Keystone Potato Producers Association

McCain Foods (Canada)

Simplot Canada Limited

2007 Potato Research Report

Prepared by: Gaia Consulting Ltd.

Canada

Manitoba Agriculture and Food

Introduction

This is the 18th report on potato research funded by Keystone Potato Producers Association (KPPA), McCain Foods Limited and Simplot Canada Limited. The Canada-Manitoba Crop Diversification Centres in Carberry and Portage la Prairie provided land and irrigation for a majority of the research trials. Other contributors are listed under the heading "Funding" at the beginning of each project report.

On behalf of above sponsors we would like to thank everyone who contributed to the success of the 2007 potato research program.

Copies of the this report can be downloaded at www.gaiaconsulting.mb.ca

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Effect of Nitrogen and Potassium Rate and Timing on the Specific Gravity of Ranger Russet

Funding: Keystone Potato Producers Association
McCain Foods
Simplot Canada
Irrigation Development Program (IDP) (50%)

In Kind: Westman Aerial Spraying

Cooperator: Keller and Sons Farming

Progress: Second year

Principal Investigators: Blair Geisel and Darin Gibson, Gaia Consulting Ltd.

Abstract: The Ranger Russet potato variety is of lesser importance to the French fry processing industry than Russet Burbank, however, it does possesses desirable traits. Ranger Russet is moderately resistant to Verticillium wilt and produces higher yield than Russet Burbank in fields where the disease is present. Ranger Russet matures earlier than Russet Burbank and is used for processing approximately 6 weeks in late August and September before Russet Burbank has matured. Unfortunately, this variety often produces very high specific gravity, which is undesirable for French fry processing. Previous research in Manitoba, Idaho, and Wisconsin has demonstrated that the rate and timing of nitrogen and potassium fertilizer will affect specific gravity. Past research has shown that maintaining higher than recommended nitrogen and potassium levels throughout the growing season will reduce specific gravity by 0.010 points. Delaying the application of nitrogen can affect utilization by the plant and the increase the residual in the soil after harvest, which can have a negative impact on surface and ground water quality. In 2007, the early split application of urea nitrogen, the preplant application of ESN nitrogen and the application of additional potassium produced the highest yields. The application of additional potassium and the late split application of nitrogen produced the lowest and most desirable specific gravity for French fry processing. The early split application of nitrogen plus the application of higher than recommended amounts of potassium will maximize yield and optimize specific gravity.

Objectives:

1. To compare the effect of polymer coated and conventional nitrogen sources on yield, grade, specific gravity and nitrate leaching.

2. To compare Ranger Russet yield, grade and processing quality between different fertility treatments on a coarse textured soil.

3. To develop a management program for producing high quality Ranger Russet with acceptable specific gravity for early harvest on coarse textured soils.

Procedure:

Plot size:	4 rows by 12 m (Assessments conducted on 2 centre rows)
Trial design:	RCB 4 replicates
Plot location:	Shilo, Manitoba – commercial field
Crop:	Potatoes
Variety:	Ranger Russet
Row spacing:	1 metre
In-Row spacing:	14 inch
Soil type:	Coarse texture soil
Soil Analysis:	Residual N = 38 lbs/ac, P_20_5 = 28, K = 264, S = 66
Fertilizer	See Table 1 for N and K treatments. 65 lbs P/acre was side banded at plant.
Planting date:	April 04/27
Treatments:	Table 1

Table 1. List of nitrogen and potassium treatments (lbs/acre).

		26-Apr		8-Jun		27-Jun		16-Jul		2-Aug			
		Pre-Plant		Split 1		Split 2		Split 3		Split 4		Total	
Trt #	Treatment	N	K	N	K	N	K	N	K	N	K	N	K
1	Preplant N & K	160	200	0	0	0	0	0	0	0	0	160	200
2	Early Split N, Preplant K	80	200	40	0	40	0	0	0	0	0	160	200
3	Late Split N, Preplant K	80	200	0	0	0	0	40	0	40	0	160	200
4	Preplant N, Early Split K	160	100	0	50	0	50	0	0	0	0	160	200
5	Preplant N, Late Split K	160	100	0	0	0	0	0	50	0	50	160	200
6	Early Split N & K	80	100	40	50	40	50	0	0	0	0	160	200
7	Late Split N & K	80	100	0	0	0	0	40	50	40	50	160	200
8	Preplant N, Early Extra Split K	160	200	0	100	0	100	0	0	0	0	160	400
9	Preplant N, Late Extra Split K	160	200	0	0	0	0	0	100	0	100	160	400
10	Preplant N (ESN) & K	160	200	0	0	0	0	0	0	0	0	160	200
	<u>Notes</u>												
	Pre-plant	Nitrogen and potassium treatments were broadcast and incorporated into the soil just prior to planting.											
	Split 1	Nitrogen and potassium treatments were broadcast and incorporated while hilling.											
	Splits 2 - 4	Nitrogen and potassium treatments were broadcast without incorporation. Urea nitrogen was coated with Agrotain to reduce volatalization.											
	N - Nitrogen	Nitrogen was applied as urea with the exception of treatment #10											

Harvest date: August 21st

Specific Gravity Analysis:

Specific gravity (SG) was determined by comparing the weight of a 4.5 kg tuber sample in air and in water.

Fry Colour Analysis:

The centre ½ inch fry strip from 10 tubers per plot was fried for 2 minutes 30 seconds in vegetable oil at 375° F. Fry colour was determined using the USDA scale, which ranges from "0" (light colour) to "4" (dark colour).

Sugar End Analysis:

Sugar end If less than 1/3 of the French fry is darker than the remainder of the fry by 2 colour gradients on the USDA fry colour scale, it is defined as a sugar end. The fry colour is determined by assessing the remaining 2/3 of the fry. However, if the dark end affects more than 1/3 of the entire fry, colour is determined by assessing the dark end.

Statistical Analysis:

An ANOVA (analysis of variance) was performed on the assessment and yield data in tables 1-5. Mean separation was determined using the least significant difference (LSD) test. The percent bonus and hollow heart data was transformed (X + 1 Log 10) to create better data distribution. An ANOVA (analysis of variance) was performed on the transformed raw data as well as on the yield data in Table 1. Actual percent bonus tubers and hollow heart data is presented in Table 2. Mean separation was determined using the least significant difference (LSD) test. Orthogonal contrasts were performed to compare specific treatments.

Results Yield and Grade (Table 2 and Table 3)

The following conclusions were determined by conducting an orthogonal contrast to compare treatments.

Yield

- The addition of 400 lbs K/ac (#s 8 & 9) produced a higher marketable yield (p=0.035) than the application of 200 lbs K/ac (#s 4 & 5).
- The preplant application of nitrogen in the form of ESN (#10) produced a higher marketable and total yield (p=0.020 and 0.066 respectively) than the application of preplant nitrogen in the form of urea (#1).
- The early split application of nitrogen (#s 2 & 6) produced a higher marketable and total yield (p=0.000) than the preplant application of nitrogen (#s 1 & 4).

- The preplant application of nitrogen (#s 1 & 5) produced a higher marketable and total yield (p=0.080 and p=0.028 respectively) than the late split application of nitrogen (#s 3 & 7).
- The early split application of nitrogen (#s 2 & 6) produced a higher marketable and total yield (p=0.000) than the late split application of nitrogen (#s 3 & 7).

Bonus

- The preplant application of nitrogen in the form of ESN (#10) produced a higher percentage of bonus tubers (p=0.010) than the preplant application of nitrogen in the form of urea (#1).
- The early split application of nitrogen (#s 2 & 6) produced a higher percentage of bonus tubers (p=0.002) than the preplant application of nitrogen (#s 1 & 4).
- The preplant application of nitrogen (#s 1 & 5) produced a higher percentage of bonus tubers (p=0.001) than the late split application of nitrogen (#s 3 & 7).
- The early split application of nitrogen (#s 2 & 6) produced a higher percentage of bonus tubers (p=0.002) than the late split application of nitrogen (#s 3 & 7).

Table 2 Effect of fertilizer treatment on yield and grade.

		Yield (cwt)						
Trt #	Treatment	Undersize (<2")	Marketable (>2")		Total		Bonus %	
6	Early Split N & K	53.5	288.6	ab	342.1	a	21.2	ab
2	Early Split N, Preplant K	54.2	275.6	ab	329.7	ab	16.3	ab
8	Preplant N, Early Extra Split K	50.5	253.5	abc	304.1	abc	14.7	abc
10	Preplant N (ESN) & K	57.8	244.8	abcd	302.6	abc	20.9	a
9	Preplant N, Late Extra Split K	66.3	229.5	bcde	295.8	bc	7.6	bc
5	Preplant N, Late Split K	71.4	204.3	cdef	275.7	cd	6.3	bc
4	Preplant N, Early Split K	73.6	199.8	def	273.4	cd	6.0	bc
1	Preplant N & K	80.5	184.8	ef	265.3	cde	6.1	bc
3	Late Split N, Preplant K	78.2	169.2	f	247.4	de	3.8	c
7	Late Split N & K	72.3	157.4	f	229.7	e	7.0	bc
Probability		0.1084	0.0000		0.0001		0.0121	
CV %		24.7	15.5		9.6		69.0	
LSD (P=0.05)		NSD	49.8		39.9		11.0	

Specific Gravity

- Both early and late split applications of 400 lbs K/ac (#s 8 & 9) reduced specific gravity (p=0.001) when compared to the early and late split applications of 200 lbs K/ac (#s 4 & 5). The reduction in specific gravity is greater (p=0.000) when comparing early and late split applications of 400 lbs K/ac (#s 8 & 9) to a preplant application of 200 lbs K/ac (#1). There is no difference in the specific gravity between the early and late split applications of 400 lbs K/ac (#s 8 & 9).

