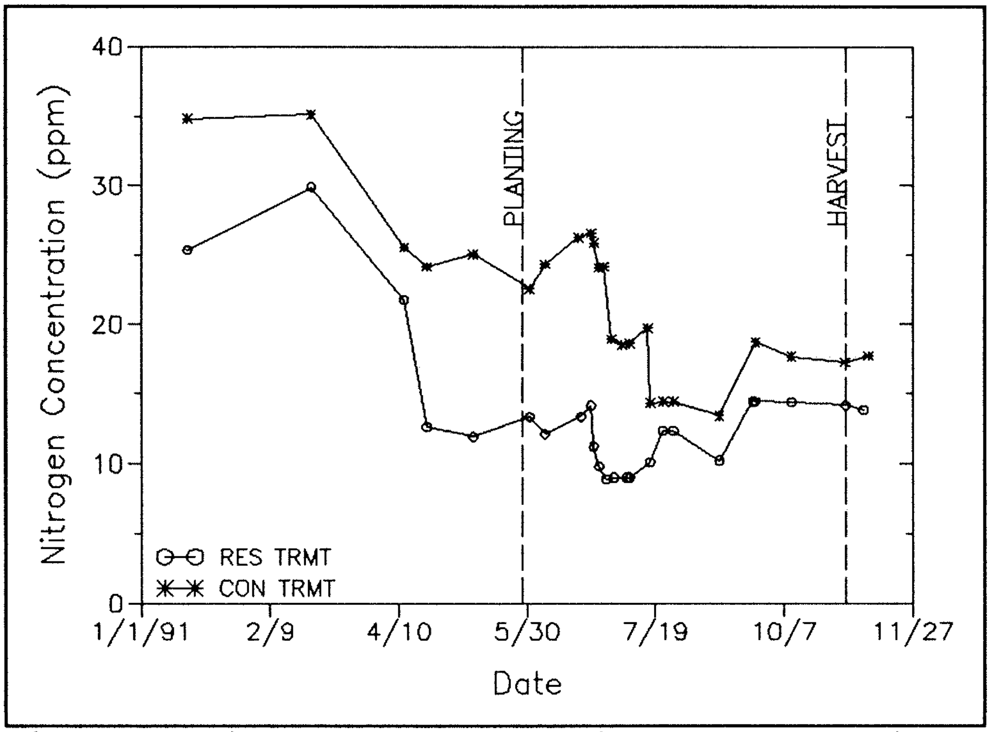


Figure 1. Nitrate-N concentrations of the drainage water from the RES and CON lysimeters. Montcalm Research Farm, 1991.

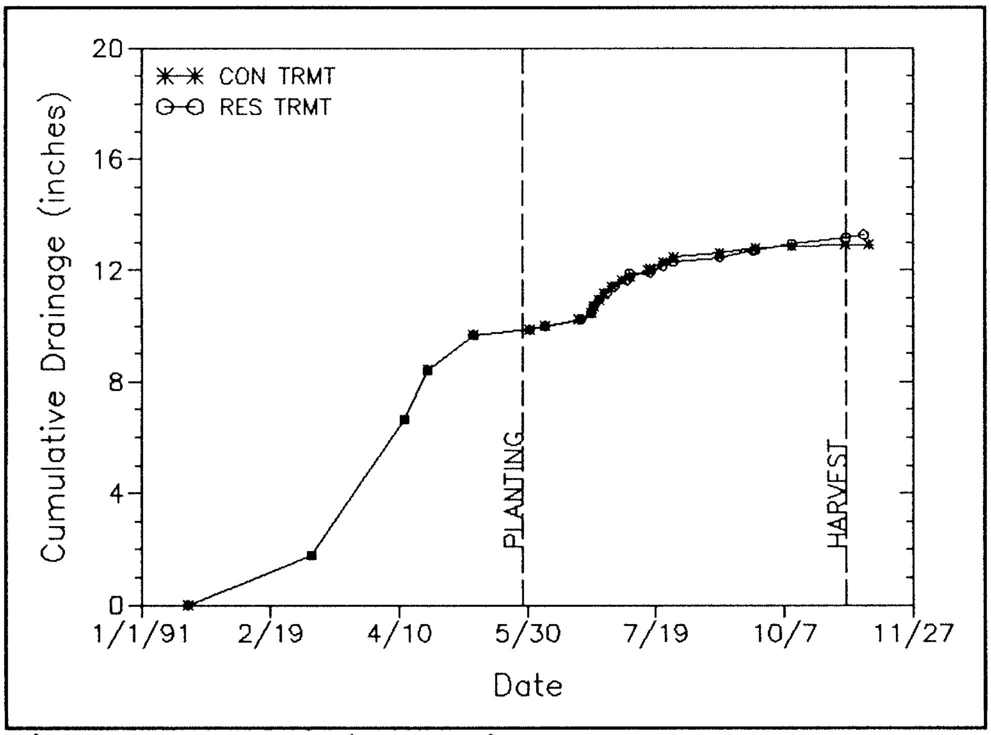


Figure 2. Cumulative drainage for the RES and CON lysimeters. Montcalm Research Farm, 1991.

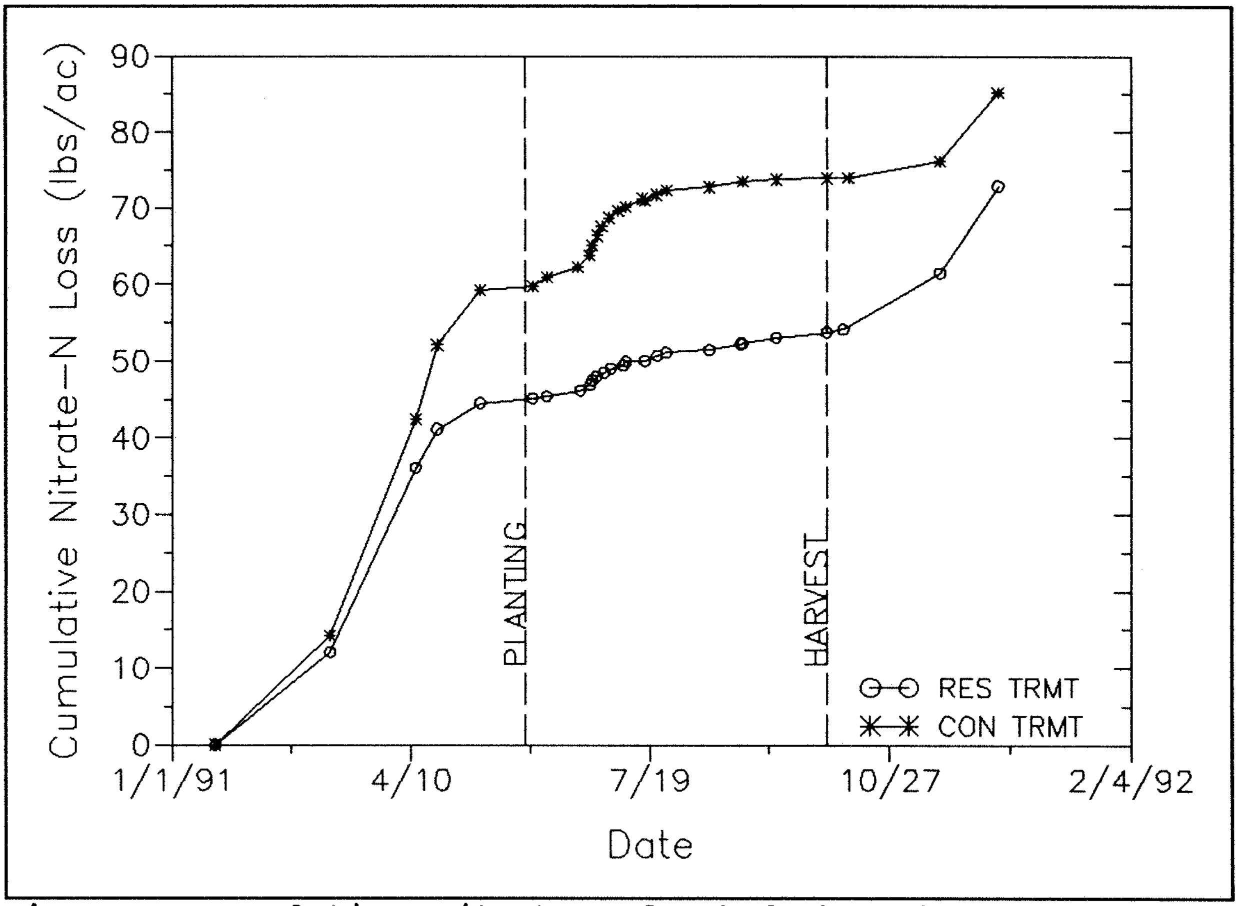


Figure 3. Cumulative Nitrate-N leached for the RES and CON lysimeters. Montcalm Research Farm, 1991.

Results: 1988-1991

Studying data obtained over a long period gives a better perspective on long term trends and/or impacts. Table 2 shows the relative yield of the RES treatment compared to the CON treatment. In 1988 and 1989, the RES treatment yields were comparable to the CON yields, with a reduction of 1.2 and 5.4 percent in each year. However, in the past two years a decrease in yield of about 1/3 has occurred. The nitrogen fertilizer strategy for the RES treatment for the last two years has been to look for signs of nitrogen deficiency and apply only the amount of nitrogen required for adequate growth. This strategy, called Plant Response Fertilization (PRF) should minimize nitrate leaching while maintaining good yields. However, if the nitrogen stress is too severe before it is detected, a reduction of yield may occur, as found in the yields of the RES treatment for 1990 and 1991. This indicates that the PRF strategy is inadequate for potato production although it does contribute to reduced leaching.

Table 2. Percent reduction in crop yield due to reduced nitrogen fertilizer application in the RES treatment for the years 1988 through 1991. Montcalm Research Farm.

YEAR	CROP TYPE	Percent Reduction of Yield in RES Treatment
1988	Potatoes	1.2
1989	Corn	5.4
1990	Potatoes	33.8
1991	Potatoes	33.5

The overall effect of the nitrogen management strategies on nitrate leaching has been a steady decrease in nitrate-N leached from the RES lysimeter while the CON lysimeter continues at a somewhat constant rate. Table 3 shows the nitrogen fertilizer applied, the nitrogen removed by the harvest, and the nitrogen loss in leaching. Adding these values over the years of study, Table 3 shows that at the end of 1989, the RES lysimeter received 160 lbs N/A less than the CON lysimeter, but produced the same yields and lost approximately the same amount of nitrogen through leaching. However, by the end of the following two years, the RES lysimeter had received about 325 lbs N/A less, taken up about 70 lbs N/A less, and leached about 100 lbs N/A less than the CON

Table 3. Cumulative nitrogen inputs and outputs for both the RES and CON treatments for the years 1988 through 1991. Montcalm Research Farm.

Year	Crop Type	CUMULATIVE NITROGEN (LBS/A)					
		Fertilizer N		Removed by * Harvest		Leached	
		RES	CON	RES	CON	RES	CON
1988	Potatoes	110	200	80	81	58#	73#
1989	Corn	240	400	180	187	258	288
1990	Potatoes	350	593	248	289	368	448
1991	Potatoes	475	793	299	368	442	532

* N uptake calculated assuming 0.33 lbs N/cwt of potatoes and 1.5% nitrogen concentration in the corn grain.

Leaching measurements began in July, 1988.

lysimeter. Performing a nitrogen balance and assuming no change in the organic matter content for the past four years, the plants in the RES treatment have used about 248 lbs/A of mineralized nitrogen while the plants in the CON treatment have used only 95 lbs/A of mineralized N.

The leaching data are shown in Figs. 4, 5, and 6. Figure 4 shows the drainage data for the last four years. Drainage from the two lysimeters was about the same. Figure 5 is the nitrate-N leached from the lysimeters for the past four years. About the same amount of nitrogen is leached from the two lysimeters during the first two years and then the RES treatment began leaching less. By the end of 1991, the RES treatment had leached 90 lbs N/A less then the CON treatment. However, Fig. 6 can give some insight into trends.

By plotting cumulative nitrate-N leached versus cumulative drainage (Fig. 6), the nitrogen leaching trends can be seen. The lysimeters lost nitrate-N at about the same rate for the first 10 inches of drainage. This coincides with the drainage that occurred up to the end of 1989 (see Fig. 4). At that point, the RES lysimeter began to lose nitrate-N at a slower rate. This is indicated by the lower slope of the curve. During the next two years, the rate of nitrate-N loss has continued to go down in the RES lysimeter while the CON lysimeter's rate has been fairly constant.

DISCUSSION AND CONCLUSIONS

1991 Season

The reduced yields in the RES treatment for the last two years indicate a weakness in the conservative approach of PRF. The RES treatment was intended to provide the most conservative approach to nitrogen fertilization in order to determine if there was a correlation between the nitrate-N leaching and the amount of nitrogen not removed by the harvested potatoes. This year, an attempt was made to measure nitrogen stress by measuring plant height, number of leaves, and number of stems. Unfortunately, these measurements did not give sufficient early detection of a nitrogen deficiency in enough time to correct the deficiency. The relatively low yields and early senescence the plant leaves in the RES plot indicate that the final 50 lbs N/A applied may not have had any beneficial effect on the crop yield.

1988-1991

The data for the last four years gives some insight into how nitrogen fertilization has impacted the leaching of nitrates. Early data, from 1988 and 1989, seem to indicate that the nitrate losses were due to previous years management and that the treatment effects were not yet causing the differences in leaching. In 1990, we began to see a

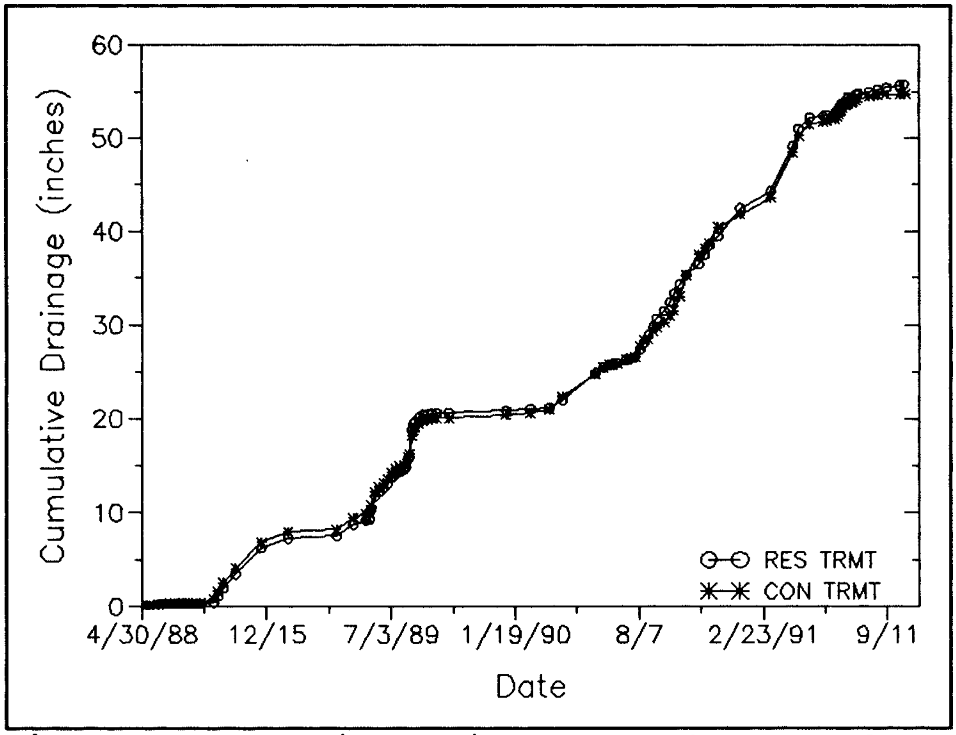


Figure 4. Cumulative drainage from the RES and CON lysimeters from 7/88 through 10/91. Montcalm Research Farm.

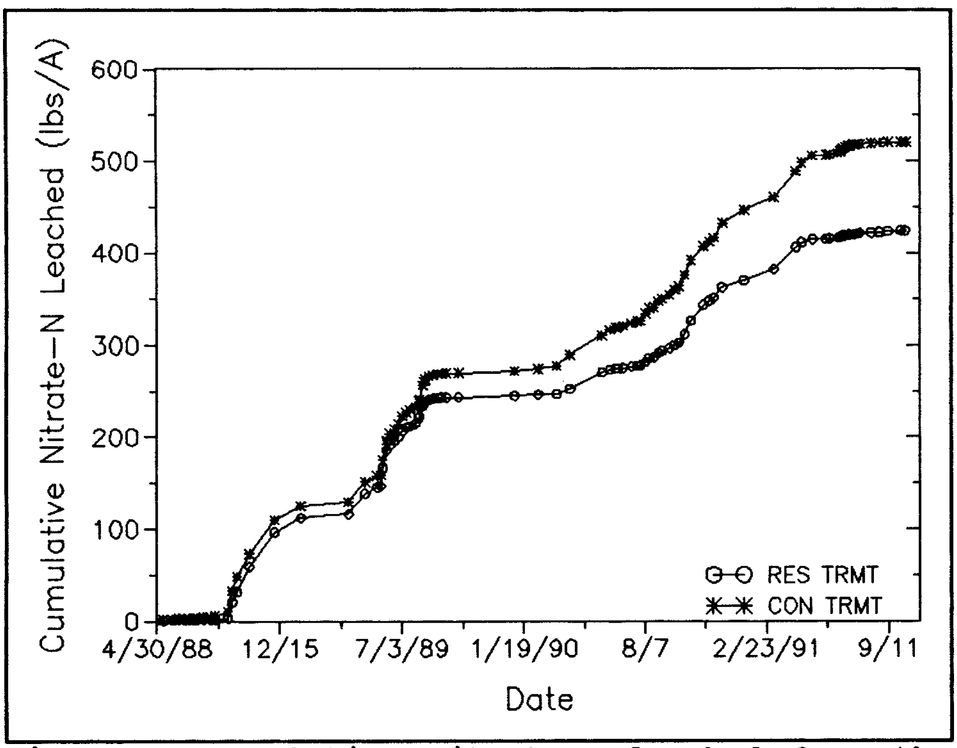


Figure 5. Cumulative nitrate-N leached from the RES and the CON lysimeters from 7/88 through 10/91. Montcalm Research Farm.

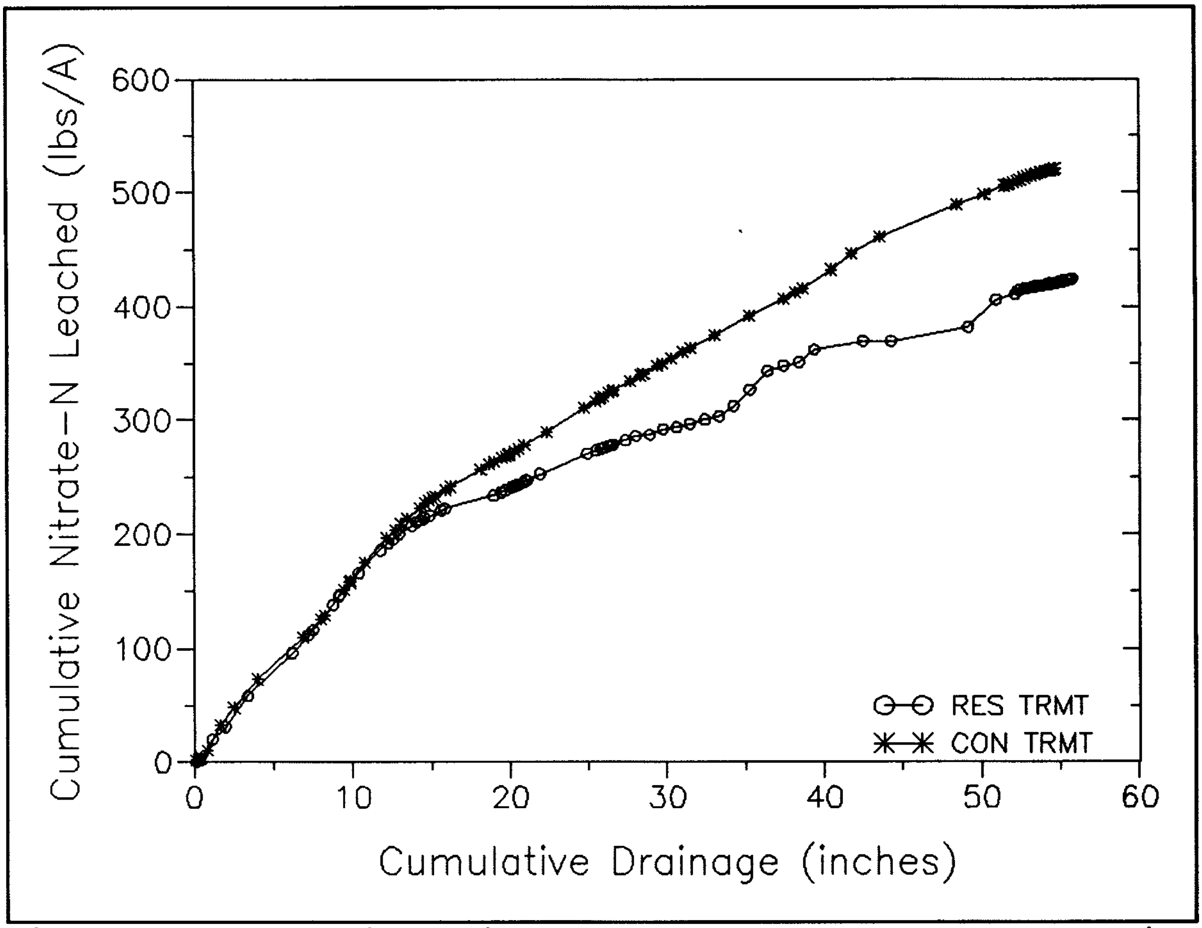


Figure 6. Cumulative nitrate-N leached versus cumulative drainage for the RES and CON lysimeters from 7/88 through 10/91. Montcalm Research Farm.

change in the nitrate-N loss from both lysimeters. Figure 6 shows a slight decrease in the nitrate-N leaching rate for the CON lysimeter and a large decrease for the RES lysimeter.

