Progress Report to the Maine Potato Board Research Subcommittee
January 26, 2018

Project Title: Nitrogen, calcium, boron, and potassium effects on potato quality.

Investigators:

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Executive Summary

The N response of Russet Burbank, Caribou Russet, and AF4172-2 (a candidate promising variety) was studied during 2017 with particular emphasis on yield, fry color, fry color uniformity, internal quality, specific gravity, size profile, skinning susceptibility, and bruise resistance. The experiment was conducted on a Caribou loam soil at Aroostook Research Farm, Presque Isle, ME. AF4172-2 had unacceptably low yields and tuber size under the stressful conditions that we encountered during 2017. Caribou Russet had the highest yields and its tuber size profile and specific gravity were equal to Russet Burbank in this trial. As expected, yield and tuber size increased with N rate, while specific gravity decreased. While there were relatively few statistically significant interactions between variety and N rate, there are several indications of differential response that are worth noting: 1) yield and tuber size of Caribou Russet were maximized at a lower N rate (200 lbs/A) than was observed for Russet Burbank (300 lbs/A); 2) incidence of misshapen tubers for Russet Burbank generally increased with N rate, while this was not observed for the other varieties; 3) fry color uniformity showed a strong variety x N rate interaction. All three varieties had light fry color; however, AF4172-2 fried the lightest followed by Caribou Russet and then Russet Burbank. AF4172-2 had the highest percentage of uniform fries and the lowest percentage of fries with moderate stem-end defects. Fry color uniformity of Russet Burbank was best at the low N rate and poorer uniformity occurred as the N rate increased. Caribou Russet had poor fry color uniformity at low N rates and uniformity was best at the two highest N rates. AF4172-2 had good fry color uniformity regardless of N rate.

Yield and quality effects potassium, calcium, and boron treatments on were studied in a field experiment using Russet Burbank potatoes. The eight treatments consisted of high versus low K_2O (150 versus 300 lbs/A), no calcium nitrate (CAN) versus 60 lbs of N per acre from CAN sidedress, and no foliar B versus 1 lb/A foliar B arranged in factorial combination to allow tests for interactions. The higher potash rate resulted in a 27 cwt/A yield and US#1 yield increase, while also slightly increasing tuber size and significantly decreasing specific gravity by 0.002. The higher potash rate also tended to decrease hollow heart incidence in large-sized tubers (5.6 vs 1.7%, $p<0.11$). Averaged over treatments, the CAN and B treatments did not significantly affect yield, tuber size, specific gravity or external defects incidence; however, the CAN treatment resulted in increased hollow heart incidence in large-sized tubers (6.8 vs 0.4%). Considering interactions, the CAN treatment resulted in a positive yield response only when the high rate of K was applied. As a result, the CAN plus 300 lbs K_2O treatment was the highest yielding treatment in the experiment (+37 cwt/A total and +26 cwt/A US#1 yield). Low potash plus CAN resulted in significantly higher hollow heart incidence (11.1%) than most of the other treatments (0.0, 0.8, and 2.5%). The B treatment resulted in a small yield boost (+32 cwt/A)

when K was applied at the low rate, but a small yield penalty (-11 cwt/A) when K was applied at the high rate. The higher K rate resulted in an increased percentage of uniform fry slices (62.5 versus 52.0%). The foliar B treatment resulted in a decreased percentage of uniform fry slices (62.9 versus 51.6%). The foliar B treatment resulted in a slightly darker fry color and a decreased percentage of fry slices in the lightest USDA color categories (OOO, OO, and O).

Potassium, calcium, and boron can have strong effects on potato quality. Potassium and boron can have strong effects on carbohydrate metabolism, transport, sugar accumulation, and starch content of tubers. Among other effects, calcium affects internal quality, bruise susceptibility, and soft rot resistance. In this objective, we studied the yield and quality effects that these nutrients can have on Russet Burbank potatoes when applied alone or in combination. Particular emphasis was placed on yield, fry color, fry color uniformity, internal quality, specific gravity, size profile, skinning susceptibility, and bruise resistance.