- The early split application of 200 lbs K/ac (#4) produced a lower specific gravity (p=0.66) than the preplant application of 200 lbs K/ac. The later split application of K did not reduce specific gravity.

- There was no difference in specific gravity between the application of preplant nitrogen in the form of ESN (#10) or urea (#1).

- The late split application of nitrogen (#s 3 & 7) produced a lower specific gravity (p=0.001) when compared to the preplant application of nitrogen (#s 1 & 5) and the early split application of nitrogen (#s 2 & 6). The late split application of nitrogen produced a lower yield than the preplant and early split applications of nitrogen.

Fry Colour – Fry colour analysis was assessed in October, January and April. Only the results of the October and January assessment are reported.

Fry colour at harvest (October) and in January was not influenced by any of the fertilizer treatments.

Sugar end – Sugar end analysis was assessed in October, January and April. Only the results of the October and January assessment are reported.

- The preplant application of nitrogen (#s 1 & 4) produced fewer sugar end defects in October (p=0.040) than the early split application of nitrogen (#s 2 & 6). These differences no longer existed when sugar ends were assessed in January.
- There was no difference in the incidence of sugar end defects between the preplant application of nitrogen (#s 1& 4) and the late split application of nitrogen (#s 3 & 7).
- The late split application of nitrogen (#s 3 & 7) produced fewer sugar end defects in October (p=0.040) than the early split application of nitrogen (#s 2 & 6). These differences no longer existed when sugar end was assessed in January. .
- There were no differences in the incidence of sugar end defect in October between treatment #9 (preplant N, late extra split K) and treatment #5 (preplant N, Late Split recommended K). In January treatment #5 had fewer sugar end defects (p=0.010) than treatment #9. Late application of K (August 2 or 98 DAP) is not recommended and was only included in this trial for purposes of comparison.

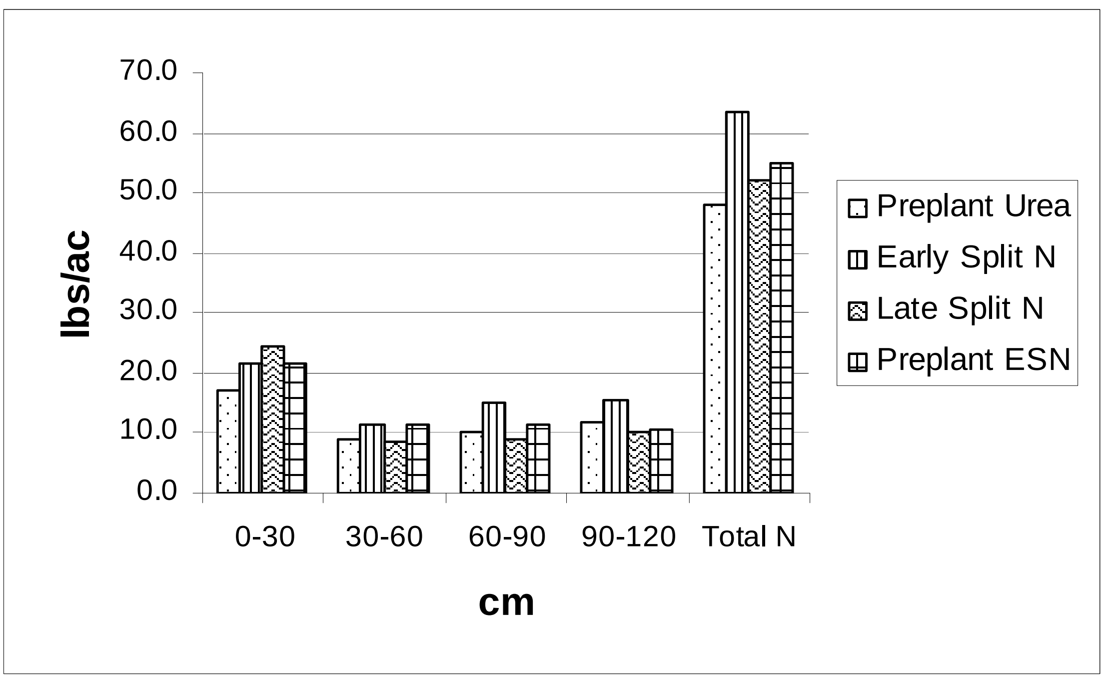
Table 3 Effect of fertilizer treatment on Specific gravity, fry colour and sugar end.

				Fry Colour		Sugar End %	
Trt #	Treatment	Specific Gravity		Harvest	January	Harvest	January
1	Preplant N & K	1.0980	a	0.13	1.68	2.5	10.56
10	Preplant N (ESN) & K	1.0975	a	0.13	1.47	2.5	2.50
2	Early Split N, Preplant K	1.0966	ab	0.08	1.40	7.5	5.90
5	Preplant N, Late Split K	1.0962	ab	0.05	0.74	5.0	2.50
4	Preplant N, Early Split K	1.0952	abc	0.16	1.26	0.0	5.00
6	Early Split N & K	1.0944	bcd	0.13	0.71	7.5	0.00
3	Late Split N, Preplant K	1.0936	bcd	0.15	0.95	0.0	5.00
7	Late Split N & K	1.0926	cd	0.15	0.85	2.5	2.50
8	Preplant N, Early Extra Split K	1.0920	d	0.10	1.11	0.0	5.63
9	Preplant N, Late Extra Split K	1.0916	d	0.05	1.19	5.0	17.55
Probability		0.0007		0.7474	0.0623	0.4635	0.1362
CV %		0.19		90.1	39.1	178.4	134.96
LSD (P=0.05)		0.0030		NSD	NSD	NSD	NSD

Results Fall Soil Analysis (Figure 1)

After harvest, there were no significant differences in residual soil N between treatments.

Figure 1 Residual nitrogen concentrations in fall for selected treatments of 2006.



Phosphorus Management for Irrigated Potato Production in Manitoba

Funding: Keystone Vegetable Producers
Simplot Canada
McCain Foods
ARDI
CMCDC (In kind, providing land and irrigation – Portage site)
Don Dickson (In kind, providing land and irrigation – Carberry site)

Principal Investigators: Blair Geisel and Darin Gibson, Gaia Consulting Ltd.

Introduction: Due to reactivity with soil, P is often in a form less available to crops. Standards for what are adequate levels of P in the soil and in potato petioles in Manitoba are not well defined. The impact of phosphorus as a non-point source contaminant has increasingly become an issue in agriculture in recent years. Concerns over water quality are a driving force in the desire to make more efficient use of P. In 2007, trials comparing different phosphorus rates and application methods were established at two sites. In 2007, differences in soil and petiole P concentrations between treatments did not translate into differences in yield or quality. The absence of response to phosphorus is surprising given the low to moderate residue levels in the soil, but consistent with other research. A Manitoba cereal study (Hedlin, 1962) reported that a response to phosphorus would occur 62 percent of the time when the soil residual level was 10-24 lbs P/acre. The lack of response in the 2007 potato trials could be due to many factors:

- Analytical methods do not accurately measure residual phosphorus concentrations in the soil.
- In 2007, there was a sufficient release of phosphorus from the organic matter in the soil to meet crop requirements.
- Soil temperatures were very warm in the spring of 2007, which would increase the availability of phosphorus to the plant.

Fall soil analysis after harvest showed that applied phosphorus had not migrated below the 0-15 cm depth.

Objectives:

1. Determine the effect of phosphorus placement on potato yield and quality.
2. Determine the effect of phosphorus rate on potato yield and quality.
3. Determine the effect of coated phosphorus product on efficient use of phosphorus, potato yield and quality.
4. Determine critical soil and tissue levels at which a response to P can be expected.
5. Improve the efficiency of phosphorus use.

Procedure:

Plot size:	4 rows by 12 m (Assessments conducted on 2 centre rows)
Trial design:	RCB 4 replicates
Plot location:	Site 1: CMCDC Portage Site 2: Carberry
Crop:	Potatoes
Variety:	Russet Burbank
Row spacing:	1 metre
Soil type:	CMCDC Portage - Neuhorst, Clay Loam. 17 lbs residual P_2O_5/acre, 80-90 lbs/acre recommended to produce 300 cwt/acre Carberry – Stockton Fine Sandy Loam. 26 lbs residual P_2O_5/acre, 40-50 lbs recommended to produce 300 cwt/acre.
Treatments:	Table 4

Table 4 List of fertilizer treatments

Trt #	Method	Product	Rate (lbs/ac)
1		Untreated Check	
2	Side band	Mono Ammonium Phosphate (MAP)	20 lbs P_20_5
3	Side band	Mono Ammonium Phosphate (MAP)	40 lbs P_20_5
4	Side band	Mono Ammonium Phosphate (MAP)	80 lbs P_20_5
5	Side band	Mono Ammonium Phosphate (MAP)	160 lbs P_20_5
6	Side band	Avail Coated MAP	40 lbs P_20_5
7	Broadcast	Mono Ammonium Phosphate (MAP)	20 lbs P_20_5
8	Broadcast	Mono Ammonium Phosphate (MAP)	40 lbs P_20_5
9	Broadcast	Mono Ammonium Phosphate (MAP)	80 lbs P_20_5
10	Broadcast	Mono Ammonium Phosphate (MAP)	160 lbs P_20_5

Results:

Tissue Testing (Table 5 and Table 6):

Fourth petioles were collected on two dates, one in July and one in August for each site. The August Carberry samples were lost in the Northwood, ND tornado that destroyed the Agvise laboratory. The highest P levels were measured in the high rate (160 lb) treatments (5 and 10).