We realize the yield reductions of the last two years due to PRF are unacceptable. There still is a need to develop a strategy that will minimize nitrate leaching while still maintaining a good yield. The results of this study indicate that the only way to reduce leaching losses in potato production is through doing the best job of matching the nitrogen supply with the plant's nitrogen demand. The leaching losses caused by nitrogen mineralization from organic matter can't be controlled and will be lost.

Funding Federal Grant

NITROGEN MANAGEMENT TO IMPROVE POTATO YIELD, QUALITY, AND GROUNDWATER QUALITY

M. L. Vitosh, R. H. Leep and G. H. Silva
Department of Crop and Soil Sciences

INTRODUCTION

Choosing the optimum nitrogen fertilizer rate for potatoes is a complex decision for the potato growers. The growers are advised to consider all sources of available nitrogen(N) from soil reserves and supplement any remaining requirement with fertilizer N. These soil reserves include fertilizer N residue from previous crop, N mineralized from organic matter and decomposing crop residues. Such reserves are site-specific and predictions of the N availability are not entirely reliable at present. Nitrogen undergoes rapid transformations and movement in the soil and potentially could be lost from the root zone. The potential for N leaching associated with growing potatoes increases greatly when N application rates exceed the crop requirements. Nitrate contamination of groundwater has become an important environmental issue in Michigan.

The mounting concern that fertilizer practices have an adverse effect on the quality of our environment has prompted a reexamination of the current N management practices. The development of new management strategies that improve the efficiency of both applied fertilizer N and available soil N can lead to a reduction in the overall fertilizer N use as well as the risk of groundwater contamination. One way to achieve this goal would be to reduce the at-planting N fertilizer rate and apply supplemental N as needed during the growing season. This approach would function optimally if combined with plant tissue and soil testing techniques that allows for rapid assessment of the crop N status and the N supplying capacity of the soil. The concept is to allow soil reserves to supply as much N as possible and supplement fertilizer N when the crop needs it. This would ensure that minimal N is left in the soil profile following harvest.

The results from previous studies have indicated that the petiole sap nitrate concentration is a sensitive guide to the N status of potatoes. To utilize this technique as an effective on-farm N management strategy, a quick and reliable procedure for sap nitrate analysis is needed. If the sap nitrate N level is found to be below a critical range, then the grower can resort to in-season corrective fertilization, thereby increasing the N use efficiency and minimizing the risk of groundwater contamination.

OBJECTIVES

1. To develop and calibrate a quick and reliable test procedure for measuring petiole sap nitrate N;

2. To establish critical nutrient ranges for petiole sap N in relationship to growth stage and tuber yield;

3. To field test and validate the use of sap nitrate test as an index of crop N status and soil N availability, and asses its use as a guide for corrective in-season N fertilization.

MATERIALS AND METHODS

Field trials were conducted at the Montcalm Research Farm, MSU soils farm, E. Lansing, and in the Upper Peninsula. At Montcalm and MSU, the treatments included five N fertilizer rates and six potato varieties. The N rates were 0, 60, 120, 180, and 240 lbs N/A (Table 1). The treatments 2-5 received 60 lbs of N at planting and the balance was sidedressed at tuber initiation as ammonium nitrate. Preplant applications of P and K were made according to soil test recommendations. The six varieties included were Onaway, Superior, R. Norkotah, Atlantic, Snowden and R. Burbank. In the Upper Peninsula, only two varieties (R. Norkotah and R. Burbank) and four N rates (0, 60, 120, 180 lbs N/A) were tested. The plots were 50 feet long and spaced 34" apart. The treatments were tested in a split plot design, with N as the main plot and replicated four times.

A. Soil Sampling for Nitrate and Ammonium analysis

A random preplant soil sample (0-12" deep) from the experiment site was taken just prior to planting. The zero N plots were sampled every week for 9 consecutive weeks to study N mineralization and availability in the soil. During the season, all N plots were sampled at emergence, tuber initiation, 2 weeks after tuber initiation, and after harvest. In the after harvest sampling, all N and variety plots were sampled to a depth of 2 feet in 1 foot increments to assess the residual N in the soil.

B. Petiole sampling for nitrate N analysis.

All plots were sampled once a week starting at tuber initiation (before the sidedress application) and continued for 5 consecutive weeks. The sap nitrate concentration was determined by the procedure developed at MSU. Samples were taken in the morning hours and consisted of 15-20 petioles taken from the fourth or fifth fully expanded leaf. In a zip lock bag, the sap was squeezed out and mixed with an extraction solution consisting of aluminum sulfate and boric acid. The nitrate N concentration of the extract was determined with a nitrate ion specific electrode.

The two early varieties (Onaway and Superior) were harvested on August 26. Atlantic and R. Norkotah were harvested on September 9. The late varieties Snowden and R. Burbank were harvested on September 23. Tubers were graded according to size and the yield and percent of US # 1 tubers determined. The specific gravity was measured by weighing samples in air and water.

RESULTS AND DISCUSSION

Petiole sap nitrate test

The technique for determining petiole sap nitrate N was effective as a rapid on-farm procedure that would permit a grower to monitor the N status of the crop during the season. The development of this method was made possible by the recent introduction of non-clogging electrodes. Historically a major drawback has been that the electrodes readily clogged in the presence of viscous and colloidal extracts. The electrode used in this procedure was designed with a free diffusion reference junction that provide fast, stable and reproducible exchange potentials free from clogging. This test does not involve any hazardous chemicals and could be assembled into a small portable kit. A highly significant linear relationship (R^2 = 0.92) was found between the nitrate N content measured by the quick sap test and the conventional oven-dried tissue procedure. This shows that the sap nitrate test with a quick turnaround can be used instead of the more time consuming conventional methods to assess the N status of the plants during the season.

Petiole sap N level in response to N rate and sampling date

Petiole sap nitrate concentration was highly sensitive to soil N and increased in proportion to the N fertilizer application rate, even up to 240 lbs N/A (Figs. 1 and 2). The changes in the sap nitrate level with sampling date are illustrated in Figs. 3 and 4. In general, the petiole nitrate N level is higher at the beginning of the season and decreases as the season progresses. This pattern, however, is interrupted in response to supplemental N applications.

The combined effects of N fertilizer rate and sampling date on the petiole sap nitrate concentration at Montcalm and MSU are illustrated in Figs. 5 and 6, respectively. At the 0 and 60 lbs N/A , the sap nitrate concentration decreased rapidly with sampling date. At higher N rates, the sap nitrate N concentration remained steady and showed only a small decrease with time. The average weekly declined in the sap nitrate level for the 5 N rates in shown in Table 2. The petiole sap concentration decreased by greater than 100 ppm per week in the 0 and 60 lbs N treatments.

Soil Test Data

Soil N transformations in the zero N plots at Montcalm and MSU are shown in Figs. 7 and 8, respectively. This data illustrates the N supplying potential of the soil. With the onset of spring, microbial activity convert organic matter into ammonium and then to nitrate. The nitrate level peaked about 28 days after planting. This corresponds with the time of potato emergence. In the following weeks, the available soil N begins to deplete as the crop's demand for N increased. It was estimated that the check plots could provide as much as 100 lbs nitrate N/A on both locations. This study reiterate that the initial N in the soil and the potential for mineralization are crucial in determining the optimum fertilizer N rate for potatoes.

The soil test N levels measured during the season closely corresponded with the N rates applied to plots (Figs. 9 and 10). The test results from the final soil sampling is still being analyzed. This data will indicate the quantity of the residual N left in the soil after potato harvest.

Tuber Yield, Quality and Critical Nutrient Range

The tuber yield, percent US #1, and specific gravity of potatoes are presented in Tables 3-8. In both locations, significant yield responses were observed only up to 120 lbs applied N /A. The response to 60 and 120 lbs N varied depending on the variety and location. In many varieties, the percent of US #1 tubers was slightly lower in the zero N treatment compared to the N treated plots. The specific gravity tended to decrease with increased N, however, significant differences were only observed in Snowden and Russet Burbank.

In order to establish the critical nutrient ranges for the sap nitrate, linear regression techniques were applied to the sap N concentration corresponding to the 5 N rates and dates of sampling. By superimposing regression curves with the yield response observed at each N rate, the sap nitrate levels were partitioned into inadequate, adequate, and excessive segments. Between the adequate and inadequate segments, is a range of concentration designated as **borderline or Critical Nutrient Range (CNR).** The CNR is defined as the range of concentration above which the crop is amply supplied and below which the crop is deficient to the extent that significant yield reductions would occur. In our study, the critical nitrate concentrations for most varieties were found to be comparable and a nutrient range was established to encompass all varieties and locations. The critical nutrient levels and their interpretations are presented in Table 5.

Once the CNR is established it can be used as a guide to assess the N status of a given potato crop if the growing stage is known. It is evident that as growth advances, the CNR progressively decrease, meaning that it is not essential to maintain a high soil N status throughout the growing season. Most varieties responded only up to 120 lbs/A of added N fertilizer. The data presented in Table 2 indicated that at N rates of 0 and 60 lbs/A, the sap N concentration decreased by greater than 100 ppm per week. The magnitude of this decline provides an added clue to the N status of the crop. If a grower measures the potato sap concentration at a particular time, and finds it to be within the CNR, it might be worthwhile to wait another week until corrective fertilization is applied. If in the following week, the sap N concentration is still within the CNR, but has decreased by more than 100 ppm, then it is advisable to apply supplemental N. If the concentration remains the same or has increased in the following week, the indication is that there is sufficient N in the soil.

The nitrogen rates tested in the Upper Peninsula are presented in Table 10. The yield data is summarized in Table 11. The previous crop at this location was alfalfa. This would partially explain the lack of clear yield response to added N at this location. Visual observations indicated that the zero N plots senesced earlier than the N treated plots. At all N rates, the US #1 yields of Russet Burbank were higher than R. Norkotah. Tuber size increased with higher N rates. In R. Norkotah, there was a significant increase in the percent tubers >10 oz. in all N treated plots compared to 0 N. Nitrogen treatments did not significantly affect the specific gravity of R. Norkotah, however, increasing N rates appeared to lower the specific gravity of R. Burbank.

Petiole sap nitrate concentration as of August 6 ranged from 500 ppm in the 0 N to 1390 ppm in the 180 lbs N treatment (Fig.11). As in the other 2 locations, the sap nitrate levels decreased rapidly with time in the 0 N treatments. At 180 lbs N, the sap nitrate level remained steady with time.
The Nitrogen mineralization curve (Fig.12) indicated that as high as 138 lbs N/A became available in the 0 N plots from soil organic matter by the middle of July. Nitrogen level rapidly declined thereafter presumably due to increased uptake by

potatoes. Soil test N levels during the season closely corresponded with the N rates applied to plots (Fig.13). Soil samples taken on July 31 indicated that all plots receiving fertilizer N tested greater than 100 lbs nitrate-N/A.

FUTURE RESEARCH

Future research should focus on expanded field testing and validating of the sap nitrate test. The test should assess the N availability in the soil, improve N fertilizer efficiency and produce high quality potato yields. One aspect that needs to be further investigated is the timing of the test, particularly in relation to changes in soil moisture level. The sap nitrate test could serve as a decision support mechanism for growers who are concerned with possible late season N deficiencies. The expanded use of the sap nitrate test in conjunction with soil tests, would enable the grower to manipulate N fertilizer rates so as to leave minimal residual N in the field. Such an integrated approach would help identify instances where the soil N mineralization rates are high, where potatoes are not likely to respond to addition of N fertilizer, and where the potential for groundwater contamination is high.

Table 1. Nitrogen rates (lbs/A) and time of application in 1991 field experiments.

Treatment #	At-planting	Tuber initiation	Total N
1	0	0	0
2	60	0	60
3	60	60	120
4	60	120	180
5	60	180	240

Table 2. The average weekly decrease in the petiole sap nitrate concentration(ppm) in response to N fertilizer rate at Montcalm and MSU.

N rate (lbs/A)	Montcalm	MSU
0	212	164
60	186	126
120	98	42
180	69	35
240	58	37

Table 3. Yield of US # 1 potatoes (cwt/a) in relation to fertilizer nitrogen fertilizer rate. Montcalm 1991.

N rate lbs/a	Onaway	Superior	R.Norkotah	Atlantic	Snowden	R.Burbank
0	306.8 b	227.6 b	328.0 c	364.7 b	286.1 b	316.6 b
60	354.8 ab	310.8 a	358.2 bc	412.1 a	340.9 b	352.9 ab
120	394.5 a	299.1 a	416.1 ab	428.4 a	421.9 a	403.5 a
180	393.0 a	310.2 a	429.7 a	440.4 a	434.9 a	421.7 a
240	374.2 ab	291.9 a	424.4 a	434.6 a	463.5 a	395.8 a

Table 4. Percent of US # 1 potatoes in relation to fertilizer nitrogen rate. Montcalm 1991.

N rate lbs/a	Onaway	Superior	R.Norkotah	Atlantic	Snowden	R.Burbank
0	88	91	92	96	91	78
60	90	95	93	97	92	83
120	91	96	94	97	95	80
180	90	96	94	97	94	78
240	88	96	93	97	94	73

Table 5. Specific gravity of potatoes in relation to fertilizer nitrogen rate. Montcalm 1991.

N rate lbs/a	Onaway	Superior	R.Norkotah	Atlantic	Snowden	R.Burbank
0	1.067	1.068	1.070	1.087	1.077 b	1.080
60	1.067	1.070	1.070	1.088	1.083 a	1.081
120	1.068	1.070	1.071	1.091	1.083 a	1.081
180	1.068	1.070	1.070	1.091	1.086 a	1.080
240	1.066	1.068	1.068	1.088	1.084 a	1.080

Table 6. Yield of US # 1 potatoes (cwt/a) in relation to fertilizer nitrogen fertilizer rate. MSU 1991.

N rate lbs/a	Onaway	Superior	R.Norkotah	Atlantic	Snowden	R.Burbank
0	256.3 b	185.7 b	248.9 b	329.6 b	253.5 b	332.9 b
60	287.7 ab	245.2 a	314.8 ab	345.6 ab	318.8 a	411.5 ab
120	314.8 a	234.4 ab	370.5 a	392.1 a	334.5 a	427.5 ab
180	317.6 a	262.1 a	385.0 a	375.4 a	315.7 a	450.3 a
240	316.6 a	229.9 ab	355.1 a	378.9 a	324.6 a	367.8 ab

Table 7. Percent of US # 1 potatoes in relation to fertilizer nitrogen rate. MSU 1991.

N rate lbs/a	Onaway	Superior	R.Norkotah	Atlantic	Snowden	R.Burbank
0	87	85	90	96	93	68
60	89	96	92	96	93	65
120	91	94	90	96	93	62
180	90	94	93	96	91	60
240	89	95	92	94	91	60

Table 8. Specific gravity of potatoes in relation to fertilizer nitrogen rate. MSU 1991.

N rate lbs/a	Onaway	Superior	R.Norkotah	Atlantic	Snowden	R.Burbank
0	1.065	1.064	1.066	1.082	1.072 b	1.076 b
60	1.069	1.068	1.068	1.081	1.079 a	1.082 a
120	1.068	1.067	1.070	1.084	1.079 a	1.081 a
180	1.068	1.066	1.068	1.081	1.078 ab	1.080 a
240	1.067	1.066	1.067	1.081	1.075 ab	1.075 b

Table 9. Proposed guidelines for interpreting sap nitrate concentration (ppm) of potato petioles for six weeks starting from a week after tuber initiation (TI)

Interpretation	June 27	July 3	July 9	July 17	July 24	Aug 1
	TI + 7	TI + 14	TI + 21	TI + 28	TI + 35	TI + 42
GDD* for Montcalm	885	1038	1175	1430	1530	1690
GDD* for MSU	970	1144	1271	1575	1674	1846
Inadequate	< 1200	< 1100	< 1000	< 900	< 800	< 700
Critical Range	1200-1399	1100-1299	1000-1199	900-1099	800-999	700-899
Adequate	1400-1599	1300-1499	1200-1399	1100-1299	1000-1199	900-1099
Excessive	>1600	> 1500	> 1400	> 1300	> 1200	>1100

* Growing degree days (base 50 F) since planting

Table 10. Nitrogen Applied (lbs/A) to 1991 trial in the Upper Peninsula

Treatment Number	Planting	Tuber Initiation	Total N Applied
1 & 2	0	0	0
3 & 4	60	0	60
5 & 6	60	60	120
7 & 8	60	120	180

Table 11. The effect of rate and time of nitrogen fertilizer application on yield, tuber size and specific gravity of potatoes in the Upper Peninsula

Treat -ment No.	N rate lb/A	Variety	U.S. No 1	Total Yield	---- Tuber Size Distribution ---- #1	<4 oz	>10 oz	Pickout	Specific Gravity
			---- cwt/A ----		------------ percentage ------------				
1	0	R Norkotah	250	304 bc	82 ab	18 a	11 c	1 b	1.073
2	0	R Burbank	295	361 abc	82 ab	16 a	14 bc	2 b	1.086
3	60	R Norkotah	264	304 bc	87 a	13 b	16 ab	0 b	1.070
4	60	R Burbank	300	393 a	76 bc	14 b	15 bc	9 a	1.085
5	120	R Norkotah	249	293 c	85 a	15 ab	16 ab	0 b	1.070
6	120	R Burbank	293	384 ab	76 bc	10 bc	15 bc	14 a	1.081
7	180	R Norkotah	283	321 bc	88 a	12 b	21 a	0 b	1.073
8	180	R Burbank	308	417 a	74 c	12 b	17 ab	14 a	1.082

Means within a column followed by the same letter are not significantly different (p<.05) according to the LSD test.