The experiment was conducted on a Caribou loam soil at Aroostook Research Farm, Presque Isle, ME. The soil pH was 5.5 and soil organic matter was 3.0% based UM soil testing procedures. The field was in timothy and clover during 2016 and in oats underseeded to timothy and clover during 2015. Soil test K was medium-high (277 lbs/A, 4.5% saturation), soil P was medium (16.9 lbs/A available P by Modified Morgan), soil test Ca was medium (1499 lbs/A, 46.1% saturation) and soil test Mg was high (307 lbs/A, 15.7% saturation). The recommended P_2O_5 and K_2O rates based on the soil test results were 142 and 175 to 278 lbs, respectively (the low K_2O recommendation is for the "sufficiency" approach and the higher is the "build and maintain" approach). Soil test boron was ML at 0.2 ppm. The experimental design was a randomized block design with four blocks as replicates. The eight treatments consisted of high versus low K_2O (150 versus 300 lbs/A), no calcium nitrate (CAN) versus 60 lbs of N per acre from CAN sidedress, and no foliar B versus 1 lb/A foliar B arranged in factorial combination to allow tests for interactions. All plots were hand planted on June 1. The seedpiece spacing for Russet Burbank was 16 inches. Total N and P_2O_5 rates were held constant at 180 and 150 lbs/A, respectively. At planting fertilizer was applied in bands using DAP (constant amount), ammonium nitrate (constant amount), and ammonium sulfate (variable due to the CAN sidedress treatment) as the blended nitrogen source. To maintain constant N while sidedressing 60 lbs N per acre as CAN, we removed an equivalent amount of ammonium sulfate N from the fertilizer band. The plots were vinekilled on September 22 (113 days after planting) and harvested on October 5 and 6. Crop vigor was monitored during the growing season. Yield, tuber size distribution, skinning susceptibility, internal defects incidence, bruise susceptibility, and specific gravity were determined at harvest. Fry color and fry color uniformity were evaluated from 50F storage in December. Fry color and fry color uniformity will be evaluated again in March.

May and June were relatively wet at the research farm, while July and August were very dry. Only 1.84 inches of rain were recorded in July, while 1.74 inches were recorded in August. This is well below normal. No supplemental irrigation was available at the research site. No significant pest problems were observed other than early dying associated with dry soil conditions.

This report provides a summary of the yield and quality results including the December 50F storage fry color (see data in Table 2). More detailed results including the crop vigor, bruise susceptibility tests, and 50F March storage fry color results will be included in the final project

reports and are available upon request.

Yield, tuber size, and specific gravity were significantly affected by the potash treatment (Table 2). The higher potash rate results in a 27 cwt/A yield and US#1 yield increase, while also slightly increasing tuber size and decreasing specific gravity by 0.002. The higher potash rate also tended to decrease hollow heart incidence in large-sized tubers (5.6 vs 1.7%, $p<0.11$). The CAN and B treatments did not significantly affect yield, tuber size, specific gravity or external defects incidence. The CAN treatment resulted in increased hollow heart incidence in large-sized tubers (6.8 vs 0.4%). Based on knowledge of potato nutrient responses, it is unlikely that this was directly a Ca effect, but rather was possibly due to the shift in N application timing and/or the change in N-source (e.g. less N from at-planting ammonium sulfate and more N from a mid-season nitrate source).

A few significant interactive effects were detected (Table 2). Yield responded interactively to the CAN and K treatments (i.e. the response to CAN was dependent on the amount of K applied). The CAN treatment resulted in a positive yield response only when the high rate of K was applied. As a result, the CAN plus 300 lbs K_2O treatment was the highest yielding treatment in the experiment (+37 cwt/A total and +26 cwt/A US#1 yield). Low potash plus CAN resulted in significantly higher hollow heart incidence (11.1%) than most of the other treatments (0.0, 0.8, and 2.5%). US#1 yield responded interactively to the B and K treatments (i.e. the response to B was dependent on the amount of K applied). The B treatment resulted in a small boost yield (+32 cwt/A) when K was applied at the low rate, but a small yield penalty (-11 cwt/A) when K was applied at the high rate. It is not clear why this interactive effect would occur. The higher K rate resulted in an increased percentage of uniform fry slices (62.5 versus 52.0%). The foliar B treatment resulted in a decreased percentage of uniform fry slices (62.9 versus 51.6%). The foliar B treatment resulted in a slight darker fry color and a decreased percentage of fry slices in the lightest USDA color categories (OOO, OO, and O).

Nutrient management programs significantly affected yield, quality, fry color, and fry uniformity in these studies. It is important to note that the results are from one growing season and that they could have been influenced by the unusually dry soil conditions during tuber bulking. As a result these experiments should be repeated during 2018.

Objectives:

1. Evaluate nitrogen fertility's effects on yield, quality, bruise susceptibility, maturity, and fry color uniformity of three processing varieties.
2. Determine the yield and quality effects of potassium, calcium, and boron treatments applied alone or in combination.

Grant Received for 2017 Growing Season:

$12,000

Accomplishments to Date:

Objective #1. Evaluate nitrogen fertility's effects on yield, quality, bruise susceptibility,

maturity, and fry color uniformity of three processing varieties.