Table 5 Effect of treatment on petiole phosphorus (Portage)

		Petiole Phosphorus (%)			
Trt #	Trt Name	17-Jul		14-Aug	
1	Untreated Check	0.222	de	0.153	bc
2	MAP 20 lb Side Band	0.220	de	0.138	c
3	MAP 40 lb Side Band	0.235	cde	0.175	bc
4	MAP 80 lb Side Band	0.233	cde	0.177	bc
5	MAP 160 lb Side Band	0.313	a	0.268	a
6	Avail 40 lb Side Band	0.242	bcde	0.183	bc
7	MAP 20 lb Broadcast	0.215	e	0.150	bc
8	MAP 40 lb Broadcast	0.265	bcd	0.213	abc
9	MAP 80 lb Broadcast	0.270	abc	0.215	abc
10	MAP 160 lb Broadcast	0.282	ab	0.222	ab
Probability		0.0007		0.0029	
CV %		11.632		21.408	
LSD (P=0.05)		0.042		0.059	

Table 6 Effect of treatment on petiole phosphorus (Carberry)

		Petiole P (%)	
Trt #	Trt Name	23-Jul	
1	Untreated Check	0.300	d
2	MAP 20 lb Side Band	0.320	cd
3	MAP 40 lb Side Band	0.370	bc
4	MAP 80 lb Side Band	0.350	cd
5	MAP 160 lb Side Band	0.420	ab
6	Avail 40 lb Side Band	0.370	bc
7	MAP 20 lb Broadcast	0.350	cd
8	MAP 40 lb Broadcast	0.370	bc
9	MAP 80 lb Broadcast	0.420	ab
10	MAP 160 lb Broadcast	0.450	a
Probability		0.0005	
CV %		11.350	
LSD (P=0.05)		0.060	

Whole plant samples (vines, roots plus stolons, tubers) from each plot at both sites were collected prior to top kill and submitted for phosphorus analysis. The results from this testing will be available at a later date.

Yield (Table 7 and Table 8):

There were no significant differences detected between treatments for undersize, marketable or total yield however there was a difference in the percentage of bonus tubers in the Portage trial.

Table 7 Effect of phosphorus treatment on potato yield (Portage)

		Yield (cwt)				
Trt #	Trt Name	Undersize (<2")	Marketable (>2")	Total	Bonus (>10 oz) %	
1	Untreated Check	51.4	364.7	416.1	25.4	bc
2	MAP 20 lb Side Band	57.4	353.9	411.4	22.1	c
3	MAP 40 lb Side Band	57.1	394.2	451.2	29.1	abc
4	MAP 80 lb Side Band	55.7	364.9	420.6	31.1	ab
5	MAP 160 lb Side Band	60.0	382.6	442.6	25.4	bc
6	Avail 40 lb Side Band	43.4	398.7	442.1	34.2	a
7	MAP 20 lb Broadcast	47.0	349.8	396.8	28.9	abc
8	MAP 40 lb Broadcast	53.5	378.9	432.3	37.2	a
9	MAP 80 lb Broadcast	41.2	396.4	437.6	34.2	a
10	MAP 160 lb Broadcast	62.0	365.1	427.1	32.1	ab
Probability		0.5780	0.5433	0.4475	0.0265	
CV %		28.8	10.0	7.7	19.5	
LSD (P=0.05)		NSD	NSD	NSD	8.5	

Table 8 Effect of phosphorus treatment on potato yield (Carberry)

		Yield (cwt)			
Trt #	Trt Name	Undersize (<2")	Marketable (>2")	Total	Bonus (>10 oz) %
1	Untreated Check	78.0	382.8	460.9	17.9
2	MAP 20 lb Side Band	87.9	360.7	448.5	15.7
3	MAP 40 lb Side Band	85.7	365.8	451.5	19.1
4	MAP 80 lb Side Band	90.3	385.3	475.6	14.2
5	MAP 160 lb Side Band	77.6	395.5	473.1	21.6
6	Avail 40 lb Side Band	67.7	407.6	475.3	17.8
7	MAP 20 lb Broadcast	77.8	400.6	478.4	20.9
8	MAP 40 lb Broadcast	78.1	393.2	471.3	16.8
9	MAP 80 lb Broadcast	91.0	377.4	468.4	18.5
10	MAP 160 lb Broadcast	104.3	355.0	459.2	15.6
Probability		0.7092	0.2268	0.8471	0.8991
CV %		29.2	7.7	6.3	39.6
LSD (P=0.05)		NSD	NSD	NSD	NSD

Hollow Heart (Table 9 and Table 10):

There was no significant difference in the number of tubers with hollow heart or the weight of tubers with hollow heart.

Table 9 Effect of phosphorus treatment on hollow heart % (Portage)

		Hollow Heart	
Trt #	Trt Name	% by Number	% by Weight
1	Untreated Check	2.1	3.5
2	MAP 20 lb Side Band	2.6	5.1
3	MAP 40 lb Side Band	0.0	0.0
4	MAP 80 lb Side Band	1.6	3.6
5	MAP 160 lb Side Band	1.5	2.8
6	Avail 40 lb Side Band	1.5	5.5
7	MAP 20 lb Broadcast	0.0	0.0
8	MAP 40 lb Broadcast	8.7	11.8
9	MAP 80 lb Broadcast	3.6	4.6
10	MAP 160 lb Broadcast	5.4	8.5
Probability		0.2892	0.5979
CV %		173.8	174.3
LSD (P=0.05)		NSD	NSD

Table 10 Effect of phosphorus treatment on hollow heart % (Carberry)

		Hollow Heart	
Trt #	Trt Name	% by Number	% by Weight
1	Untreated Check	10.7	15.2
2	MAP 20 lb Side Band	4.3	2.4
3	MAP 40 lb Side Band	9.1	13.8
4	MAP 80 lb Side Band	4.0	8.0
5	MAP 160 lb Side Band	8.3	12.3
6	Avail 40 lb Side Band	5.2	9.6
7	MAP 20 lb Broadcast	6.3	9.2
8	MAP 40 lb Broadcast	9.0	12.2
9	MAP 80 lb Broadcast	7.1	11.0
10	MAP 160 lb Broadcast	3.0	5.7
Probability		0.8219	0.8774
CV %		102.2	112.6
LSD (P=0.05)		NSD	NSD

Fry Quality (Table 11 and Table 12):

There were no statistical differences between treatments with respect to fry quality.

Table 11 Effect of phosphorus treatment on fry quality (Portage)

		Fry Colour		Sugar End %	
Trt #	Trt Name	Harvest	January	Harvest	January
1	Untreated Check	0.80	0.70	50.0	60.0
2	MAP 20 lb Side Band	0.66	0.67	51.1	68.9
3	MAP 40 lb Side Band	0.48	0.58	50.0	62.5
4	MAP 80 lb Side Band	0.53	0.75	56.1	60.0
5	MAP 160 lb Side Band	0.66	0.95	38.9	37.5
6	Avail 40 lb Side Band	0.83	0.73	30.0	45.0
7	MAP 20 lb Broadcast	0.63	0.95	52.5	65.0
8	MAP 40 lb Broadcast	0.90	0.78	50.0	58.1
9	MAP 80 lb Broadcast	0.68	1.15	47.5	48.2
10	MAP 160 lb Broadcast	0.80	0.80	40.0	40.0
Probability		0.9448	0.3858	0.5829	0.1347
CV %		65.3	39.6	36.9	30.8
LSD (P=0.05)		NSD	NSD	NSD	NSD

Table 12 Effect of phosphorus treatment on fry quality (Carberry)

		Fry Colour		Sugar End %	
Trt #	Trt Name	Harvest	January	Harvest	January
1	Untreated Check	1.30	1.05	5.00	25.0
2	MAP 20 lb Side Band	1.35	0.50	12.50	17.5
3	MAP 40 lb Side Band	1.03	0.98	7.50	29.4
4	MAP 80 lb Side Band	1.50	0.62	2.50	27.8
5	MAP 160 lb Side Band	1.33	0.93	0.00	12.5
6	Avail 40 lb Side Band	1.23	0.18	5.00	31.8
7	MAP 20 lb Broadcast	1.55	0.98	10.00	30.0
8	MAP 40 lb Broadcast	1.30	0.63	5.00	20.0
9	MAP 80 lb Broadcast	1.68	1.00	5.00	15.0
10	MAP 160 lb Broadcast	1.48	0.83	7.50	22.5
Probability		0.4515	0.2701	0.5136	0.5377
CV %		25.4	44.1	123.4	61.3
LSD (P=0.05)		NSD	NSD	NSD	NSD

Soil Sampling (Table 13 and able 14):

Soil samples were collected (0-15 cm) and analyzed for phosphorus prior to planting. Results indicated that the Portage and Carberry sites had phosphorus levels of 12 and 26 lb/ac, respectively. Fall soil samples were collected from each plot after harvest to 60 cm, and tested for phosphorus. This sampling will be conducted again in spring 2008.