Fig.1. Petiole nitrate concentration
in relation to N rate - Montcalm 1991

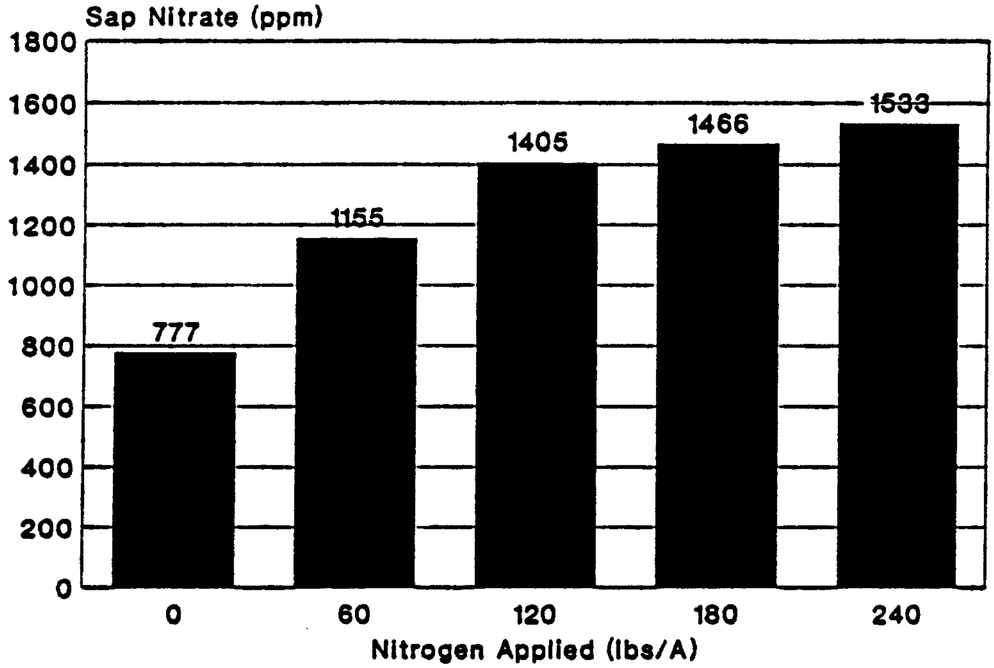


Fig.2.Petiole nitrate concentration
in relation to N rate MSU 1991

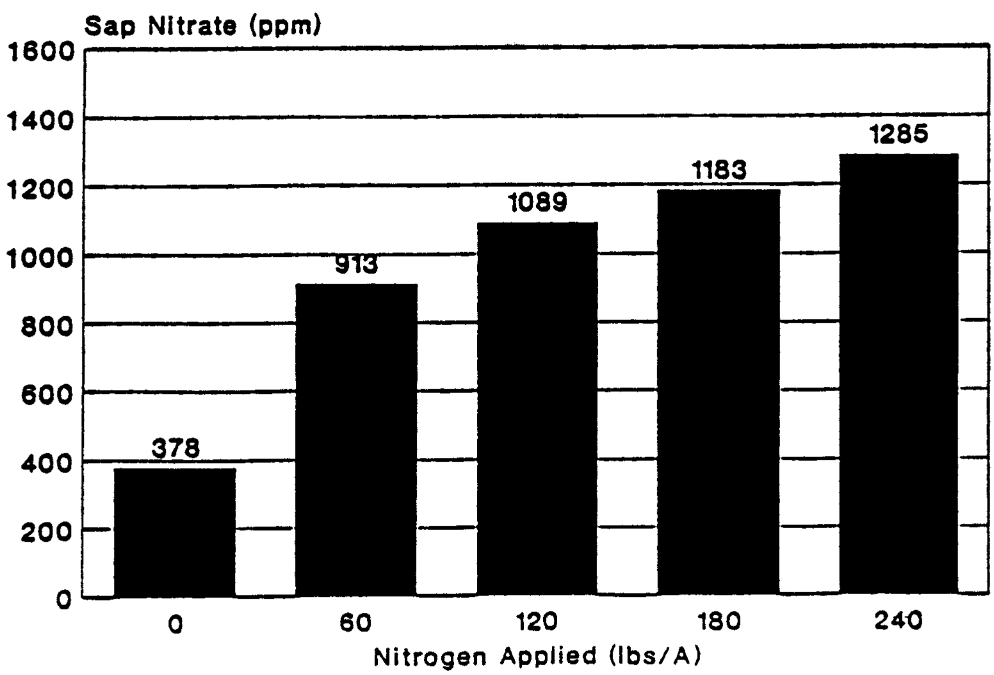


Fig 3. Sap nitrate level in relation to date of sampling - Montcalm 1991

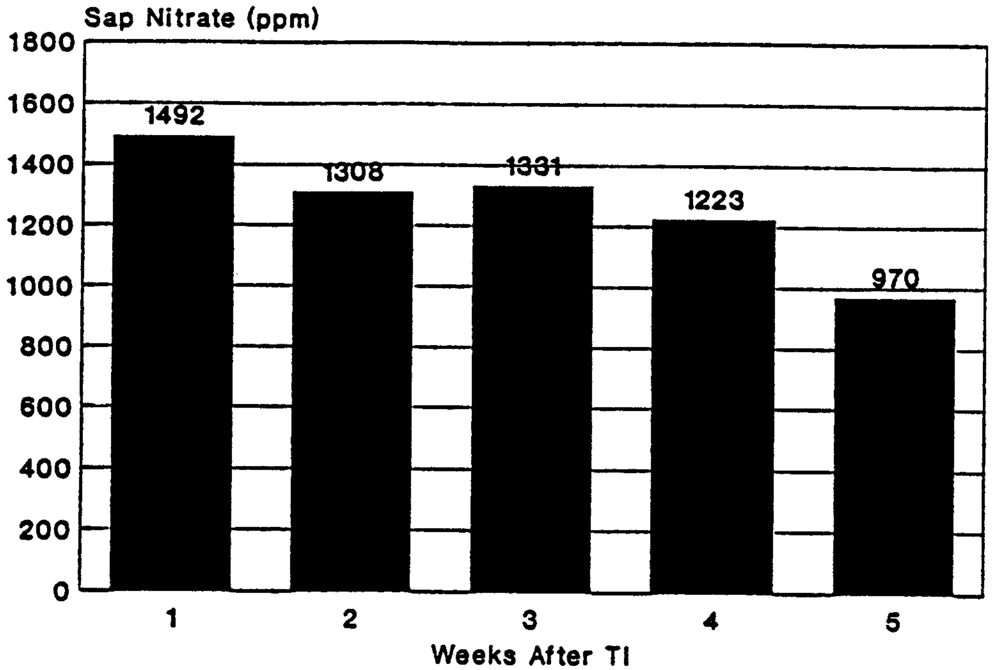


Fig 4. Sap nitrate level in relation to date of sampling - MSU 1991

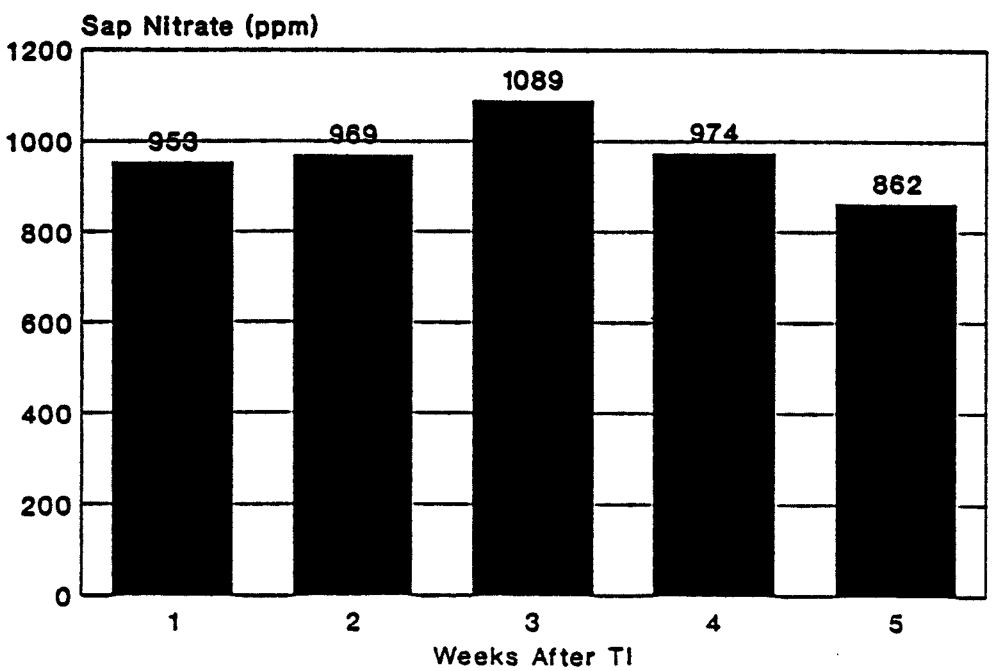


Fig 5. Petiole sap Nitrate in relation to N rate and sampling date at Montcalm

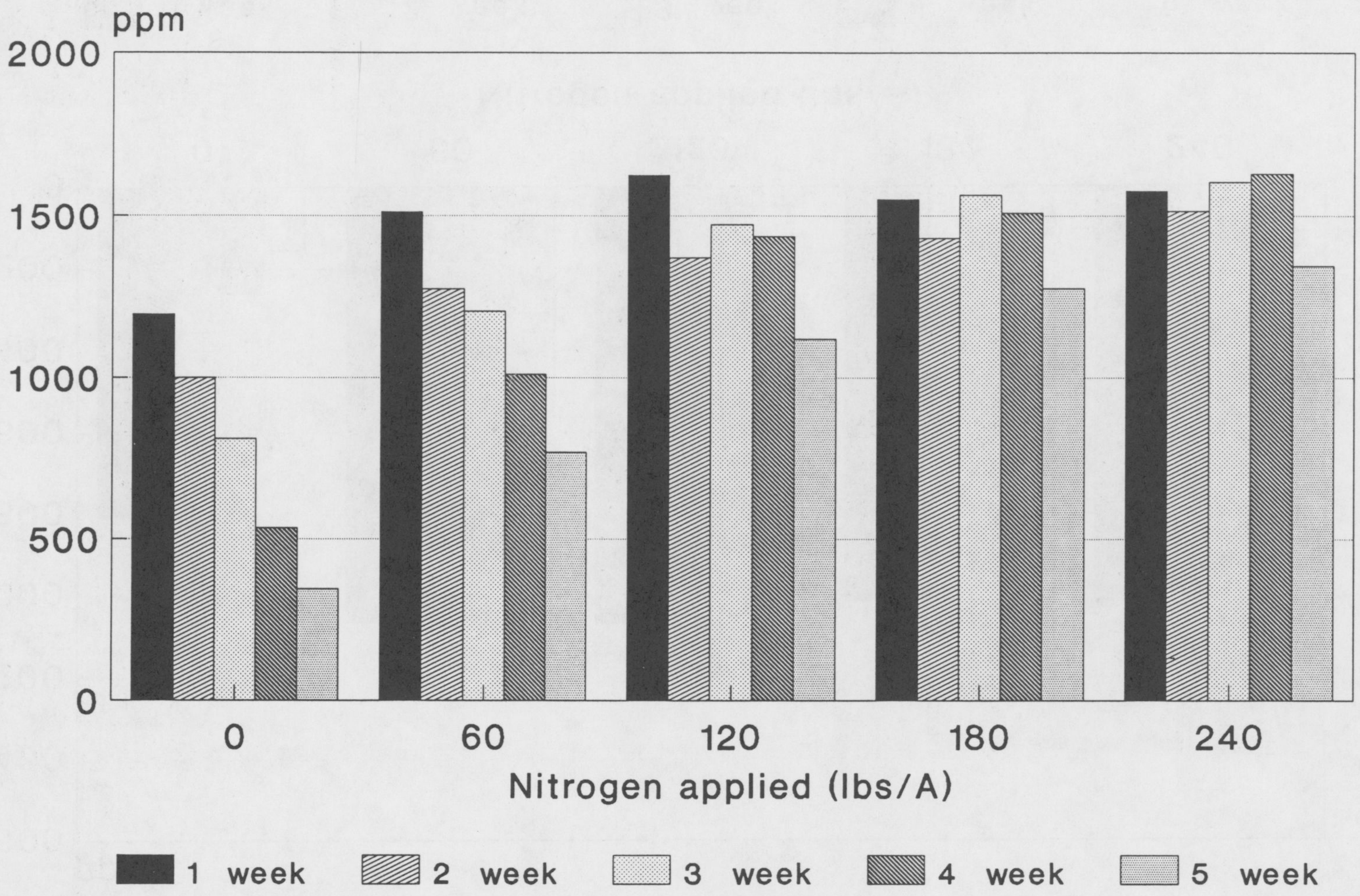


Fig 6. Petiole Sap Nitrate in relation to N rate and sampling date at MSU

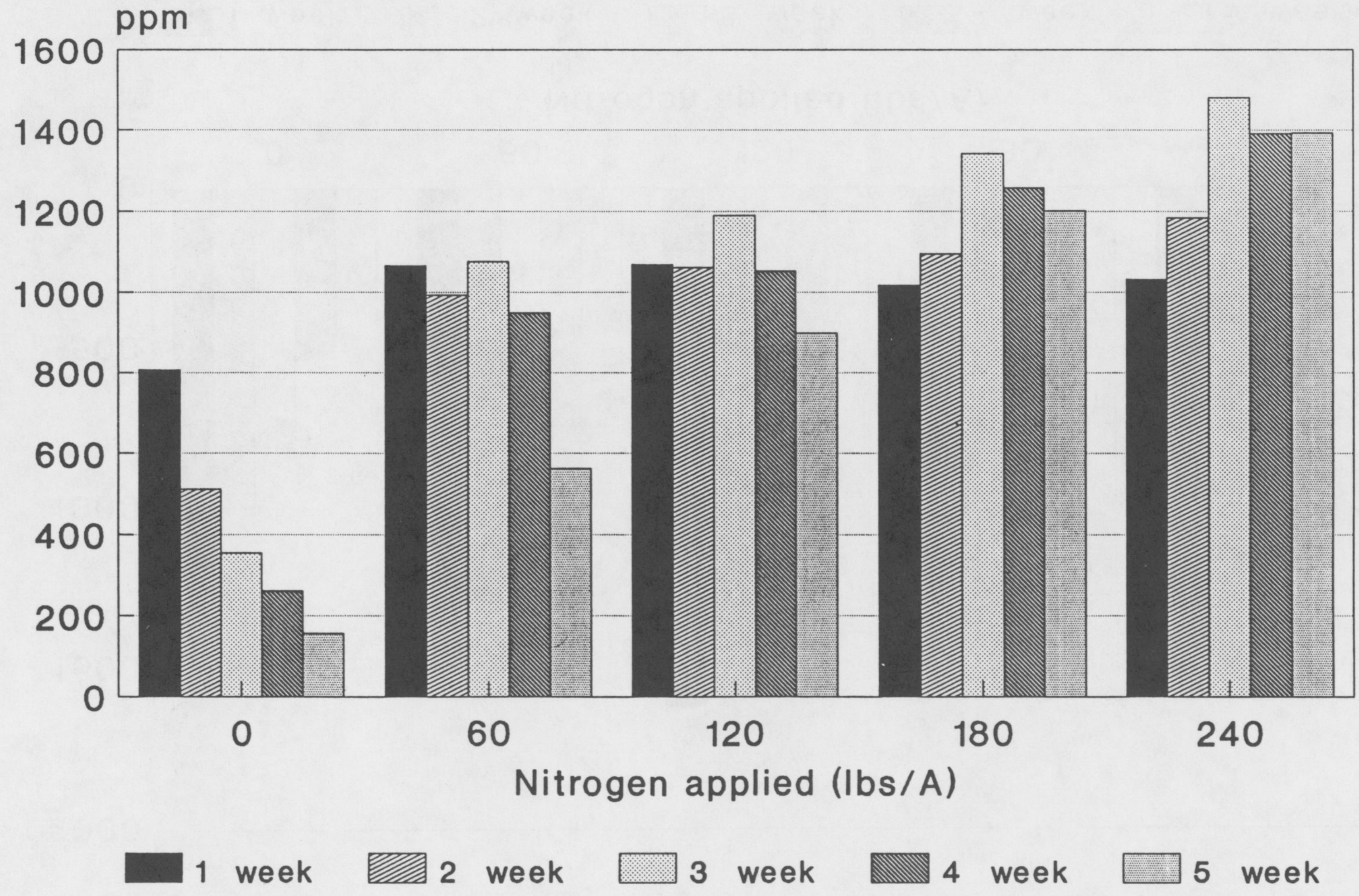


Fig.7. Nitrogen transformations in zero N plots at Montcalm 1991

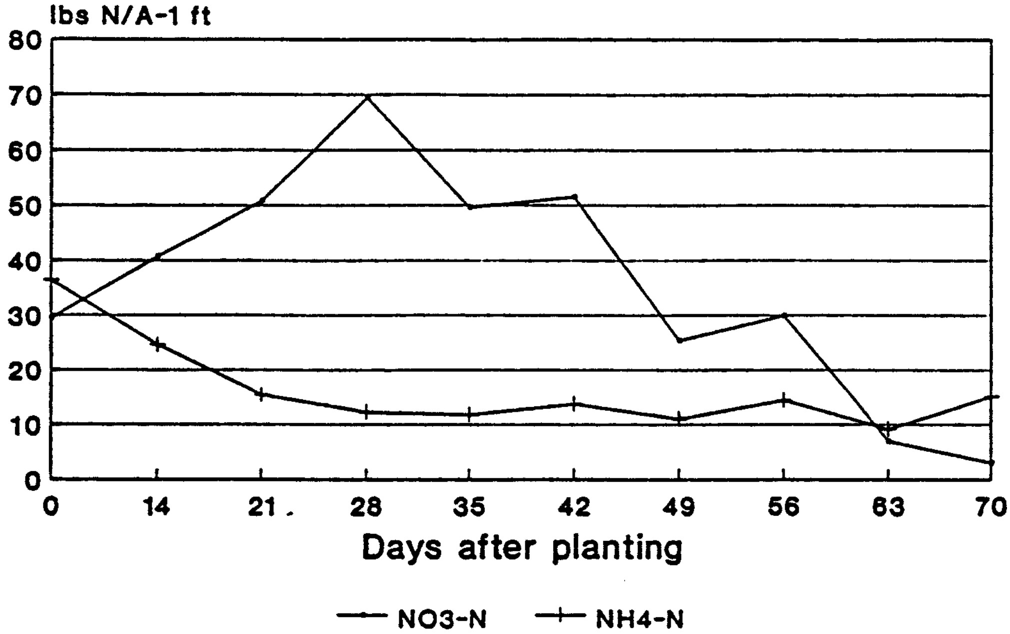


Fig 8.Nitrogen transformations in zero N plots - MSU 1991

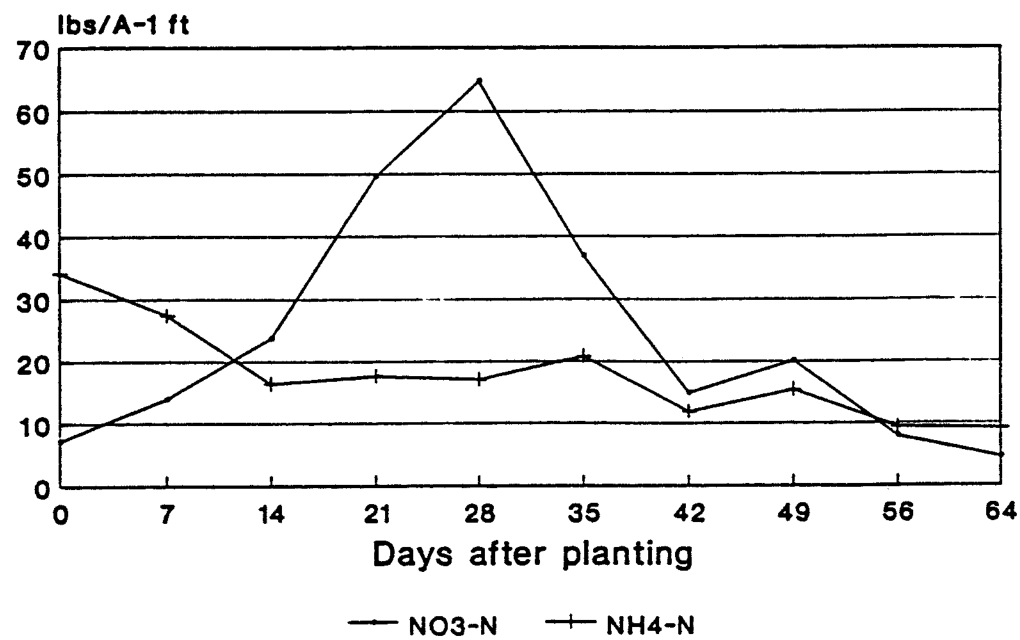


Fig 9. Soil test N in relation to fertilizer N rate - Montcalm 1991

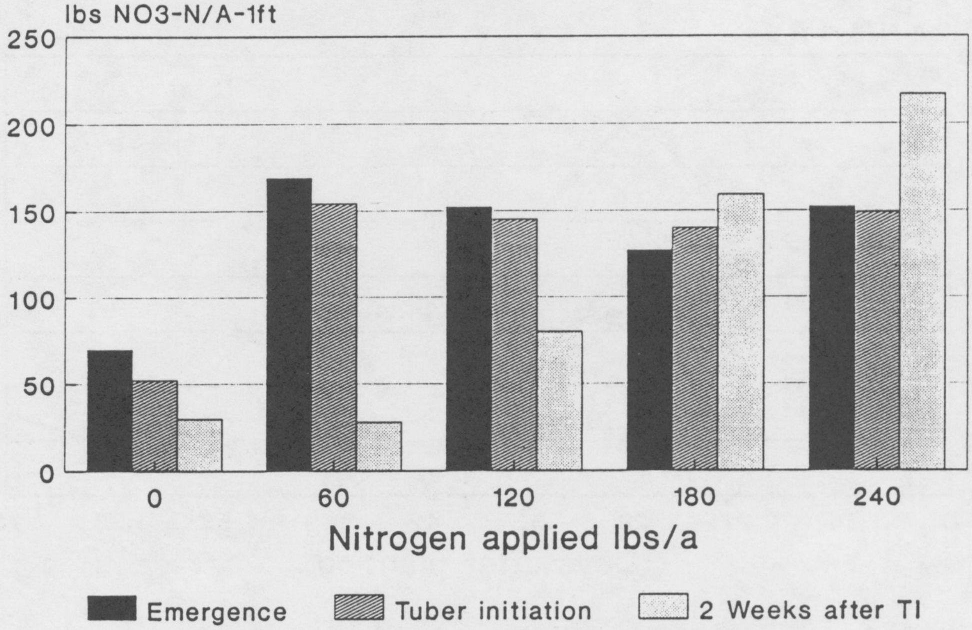


Fig 10. Soil test N in relation to fertilizer N rate - MSU 1991

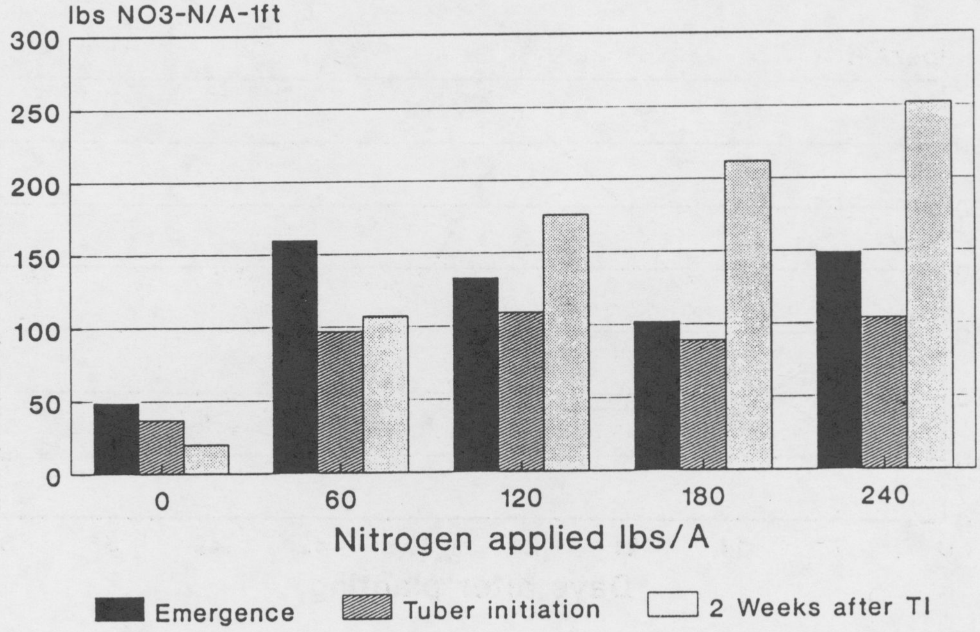


Fig.11 Petiole Sap Nitrate in relation N rate and sampling date - U.P. 1991

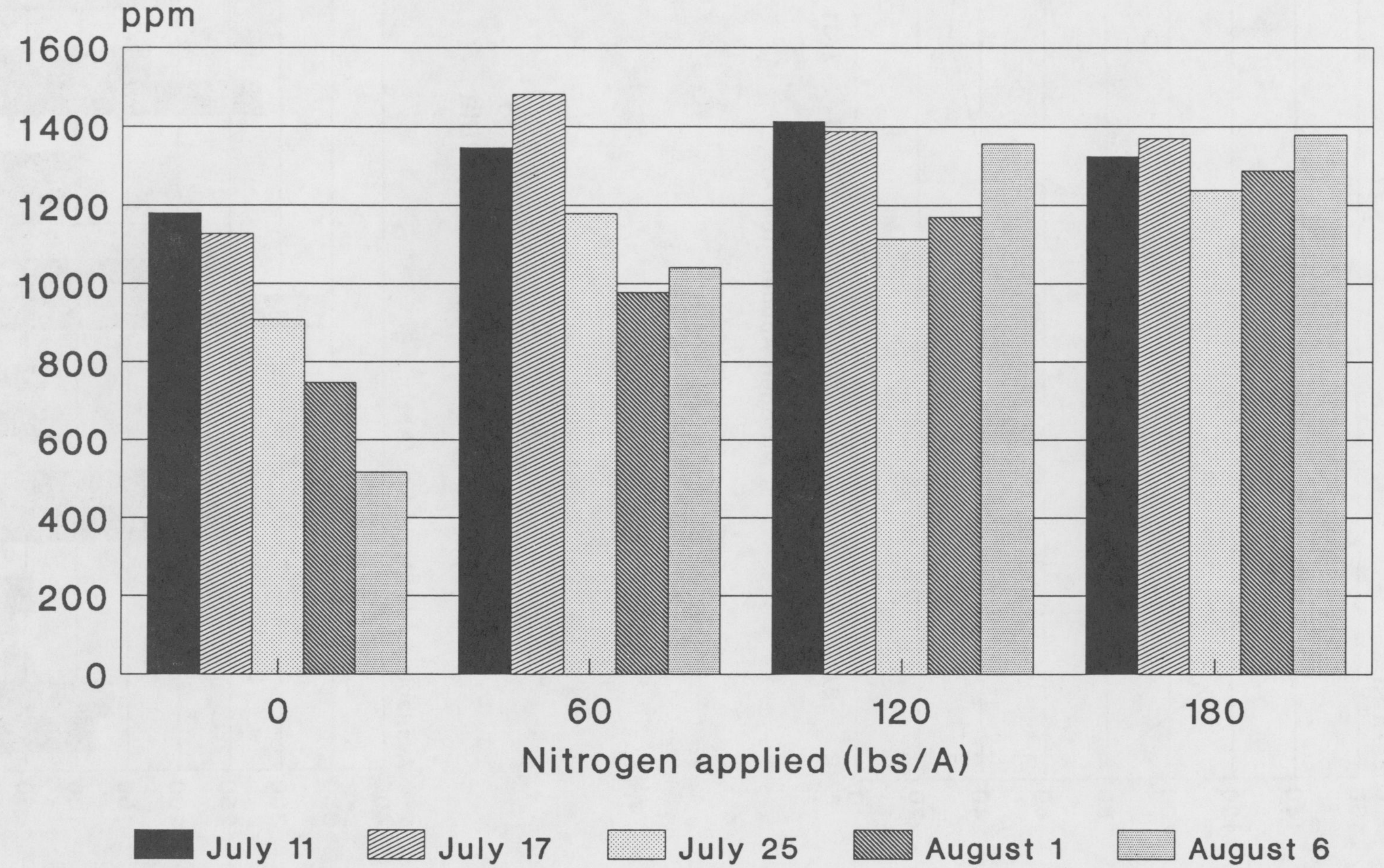


Fig 12. Nitrogen mineralization in the Upper Peninsula 1991

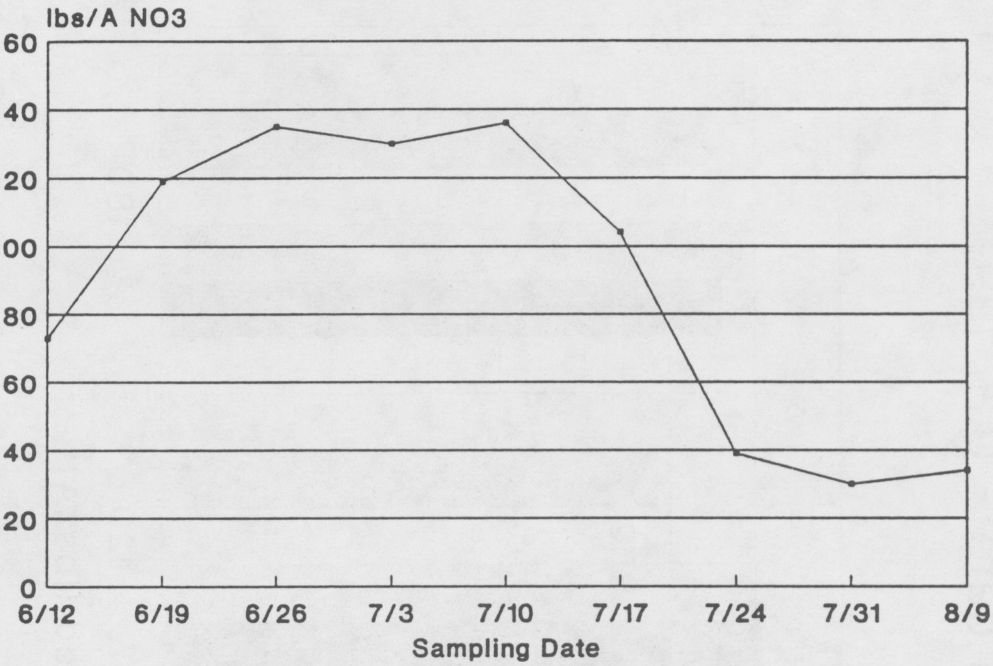
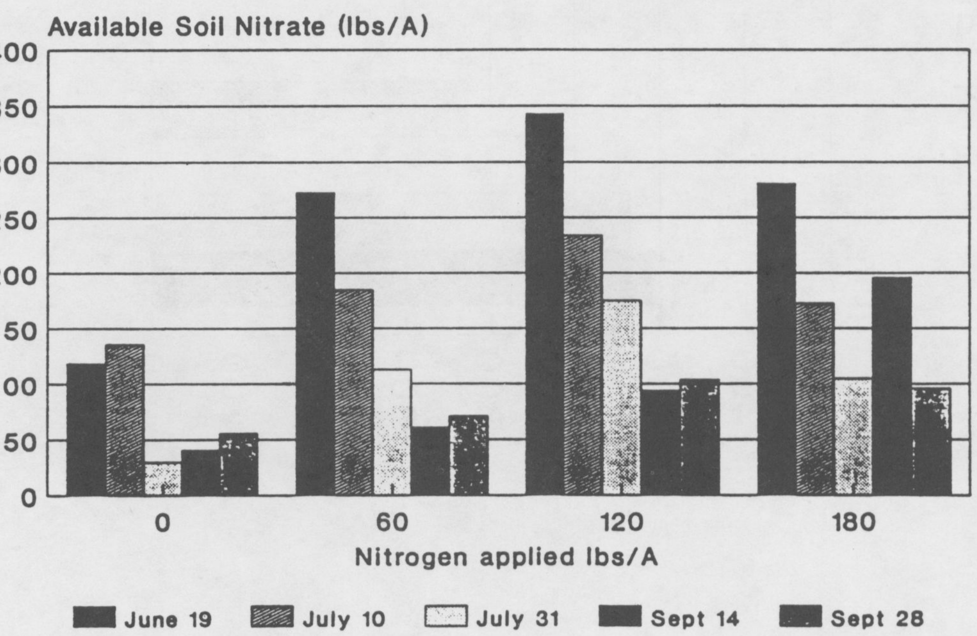


Fig 13. Soil test N in relation to fertilizer N rate-Upper Peninsula



Funding MPIC

UNDERSTANDING THE RESPONSE OF POTATOES TO PHOSPHORUS

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Although the phosphorus requirement of a potato crop is similar to that of other field and vegetable crops, potatoes require higher levels of phosphorus fertilization to produce good yields. Field studies with Russett Burbank potaotes have shown improved yields with band application of phosphorus at planting time even though phosphorus soil test levels have been very high, greater than 400 lb P/A. This is a source of concern for efficient use of resources, monetary and phosphorus, and for the loading of phosphorus into surface waters. On fields where surface runoff occurs phosphorus is carried with the soil. With these issues in mind a better understanding of the response of potatoes to soil and fertilizer phosphorus is needed.

A number of studies were conducted in 1991 to improve our understanding of the response of potatoes to phosphorus. Preliminary studies have indicated that the soluble phosphorus concentration in many soils used for growing potatoes is very low and may be limiting phosphorus uptake and potato plant growth. Potato plants were grown in solution culture to study the ability of potato roots to take up phosphorus from solution at varying phosphorus concentrations. In two separate studies plants of Atlantic, Sebago and Onaway were grown in aerated nutrient solution containing limited phosphorus. The roots of these plants were able to reduce the concentration of phosphorus to between 0.05 and 0.08 mg/l which is similar to that found in the soil solution of some soils. In a separate study plants of Atlantic and Sebago potatoes were grown for 8 hours in aerated nutrient solutions containing six different phosphorus concentrations. The relative rate of phosphorus uptake decreased greatly as the solution phosphorus concentration was decreased (Table 1). At a solution concentration of 0.1 mg P/l (many soils have solution concentrations less than this) the phosphorus uptake rates were less than 20 and 15 percent of the maximum, respectively, for Atlantic and Sebago.

McBride sandy loam soil was collected from two separate fields and blended to give a range of available soil phosphorus from 200 to 700 lb P/A. In a previous field study each soil blend had received the equivalent of 0, 50, 100, 150 or 200 lb P_2O_5 /A. Prior to using the soil in this greenhouse study each soil treatment was thoroughly mixed and fumigated. Two sets of each soil treatment were put into 3 gallon containers. Corn was grown for 5 weeks in one set and Russett Norkotah potatoes were grown for 8 weeks in the other set. The objective was to compare the response of corn and potato to the indigenous soil phosphorus and to applied phosphorus fertilizer. This study primarily provided a comparison of the vegetative growth stages, although at harvest the potato plants had set some tubers. Data presented in Tables 2 and 3 indicate that the soil phosphorus level and the rate of phosphorus fertilization had little effect on the vegetative top growth of the corn or potatoes. However, the level of soil phosphorus did affect the underground development of the potato plant (Table 4). Although the number of tubers set after 8 weeks of growth were similar across all soil phosphorus levels, the number of rhizomes and the number of set tubers plus initiated rhizome tips (potential tubers) did increase with soil phosphorus level. This indicates that phosphorus may improve the potential for better yields by stimulating increased tuber numbers.

To further evaluate the effect of soil phosphorus level and phosphorus fertilizer application on potato growth and yield, Russett Norkotah potatoes were grown in McBride sandy loam soil contained in a 12 inch length of a 10 inch diameter solid plastic tile. McBride sandy loam soil was collected from two separate fields and blended to give soil with extractable phosphorus levels ranging from 200 to 900 lb P/A. The soil was fumigated with Metham to eliminate nematodes and verticillium (early die complex). The tile were placed vertically in a trench prior to being filled halfway with the respectively blended soil. A ring of phosphorus fertilizer was placed on the soil to provide the equivalent of 0, 50 ,100, 150 or 200 lb P_2O_5/A. After adding two more inches of soil a tuber was placed in each container and each container was filled with the respective soil blend. The potatoes were grown to maturity with watering and supplemental nitrogen and potassium as needed.

The yield data for this study are given in Tables 5 and 6. There was no interaction between soil phosphorus level and phosphorus fertilizer rate. Total tuber weight and tuber numbers tended to increase with increasing level of phosphorus in the soil. However, the biggest increase occurred in going from a soil phosphorus level of 200 lb P/A to 375 lb P/A. Specific gravity of the tubers decreased as the soil phosphorus levels increased. This may have been do to more small tubers being present with the higher phosphorus levels. Total tuber weight and tuber numbers tended to be increased by increased rates of phosphorus fertilizer (Table 6). The biggest increase occurred with the first 100 lb P_2O_5/A. Addition of more phosphorus was of little benefit. Specific gravity was not affected by the rate of phosphorus fertilization. Hence, it appears that near maximum tuber yields can be obtained with a soil phosphorus level of 375 lb P/A and a fertilizer rate of 100 lb P_2O_5/A.

Much of the potato-phosphorus response data has been developed with the cultivar Russett Burbank. Since Russett Burbank is a long season variety the response to phoshporus may differ from that of other varieties. Six varieties, Atlantic, Onaway, Snowden, Superior, Russett Burbank and Russett Norkotah were grown at three locations with four phosphorus fertilizer rates; 0, 75, 150 and 225 lb P_2O_5/A. This group of varieties includes both fresh market and chip types, and early and late season varieties. Each of the varieties was planted at the Montcalm Research Farm on a McBride sandy loam on May 3 and on an Essexvelle loamy sand in Bay County on April 26. Each treatment was replicated four times. Planting at the Monroe County site was delayed by heavy rains and wet soil until May 21. This site was plagued by heavy rain and most of the plots were lost to flooding. Hence, no meaningful data was collected from the Monroe County site.