Nitrogen has strong effects on plant growth, vine maturity, yields, and tuber quality. Our past research shows that fry color uniformity of some varieties (e.g. Russet Burbank) can be decreased by excess N. Producing high yielding potato crops that meet the stringent quality requirements for processing are keys to the future success of the industry. Excess N supply has negative consequences on Russet Burbank quality and many new processing varieties that are grown in our cool, short-season climate. These negative effects include skinning and shatter bruise susceptibility, low specific gravity, elevated tuber sugars, poor fry color, and poor fry color uniformity. For these reasons, N management programs need to be tailored so that quality is optimized without sacrificing yields of established processing varieties (e.g. Russet Burbank) or new varieties that will be adopted to replace Russet Burbank, Shepody, Blazer Russet, and Innovator. Bruise susceptibility, often aggravated by excess N fertilizer, is a frequent cause of problems for growers adopting new processing varieties.

The N response of Russet Burbank, Caribou Russet, and AF4172-2 (a candidate promising variety) was studied during 2017 with particular emphasis on yield, fry color, fry color uniformity, internal quality, specific gravity, size profile, skinning susceptibility, and bruise resistance. The experiment was conducted on a Caribou loam soil at Aroostook Research Farm, Presque Isle, ME. The soil pH was 5.8 and soil organic matter was 3.0% based UM soil testing procedures. The field was in timothy and clover during 2016 and in oats underseeded to timothy and clover during 2015. Soil test K was high (352 lbs/A, 6.8% saturation), soil P was medium-high (25.5 lbs/A available P by Modified Morgan), soil test Ca was medium-high (1812 lbs/A, 57.7% saturation) and soil test Mg was high (318 lbs/A, 18.6% saturation). Each variety was grown at four N rates (0, 100, 200, and 300 lbs/A, banded at planting using a blend of DAP, ammonium sulfate, and ammonium nitrate) in a randomized complete block design (RCBD) with four replications per treatment. P and K rates were held constant at recommended rates based on soil test (150 lbs/A P_2O_5 and 180 lbs/A K_2O for this site). Crop vigor was monitored during the growing season. Pre-harvest tuber sugar concentrations (glucose and sucrose) were determined at four dates to monitor chemical maturity. Yield, tuber size distribution, skinning susceptibility, internal defects incidence, bruise susceptibility, and specific gravity were determined at harvest. Fry color and fry color uniformity were evaluated from 50F storage in December. Fry color and fry color uniformity will be evaluated again in March.

The experiment was planted on May 23, vinekilled on September 15 (115 days after planting), and harvested on October 4. The in-row seedpiece spacing was 16 inches for Russet Burbank and AF4172-2, while Caribou Russet was spaced at 10 inches. May and June were relatively wet at the research farm, while July and August were very dry. Only 1.84 inches of rain were recorded in July, while 1.74 inches were recorded in August. This is well below normal. No supplemental irrigation was available at the research site. No significant pest problems were observed other than early dying associated with low N and dry soil conditions.

This report provides a summary of the yield and quality results including the December 50F storage fry color (see data in Table 1). More detailed results including the crop vigor, pre-harvest tuber sugars, bruise susceptibility tests, and 45F storage fry color results will be included in the final project reports and are available upon request.

Yield, tuber size, specific gravity, and external defects incidence were strongly affected by variety (Table 1). AF4172-2 had unacceptably low yields and tuber size under the stressful conditions that we encountered during 2017. Caribou Russet had the highest yields and its tuber size profile and specific gravity were equal to Russet Burbank in this trial (note that the in-row seedpiece spacing was 16 inches for Russet Burbank, while Caribou Russet was spaced at 10 inches to compensate for its lower tuber set). Russet Burbank had the highest external defects incidence (misshapes), while Caribou Russet had the lowest incidence. Very little hollow heart was observed in this study.

Nitrogen rate strongly affected yield and quality responses and the response was generally consistent among the varieties (Table 1). As expected, yield and tuber size increased with N rate, while specific gravity decreased. Specific gravity of all three varieties remained acceptable during 2017 regardless of the N rate, but this was an experiment with relatively high specific gravity and in a year with lower gravities the highest N rate would likely have resulted in unacceptably low gravities for Caribou Russet and Russet Burbank. While there were relatively few statistically significant interactions between variety and N rate, there are several indications of differential response that are worth noting: 1) yield and tuber size of Caribou Russet were maximized at a lower N rate (200 lbs/A) that was observed for Russet Burbank (300 lbs/A); 2) incidence of misshapen tubers for Russet Burbank generally increased with N rate, while this was not observed for the other varieties; 3) fry color uniformity showed a strong variety x N rate interaction (see below).

Fry color and fry color uniformity were strongly determined by variety (Table 1). All three varieties had light fry color; however, AF4172-2 fried the lightest followed by Caribou Russet and then Russet Burbank. AF4172-2 had the highest percentage of uniform fries and the lowest percentage of fries with moderate stem-end defects. When averaged over varieties, N did not strongly affect fry color or uniformity; however, fry color uniformity of the individual varieties was strongly influenced by N rate. Fry color uniformity of Russet Burbank was best at the low N rate and poorer uniformity occurred as the N rate increased. AF4172-2 had good fry color uniformity and this was not greatly affected by N rate. Caribou Russet had poor fry color uniformity at low N rates and uniformity was best at the two highest N rates.