Table 13 Effect of phosphorus treatment on soil P (Portage)

		Soil P-Olsen (ppm)		
Trt #	Trt Name	0-15	15-30	30-60
1	Untreated Check	6.5	3.0	2.0
2	MAP 20 lb Side Band	6.0	3.5	2.8
3	MAP 40 lb Side Band	6.5	4.0	2.8
4	MAP 80 lb Side Band	15.0	3.3	3.0
5	MAP 160 lb Side Band	19.8	4.0	2.3
6	Avail 40 lb Side Band	8.8	4.5	2.0
7	MAP 20 lb Broadcast	7.0	3.3	2.3
8	MAP 40 lb Broadcast	16.3	4.3	2.5
9	MAP 80 lb Broadcast	13.5	4.3	2.8
10	MAP 160 lb Broadcast	18.5	4.0	2.5
Probability		0.0531	0.6931	0.7799
CV %		61.7	31.9	35.5
LSD (P=0.05)		NSD	NSD	NSD

Table 14 Effect of phosphorus treatment on soil P (Carberry)

		Soil P-Olsen (ppm)				
Trt #	Trt Name	0-15		15-30	30-60	
1	Untreated Check	13.0	b	5.3	8.0	d
2	MAP 20 lb Side Band	14.8	b	7.3	8.0	d
3	MAP 40 lb Side Band	14.5	b	6.3	12.5	a
4	MAP 80 lb Side Band	13.5	b	6.5	8.3	d
5	MAP 160 lb Side Band	38.5	a	6.8	8.5	d
6	Avail 40 lb Side Band	21.3	b	7.5	9.8	abcd
7	MAP 20 lb Broadcast	13.8	b	6.5	12.0	ab
8	MAP 40 lb Broadcast	17.3	b	7.3	9.5	bcd
9	MAP 80 lb Broadcast	19.3	b	6.5	11.8	abcd
10	MAP 160 lb Broadcast	23.5	b	6.5	9.0	cd
Probability		0.0328		0.9030	0.0097	
CV %		52.0		29.1	20.1	
LSD (P=0.05)		14.3		2.8	2.8	

Effect of Irrigation Timing, Nitrogen Rate and Timing on Sugar-End Disorder 2004-2007

Principal Investigators: Blair Geisel and Darin Gibson, Gaia Consulting Ltd.
Elaine Gauer and Dale Tomasiewicz, CMCDC Carberry

Funding: Irrigation Development Project (75%)
Keystone Potato Producers Association
McCain Foods (Canada)
Simplot Canada Ltd,
Canada Manitoba Crop Diversification Centre Carberry and Portage

Progress: Fourth year of ongoing research.

Abstract:

Sugar-end, dark end or translucent end in potato is a disorder affecting the stem end of tubers. The affected tissue has a lower dry matter content and a higher reducing sugar (glucose and fructose) content. This disorder is brought about by various stresses to the potato plant, and the Russet Burbank variety is particularly susceptible. As moisture stress and over-fertilization have often been implicated as causes of this disorder, a two factor study (nitrogen x irrigation) was initiated in 2004.

Irrigation decreased the incidence of sugar end and specific gravity, caused darker fries, and increased yield, tuber size profile and the incidence of hollow heart.

The incidence of sugar end was high in 2006 and 2007. In 2006 and 2007, the addition of irrigation water reduced the incidence of sugar end defect from 45.3% in the rain fed treatment to 22.9% in the optimum irrigation treatment. Nitrogen rate had more effect on sugar end in the irrigation than in the rain fed treatments. Additional nitrogen (treatments 4 and 5) and delayed (split) application of nitrogen at the recommended rate (treatments 2 and 3) reduced the incidence of sugar end in the irrigated treatments. Additional nitrogen applied late in the season (treatment 6) did not improve the incidence of sugar end compared to the recommended rate of nitrogen applied at plant (treatment 1).

Irrigation lowered specific gravity by 0.004 points compared to rain fed production. Delaying application or applying additional nitrogen also decreased specific gravity by 0.004 points. The effect of nitrogen rate and timing was more pronounced in the irrigation than in the rain fed treatments.

Both irrigation treatments (#2 & 3) produced 104 and 130 cwt/ac more marketable yield respectively than the rain fed treatment (#1). The timing of the nitrogen application had a greater effect on total and marketable yield in the recommended rate of nitrogen treatments (#s 1, 2 & 3) than in the additional nitrogen treatments (#s 4, 5 & 6). The early nitrogen split 40 days

after planting (#2) produced the highest yield of the recommended rate treatments (#s 1, 2 & 3) and yields similar to treatments 4, 5 & 6 which received additional nitrogen.

Objective: To assess the effects of irrigation timing, nitrogen rate, and nitrogen timing on sugar-ends in potato.

Procedure:

- Plot size: 4 rows by 12 m (Assessments conducted on 2 centre rows)
- Trial design: RCB for irrigation treatment (main plot), with nitrogen treatment a split plot on irrigation (subplot).
- Plot location: 4 years at CMCDC Carberry and 1 year at CMCDC Portage la Prairie
- Soil types: Wellwood Clay Loam (Carberry) and Neuhorst clay loam (Portage)
- Crop: Potatoes
- Variety: Russet Burbank
- Row spacing: 1 metre
- Treatment: Table 15 and Table 16.

Table 15: Treatment List

Irrigation Treatment No. and Name			Trt #	Nitrogen Regime
1	Rainfed		1	Recommended rate all broadcast prior to planting
2	Sub-Optimum Irrigation [1]		2	Recommended rate (1/3:2/3 split)[3] early hilling[4]
3	Optimum Irrigation [2]		3	Recommended rate (1/3:2/3 split)[3] late hilling[5]
			4	Recommended rate + 75 lb all broadcast prior to planting
			5	Recommended rate + 75 lb (1/3:2/3 split)[3] early hilling[4]
			6	Recommended rate + 75 lb (1/3:2/3 split)[3] late hilling[5]

[1] Irrigation onset was delayed and frequency was reduced to allow the soil to develop a moisture deficit

[2] Soil Moisture maintained above 70% available soil water

[3] Ratio indicates 1/3 N broadcast prior to planting and 2/3 N broadcast at time of hilling

[4] Approximately 39 days after planting

[5] Approximately 59 days after planting

Table 16. Actual Irrigation and Nitrogen applied:

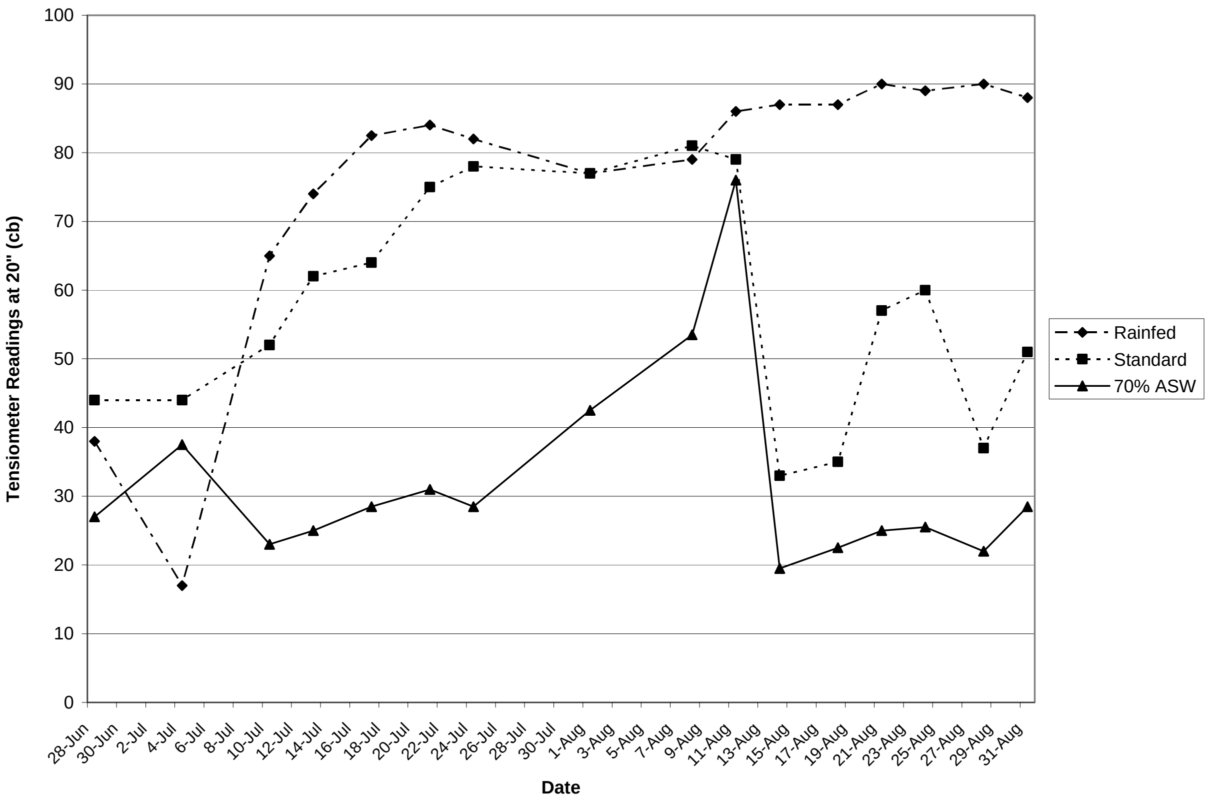
		Precipitation[1] + Irrigation (mm)			Nitrogen lbs/ac		
Year	Site	Rainfed	Standard	Optimum	Residual	Recommended	Recommended + 75 lbs/ac
2004	Carberry	318	356	388		90	165
2005	Carberry	286	357	418		75	150
2006	Carberry	198	381	511	85	80	155
2007	Carberry	271	400	486	36	150	225
2007	Portage	221	348	437	34	150	225

[1] Precipitation from planting to September 15th.

Irrigation Scheduling:

The checkbook method was used to schedule irrigation events for irrigation treatment #3 where an attempt was made to maintain available soil water (ASW) for the first 500 p-days above 70% and above 65% thereafter in the top 60 cm of soil. Moisture readings from tensiometers located at a depth of 10 and 20 inches were used monitor soil moisture and to correct checkbook values if necessary. In treatment #2, initiation of irrigation was delayed and fewer irrigation events were scheduled than treatment #3 to create less than optimum soil moisture status. Figure 2 shows the typical differences in soil moisture between treatments at the 20 inch depth, similar trends were observed with the 10 inch readings.

Figure 2 Average tensiometer readings at 20 inch depth.