At the Montcalm Research Farm five hills were harvested early, August 6, from the no and high phosphorus fertilizer rows of each variety to determine whether any differences existed in the development of tubers to that point in time. The harvest data is presented in Table 7. For Superior and Atlantic there were more tubers per hill with the potatoes receiving phosphorus. For the other varieties the tuber numbers were similar regardless of phosphorus fertilization. Total yield of tubers was markedly higher with phosphorus for Atlantic, but for Snowden the tuber weight was higher in the no phosphorus plots. With the exception of Russett Norkotah and Onaway the percent of tubers of less than 2 inch diameter or 4 ounce in weight was higher for the potatoes receiving phosphorus. This indicates there was more potential for increased yield by the potatoes receiving phosphorus. Specific gravity was higher in the potatoes fertilized with phosphorus for the Superior and Atlantic varieties. With the other varieties specific gravities were similar regardless of phosphorus fertilization.

End-of-season yield data are given in Table 8 for the four round white varieties grown on the McBride sandy loam with a phosphorus test level of over 500 lb P/A . With Atlantic total tuber yield and yield of 2 to 3.25 inch tubers were significantly increased by the application of phosphorus fertilizer. With the other three varieties there was a trend toward higher tuber yield with phosphorus fertilizer application, but the differences were not significant. In general there was a trend toward improved specific gravity with phosphorus application. Phosphorus fertilization with 75 lb P_2O_5/A improved total tuber and 4 to 10 ounce tuber yields of Russett Norkotah (Table 9). Increasing the phosphate rate beyond 75 lb P_2O_5/A provided no additional increase in tuber yield. Tuber yields of Russett Burbank were not affected by phosphorus fertilization. The specific gravity of Russett Norkotah tubers was improved by phosphorus application.

Growing conditions at the Bay County site were less than ideal during much of the growing season. The soil test phosphorus level in this Essexville loamy sand averaged 515 lb P_2O_5/A. The soil was quite wet during the early part of the growing season. Later in the season it was hot and dry, although water was applied by irrigation. Tuber yields were not significantly affected by phosphorus application in all six varieties (Tables 10, 11 and 12). Tuber yields of Superior were improved by application of up to 150 lb P_2O_5/A although the increase was not significant. With the low tuber yields phosphorus apparently was not a limiting factor. With higher yields and a greater demand for phosphorus a response to applied phoshorus would be more likely. Phosphorus application had no effect on specific gravity of tubers of all six varieties from this location.

Core samples of the tubers were analyzed for the nutrient content. The phosphorus content of the tubers, averaged across all varieties, increased as the phosphorus fertilizer increased. On the McBride sandy loam the average phosphorus contents of the harvested number 1 tubers were 0.206, 0.208, 0.218 and 0.228 percent on a dry weight basis for phosphorus fertilizer rates of 0, 75, 150 and 225 lb P_2O_5/A. The same respective phosphorus contents for the tubers harvested from the Essexville loamy sand were 0.242, 0.260, 0.279 and 0.273 percent. The order of phosphorus concentration in tubers of the six varieties was the same at the two sites. The average phosphorus content of the varieties across the two sites was: Atlantic - 0.210 %; Snowden - 0.214 %; Onaway - 0.244 %; Superior - 0.242 %; Russett Burbank - 0.250 %; Russett Norkotah - 0.279 %. Hence, depending on the variety and the specific gravity the phosphorus removal in the harvested tubers will be near 4 lb P/cwt (9.1 lb P_2O_5/cwt).

In summary, even though the roots of potatoes have the ability to take up phosphorus at very low concentrations in solution, the rate of phosphorus uptake is greatly reduced compared with the uptake rate at higher solution phosphorus concentrations. Thus in soils having low levels of phosphorus in the soil solution extensive root growth would be necessary for adequate phosphorus uptake to occur. Greenhouse studies indicate that the response of potatoes to high levels of phosphorus is not in vegetative growth , but is related to the effects on initiation of rhizomes and tubers. Rhizome numbers and number of initiated tuber tips increased with soil phosphorus level. In a field study the number of tubers set and developed increased with increasing soil phosphorus levels and with phosphorus fertilizer application up to 100 lb P_2O_5/A. The yields of

Atlantic and Russett Norkotah potatoes were significantly increased by the application of 75 lb P_2O_5/A when grown on a McBride sandy loam having an extractable phosphorus level of over 500 lb P/A. With the other four varieties (Onaway, Snowden, Superior and Russett Burbank) there was only a limited response to the application of phosphorus. When grown in an Essexville loamy sand with a phosphorus test level of 515 lb P/A none of the six varieties responded to the application of phosphorus fertilizer. The effect of phosphorus fertilization on specific gravity was mixed. In most cases phosphorus application had no effect on specific gravity, but in a few cases the highest rate of phosphorus application did increase the specific gravity.

Table 1. Ability of potato roots to reduce the phosphorus concentration in a nutrient solution.

Initial Solution P Concentration	Relative Uptake Rate	8 hour change in P concentration Atlantic	Sebago	Relative Uptake Rate
mg P/l	%	mg/l	mg/l	%
0.07	2	.016	.014	1.4
0.11	8	.061	.049	5
0.25	20	.147	.055	6
0.55	53	.382	.385	39
1.26	95	.691	.748	75
2.79	100	.724	.992	100

Table 2. Corn and potato growth with increasing soil phosphorus.

Soil P level[z]	Corn Top Fresh Weight	Potato Top Fresh Weight
lb P/A	g	g
200	265	197
325	274	186
450	287	202
575	290	189
700	270	194

[z]Bray-Kurtz P1 extractable phosphorus in a Mc Bride sandy loam.

Table 3. Corn and potato growth with increasing phosphorus fertilization.

Phosphorus Rate	Corn Top Fresh Weight	Potato Top Fresh Weight
lb P_2O_5/A	g	g
0	273	198
50	290	190
100	277	195
150	268	189
200	271	196

Table 4. Influence of soil phosphorus level on potato rhizome and tuber development.

Soil P Level	Rhizomes	Tubers Set	Set Tubers + Initiated Tips
lb P/A	#/plant	#/plant	#/plant
200	5.6	3.1	10.2
325	4.6	3.4	7.7
450	5.7	3.7	11.8
575	6.4	3.1	12.3
700	7.1	2.4	14.2

Table 5. Influence of extractable soil phosphorus level on the yield of potatoes (cv.Russett Norkotah) grown in McBride sandy loam soil.[z]

Soil P[y] level	Yield		Number		Specific Gravity
	Total	> 4oz	Total	> 4oz	
lb P_2O_5/A	- - - cwt/A - - -		- Tuber/plant -		
200	211	98	7.0	1.7	1.071
375	242	108	7.9	1.9	1.069
550	220	83	8.1	1.5	1.068
725	257	107	6.8	1.8	1.067
900	248	108	8.6	1.9	1.066

[z]Soil was contained in a 12 inch length of a 10 inch diameter plastic tile. Yield data is across five different fertilizer rates.
[y]Soil P level as determined by Bray-Kurtz P1 extraction.

Table 6. Influence of phosphorus fertilization on the yield of potatoes (cv Russett Norkotah) grown in McBride sandy loam soil.[z]

Soil P[y] level	Yield		Number		Specific Gravity
	Total	> 4oz	Total	>4oz	
lb P_2O_5/A	- - - cwt/A - - -		- Tuber/plant -		
0	170	53	6.3	1.1	1.069
50	229	109	7.1	1.9	1.067
100	259	104	8.0	1.8	1.069
150	250	115	8.1	1.9	1.068
200	271	122	9.0	2.1	1.068

[z]Soil was contained in a 12 inch length of a 10 inch diameter plastic tile. Yield data is across five different fertilizer rates.
[y]Yield data is across five different soil P levels.

Table 7. Influence of phosphorus fertilzation on potato growth and yield data in a McBride sandy loam. Harvested August 6, 1991.

Variety	P_2O_5 Rate	Tubers/ Hill	Total	>2" by wt.	< 2" count	Specific Gravity
			cwt/A	%	%	
Onaway	0	10.3	350	89	35	1.064
	225	9.7	362	89	37	1.063
Superior	0	7.1	310	77	38	1.064
	225	8.3	318	79	44	1.069
Atlantic	0	7.6	310	93	25	1.086
	225	9.5	370	89	32	1.091
Snowden	0	10.7	350	82	38	1.078
	225	10.0	320	74	47	1.077
				> 4oz	< 4oz	
Rus. Burbank	0	9.7	300	67	61	1.070
	225	9.7	275	55	69	1.071
Rus. Norkotah	0	6.1	317	82	50	1.066
	225	5.7	300	83	37	1.067

Table 8. Influence of band phosphorus applicaton on the yield of four round white potato varieties grown in a Mc Bride sandy loam.

Phosphorus Rate	Yield: Total	>3¼"	2-3¼"	<2"	Specific Gravity
lb P_2O_5/A	- - - - - - - - -	cwt/A	- - - - - - - - - -		
		Superior			
0	190	17 a	154	17 b	1.063 b
75	181	8 b	156	15 b	1.064 b
150	180	6 b	157	17 b	1.064 b
225	206	6 b	176	22 a	1.067 a
	ns		ns		
		Onaway			
0	219	75 ab	128	11 ab	1.063
75	198	60 b	119	6 c	1.064
150	206	76 ab	116	8 bc	1.063
225	233	84 a	132	12 a	1.063
	ns		ns		ns
		Atlantic			
0	373 b	110	230 b	23	1.082 b
75	472 ab	116	325 ab	26	1.085 a
150	497 a	112	351 a	29	1.085 a
225	489 a	101	348 a	29	1.084 ab
		ns		ns	
		Snowden			
0	459	34	377	41	1.079 b
75	478	37	397	38	1.079 b
150	459	39	378	38	1.080 ab
225	483	46	388	42	1.83 a
	ns	ns	ns	ns	

Table 9. Influence of band phosphorus applicaton on the yield of two long white russett potato varieties grown on a McBride sandy loam.

Phosphorus Rate	Yield				Specific Gravity
	Total	>10 oz	4-10 oz	<4 oz	
lb P_2O_5/A	- - - - - - - - -	cwt/A	- - - - - - - - - -		
		Russett Norkotah			
0	436 b	161	202 b	55	1.062 b
75	474 ab	184	223 ab	51	1.067 a
150	488 a	168	243 a	55	1.065 ab
225	489 a	191	228 ab	53	1.066 a
		ns		ns	
		Russett Burbank			
0	424	80	194	80	1.072
75	450	75	200	81	1.071
150	449	69	194	87	1.070
225	427	54	202	90	1.072
	ns	ns	ns	ns	ns

Table 10. Influence of band phosphorus application on yields of potatoes grown in an Essexville loamy sand.

Phosphorus Rate	Atlantic			Snowden		
	Total Yield	2-3¼	Specific Gravity	Total Yield	2-3¼	Specific Gravity
lb P_2O_5	- - - cwt/A - - -			- - - cwt/A - - -		
0	288	233	1.079	283	215	1.075
75	297	231	1.073	274	210	1.076
150	301	234	1.076	252	182	1.073
225	275	225	1.078	263	187	1.071
	ns	ns	ns	ns	ns	ns

Table 11. Influence of band phosphorus application on yields of potatoes grown in an Essexville loamy sand.

Phosphorus Rate	Onaway Total Yield	Onaway 2-3¼	Onaway Specific Gravity	Superior Total Yield	Superior 2-3¼	Superior Specific Gravity
lb P_2O_5	- - - cwt/A - - -			- - - cwt/A - - -		
0	293	228	1.058	203	158	1.064
75	245	178	1.059	219	172	1.064
150	268	201	1.059	252	196	1.064
225	272	213	1.063	257	195	1.066
	ns	ns	ns	ns	ns	ns

Table 12. Influence of band phosphorus application on yields of potatoes grown in an Essexville loamy sand.

Phosphorus Rate	Russet Norkotah Total Yield	Russet Norkotah 4-10 oz	Russet Norkotah Specific Gravity	Russet Burbank Total Yield	Russet Burbank 4-10 oz	Russet Burbank Specific Gravity
lb P_2O_5	- - - cwt/A - - -			- - - cwt/A - - -		
0	272	140	1.060	232	122	1.064
75	261	132	1.058	263	154	1.068
150	289	157	1.059	229	118	1.064
225	270	141	1.060	239	117	1.066
	ns	ns	ns	ns	ns	ns

Funding Federal Grant

Colorado Potato Beetle Management
1991 Potato Research Report

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Summary

Research in 1991 focused on 1) evaluation of genetically-engineered *Bacillus thuringiensis* potato plants for control of Colorado potato beetle, 2) trap crop systems to increase the efficiency of mechanical control of CPB, 3) comparison of flight behavior and flight muscle status between fed and starved adult CPB, 4) insecticides for control of CPB, 5) evaluation of Trigard for control of CPB, 6) design and evaluation of corn/potato rotational systems for minimizing dispersal of postdiapause CPB, and 7) preparation and distribution of insecticide-resistance test kits.

Research clearly showed that vacuuming early in the season and propane burning at vine kill could effectively control large larvae. Genetically-engineered *Bacillus thuringiensis* potato plants had significantly less CPB defoliation than non-transformed potatoes or a commercial cultivar sprayed with insecticide. Examination of transmission electron micrographs shows differences between flight muscles of fed and starved beetles. These differences indicate that beetles that have been starved for longer than 5 days have a reduced ability to disperse by flight. Insecticide evaluation studies showed that several insecticides, including Kryocide, Cryolite, Imidan & PBO and M-Trak gave adequate control of CPB larvae, reduced defoliation, and resulted in the highest yields. In addition, the insect growth regulator Trigard gave good control of CPB at three different rates. The presence of volunteer potatoes in a rotated corn field reduced dispersal of overwintered CPB out of the corn and into the new potato field. Reduced dispersal due to the volunteers could potentially reduce the number of CPB colonizing a new potato field, resulting in increased effectiveness of rotation as a management strategy. In addition, by discouraging dispersal, volunteer potatoes in a rotational crop may minimize the spread of insecticide resistance genes. Analysis of results of the resistance test kit indicates that resistance to most insecticides in CPB has increased dramatically in Michigan over the past few years.

Introduction

1991 was a banner year for Colorado potato beetles. The very warm temperatures early in the year resulted in many beetles emerging from overwintering diapause before crops were up. There was much dispersal early in the year and flight was observed often. This dispersal may have spread insecticide resistance genes to new populations, resulting in many fields where CPB were uncontrollable with standard insecticides.

Research in 1991 focused on finding new methods to control CPB. The insecticide resistance test kit developed in 1988 was available to growers for $10 through the M.S.U. Plant and Pest Diagnostic Laboratory. Two sets of insecticide evaluation trials were conducted. One set evaluated the insect growth regulator Trigard for control of CPB. In addition, potato plants that were genetically engineered by Montsanto with the Btt gene were tested in the field for control of CPB.

Research also focused on non-insecticide methods of CPB control. Ways to increase the effectiveness and efficiency of mechanical vacuum cleaners were investigated by planting perferred "trap crops" to attract beetles. Studies on CPB dispersal were also continued. Furthur investigations into the effect of feeding on beetles' flight behavior and flight muscle status were done. Also studied was the potential for volunteer potatoes to inhibit dispersal of overwintered CPB out of a rotated crop (last year's potatoes) and into the current year's potatoes, thus reducing the number of beetles colonizing the new crop.

Funding for these projects was provided by the Michigan Potato Quality Grant and the National Potato Council Grant Program. Funding for studies in previous years was obtained from the North Central Regional IPM Grant Program. Additional support was provided by the respective agrichemical industries. Resistance test kits were developed with support from the Michigan Energy Conservation Program.

Evaluation of trap crop systems to increase the efficiency of mechanical control of CPB. Trap crops were planted at the Smith Brothers Farm in Monroe Co. MI, on April 26, 1991. Eggplant and shallow or normal planted 'Snowden' potatoes were planted in four row plots at the border of a side-by-side crop rotation field. The number of CPB per plant was recorded weekly when the first CPB were found at the field. The eggplant and 'Snowden' potatoes were highly attractive as trap crops. Ten days after the adults had emerged there were 4.1 beetles per plant in the Snowden trap crop compared to 1.8 per plant, seven rows into the planting.

Full evaluation of the trap crop system was not possible in 1991 due to emergence of beetles 3 weeks earlier than normal. The vacuum that was most extensively tested arrived late (on time for most years) and required extensive modifications to improve effectiveness. As a result, the trap crops were destroyed by the beetles before vacuuming was implemented and the beetles went on to invade the rest of the field.

Research in 1991 clearly showed that vacumming early in the season and propane burning at vine kill could be effective (e.g. 88 and 79% contol of large larvae for two different crop vacuums and a burner, respectively). In addition to the direct effects of the vacuums on the adults and larvae, eggs were also removed or injured as the result of the movement of soil caused by the vacuum. Scanning electron micrographs of CPB eggs after vacuuming show severe abrasion to egg surface (Figure 1). The impact of this abrasion on eggs and small larvae has not been evaluated. It may be critical, however, since these CPB stages are the least effectively vacuumed and effects on these stages may allow longer intervals between vacuuming.

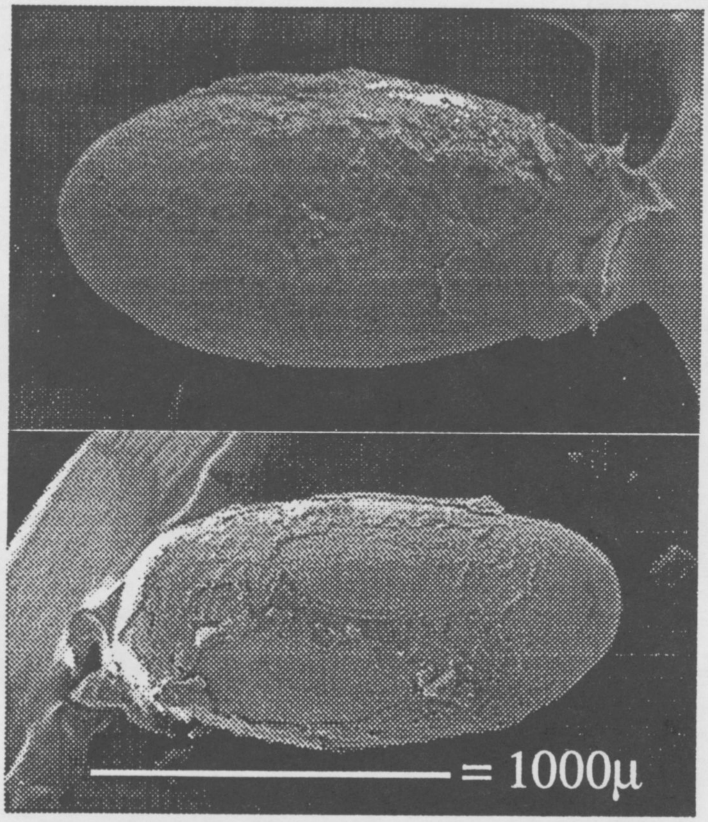

Figure 1. Scanning electron micrographs of normal (top) and vacuumed (bottom) Colorado potato beetle eggs. Cracks on surface of normal egg are artifacts of the electron beam. In the vacuumed egg, severe surface abrasion and sand particles can be seen.

Evaluation of genetically-engineered <u>Bacillus thuringiensis</u> potato plants for control of Colorado potato beetle. Transgenic and nontransformed seed potatoes were planted on 20 May at the MSU Montcalm Potato Research Station, Entrican, MI. Treatments included four Btt transformed minituber lines, a nontransformed minituber line, commercial 'Russet Burbank' seed, and commercial 'Russet Burbank' seed that was treated with Asana XL and PBO (0.05 #ai/A and 8.0 oz/A, respectively) weekly from 6 June through 8 August. Treatment effectiveness was determined by counting the total number of insects found on the center six plants of each treatment twice weekly from 19 Jun through 9 Aug. Plants were visually assessed for defoliation on 8 Jul. On 3 Oct all treatment rows were harvested and tubers were separated by size (A's and B's) and weighed.

Slow plant emergence was characteristic of all transgenic plant types compared to the nontransformed minitubers and commercial cultivar. This slow growth rate was probably the result of inadequate vernalization of the transgenic seed. Commercial seed emerged sooner than the minitubers (transgenic and nontransformed) and plants were defoliated due to the extreme beetle pressure in mid May and early Jun. Significant differences in the number of egg masses, small larvae, large larvae, and adults were found between the transgenic and other plant types on the various sampling days. No significant differences in insect number or defoliation were found between transgenic lines (Table 1). The transgenic plants had significantly lower defoliation ratings than the nontransformed and commercial plant types. The small amount of defoliation of the transgenic plants was caused by beetles girdling stems. The low yield data of all treatments is the result of late planting, inadequate vernalization (transgenic plants), and the severe beetle pressure (nontransformed and commercial plants).

Table 1. Defoliation Rating[1] and Plant Yield[1] From Transgenic and Nontransformed Plants.
Montcalm, MI. 1991

Btt19c	0.50 a	3.79 a
Btt16a	0.33 a	3.21 a
Btt25a	1.00 a	4.00 a
Btt13d	0.17 a	3.50 a
Nontransformed	5.00 b	0.04 b
Commercial seed	5.00 b	0.00 b
Comm Seed & Asana	4.50 b	0.38 b

[1]Means followed by different letters are significantly different ($P<0.05$, Tukey's honestly different method).
[2]0 = 0 to 5%, 1 = >5 to 10%, 2 = >10 to 25%, 3 = >25 to 50%, 4 = >50 to 75%, and 5 = >75 to 100% defoliation.

The effect of CPB feeding on flight behavior and status of flight. Studies to compare the flight behavior of starved and fed beetles were conducted in the summer of 1991 in the field at the M.S.U. Collins Rd. Research Station. Three tests were done on the overwintered generation and one test was done on the summer generation. Beetles were starved or fed for varying lengths of time. Tests of flight behavior of starved and fed beetles were done at different times during the test.

There appeared to be no differences between fed and starved beetles in flight behavior of overwintered CPB. On some days of the second test more starved beetles flew than did fed beetles. However, this was not a consistent trend.

Preliminary analysis of the summer generation data indicates that starved beetles tended to fly more often than fed beetles on days 1, 4, and 10, but on day 15 there was no difference between the two treatments.

The dorso-longitudinal flight muscles of fed and starved beetles were also examined to note any muscle degeneration, which might indicate a loss of the beetles' ability to fly. Muscles of starved and fed overwintered beetles were analyzed via transmission electron microscopy. These analyses indicated that the muscles of starved CPB degenerate over time. Distinguishable differences occurred in the size and organization of flight muscles. This degeneration was progressive and the muscle of a starved beetle started to differ from that of a fed beetle after 5 to 10 days of starvation (Figure 2). The muscle of a fed beetle was well-organized, the fibrils are closely packed, with many mitochondria betwen the fibrils and virtually no space. The muscle of a starved beetle had markedly smaller fibrils, less organization, fewer mitochondria and many vacuoles. The smaller muscles of the starved beetle indicate that the ability of that beetle to fly may be reduced. Dispersal of starved beetles, therefore, may be limited once wing muscles begin to degenerate.

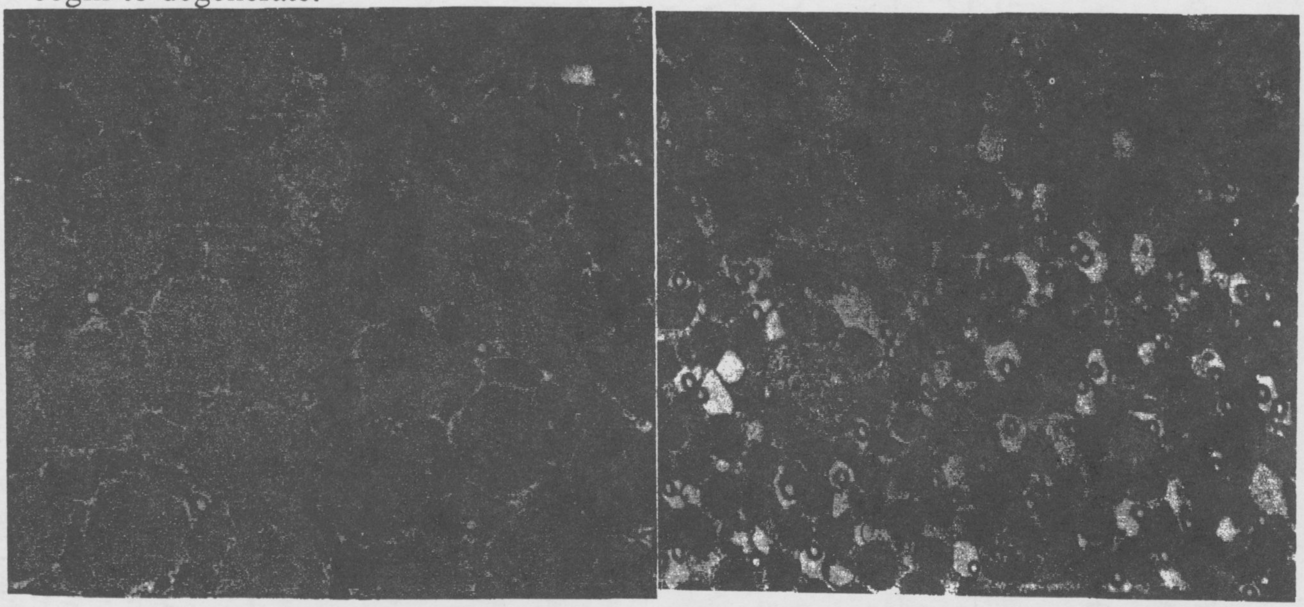

Figure 2. Transmission electron micrograph of dorso-longitudinal flight muscles of Colorado potato beetles at 4500 x. Fed Beetle (left). Starved Beetle (right).

Insecticide Efficacy Tests for CPB Control. Insecticide trials were conducted at the MSU Montcalm Research Farm in Entrican, MI. Potatoes (cv 'Atantic') were planted on 25 and 26 April. Plots were three rows wide and 45 ft long and were

Table 2. Mean number of Colorado potato beetles per plant over four sampling dates, and defoliation rating. Montcalm Co. 1991.