Specific Gravity Analysis:

Specific gravity (SG) was determined by comparing the weight of a 10 lb sample of tubers in air and in water.

Fry Colour Analysis:

The centre ½ inch fry strip from 10 tubers per plot was fried for 2 minutes 30 seconds in vegetable oil at 375° F. Fry Colour was determined using the USDA fry colour chart. Colour scale ranges from "0" (light) to "4" (dark). Fry strips were considered to have sugar end defect if less than 1/3 of the French fry was 2 colours darker on the USDA scale than the remainder of the fry. In these cases the fry colour was determined by assessing the remaining 2/3 of the fry.

However, if the dark end affected more than 1/3 of the entire fry, colour was determined by assessing the darker portion of the fry. The number of fried strips with sugar end was recorded and expressed as a percentage.

Statistical Analysis:

An ANOVA (analysis of variance) was performed on all raw data. Mean separation was determined using the least significant difference (LSD) test.

Results: Fry Colour and Specific Gravity (Table 17).

Both irrigation treatments caused the tubers to fry darker. This may due to the effect of irrigation on physiological maturity. Irrigated plants were more vigorous than rain fed plants at harvest and the tubers may have had a higher concentration of reducing sugars, which causes dark fry colour. Fry colour was not affected by the timing of nitrogen application or by the application of additional nitrogen. The incidence of sugar end in 2004 and 2005 was very low 0.333 and 1.389 percent respectively, so this data was excluded from the analysis. Only data from 2006 and 2007 (3 sites) was included in the sugar end analysis. In 2006 and 2007, the addition of irrigation water reduced the incidence of sugar end defect from 45.3% in the rain fed treatment to 22.9% in the optimum irrigation treatment. There was no difference in the incidence of sugar end between the sub optimum and optimum irrigation treatments. Nitrogen rate had more effect on sugar end in the irrigation than in the rain fed treatments. Additional nitrogen (treatments 4 and 5) and delayed (split) application of nitrogen at the recommended rate (treatments 2 and 3) reduced the incidence of sugar end in the irrigated treatments. Additional nitrogen applied late in the season (treatment 6) did not improve the incidence of sugar end compared to the recommended rate of nitrogen applied at plant (treatment 1).

Irrigation lowered specific gravity compared to rain fed production. There was no difference in specific gravity between irrigation treatments. In a growing season where the crop is under severe moisture stress, as it was at the Portage site in 2007, irrigation increased specific gravity. At this site, the rain fed treatment plants were not growing vigorously so solids did not accumulate in the tubers. Delaying nitrogen application or adding additional nitrogen decreased specific gravity. The effect of timing and rate of nitrogen application on specific gravity was much greater in the irrigated than in the rain fed treatments.

Table 17. Effect of irrigation and nitrogen application on fry colour and specific gravity.

Irrigation Treatment	Nitrogen Treatment	Specific Gravity		Mean Fry Colour [1]		Sugar End %	
1		1.0943	a	0.53	b	45.3	a
2		1.0915	b	0.61	ab	27.6	b
3		1.0906	b	0.70	a	22.9	b
	Prob.	0.0000		0.0106		0.0001	
	CV %	0.23		45.33		38.75	
	LSD. 0.05	0.00095		0.1087		6.619	
	1	1.0942	a	0.61		37.2	a
	2	1.0938	a	0.63		33.6	ab
	3	1.0929	b	0.55		30.8	bc
	4	1.0912	c	0.64		28.3	c
	5	1.0904	c	0.65		27.5	c
	6	1.0904	c	0.60		34.2	ab
	Prob.	0.0000		>0.9000		0.0081	
	CV%	0.23		45.3		38.8	
	LSD. 0.05	0.000927		NSD		4.469	
1	1	1.0953	a	0.62		49.2	ab
1	2	1.0951	a	0.52		42.5	bc
1	3	1.0949	ab	0.46		40.8	c
1	4	1.0938	abc	0.53		46.7	abc
1	5	1.0933	c	0.53		39.2	cd
1	6	1.0937	abc	0.53		53.3	a
2	1	1.0937	abc	0.58		30.8	e
2	2	1.0933	c	0.64		31.7	de
2	3	1.0926	cd	0.55		26.7	ef
2	4	1.0902	ef	0.60		17.5	gh
2	5	1.0902	ef	0.64		28.3	ef
2	6	1.0892	fgh	0.65		30.8	e
3	1	1.0935	bc	0.64		31.7	de
3	2	1.0932	c	0.73		26.7	ef
3	3	1.0911	de	0.65		25.0	efg
3	4	1.0896	fgh	0.79		20.8	fgh
3	5	1.0878	h	0.78		15.0	h
3	6	1.0883	gh	0.63		18.3	gh
	Prob.	0.0132		>0.9000		0.0328	
	CV%	0.23		45.3		38.8	
	LSD. 0.05	0.001598		NSD		7.741	

Results: Yield and Grade (Table 18).

Both irrigation treatments (#2 & 3) produced higher total and marketable and lower undersize yield than the rain fed treatment (#1). The optimum irrigation treatment (#3) produced a higher total and marketable and lower undersize yield than the sub-optimal irrigation treatment (#2).

The timing of the nitrogen application had a greater effect on total and marketable yield in the recommended rate of nitrogen treatments (#s 1, 2 & 3) than in the additional nitrogen treatments (#s 4, 5 & 6). The early nitrogen split 40 days after planting (#2) produced the highest yield of the recommended rate treatments (#s 1, 2 & 3) and yields similar to treatments 4, 5 & 6 which received additional nitrogen. Applying additional nitrogen might produce slightly higher yields, but would contribute to nitrogen leaching.

Irrigation increased tuber size and the incidence of hollow heart. These two factors are related because as tuber size increases, so does the incidence of hollow heart. Delaying nitrogen application or applying additional nitrogen decreased the incidence of hollow heart.

Table 18. Effect of irrigation and nitrogen on yield and grade.

		Yield cwt/ac									
Irrigation Treatment	Nitrogen Treatment	Undersize < 2"		Maingrade >2"		Total		Bonus >10 oz %		Hollow Heart %	
1		73.4	a	229.8	c	303.2	c	16.9	b	1.8	c
2		57.2	b	333.0	b	390.2	b	27.3	a	4.2	b
3		51.3	c	359.5	a	410.8	a	29.9	a	7.2	a
	Prob.	0.0000		0.0000		0.0000		0.0000		0.0001	
	CV %	28.29		9.79		7.11		31.62		156.62	
	LSD. 0.05	5.952		12.25		11.06		2.576		2.064	
	1	65.4	a	294.7	c	360.2	b	22.1	b	7.6	a
	2	60.4	ab	307.2	ab	367.6	b	24.5	ab	6.2	ab
	3	63.6	a	303.6	bc	367.2	b	24.2	ab	4.5	bc
	4	55.7	b	311.2	ab	366.9	b	25.8	a	3.9	bc
	5	57.0	b	312.1	ab	369.1	ab	25.8	a	2.0	c
	6	61.5	ab	315.9	a	377.4	a	25.8	a	2.1	c
	Prob.	0.0159		0.0027		0.0217		0.0560		0.0000	
	CV%	28.29		9.79		9.11		31.62		156.62	
	LSD. 0.05	6.169		10.03		9.417		2.808		2.47	
1	1	72.4		223.2		295.6		16.4		2.3	
1	2	70.6		233.5		304.1		16.4		3.2	
1	3	77.7		220.8		298.5		14.1		1.2	
1	4	71.0		235.8		306.8		17.3		1.6	
1	5	71.1		236.7		307.8		19.5		1.2	
1	6	77.3		228.8		306.2		17.7		1.5	
2	1	64.3		309.2		373.5		23.6		8.1	
2	2	62.6		327.2		389.8		28.4		4.8	
2	3	58.4		337.7		396.1		27.6		3.7	
2	4	49.5		338.5		388.0		29.2		5.3	
2	5	54.4		336.2		390.5		27.2		1.0	
2	6	54.3		349.3		403.6		27.9		2.0	
3	1	59.7		351.7		411.4		26.2		12.4	
3	2	48.0		360.8		408.8		28.6		10.5	
3	3	54.8		352.2		407.0		30.9		8.6	
3	4	46.8		359.2		406.0		31.0		4.8	
3	5	45.5		363.6		409.1		30.7		4.0	
3	6	53.0		369.6		422.6		31.7		2.7	
	Prob.	0.4278		0.3142		0.4420		0.0609		0.0998	
	CV%	28.29		9.79		9.11		31.62		156.6	
	LSD. 0.05	NSD		NSD		NSD		NSD		NSD	

Evaluation of Nitrogen Uptake in the Potato Plant

Funding: Agriculture and Agri-Food Canada
Keystone Vegetable Producers
Simplot Canada
McCain Foods
Agricultural Research Development Initiative (37%)

In-Kind Support: CMCDC provided land and irrigation management.

Principal Investigators: Blair Geisel and Darin Gibson, Gaia Consulting Ltd.
Bernie Zebarth, Agriculture and Agri-Food Canada

Progress: Third and final year

Abstract:

How the potato plant utilizes nitrogen (nitrogen cycle) is not well understood under Manitoba growing conditions. In Manitoba, potato plants tend to produce more vines and less tuber yield than other production areas. Also, it is not understood how the partitioning of nitrogen between vines and tubers is affected by the rate and time of nitrogen application. Understanding the nitrogen cycle in the soil and plant (vines, tubers and roots) is a prerequisite to reforming nitrogen recommendation for potatoes.