MEAN NUMBER OF CPB OVER 4 SAMPLING DATES AND DEFOLIATION RATING

TREATMENT	EGG MASSES	ADULTS	SMALL LARVAE	LARGE LARVAE	DEFOLIATION[7]	
	NUMBER OF CPB PER PLANT [1,2]				21 JUNE	28 JUNE
UNTREATED	11.75(1.11)a	10.75(2.56)	127.75(22.70)	150.50(56.31)ab	4.94	5.00
M-1 PLUS 1 gal/A	23.75(2.25)ab	14.25(4.70)	182.00(41.12)	100.50(17.69)ab	2.58	2.70
FOIL DF 1 lb/A	15.25(3.17)a	10.75(2.29)	151.50(27.36)	194.50(21.38)ab	4.29	4.56
FOIL DF,1.5 lb/A [3]	23.00(1.68)ab	10.50(3.80)	163.50(32.92)	152.00(14.09)ab	4.14	4.41
FOIL DF 2 lb/A	24.75(3.99)ab	12.75(1.98)	140.25(15.04)	245.25(52.38)a	4.31	4.68
FOIL OF 1.45 qt/A	18.75(1.75)ab	9.50(1.56)	134.50(15.50)	217.25(34.20)ab	3.71	4.14
FOIL OF 2.18 qt/A	20.00(2.80)ab	7.50(2.36)	125.00(21.00)	171.25(15.78)ab	3.88	3.95
FOIL OF 2.9 qt/A	15.25(4.35)a	10.50(1.66)	86.75(22.79)	150.50(19.46)ab	3.76	3.84
ECX-9124EH 1 lb/A [4,5]	22.00(5.87)ab	11.75(2.78)	205.00(39.13)	178.25(19.66)ab	4.70	4.96
ECX-9124EH 1.5 lb/A [5]	16.25(3.43)ab	9.00(1.08)	157.25(42.14)	150.00(33.77)ab	4.75	4.99
KRYOCIDE 11.5 lb ai/A	39.00(4.67) b	22.50(7.41)	187.50(49.61)	84.00(10.03) b	2.53	2.66
TENAX 25 lb/A	16.00(3.03)a	11.00(2.94)	107.75(21.04)	150.25(27.20)ab	4.64	4.96
IMIDAN 1 lb/A + PBO 6 oz/A [6]	14.50(2.40)a	13.75(4.73)	141.00(51.17)	86.00 (9.10) b	2.86	3.21
CRYOLITE 9 lb/A	19.75(3.57)ab	15.25(3.52)	141.50(18.12)	132.75(11.34)ab	3.26	3.91
		NS	NS			

1 Means followed by the same letter are not significantly different (Tukey's HSD, $p > 0.05$).
2 Data transformed using ln (x + 1) for Tukey's HSD.
3 Mean substituted for missing data from Plot 53 on 14 June for analysis.
4 First treatment of ECX-9124EH was on 12 June.
5 Mean substituted for missing data from Plot 18 on 7 June for analysis.
6 Mean substituted for missing data from Plot 43 on 21 June for analysis.
7 Rating: 1 = No defoliation; 2 = 1%-25% defoliation; 3 = 26%-50% defoiation (some whole leaves eaten); 4 = 51%-75% defoliation (some stems bare); 5 = 76%-100% defoliation.
NS Means within a column are not significantly different.

arranged in a randomized complete block design with four replications per treatment. The Tenax treatment was applied at planting in an 8 to 10 in band in the furrow. Foliar treatments were applied at 30 gal/acre and 60 psi with a hand-held CO_2 sprayer or a tractor-mounted boom sprayer. Foliar treatments were applied on 4, 12, 18 and 25 June. Plots were sampled by searching two plants from the middle row of each plot for all stages of CPB. Plots were sampled on 7, 14, 21 and 28 June. Plots were rated for defoliation on 21 and 28 June. Due to heavy CPB pressure and severe defoliation, the middle row of each plot was harvested on 31 July. Harvested potatoes were separated by size and weighed.

Kryocide gave the best control of large larvae and had the lowest defoliation (table 1) and best yield (Tables 2 & 3). M-1 Plus (M-Trak), Imidan & PBO and Cryolite gave fair control of large larvae, had low defoliation and good yields. The accelerated development of CPB in 1991 due to very warm weather early in the season, and the very high densities of beetles in this field (which resulted in complete defoliation of the field by the end of July) may have affected the performance of many of the insecticides.

Table 3. Mean Potato Yield. Montcalm Co., MI. 1991.

TREATMENT	SIZE A[1]	SIZE B
	LBS PER 20 ROW FEET (S.E.)	
UNTREATED	1.13(1.13) a	1.50(0.46) ab
M-1 PLUS 1 gal/A	13.25(1.61) bc	5.25(1.44) ab
FOIL DF 1 lb/A	5.75(1.09) a cd	4.50(0.68) ab
FOIL DF 1.5 lb/A	9.88(2.70) b d	3.75(0.83) ab
FOIL DF 2 lb/A	5.75(2.76) a cd	2.75(0.60) ab
FOIL OF 1.45 qt/A	11.25(1.30) bc	3.88(0.55) ab
FOIL OF 2.18 qt/A	9.63(1.68) bcd	3.75(1.36) ab
FOIL OF 2.9 qt/A	11.50(3.73) bc	3.00(0.79) ab
ECX-9124EH 1 lb/A	0.63(0.32) a	1.75(0.60) ab
ECX-9124EH 1.5 lb/A	2.06(1.10) a	2.50(0.74) ab
KRYOCIDE 11.5 lb ai/A	19.13(2.55) b	6.88(1.39) b
TENAX 25 lb/A	3.13(1.81) a d	1.19(0.34) a
IMIDAN 1 lb/A + PBO 6 oz/A	9.75(7.96) b	5.50(1.21) ab
CRYOLITE 9 lb/A	12.13(1.43) bc	3.88(0.72) ab

1 Means followed by the same letter are not significantly different (Tukey's HSD on square root of weight + 0.5 transformation, $p > 0.05$).

Control of CPB with Trigard. Trials using the insect growth regulator Trigard were conducted at two commercial potato fields in Bay County, MI. Potatoes (cv 'Onaway') were planted on the Brian Hugo farm on 17 April and on the Jim Kryszak farm on 3 May, 1991. Plots were 14 rows wide and 60 ft long and were arranged in a randomized complete block design with four replications per treatment. Treatments included: no Trigard (control), and low (0.125lb AI/acre), medium (0.25 lb AI/acre), and high (0.375 lb AI/acre) rates of Trigard. Treatments were applied on 7 and 19 June with a tractor-mounted boom sprayer at 25 gal/acre and 40 psi. One or two plants per plot were sampled for CPB on 7 June (pre-treatment sample). Four plants per plot were sampled on 13, 20 and 27 June, and on 2 July. Potatoes were harvested in each plot from two 10 ft sections of row on 19 August. Plots were assessed for defoliation on 2 July. Harvested potatoes were separated by size and weighed.

In both fields, plots treated with Trigard had significantly fewer large larvae on all sampling dates than plots that were untreated (Figure 3). On some dates the numbers of adults per plant were significantly lower in Trigard-treated plots. There were no significant differences between treatements in the number of egg masses per plant. There was also no significant differences between plots treated with different rates of Trigard in the number of CPB of any stage. Defoliation was lower in treated than in untreated plots at both sites. Yields of treated plots were significantly higher than yields in untreated plots at both sites (Figure 4).

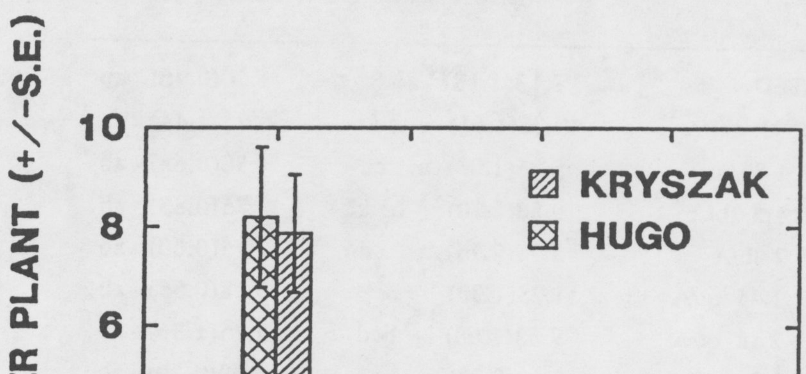

Figure 3. Number of large Colorado potato beetle larvae per plant on plots treated with different rates of Trigard.

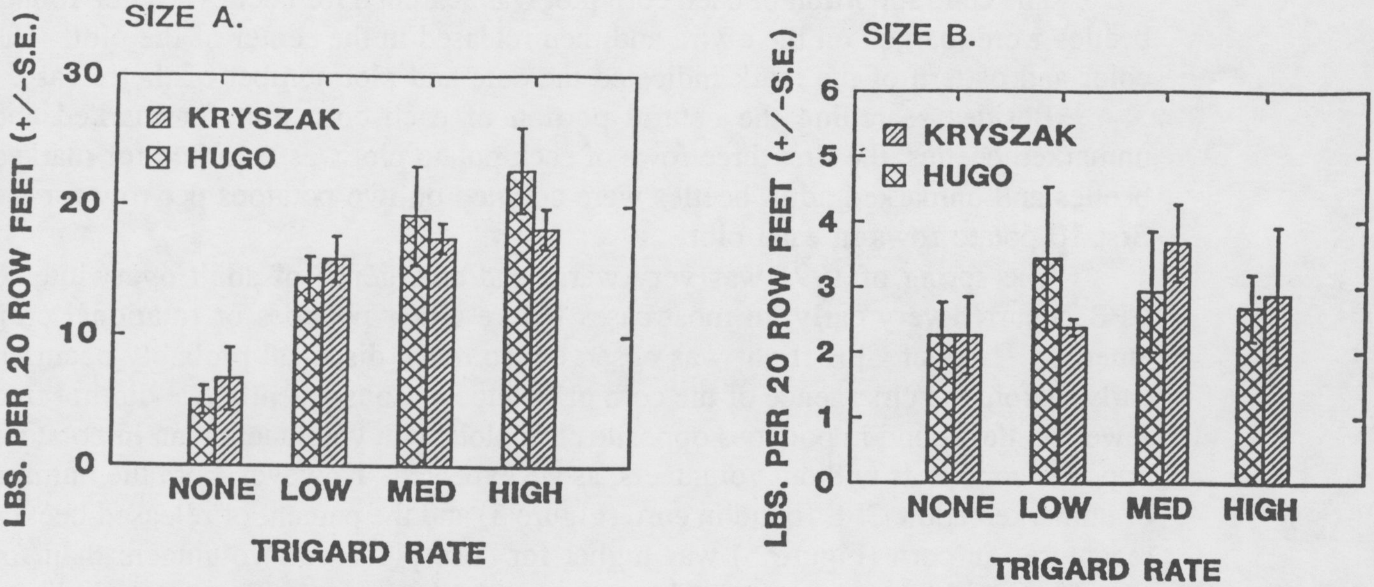

Figure 4. Yield of potatoes treated with three rates of Trigard.

Corn/Potato rotational systems for controlling dispersal of postdiapause Colorado potato beetle. Our ultimate aim in this research is to develop crop rotational systems that will prevent overwintered CPB adults from moving from the rotational crop (last year's potato field) to the current year's potatoes. The effect of volunteer (or intentionally planted) potatoes in a rotated corn field on dispersal of overwintered Colorado potato beetle adults was evaluated. We hypothesized that the presence of potatoes in the corn would keep the newly-emerged adult CPB in the corn. Later, these volunteer potatoes and the beetles could be destroyed. If dispersal from the corn to the potatoes were reduced, this would both reduce the size of the CPB population on the potatoes and prevent the spread of insecticide-resistance genes to new sites.

Plots were set up at two commercial fields in Montcalm County, Sandyland Farms (Larry Young) and Pleasant Valley Farm (Dan Evans). Plots were set up along the border of a side-by-side corn/potatoes rotation (i.e., the 1991 corn field had been in potatoes in 1990, and visa versa). Plots were ca. 75 ft long and extended 20 rows into the corn and potato field. Treatments were arranged in a randomized complete block design with four replications per treatment. Treatments included: A high density (1 per m^2) of "volunteer" potatoes planted in the corn, a low density (1 per 5 m^2) of "volunteer" potatoes planted in the corn, and no volunteers. At the Sandyland site the low-density volunteer treatment was not included.

The central portion of each corn plot was searched for beetles. When found, beetles were marked on the elytra and then released in the center of the plot. The color and pattern of the mark indicated the date and plot number of the release.

Besides searching the central portion of each corn plot for marked and unmarked beetles, the first three rows of each potato plot was searched for marked beetles and unmarked adult beetles were counted on two potatoes per row for the first 10 potato rows in each plot.

The spring of 1991 was very warm and emergence of adult overwintered CPB occurred very early, in most cases before either potatoes or rotational crop emerged. Lots of CPB flight was observed, so much dispersal probably occurred early, before the emergence of the corn or potatoes. Consequently, we did not find fewer beetles found in potatoes opposite corn plots with volunteers than in potatoes opposite corn plots without volunteers, as we expected. However, both the number of unmarked adult CPB found in corn (Figure 5) and the percent of released beetles recaptured in corn (Figure 6) was higher for corn plots with volunteers than for corn plots without volunteers. This was true for both sites. These data indicate that the presence of volunteer potatoes in a rotated crop, such as corn, may discourage newly-emerging overwintered CPB from moving from the corn to the new potatoes. Of marked beetles that were recaptured, a higher proportion was found in the potatoes (rather than in the corn) when the beetles were released into corn plots without volunteers. This, and other results, suggest that lack of food (potatoes or solanaceous weeds) in the rotated crop may contribute to dispersal of overwintered CPB, perhaps over fairly long distances. This dispersal may lead to colonization of distant potato fields and the spread of insecticide genes, thus reducing the effectiveness of crop rotation as a management strategy for CPB.

These preliminary investigations into methods of reducing dispersal of CPB out of rotated fields are encouraging. However, there were several problems that probably reduced the effectiveness of volunteers in preventing dispersal. First, as mentioned above, an early, very warm spring resulted in beetles emerging and dispersing before the corn, potato crop or volunteers. A good amount of dispersal had already occurred before our experiments began. Second, at both sites the corn field was cultivated shortly after our experiments began. The majority of the volunteer potatoes in the corn were destroyed by this cultivation. Therefore, the volunteer potato density was much lower than we originally planted.

To correct for these problems, we did a series of experiments at the M.S.U. Research Farm. Plots (4 m x 4 m) were set up in a corn field. Potted potato plants were buried within these plots to simulate volunteers. A row of 9 potted potato plants was planted in the ground 0.5 m from the corn plot to simulate the potato field. Treatments included a low and high density of volunteers, and no volunteers. Marked beetles were released in the center of the corn plot. Both the corn plot and the row of potatoes were searched for marked several times from 4 to 48 hours after the beetles were released. Preliminary results of these experiments show that

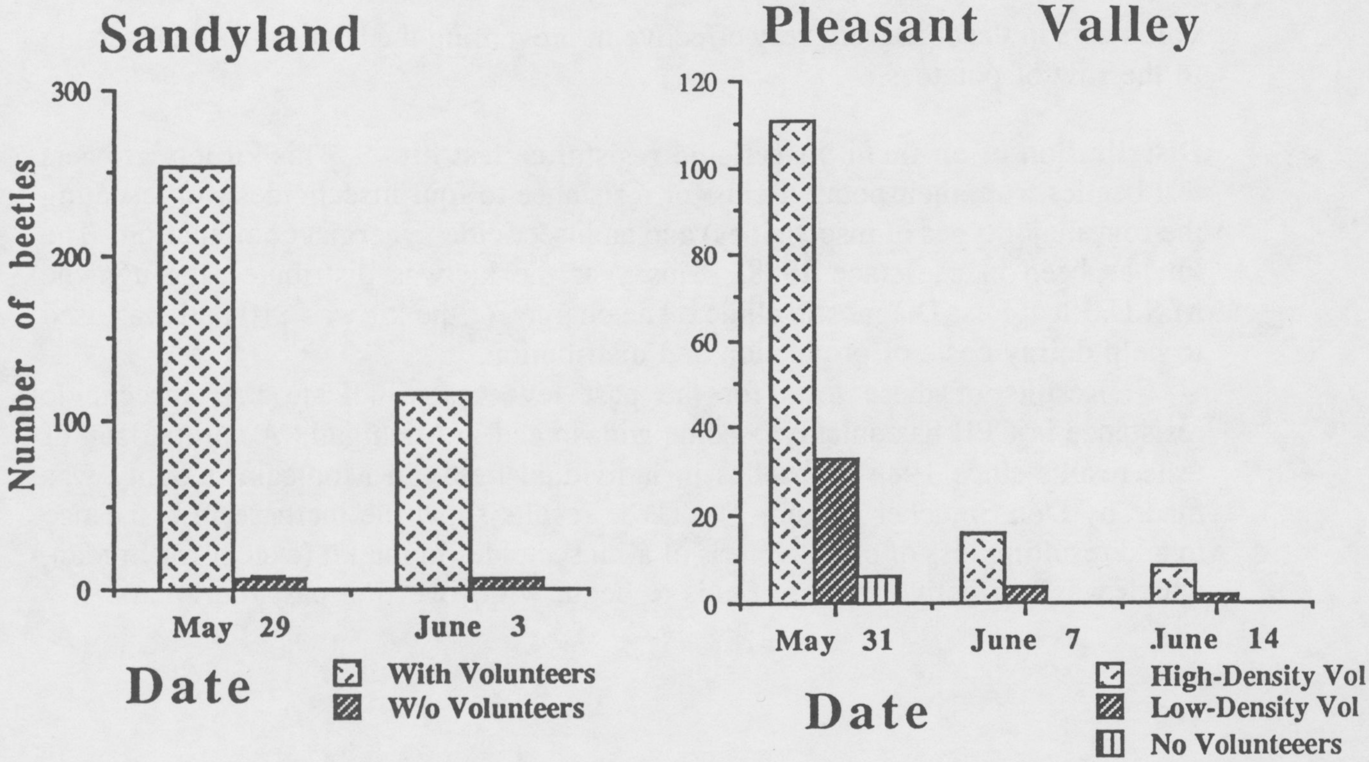

Figure 5. Number of adult CPB found in rotated corn plots with or without volunteer potatoes.

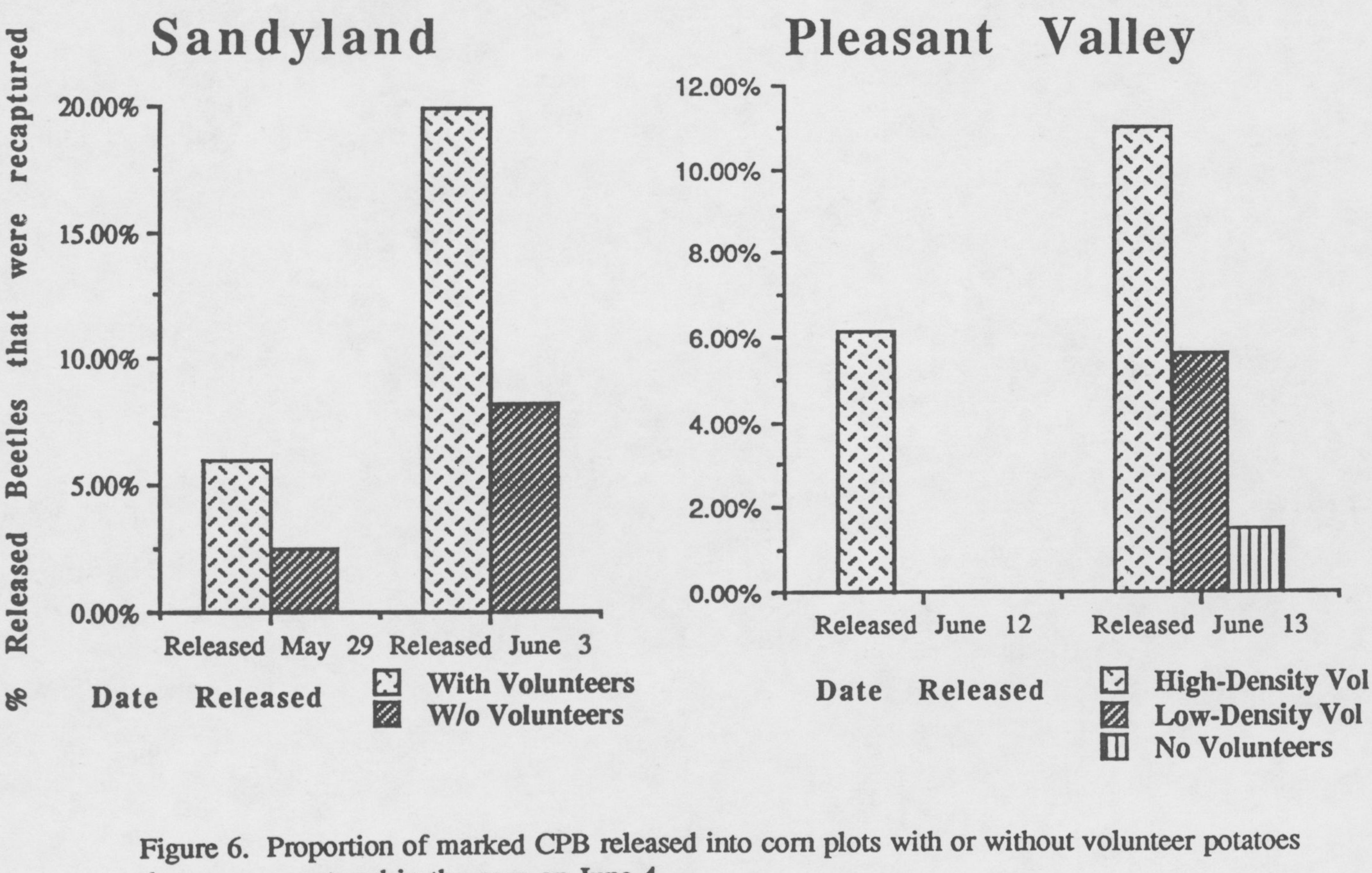

Figure 6. Proportion of marked CPB released into corn plots with or without volunteer potatoes that were recaptured in the corn on June 4.

volunteers in the corn were very effective in preventing the beetles from dispersing to the row of potatoes.

Distribution of on-farm, insecticide resistance test kit. This kit lets growers test beetles from their potato fields for resistance to four insecticides (representing the four major types of insecticides) and an insecticide-synergist combination. The kit has been in use since 1988. This year the kit was distributed through the M.S.U. Plant Pest Diagnostic clinic. The charge for the kit was $10 and was used to help defray costs of production and distribution.

Results of these tests for the past few years indicate that insecticide resistance in CPB has quickly become widespread in Michigan. A comparison of tests results since 1988 of beetles in individual fields in Montcalm County was made by Don Smucker (Figure 7). These results show the increase in resistance to and resulting loss of effectiveness of all insectcides in the kit (except for Imidan, which was ineffective in these fields to begin with) over the past four years.

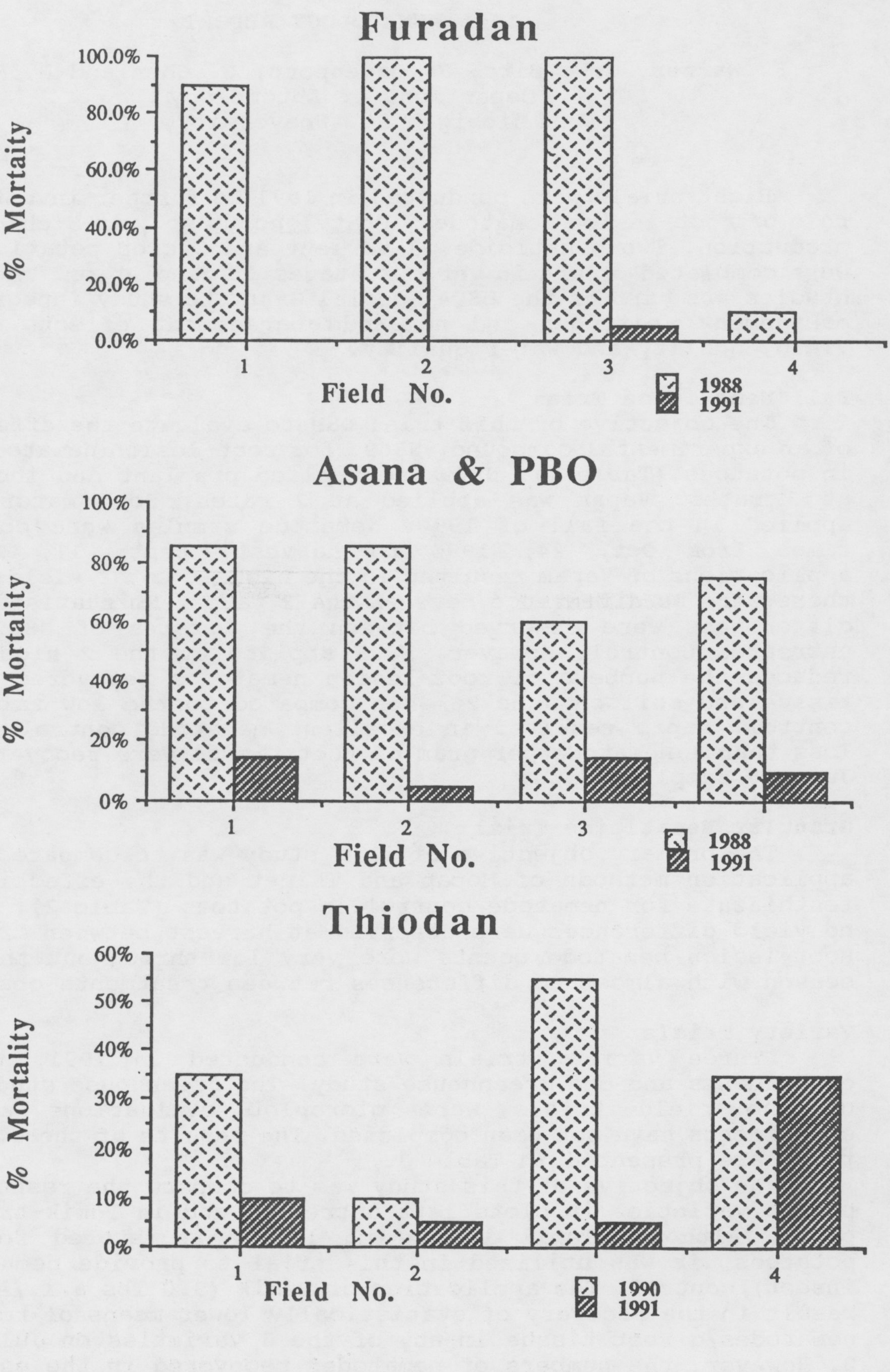

Figure 7. Results of insecticide resistance tests on Colorado potato beetles in four fields in Montcalm County, Michigan. Results are from years 1988 to 1991.

Funding ___Federal Grant/MPIC___

1991 NEMATOLOGY REPORT

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Eight trials were conducted in 1991 to further investigate the role of root-lesion nematodes, Pratylenchus sp., in Michigan potato production. Two nematicide, 3 variety and 3 crop rotation studies were completed or are in various stages of completion. The rotation studies are part of the USDA Special Grant to study integrated crop management: nitrogen and nematode management effects on potato yield, quality and water quality.

Fall Nematicide Trial

The objective of this trial was to evaluate the effectiveness of an experimental compound, N869, for root-lesion nematode control in potatoes (Table 1). N869 was applied preplant and incorporated at 3 rates. Vapam was applied at 2 rates. Both materials were applied in the fall of 1990. Nematode samples were collected 4 times from Oct. 24, 1990 to harvest, Sept. 11, 1991. The applications of Vapam resulted in the highest total yields although there were no difference between the 2 rates. No statistical yield differences were observed between the 3 rates of N869 and the untreated control. However, N869 applied at the 2 highest rates reduced the numbers of root-lesion nematodes recovered from root tissue and soil on June 26 when compared to the low rate and the control. Vapam resulted in excellent nematode control, means of less than 1 nematode per gram of root tissue were recovered on the June 26 sampling date.

Granular Nematicide Trial

The primary objective of this study was to compare different application methods of Mocap and Thimet and the effectiveness of fosthiazate for nematode control in potatoes (Table 2). Virtually no yield differences were observed at harvest between treatments. Root-lesion nematode counts were very low throughout the growing season with almost no differences between treatments observed.

Variety Trials

Three variety trials were conducted in 1991, two field experiments and one greenhouse study. The greenhouse study and one of the field trials were microplot evaluations and these experiments have not been completed. The results of the other field trial are presented in Table 3.

The objective of this study was to compare the responses of 3 potato varieties in plots left untreated and in Temik-treated plots. Although Temik 15G is no longer registered for use in potatoes, it was utilized in this trial to provide nematode (and insect) control. The application of Temik (3.0 lbs a.i./A) did not result in the recovery of statistically lower means of root-lesion nematodes/g root tissue in any of the 3 varieties on July 2. However, the numbers of nematodes recovered in the soil at harvest were lower in Onaway plots and Russet Norkotah plots where Temik had been applied. Temik resulted in a favorable yield response for all 3 varieties. Snowden produced the highest yields in the trial, yields of Russet Norkotah were the lowest.

Rotation Trials

Three crop rotation experiments were conducted in 1991. One trial, located at the Experimental Farm in Montcalm Co. was completed in 1991. Two other trials, one at the Experimental Farm and the other at the Jon Haindl Farm in Cooks are long term studies that were established in 1991.

The primary objective of the crop rotation trials is to evaluate a broad range of potential potato production system rotation crops that will alleviate potato tuber yield and quality losses caused by the joint action of the root-lesion nematode, Pratylenchus penetrans, and the Verticillium wilt fungus, Verticillium dahliae. The experimental design of the long term study in Montcalm Co. is shown in Table 4. Three crops were grown at this location in 1991, potato (Russet Burbank), oats and alfalfa. There were no differences in the number of lesion nematodes recovered in root tissues and surrounding soil of the 3 crops on July 2 (Table 5). However, on Sept. 11, fewer nematodes were recovered from potato roots and soil than the other 2 crops. As expected, both oats and alfalfa were good hosts for P. penetrans.

Five crops were grown in the trial located at the Haindl Farm in the U.P., potato (Superior), oats, alfalfa, june (red) clover and yellow sweet clover. All the crops appeared to be hosts for the lesion nematode, although fewer nematodes were recovered from potato roots and soil on July 8 than from roots and surrounding soil of the other crops investigated (Table 6). However, the means were not statistically different except where oats and alfalfa were intercropped compared to all the other crops but june clover. On Oct 7, the two species of clover supported higher populations of Pratylenchus sp. than either alfalfa or oats/alfalfa. Clovers are considered good hosts for root-lesion nematodes.

A 3-year rotation study was terminated in the fall of 1991. Five crops were utilized, potato (Superior), corn, sudax, sweet clover and alfalfa. Potato was the only crop grown in 1991, the other crops had been grown for 1 or 2 years prior to potato (Table 7). P. penetrans counts ranged from 85-229 nematodes/g root tissue and 100 cm^3 soil on June 28. Two years of clover or alfalfa followed by potatoes resulted in the highest yields. Yields were not high, ranging from 154 cwt/A to 302 cwt/A. However, no nematicides were used and nematode counts were considered high.

The following trends can be observed in Table 7. Although, the differences were not significantly different, two years of corn or sudax followed by 1 year of potatoes resulted in lower yields in 1991 than 1 year of corn or sudax followed by 2 years of potatoes. However, 2 years of sweet clover or alfalfa followed by potatoes in 1991 resulted in significantly higher yields than 1 year in either commodity followed by potatoes for 2 years.

Table 7 does not include the 1990 potato yield data. Yields ranged from 232 cwt/A (sudax/potato) to 270 cwt/A (corn/sudax) in 1990. Further analyses were conducted to compare potato yields from 1990 following 1 year in a rotational crop to yields in 1991 following 2 years in the respective crops. Two years of corn and sudax followed by a potato crop resulted in significantly lower potato yields than only rotating for 1 year with corn or sudax. Two years of sweet clover produced a statistically significant potato yield increase when compared to 1 year of sweet clover followed by potato. There was no significant difference between growing alfalfa for 1 or 2 years between potato crops. Therefore, it's very apparent that cropping sequences will affect potato yields.

Table 1. Montcalm Potato Nematicide Fall Application Test in Montcalm, MI in 1991

Treatment	Application	Root-lesion Nematode Population				Potato Yield (cwt/A)
		10/24/90 soil	5/2/91 soil	6/26/91 root & soil	9/11/91 soil	
1. Metham	75 gal/A Broadcast	59[1] a[2]	< 1 b	1 c	1 c	435.1 a
2. Metham	150 gal/A Broadcast	82 a	< 1 b	< 1 c	< 1 c	451.8 a
3. N869 29.26 G	37.5 lb/A P.P.I.	77 a	5 ab	138 a	29 a	236.4 bc
4. N869 29.36 G	75 lb/A P.P.I.	92 a	11 ab	68 b	24 ab	261.0 bc
5. N869 29.34 G	150 lb/A P.P.I.	42 a	7 ab	48 b	14 b	287.2 bc
6. CK	no treatment	124 a	12 a	142 a	30 a	209.4 c

Note:
1. The mean population of root-lesion nematode is presented as nematodes per 1.0 gram root tissue and nematodes per 100 cm^3 soil.
2. Means followed by the same letter are not significantly (P=0.05) different according to the Duncan's Multiple Range Test.

Table 2. The Granular Nematicide Trial in Montcalm Research Farm

AP Nematicide Treatment in 1991	Root-lesion Nematode Population			Potato Yield (cwt/A)
	5/14/91 soil	6/26/91 root & soil	9/6/91 soil	
1.CK without AP application in 1991	3 a	7 a	9 a	263.5 ab
2.Temik 15G 3.0 lb ai/A IFF	< 1 a	3 b	1 c	331.5 a
3.Vydate 2L 3.0 lb ai/A 12" band	< 1 a	1 b	2 bc	295.5 ab
4.Mocap 10G 3.36 oz/1000 ft 5-7' band behind planter shoe, before closing discs	< 1 a	2 b	5 abc	276.8 ab
5.Mocap 10G 3.36 oz/1000 ft 5-7" band before planter shoe, behind closing discs	< 1 a	< 1 b	2 bc	298.2 ab
6.Mocap 10G 3.36 oz/1000 ft 5-7" band behind shoe, before discs Phorate 20G 3.46 oz/1000 ft ISPF	< 1 a	< 1 b	5 abc	291.1 ab
7.Mocap 10G 3.36 oz/1000 ft 5-7" band before shoe, behind discs Phorate 20G 3.46 oz/1000 ft ISPF	2 a	< 1 b	7 ab	224.1 b
8.Mocap 10G 3.36 oz/1000 ft 5-7" band before shoe, behind discs Phorate 20G 3.46 oz/1000 ft 5-7" band before shoe, behind discs	< 1 a	< 1 b	4 abc	258.9 ab
9.Mocap 20G 90 lb/A Broadcast/Incorporate	2 a	< 1 b	4 abc	297.4 ab
10.Fosthiazate 6 lb ai/A 12" band	1 a	< 1 b	3 bc	303.2 ab
11.Fosthiazate 8 lb ai/A 12" band	3 a	1 b	1 c	282.4 ab
12.Fosthiazate 12 lb ai/A 12" band	< 1 a	4 ab	5 abc	295.7 ab

Table 3. Potato Variety Trial in 1991

Variety	Aldicarb	Root-lesion Nematode Population			Tuber Yields
		5/15/91 soil	7/2/91 root	9/1/91 soil	(cwt/A)
1.Onaway	-	56 a	18 b	72 a	241.4 c
2.Onaway	+	58 a	3 b	5 c	279.1 b
3.Norkotah Russet	-	64 a	44 ab	76 a	194.4 d
4.Norkotah Russet	+	55 a	6 b	5 c	247.8 c
5.Snowden	-	52 a	17 b	40 b	302.2 b
6.Snowden	+	50 a	3 b	11 bc	340.7 a

1. The root-lesion nematode population is presented as nematodes per 1.0 gram root tissue and nematodes per 100 cm^3 soil.
2. Means followed by the same letter are not significantly (P=0.05) different according to the Duncan's Multiple Range Test.

Table 4. Experimental Design of 1991-2000 Crop Rotation Montcalm Component

Year	Tmt 1	Tmt 2	Tmt 3	Tmt 4	Tmt 5	Tmt 6	Tmt 7	Tmt 8	Tmt 9	Tmt10
1991	Potato	alf	alf	oats	oats	oats	oats	oats	oats	oats
1992	Potato	Potato	alf	alf	soy	soy	soy	soy	soy	soy
1993	Potato	Potato	Potato	alf	alf	kid	kid	kid	kid	kid
1994	Potato	Potato	Potato	Potato	alf	alf	wh	wh	wh	wh
1995	Potato	Potato	Potato	Potato	Potato	alf	alf	pea	pea	pea
1996	Potato	Potato	Potato	Potato	Potato	Potato	alf	alf	wh	wh
1997	Potato	Potato	Potato	Potato	Potato	Potato	Potato	alf	alf	soy
1998	Potato	Potato	Potato	Potato	Potato	Potato	Potato	Potato	alf	alf
1999	Potato	Potato	Potato	Potato	Potato	Potato	Potato	Potato	Potato	alf
2000	Potato	Potato	Potato	Potato	Potato	Potato	Potato	Potato	Potato	Potato

Table 5. 1991-2000 Crop Rotation Montcalm Component - 1991 Data

Treatment	Root-lesion Nematode Population		
	5/13/91 soil	7/2/91 root & soil	9/11/91 root & soil
1. Potato	8 a	118 a	21 c
2. Alfalfa	7 a	85 a	183 b
3. Alfalfa	11 a	115 a	176 b
4. Oats	7 a	138 a	269 ab
5. Oats	7 a	125 a	241 ab
6. Oats	9 a	120 a	318 a
7. Oats	8 a	123 a	369 ab
8. Oats	6 a	131 a	246 ab
9. Oats	7 a	85 a	224 ab
10. Oats	6 a	146 a	205 b

Table 6. 1991-2000 Crop Rotation UP Component - 1991 Data

Treatment	Root-lesion Nematode Population			
	5/28/91 soil	7/8/91 root+soil	10/7/91 soil	10/7/91 root
1.Potato	43 a	74 b	26 c	
2.Oats	29 a	248 b	56 ab	
3.Alfalfa	39 a	132 b	36 bc	6 b
4.June Clover	27 a	337 ab	12 c	55 a
5.Yellow Sweet Clover	37 a	279 b	32 bc	47 a
6.Oats & Alfalfa	35 a	568 a	65 a	20 b

Table 7. 1989-1991 Crop Rotation Trial - 1991 Data

1989	1990	1991	Root-lesion Nematode Population			Potato Tuber Yields (cwt/A)
			5/21/91 soil	6/28/91 root & soil	8/20/91 soil	
Potato	Potato	Potato	9 c	106 cd	144 a	203.8 ab
Potato	Rye	Potato	28 b	143 abcd	145 a	217.1 ab
Corn	Potato	Potato	12 bc	85 d	90 ab	228.1 b
Corn	Corn	Potato	54 a	229 a	71 b	176.8 ab
Sudax	Potato	Potato	13 bc	191 abc	127 ab	184.4 ab
Sudax	Sudax	Potato	12 bc	132 bcd	70 b	154.5 a
Clover	Potato	Potato	16 bc	201 ab	138 a	209.0 ab
Clover	Clover	Potato	9 c	144 abcd	67 b	301.8 c
Alfalfa	Potato	Potato	24 bc	154 abcd	118 ab	214.5 ab
Alfalfa	Alfalfa	Potato	13 bc	146 abcd	67 b	288.8 c

POTATO STORAGE MANAGEMENT: Atlantic vs. Snowden

Potatoes harvested in the fall of 1990 were compared for storage response in the MSU potato storage research facility. Varieties evaluated were Atlantic and Snowden (formerly W855). The goal was to store the potatoes for an extended season and to monitor their response to the storage management strategy used in previous research on Atlantic potatoes. Any differences in storage response by variety can be a guide for managing a commercial potato storage.

Storage System

The MSU potato storage research facility is a set of bins, each measuring 8' x 8' x 18' high. Two of the storage bins were installed during the summer of 1990 in a commercial potato storage facility at Bishop Potato Farm (Pinconning, MI). A floor plan of the storage facility is shown in Figure 1.

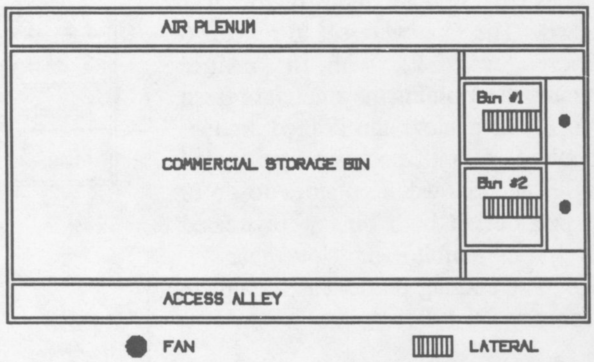

Figure 1. Floor plan of the potato storage research facility.

Ventilation System - Each potato storage research bin has an independent air handling system capable of maintaining a desired storage environment for that bin. Each fan is capable of providing upto 3 cfm of air per cwt of potatoes stored in the bin. The ventilation specifications are given in Table 1. The intake air is drawn from outside through a common insulated fresh air manifold. The exhaust air is directed into the headspace of the pile in the commercial bin.

Control System - Each ventilation system is controlled using a 656 FANCOM* environmental control computer. The computer controls fresh air and recirculation air volume and humidifying and heating devices. Control changes are made based on feedback from the sensors that are placed in the ventilation and in the pile as illustrated in Figure 2:

- temperature sensors at three foot increments within the pile
- temperature and relative humidity of ventilation air
- temperature and relative humidity of recirculation air

Storage Management

The potatoes were harvested on September 26, 1990. Pulp temperatures were 67°F for the Atlantic potatoes and 57°F for the Snowden potatoes. Potato samples were taken weekly from the top of the pile, and from 3 levels within the pile. These samples were analyzed for fry color and for sucrose and glucose sugar content. Samples were also taken monthly for analysis of changes in wound healing ability and resistance to decay by Fusarium sambucinum.

Authors are Roger Brook, professor and Robert Fick, graduate research assistant, Agricultural Engineering Department, Michigan State University, and Ray Hammerschmidt, professor, Botany and Plant Pathology Department.

* Trade names are used solely to provide specific information. Mention of a trade name does not constitute a warranty of the product by the authors or by Michigan State University or an endorsement of the product to the exclusion of other products not mentioned.

After the storages were filled, the potatoes were controlled at a temperature of 60°F for suberization and pre-conditioning.

The cooling phase began on October 31, 1991. The control system was programmed to reduce the average potato pile temperature by 0.2°F per day until the desired storage temperature was attained. The fans were set to run for 6 hours of every 12, with the control computer determining the amount of fresh air to use to achieve the desired amount of cooling. Atlantic potatoes were cooled to 50°F and Snowden potatoes to 45°F. The potatoes in both bins were treated with sprout inhibitor on November 12, 1990. The cooling phase was complete on January 22, 1991.

During the holding phase, the control system was programmed to run the fan for 3 hours of every 12 to maintain the desired storage temperatures. Sampling for sugar analysis and for decay resistance continued. The potatoes were marketed on April 9, 1991.