Data was collected in 2004, 2006 and 2007. Unfortunately conditions during those growing seasons were not typical. In 2004 the plot was planted very late in the season due to wet soil conditions, so the crop was not able to achieve a high yield. In 2006, above average amount of P-day units were received, which produced plot yields that were 1.5 greater than average for irrigated research plots. 2007 was a more typical growing season, but for some inexplicable reason the plot lacked vigour and didn't yield well. This information should be considered when interpreting the results. The reader must also consider that this study was carried out on a fine textured soil with medium organic matter content, which has the ability to mineralize large quantities of nitrogen throughout the season. Coarse textured soils with less organic matter will react differently to nitrogen rate and application method.

For the same method of application, the petiole nitrate concentration increased with increasing rates of nitrogen application. There is no difference in the concentration of nitrogen in the petiole between the same application rate and different application methods (treatments #s 4,7,8,9 & 11).

Specific gravity decreased with increasing rate of nitrogen. There was no difference in specific gravity between nitrogen application methods.

Preplant residual soil nitrogen levels were 23, 48 and 34 lbs/acre for 2004, 2006 and 2007 respectively. Maximum marketable yield was achieved by applying 100-150, 150-200 and 0 lbs/acre in 2004, 2006 and 2007 respectively. There was no difference in yield between application method and timing for the same rate of application (treatments #s 4,7,8,9 & 11). Applications greater than 150 lbs N/acre produce little or no increase in yield, but increased the quantity of residual N in the soil after harvest.

There was no difference in incidence of hollow heart between treatments. Increasing the rate of nitrogen increased the percentage of bonus tubers.

Nitrogen use efficiency varied from 36% in 2007 to 60% in 2006. Analysis of nitrogen uptake indicated that in 2004 and 2007 large amounts of residual N remained in the foliage after harvest. The nitrogen that was taken up by the crop did not translate into yield in 2004 because the crop did not have time to mature and in 2006 the crop lacked vigour late in the season and did not develop yield.

Objectives:

1. Effect of N rate at planting on tuber yield, size distribution and specific gravity, and on plant dry matter and N accumulation and partitioning.

2. Effect of timing of N application (pre-plant versus split application) on tuber yield, size distribution and specific gravity, and on plant dry matter and N accumulation and partitioning.

3. Effect of fertilizer placement (pre-plant broadcast versus banded at planting) on tuber yield, size distribution and specific gravity, and on plant dry matter and N accumulation and partitioning.

Procedure:

Plot size:	4 rows by 12 m (Assessments conducted on 2 centre rows)
Trial design:	RCB 4 replicates
Plot locations:	CMCDC Portage la Prairie, MB
Crop:	Potato
Variety:	Russet Burbank
Plant Spacing:	38 cm
Row spacing:	1 metre
Soil type:	Neuhorst Clay Loam
Nutrient Analysis:	34 lbs N/ac, 17 lbs P/ac, 398 lbs K/ac, 154 lbs S/ac
Nutrients Applied:	N (see Table 19), 40 lbs P/ac, 100 lbs K/acre and 20 lbs S/ac
Treatments:	Table 19
Planting Date:	May 3rd

Precipitation: From planting to September 15th.
221 mm precipitation + 216 mm irrigation = 437 mm
8.7 inches precipitation + 8.5 inches irrigation = 17.2 inches

Harvest Date: September 19th

Table 19 Nitrogen fertility treatments.

	lbs N/ac Applied as Ammonium Nitrate[a]			
Trt No.	N Broadcast[b] Pre-Plant	N Banded[c] at Planting	Split[d] N	Total N Applied
1	0	0	0	0
2	50	0	0	50
3	100	0	0	100
4	150	0	0	150
5	200	0	0	200
6	250	0	0	250
7	100	0	50	150
8	50	0	100	150
9	0	0	150	150
10	0	100	0	100
11	0	150	0	150
12	0	200	0	200

[a] Ammonium nitrate (34-0-0) was the source of nitrogen for all treatments.
[b] Pre-plant surface broadcast and incorporated
[c] N at-plant was banded 2" below and 2" to the side of seed piece.
[d] Apply split nitrogen 31-36 days after planting

Statistical Analysis: The percent bonus and hollow heart data was transformed (X + 1 Log 10) to create better data distribution. An ANOVA (analysis of variance) was performed on the transformed raw data as well as on the yield data. Actual percent bonus tubers and hollow heart data is presented in the report. Mean separation was determined using the least significant difference (LSD) test.

Petiole Sampling:

Petioles samples were collected (06/28, 07/12, 07/19, 08/09 and 08/23). Thirty (30) petioles were collected from each plot (12 treatments X 4 replicates = 48 plots) for analysis. There is no data from the petiole samples collected on 08/23 because the sample was destroyed at the laboratory.

Dark Ends:

One end of the fry strip must be a minimum of 2 shades darker and the dark end must be a minimum of 1/4 inch into the strip from either end. Results are expressed as a percentage of 20 strips.

Specific Gravity Analysis:

Specific gravity (SG) was determined by comparing the weight of a 4.5 kg sample of tubers in air and in water.

Harvest Sampling:

Prior to main harvest, tuber, root and stem samples from 4 consecutive plants per plot were collected by Gaia Consulting and submitted to AAFC for nutrient analysis. The weight of the harvest samples was included in the calculation for yield.

Results Petiole Analysis:

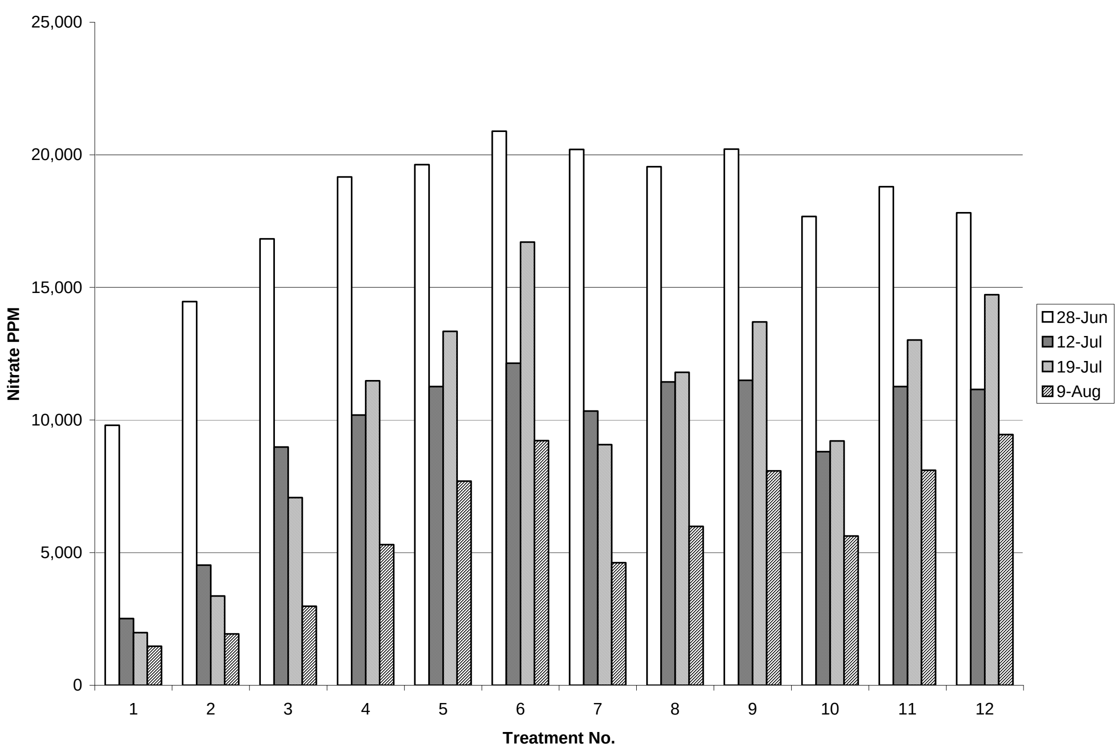
The following observations were made regarding the petiole nitrate concentrations (Table 20 and Figure 3):

- All nitrogen treatments, with the exception of treatment #2 on 06/28 and 07/12, had higher petiole nitrate concentrations than the check (# 1)
- For the same method of application, the petiole nitrate concentration increased with increasing rates of nitrogen application.
- Side banding had higher petiole N concentration than broadcasting for the same rates of application.
- For the same rate of application the later nitrogen is applied the higher the petiole N concentration at the end of the season (treatments #s 7, 8 & 9).

Table 20 Results of petiole nitrate analysis

	Nitrate ppm							
Trt. No.	28-Jun		12-Jul		19-Jul		9-Aug	
1	9805.0	g	2516.0	f	1979.8	g	1472.8	f
2	14469.0	f	4531.8	e	3362.8	g	1939.3	f
3	16829.3	e	8980.8	cd	7076.8	f	2975.0	ef
4	19162.3	abcd	10190.5	bcd	11481.5	cde	5303.0	cde
5	19625.8	abc	11263.5	ab	13346.5	bc	7701.0	abc
6	20892.3	a	12144.0	a	16712.8	a	9224.3	abc
7	20203.8	ab	10341.0	bc	9070.5	ef	4622.5	de
8	19552.3	abcd	11436.5	ab	11798.0	cd	5985.5	bcd
9	20209.5	ab	11496.3	ab	13701.0	bc	8088.5	ab
10	17671.5	de	8806.5	d	9207.5	def	5628.3	bcd
11	18802.3	bcd	11264.0	ab	13018.3	bc	8109.5	ab
12	17809.8	cde	11153.3	ab	14726.3	ab	9450.0	a
Prob.	0.0000		0.0000		0.0000		0.0000	
CV %	7.50		10.98		17.71		29.60	
LSD = 0.05	1933		1502		2664		2501	

Figure 3 Results of petiole analysis



Results Specific Gravity, Fry Colour and Tuber Length/Width Ratio:

Fry colour and sugar end assessment was conducted at harvest (October) and January. Between October and January fry colour lightened and the incidence of sugar end increased.