Table 1. Details of potato storage research ventilation system.

	Atlantic	Snowden
Capacity (cwt)	370	345
Ventilation rate (cfm/cwt)	2.2	2.8
Slot height (inch)	0.5	0.5
Slot area (sq. ft)	0.69	0.69
Slot velocity (ft/min)	1180	1400
Lateral size (sq. ft)	1.2	1.2
Main size (sq. ft)	24	24

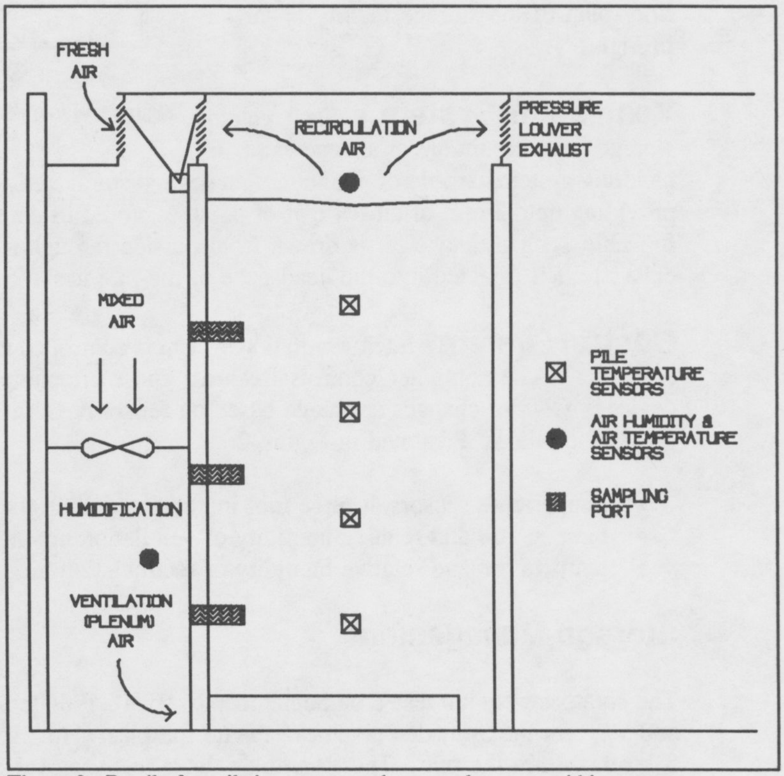

Figure 2. Detail of ventilation system and sensor placement within potato storage research bins.

Environment Control - An analysis of the data for potato temperatures and for ventilation air relative humidities is presented in Table 2. The data shows an adequate environment control in both bins. The controller was set to maintain the following values or differences:

- difference between any two pile temperature sensors of 2°F
- difference between average pile temperature and ventilation air temperature of 4°F
- relative humidity of 90%

Potato Quality - The sucrose and glucose sugar contents for the potato samples during the storage season are shown in Figure 3 for the Atlantic variety and in Figure 4 for the Snowden variety. There was no significant difference in the sugar contents between the levels in any storage research bin. All samples during the storage season had acceptable fry color.

Both the Atlantic and the Snowden varieties exhibited near constant ability to suberize and to restrict dry rot development. However, after January, the ability of both varieties to carry out these two functions declined. Overall, Snowden appeared to have somewhat more resistance to Fusarium than did Atlantic. The level of resistance, however, was not great enough to prevent rot development. Snowden also appeared to have somewhat greater wound healing ability.

It appears from limited observations that the Snowden variety potatoes sprouted somewhat earlier than did the Atlantic variety potatoes which would indicate that they should be managed with a faster cooling rate.

Recommendations

The Snowden variety potatoes stored at 45°F appear to respond to storage management in a manner similar to the Atlantic variety potatoes stored at 50°F. Chip color and sugar analysis were acceptable throughout the duration of the storage. We believe uniform and gradual temperature changes are important for maintaining potato color and quality through extended storage. It is important to use a temperature control system that will maintain the temperature of the cooling air above 42-45°F. It appears that re-conditioning will not normally be necessary, but the feasibility and strategies for re-conditioning of Snowden variety potatoes need to be evaluated.

Table 2. Controller performance for average pile temperature and inlet air relative humidity.

	Atlantic	Snowden
Pile temperature difference (°F)	0.5 (0.5)	0.5 (0.5)
Plenum-Pile temperature difference (°F)	0.5 (0.5)	1.0 (0.6)
Plenum-Pile max temp difference (°F)	3.1	3.6
Inlet air relative humidity (%)	2 (3)	3 (2)

* numbers in parenthesis are standard deviations of the averages

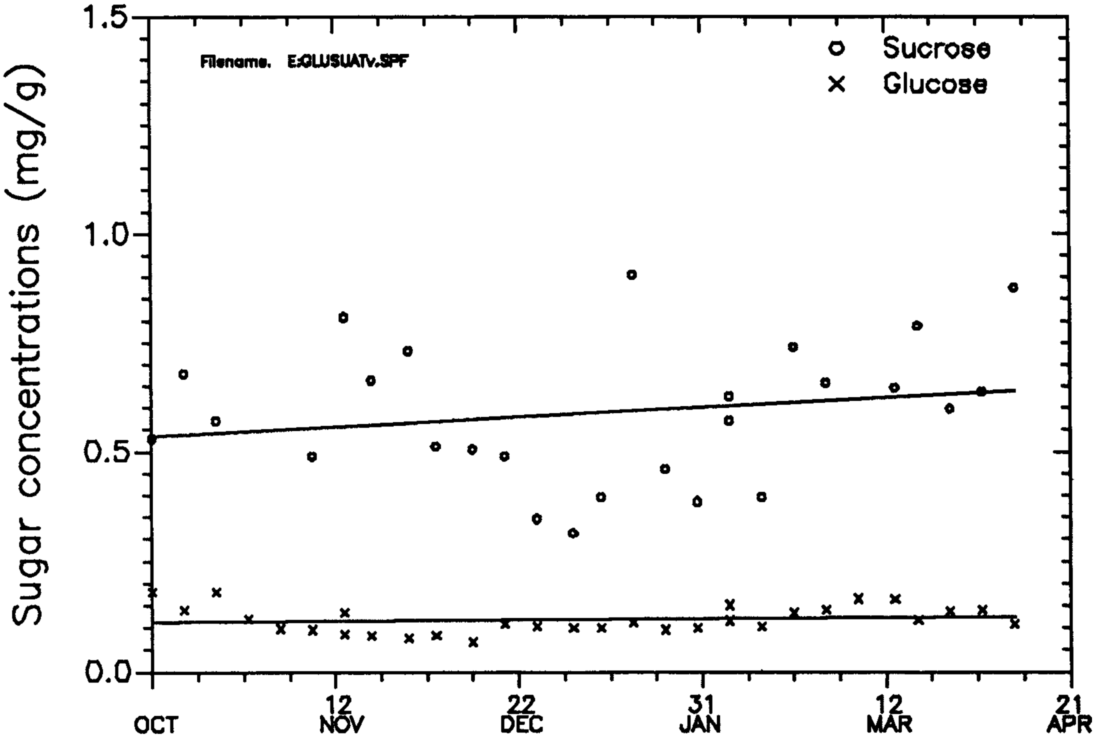

Figure 3. Potato sample sugar analysis for Atlantic variety potatoes, 1990-1991.

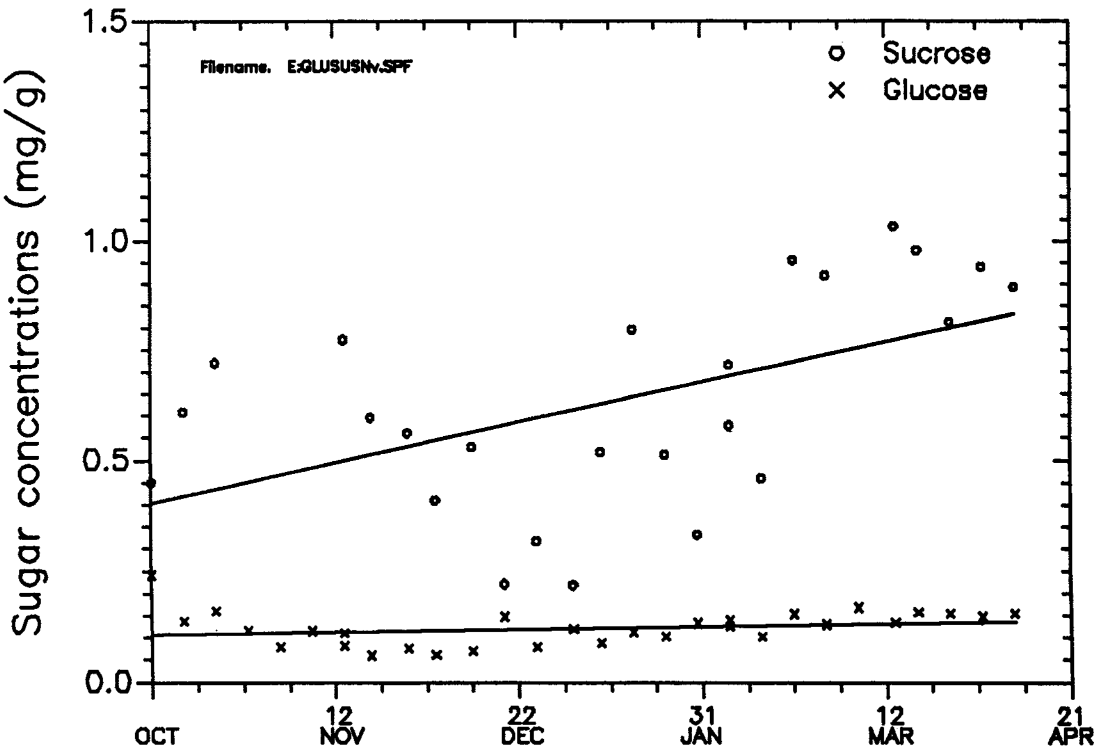

Figure 4. Potato sample sugar analysis for Snowden variety potatoes, 1990-1991.

Funding Federal Grant

PACKAGING ALTERNATIVES FOR LIGHT USERS OF TABLESTOCK POTATOES

A Summary of Mall Intercept Interviews

Mary D. Zehner[1]

Mall intercept interviews were conducted with consumers of fresh potatoes in March, 1990 in metropolitan Detroit, Michigan. While the overall goal of the study was to suggest how the Michigan potato industry compete more effectively in the marketplace for tablestock potatoes (especially for round, white potatoes), specific objectives included:

* To evaluate light potato users' rating of six packaging options for buying fresh potatoes (three varieties in bulk, tray pack, three- and five-pound bags).

* To evaluate consumers' variety and size preferences for three potato varieties.

* To examine consumers' level of awareness, and reasons cited for the greening (glyco-alkaloids) on potatoes skins.

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

The research was conducted through the Agricultural Experiment Station (AES) of Michigan State University and funded as a part of the Potato Research Special Federal Grant.

METHODOLOGY

Mall intercept interviews were conducted with light users of fresh potatoes at two mall sites in early March 1990. Mall intercept interviews are a quantitative survey method used to follow-up of focus group interviews carried out in December, 1989.

1. Background questions were asked on purchasing patterns and preferences for potatoes (size and type package bought, size, etc.)

2. Participants evaluated a display with 6 packaging options for potatoes. All three potato varieties included in the study (Superior, Russet Norkotah and Russet Burbank) are readily available in Michigan supermarkets during the winter months. Two of the six options displayed were packaging alternatives readily available in Michigan supermarkets...unpackaged, bulk Russet Burbank potatoes and a 5-pound bag of U.S. No.1 all-purpose potatoes. Average current retail prices were used during the time period of the study but the prices did not include any "specials." The information provided about varieties was typically used for bags and/or signs for potatoes..."all-purpose potatoes" rather than listing the varietal name Superior, or "Russet potatoes" rather than Russet Norkotah. The packages in the display were rotated after each ten participants in order to avoid positional bias.

3. If growers move in the direction of providing consumers with more closely sized potatoes, the question arises, "What size(s) potatoes of which varieties would best meet the needs of consumers?" Participants were to select their top choice among the two sizes of Russet Burbanks and three sizes of both the Superiors and Russet Norkotahs. The potatoes were displayed in a matrix with six to twelve potatoes (more of the small potatoes and fewer of the large potatoes), each in an individual tray. No retail price or variety identification was provided. The trays displayed were rotated to avoid positional bias.

4. What are consumers' level of awareness regarding seeing greening on potato skins and the perceived cause of this greening? Long a problem for growers, greening is the main reason for packaging round, white potatoes in paper.

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Chi-square analysis was carried out on all the responses versus the ages of participants, income level, size of household, and households with and without children under 18 at home. Comparisons are reported where the differences were at the 5 percent level or higher in the chi-square tests.

FINDINGS

Mall intercept interviews were conducted in a middle class shopping mall where the criteria for participation was that shoppers bought 1- to 10-lbs. of fresh potatoes in an average month. Data on the 190 participants revealed: 84% were female; about one fourth were in each of the following age groups: 18 to 34 years, 35-44 years, 45 to 64 years and 65 and older; half the respondents were in one or two member households; 38% had children under 18 at home; and half the households had women employed outside the home. Forty-one percent had yearly incomes between $20,000 to $45,000 while 22% had incomes over $45,000. Microwave oven ownership was 89% and two-thirds of the microwave owners reported cooking potatoes in their microwave ovens.

1. Purchase Patterns - Based on the 190 respondents, 88% purchased tablestock potatoes in bags, 46% from unpackaged, bulk displays and 7% from a tray pack at least once during the past six months. A second question revealed that three-fourths of the participants bought potatoes in bags more often than any other type of packaging while 21% most often bought from a bulk display. The majority bought their potatoes in net or mesh bags (51%) followed by paper bags (34%).

Slightly more of these 167 respondents who bought potatoes in bags, reported purchasing potatoes in the 10-lb. bags (52%) than in 5-lb. bags (41%). The majority indicated they usually bought potatoes in a net or mesh bag (51%), a type of bag not generally used by Michigan shippers. Just under half (46%) of the 190 respondents reported purchasing potatoes from an unpackaged, bulk display during the past six months. Participants were asked how satisfied they were with the way they usually bought potatoes. Those buying bulk, unpackaged potatoes reported being the most satisfied...followed by those buying bagged potatoes while buyers of the tray wrap reported being least satisfied.

2. Packaging Alternatives - These light users of potatoes clearly favored the more traditional alternatives for buying potatoes over the newer options, as shown in Table 1. Almost half of the participants reported they would be most likely buy Russet Burbanks (9 oz) from the bulk display even though they were more expensive than the bulk all-purpose potatoes ($.49 versus $.39 per pound), plus the Russet Burbank potatoes had rhizoctonia (black spots) on the skin surface. This was followed by 17% who would buy the 5 lb. bag of all-purpose potatoes (Superiors). Very few favored the tray wrap of three Russet Norkotahs (4 percent) and there appears to be a limited market for this specialized pack.

Both the bulk displays (9 oz. Superiors and 9 oz. Russet Burbanks) were most popular as the second choice. The one potato pack they would be least likely to buy was the tray wrap with the three Russet Norkotahs.

Participants were asked to report the reason for their choice of a particular potato package. A common thread throughout the responses was "size of the potatoes." The type of package and variety were also mentioned. Because of the keen interest in the size of potatoes as the reason for selecting a particular packaging option, many Michigan potatoes are at a disadvantage (from shoppers' perspective) since they are sold predominantly in paper bags which do not allow for inspecting size and quality before purchase.

3. Potato Size Preferences - What specific size(s) of potatoes would best meet the needs of light potato users? Three varieties (Superior, Russet Burbank and Russet Norkotah) were displayed with small (4 to 5 oz.), medium (6 to 7 oz.) and large potatoes (9 to 10 oz.). From outward appearance, the Norkotah is a russet type potato very similar to the shape to the Burbank, but with a darker netting. Although the study was directed at round, white potatoes, the Michigan acreage of Russet Norkotahs is increasing. Hence it was meaningful to learn how Russet Norkotahs are perceived by consumers as compared with the Superiors and Russet Burbanks.

Table 1.
Potato Packaging Respondents Most Likely, Least Likely to Buy
(Six Packaging Options, with Current Prices)

Display	Most Likely to Buy: First Choice		Most Likely to Buy: Second Choice		Least Likely to Buy	
	Number	Percent	Number	Percent	Number	Percent
Bulk - 9 oz Russet Burbank ($.49/lb)	87	46%	47	23%	8	4%
5 lb bag, U.S. No 1 - Superior ($1.59)	33	17	43	16	25	13
3 lb bag, 4-6 oz Russet Norkotah ($1.29)	25	13	30	12	27	14
Bulk Superior (9 oz) ($.39/lb)	21	11	29	25	30	16
3 lb bag, 2 ¼ - 2 ¾" Superior ($1.19)	17	9	23	15	20	11
Tray pack - (8 oz) Russet Norkotah ($.99)	7	4	17	9	77	41
No response	----	----	1	----	3	1
	190	100%	190	100%	190	100%

Table 2 reveals that the Russet Burbanks were again the preferred choice as 30% favored the large Burbanks and 24% the medium size Burbanks (sometimes called "strippers"). This was followed by large Superior and the large Norkotah potatoes. Although there were only two sizes of Russet Burbanks displayed, they commanded over half the first choices for buying while the three sizes of both the Russet Norkotahs and Superiors were the combined first choices of 25 percent and 21 percent respectively.

Table 2.
Respondents' Choice of Potato Variety and Size to Buy
(No Price Information or Variety Names are Provided)

Variety	Size	First Choice	Second Choice
Russet Burbank	(9-10 oz)	30%	24%
Russet Burbank	(6-7 oz)	24	21
Superior	(9-10 oz)	13	15
Russet Norkotah	(9-10 oz)	10	8
Superior	(6-7 oz)	8	12
Russet Norkotah	(6-7 oz)	7	10
Superior	(4 oz)	4	2
Russet Norkotah	(4 oz)	4	8
		100%	100%

If one considers the participants first choice preferences by size of potatoes, then the large potatoes (for the three varieties) were the choice of over half (54%) while 39% favored the medium size potatoes (6-7 oz). Clearly there is a very limited market for the small potatoes as only 8% selected them as their first choice. The most popular methods for preparing any variety of potato were baking and mashing, with the exception of the small Superiors.

The question arises whether the darker netting on the Norkotah potatoes had an adverse effect on participants' perception of the potatoes. Perhaps respondents felt the Norkotahs, because of the dark color due to the netting, appeared dirty. It should be noted that the large Burbanks did have rhizoctonia (black spots) on the skins. Apparently the more familiar Burbanks, when placed next to the Norkotahs, were strongly favored.

3. Greening of Potatoes - Almost nine out of ten (89 percent) respondents reported, "Yes" to the question "Have you ever seen fresh potatoes that have skins with a greenish tinge?" Those over 34 years old were more likely than the younger respondents to have seen this greenish tinge (glyco-alkaloids).

Most of the respondents reported clearly incorrect reasons or indicated that they did not know what causes greening in potatoes. Half (50%) believed greening was caused because the potatoes were "not ripe"/"premature harvesting," 24% reported they "don't know or had no opinion" and 19% mentioned "other" causes (such as soil/dirt, chemicals, frost or cold, oxidation, it's normal, fungus or bacteria, pollution, radiation, pigment etc.) Bananas, tomatoes and apples are green before they ripen, but a large proportion of these respondents incorrectly associate the greening of potatoes with immaturity.

Very few were even on the right track as to the cause(s) of greening of potatoes. About 14 percent believed it was caused by sunlight or the potatoes growing close to the surface of the ground (a possibility), and only three percent reported that the greening could be related to fluorescent or store light. Two percent believed green potatoes weren't good for you/poisonous, but didn't know the cause.

SUMMARY...Where Do We Go From Here

This report summarizes the findings from the mall intercept interviews conducted with light users of potatoes in metropolitan Detroit, Michigan in early March 1990.

1. Michigan producers must become more customer-oriented in order to maintain their share of the tablestock potato market by better meeting the needs of a growing number light users of fresh potatoes (i.e., shoppers who want to see the potatoes in bags, have smaller households so need smaller units of purchase, the option of selecting the exact number of potatoes needed, and improved quality and more closely sized than U.S. No. 1 potatoes). An increasing number of consumers are less price-driven and more interested in convenience and value of products bought.

2. For in-home use of fresh potatoes, the potential appears greatest for baked potatoes. This is related to more convenience-oriented shoppers and increased ownership and use of the microwave oven to speed up food preparation. Findings from the mall intercept interviews revealed a strong preference for Russet Burbanks over the Russet Norkotahs potatoes. In the short run, it is important to carry out consumer sensory tests to learn how the perceived attributes of the Russet Norkotah variety compare with the Russet Burbanks and Superiors (shape, color of skin, appearance of skin, texture and taste). The findings may provide direction for marketing of Russet Norkotahs and Superiors.

3. There is a large educational gap between consumers' level of awareness and their understanding of the cause of greening of potato skins. It is important to develop an promotional/educational program (especially targeted toward younger consumers) to clear up the confusion and misinformation about what causes the greening of potatoes, as well as how to buy and store potatoes to maintain quality and minimize greening.