At harvest, there were no differences, but in January there were differences in fry colour and the incidence of sugar end between treatments. For the same method of application, increasing the rate of nitrogen darkened fry colour and decreased the incidence of sugar end.

Table 21 Effect of nitrogen rate and application method on fry colour and dark ends.

	Fry Colour			Sugar End %		
Trt #	Harvest	January		Harvest	January	
1	0.82	0.77	bc	50.0	66.9	bcd
2	0.50	0.37	d	60.0	92.2	a
3	0.32	0.70	cd	79.8	83.9	ab
4	0.78	0.93	abc	71.9	71.7	abcd
5	0.80	1.05	ab	64.4	75.3	ab
6	0.65	0.90	abc	42.5	47.5	d
7	0.85	0.82	abc	57.5	66.1	bcd
8	0.80	0.74	bc	62.5	60.9	bcd
9	0.60	0.83	abc	55.0	48.6	cd
10	0.57	0.70	bcd	40.0	69.2	abcd
11	0.70	0.88	abc	59.4	67.5	bcd
12	0.68	1.12	a	52.5	73.2	abc
Probability	0.9383	0.0200		0.5446	0.0378	
CV %	71.8	29.6		41.0	24.9	
LSD (P=0.05)	NSD	0.347		NSD	24.561	

Results Yield and Grade (Table 22):

- All treatments with the exception of #2 (63 lbs N/ac) produced a higher marketable yield than the untreated check.
- Maximum yield was achieved by the application of 100 to 150 lbs N/acre.
- No difference in yield between application method and timing for the same rate of application (treatments #s 4,7,8,9 & 11).

- No difference in incidence of hollow heart between treatments.
- Increasing the rate of nitrogen increases the percentage of bonus tubers.

Table 22 Effect of nitrogen treatment on yield and grade.

	Yield (cwt)					
Trt #	Undersize (<2")	Marketable (>2")	Total	Bonus %	Bonus Log	Sepecific Gravity
1	64.3	238.0	302.3	19.4	1.1	1.084
2	72.4	293.1	365.5	16.5	1.2	1.087
3	78.8	266.8	345.5	11.0	1.0	1.085
4	78.7	277.5	356.2	15.6	1.2	1.086
5	67.6	297.2	364.8	19.4	1.3	1.084
6	65.6	276.0	341.6	20.6	1.3	1.085
7	72.3	298.7	371.1	18.2	1.3	1.087
8	69.7	283.1	352.8	20.8	1.3	1.087
9	71.0	308.0	379.0	20.0	1.3	1.088
10	65.9	301.6	367.5	21.7	1.3	1.085
11	77.7	288.5	366.2	17.7	1.2	1.082
12	67.6	299.2	366.9	20.4	1.3	1.1
Probability	0.9934	0.8185	0.4806	0.9640	0.8845	0.3948
CV %	30.2	17.5	11.4	54.1	20.4	0.29
LSD (P=0.05)	NSD	NSD	NSD	NSD	NSD	NSD

Screening of Verticillium Wilt Resistant Potato Varieties

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McCain Foods Limited
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Cooperator: Itzerd Boersma, Riverside Growers

Progress: Fourth Year

Principal Investigators: Blair Geisel and Darin Gibson, Gaia Consulting Ltd.

Abstract: In Manitoba, Early Dying Complex (EDC), a pattern of premature vine death and declining yields, is becoming more of a production problem as the number of years that potatoes have been included in a rotation increases and as rotations become shorter. In addition to reduced yield and specific gravity, EDC can cause vascular necrosis, which detracts from the appearance of the tuber and the French fry. The causal organisms involved in EDC are the soil borne fungus Verticillium wilt (*Verticillium dahliae)* and root lesion nematode (*Pratylenchus penetrans*). The primary pathogen is *V. dahliae*, to which potato varieties have varying levels of resistance. Growing resistant varieties may prove to be an economical way to mitigate the effects of EDC, resulting in increased yields and improved quality. The varieties assessed in the past four years were selected by the French fry processors and include two susceptible standards (Russet Burbank, Shepody) and 6 varieties with varying levels of disease resistance (Ranger Russet, Umatilla Russet, Bannock Russet, Prospect, Alturus and Summit Russet). Alturus and Summit Russet were dropped from the study because they were found to be unsuitable for French fry processing. Over the past four years, the trial was conducted in the same commercial field, but at different sites within the field each year. Analysis of the soil from the field indicated extremely high levels of *Verticillium dahliae*, no matter where in the field the samples were taken. No nematode species that contribute to EDC were identified in soil or root samples collected at the test site. Results since 2004 show that all varieties (Ranger Russet, Umatilla Russet, Bannock Russet and Prospect) described as being moderately resistant to resistant to Verticillium wilt were more vigorous than the standard varieties Russet Burbank and Shepody and produced higher total yields. Of the moderately resistant to resistant varieties Bannock Russet and Prospect produced the greatest total and marketable yields. Ranger Russet and Umatilla Russet, which are currently processed into French fries, performed better than the Russet Burbank and Shepody. The disease resistant varieties tended to produce tubers with lighter fry colour and fewer tubers with sugar end defects and vascular necrosis. Of the disease resistant varieties Prospect, Umatilla and Bannock Russet produce tubers with specific gravity ranging from 1.084-1.095. Ranger Russet produces specific gravity >1.095, which is less desirable for French fry processing. After 4 years of study, it has been demonstrated that disease resistant varieties can improve yield and quality when growing potatoes on soils with high levels of *Verticillium dahliae.*

Objective: To compare the yield and quality of standard French fry processing varieties to recently released Verticillium wilt resistant varieties. This study was conducted in a commercial field with a history of EDC and a high level of Verticillium dahliae in the soil.

Procedure:

Plot size: 2 rows by 12 m.
Trial design: RCB with 4 replicates.
Plot location: Rain fed potato field in Portage la Prairie with a history of EDC. Potatoes have been grown in this field since the 1940s.
Soil type: LaSalle clay loam
Planting date: May 17
Row spacing: 1 metre
Seed spacing: Table 23
Varieties: Table 23
Seed Source: In 2006, bacterial ring rot was detected on the research station where the seed nursery was located. All seed that was intended for the 2007 variety trial was discarded and new seed was acquired from multiple sources (Table 23). Seed source, specifically the field and climatic conditions contributing to the production of seed, has an impact on the performance of the progeny. In 2007, this factor contributed to some of the difference between varieties. To account for this effect, Russet Burbank and Shepody from Manitoba (MB) and Saskatchewan (SK) seed sources was included in the trial, so that each test variety could be compared to a standard originating from the same source. There was no standard from the same source as Bannock Russet and Umatilla.

Harvested: September 24th

Table 23. List of varieties and seed spacing.

					Contracted for French Fries		
Var #	Variety Name	Seed Spacing (cm)	Verticillium Resistance	Maturity	US	Canada	Seed Source
1	Russet Burbank	38	Susceptible	Late to very late	Yes	Yes	SK
2	Russet Burbank	38	Susceptible	Early	Yes	Yes	MB
3	Shepody	30	Susceptible	Early	Yes	Yes	SK
4	Shepody	30	Susceptible	Early	Yes	Yes	MB
5	Umatilla Russet	38	Moderately Susceptible	Mid-season to late	Yes	Yes	AB
6	Ranger Russet	30	Moderately Resistant	Medium-late	Yes	Yes	MB
7	Bannock Russet	30	Resistant	Late	Yes	No	USA
8	Prospect	30	Resistant	Mid-season	No	Yes	SK

Specific Gravity Analysis:

Specific gravity (SG) was determined by comparing the weight of a 4.5 kg tuber sample in air and in water.

Fry Colour Analysis:

The centre ½ inch fry strip from 10 tubers per plot was fried for 2 minutes 30 seconds in vegetable oil at 375° F. Fry colour was determined using the USDA scale, which ranges from "0" (light colour) to "4" (dark colour).

Sugar End Analysis:

If less than 1/3 of the French fry is darker than the remainder of the fry by 2 colour gradients on the USDA fry colour scale, it is defined as a sugar end. The fry colour is determined by assessing the remaining 2/3 of the fry. However, if the dark end affects more than 1/3 of the entire fry, colour is determined by assessing the dark end.

Statistical Analysis:

An ANOVA (analysis of variance) was performed on the data. Mean separation was determined using the least significant difference (LSD) test.

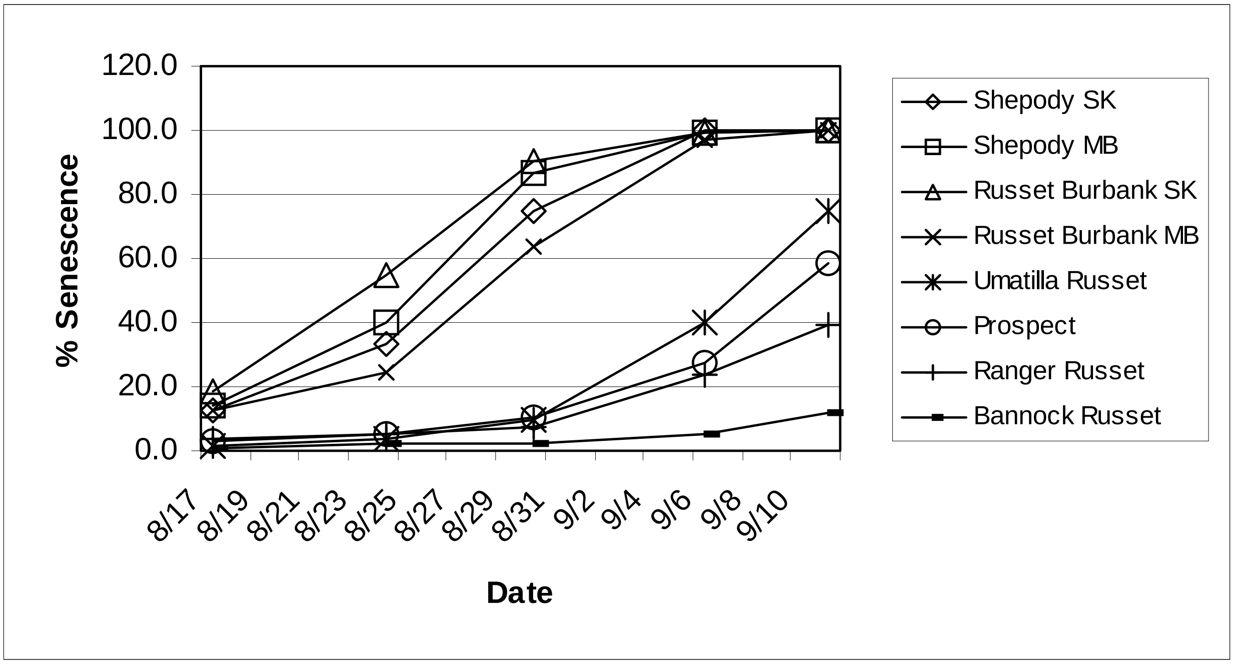
Results: Disease Analysis

A visual rating estimating the percentage of senescent tissue per plot was conducted as a measure of disease severity and vigour (Table 24 and Figure 4). All varieties (#s 5-8) described as being moderately resistant or resistant to Verticillium wilt were more vigorous than the standard varieties (Russet Burbank and Shepody). Of the resistant varieties, Ranger Russet and Bannock Russet were more vigorous than Umatilla and Prospect. These results are an exception when compared to last four years where Prospect was more vigourous than Ranger Russet.

Table 24: Assessment of the percentage of senescent plant tissue

		Senescence (%)									
Var #	Variety Name	17-Aug		24-Aug		30-Aug		6-Sep		11-Sep	
3	Shepody SK	12.8	a	33.0	b	75.0	b	100.0	a	100.0	a
4	Shepody MB	14.3	a	40.0	ab	86.3	a	99.5	a	100.0	a
1	Russet Burbank SK	18.5	a	55.0	a	90.0	a	99.3	a	99.8	a
2	Russet Burbank MB	12.5	a	24.3	b	63.8	c	97.0	a	99.8	a
5	Umatilla Russet	1.8	b	4.0	c	9.8	d	40.0	b	75.0	b
8	Prospect	2.8	b	5.0	c	10.5	d	27.5	c	58.8	b
6	Ranger Russet	4.0	b	5.5	c	7.5	d	23.8	c	39.3	c
7	Bannock Russet	0.8	b	2.3	c	2.5	d	5.3	d	11.8	d
	Prob.	0.0002		0.0000		0.0000		0.0000		0.0000	
	CV%	61.6		50.7		16.4		6.9		16.8	
	LSD 0.05	7.6		15.8		10.4		6.2		18.1	

Figure 5: Assessment of the percentage of senescent plant tissue.



Results: Yield and Grade (Table 25)

The site was rain fed with the exception of a single irrigation event in early August. Plants were under moisture stress for most of July and August, which reduced yield and contributed to higher coefficient of variations (CV). In 2007, total yields for irrigated Russet Burbank and Shepody research plots on similar soil types were 2 to 3 times greater than the yields reported for the same varieties in this trial.

Table 25: Yield and grade

		Yield cwt/ac							
Var #	Variety Name	Undersize <2"		Marketable >2"		Total		>10 oz. (%)	
7	Bannock Russet	33.0	c	210.9	a	243.9	a	25.1	a
8	Prospect	41.8	c	198.4	a	240.1	a	14.5	ab
6	Ranger Russet	46.3	c	192.8	a	239.2	a	21.1	a
2	Russet Burbank MB	63.6	b	177.9	ab	241.5	a	6.8	cd
5	Umatilla Russet	62.8	b	153.9	bc	216.8	ab	11.9	abc
3	Shepody SK	62.7	b	119.7	c	182.4	bc	6.1	d
1	Russet Burbank SK	98.6	a	116.9	d	215.5	ab	4.6	d
4	Shepody MB	44.0	c	112.8	d	156.8	c	7.4	bcd
	Prob.	0.0000		0.0000		0.0006		0.0000	
	CV%	19.3		15.4		12.1		41.4	
	LSD 0.05	16		36.4		38.5		7.4	

The resistant varieties (Prospect, Ranger Russet and Bannock Russet) produced a higher marketable yield than the moderately resistant Umatilla Russet, both Shepody entries and the Saskatchewan Russet Burbank. The Manitoba Russet Burbank produced a yield similar to the resistant varieties (Prospect, Ranger Russet and Bannock Russet). The moderately resistant Umatilla Russet produced a higher marketable yield than Saskatchewan Russet Burbank and the Manitoba Shepody.

The resistant varieties (Prospect, Ranger Russet, Umatilla Russet and Bannock Russet) had a larger tuber profile and evidenced by more bonus tubers (>10 oz.) and fewer undersize tubers.

Results: Specific Gravity (Table 26)

There were significant differences in mean specific gravity between varieties. Mean specific gravity is not the best measure for determining French fry processing quality. The most desirable specific gravity is between 1.083 and 1.088. Gravities lower or higher than this range are less desirable. To better assess gravity for French fry processing, the values were rated according to a scale developed by Washington State University (Table 26), where "0" is least desirable and "5" is most desirable for French fry processing. The Russet Burbank and Shepody sourced from Manitoba followed by Bannock Russet and Prospect produced the most desirable specific gravity.

Table 26: Specific Gravity

Var #	Variety Name	Specific Gravity		Specific Gravity Ranking [1]
2	Russet Burbank MB	1.085	c	4.8
4	Shepody MB	1.089	bc	4.0
7	Bannock Russet	1.094	b	2.8
8	Prospect	1.094	b	2.8
3	Shepody SK	1.094	b	2.3
5	Umatilla Russet	1.092	b	2.3
6	Ranger Russet	1.106	a	1.0
1	Russet Burbank SK	1.072	d	0.3
	Prob.	0.0000		
	CV%	0.3752		
	LSD 0.05	0.006		
[1]	Method of ranking specific gravity was developed by Washing State University. Ranking goes from 0 (poor quality) to 5 (highest quality) according to the following categories			
	5 = 1.083 - 1.088			
	4 = 1.081 - 1.082 and 1.089 - 1.091			
	3 = 1.080 and 1.092 - 1.093			
	2 = 1.078 - 1.079 and 1.094 - 1.095			
	1 = 1.076 - 1.077 and 1.096 or higher			
	0 = 1.075 or lower			

Results: Fry Colour, Sugar End Defect and Vascular Necrosis

Fry colour and sugar end analysis will be assessed in October, January and April. Only the results of the October and January assessment are reported. There was a significant difference in fry colour, percent sugar ends and vascular necrosis between varieties. At harvest, the resistant varieties (Prospect, Ranger Russet, Umatilla Russet and Bannock Russet) and Shepody produced lighter coloured fries compared to the two Russet Burbank entries. Between October and January the fry colour became lighter for all varieties with the exception of both Shepody entries. In January, the resistant varieties (Umatilla Russet, Ranger Russet, Bannock Russet and Prospect) produced fry colours significantly lighter than the Shepody and Russet Burbank entries.

The incidence of sugar end defect was high in 2007 due to the prolonged drought. At harvest the resistant varieties (Umatilla Russet, Ranger Russet, Bannock Russet and Prospect) had the lowest incidence of sugar end defect. In January, the incidence of sugar end in the Bannock Russet and Prospect varieties increased slightly, so only the Umatilla Russet and Ranger Russet had incidences less than the standard varieties.

Vascular necrosis, also known as stem-end browning, stem-end discoloration or necrosis, vascular discoloration or browning and phloem necrosis is an internal brown discoloration of tuber tissue in the region of the vascular ring, which can be caused by Verticillium wilt. The incidence of vascular necrosis was high for all entries in 2007, but was especially high for those varieties that died prematurely. There is a positive correlation of 0.713 ($p<0.0001$) between percent vascular necrosis and percent senescence on 08/30.

Table 27. Fry Colour and Vascular Necrosis

			Mean Fry Colour [1]		Sugar End % [2]	
Var #	Variety Name	Vascular Necrosis %	Harvest	January	Harvest	January
1	Russet Burbank SK	95.7 a	1.45 a	0.96 a	17.50 bc	22.00 ab
2	Russet Burbank MB	96.4 a	0.93 a	0.56 b	32.50 ab	31.83 ab
3	Shepody SK	89.9 a	0.10 b	0.43 b	27.50 ab	25.00 ab
4	Shepody MB	98.0 a	0.18 b	0.52 b	40.00 a	10.00 bc
5	Umatilla Russet	70.2 b	0.35 b	0.05 c	7.50 c	2.50 c
6	Ranger Russet	90.3 a	0.11 b	0.00 c	0.00 c	0.00 c
7	Bannock Russet	52.3 c	0.10 b	0.05 c	7.50 c	10.00 bc
8	Prospect	67.1 b	0.23 b	0.00 c	5.00 c	10.00 bc
	Prob.	0.0000	0.0016	0.0000	0.0016	0.0002
	CV%	9.7	102.4	61.9	75.0	59.81
	LSD 0.05	11.8	0.6	0.3	19.0	12.2

[1] Weighted mean for fry colour from 10 potatoes per subsample. Fry Colour was determined using the USDA fry colour chart. Colour scale ranges from "0" (light) to "4" (dark).

[2] Incidence out of 10 tubers tested