Objective #2. Determine the yield and quality effects of potassium, calcium, and boron treatments applied alone or in combination.

Potassium, calcium, and boron can have strong effects on potato quality. Potassium and boron can have strong effects on carbohydrate metabolism, transport, sugar accumulation, and starch content of tubers. Among other effects, calcium affects internal quality, bruise susceptibility, and soft rot resistance. In this objective, we studied the yield and quality effects that these nutrients can have on Russet Burbank potatoes when applied alone or in combination. Particular emphasis was placed on yield, fry color, fry color uniformity, internal quality, specific gravity, size profile, skinning susceptibility, and bruise resistance.

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A few significant interactive effects were detected (Table 2). Yield responded interactively to the CAN and K treatments (i.e. the response to CAN was dependent on the amount of K applied). The CAN treatment resulted in a positive yield response only when the

high rate of K was applied. As a result, the CAN plus 300 lbs K_2O treatment was the highest yielding treatment in the experiment (+37 cwt/A total and +26 cwt/A US#1 yield). Low potash plus CAN resulted in significantly higher hollow heart incidence (11.1%) than most of the other treatments (0.0, 0.8, and 2.5%). US#1 yield responded interactively to the B and K treatments (i.e. the response to B was dependent on the amount of K applied). The B treatment resulted in a small boost yield (+32 cwt/A) when K was applied at the low rate, but a small yield penalty (-11 cwt/A) when K was applied at the high rate. It is not clear why this interactive effect would occur.

Fry color was not strongly affected by the K, CAN, and B treatments and no significant interactive effects of treatments were detected (Table 1). The higher K rate resulted in an increased percentage of uniform fry slices (62.5 versus 52.0%). The foliar B treatment resulted in a decreased percentage of uniform fry slices (62.9 versus 51.6%). The foliar B treatment resulted in a slight darker fry color and a decreased percentage of fry slices in the lightest USDA color categories (OOO, OO, and O). While these nutrient management treatments did not have huge effects on fry color, they did have enough influence to warrant further study. It is also important to note that the results could have been influenced by the unusually dry soil conditions during tuber bulking.

Table 1. Response of Russet Burbank, Caribou Russet, and AF4172-2 potatoes to nitrogen fertilizer rate, Aroostook Research Farm, 2017.

Variety[1] & N Rate[1]		Yield (cwt/A) Total	US#1	% of Yld. <2"	>10oz	Spec Grav.	% Ext. Defects	% HH >10 oz.	Fry Color[2] Color Index	% VG, Color	% Unif. Fries	%Stem Defs.
Variety Averages:												
R. Burbank		257	218	18	17	1.082	14.2	1.4	0.60	76.3	49.4	6.9
Caribou R.		303	296	12	18	1.083	2.1	0.0	0.46	88.8	51.9	11.9
AF4172-2		181	170	38	7	1.097	5.6	0.0	0.17	98.1	88.8	1.3
W-D LSD $_{0.05}$		31	30	7	4	0.005	1.8	ns	0.09	8.6	13.8	4.7
Nitrogen Rate Averages:												
0 lbs/A		133	126	44	3	1.091	5.6	0.0	0.40	83.3	67.5	8.3
100 lbs/A		256	240	20	13	1.089	6.3	0.0	0.37	91.7	61.7	8.3
200 lbs/A		294	265	14	19	1.085	9.7	0.9	0.47	85.8	63.3	3.3
300 lbs/A		303	281	13	21	1.084	7.6	0.9	0.41	90.0	60.8	6.7
Variety x Nitrogen Rate:												
R. Burbank	0	125	113	44	1	1.088	8.9	0.0	0.62	67.5	82.5	0.0
R. Burbank	100	268	231	13	16	1.082	14.1	0.0	0.56	82.5	40.0	10.0
R. Burbank	200	306	241	9	23	1.079	21.0	2.5	0.62	80.0	45.0	2.5
R. Burbank	300	328	285	6	26	1.078	12.9	2.5	0.62	75.0	30.0	15.0
Caribou R	0	176	172	28	5	1.085	1.8	0.0	0.46	82.5	25.0	25.0
Caribou R	100	312	307	10	16	1.085	1.8	0.0	0.42	92.5	50.0	15.0
Caribou R	200	367	357	5	27	1.081	2.8	0.0	0.49	85.0	67.5	5.0
Caribou R	300	356	348	6	24	1.079	2.0	0.0	0.49	95.0	65.0	2.5
AF4172-2	0	100	94	62	2	1.098	6.0	0.0	0.12	100.0	95.0	0.0
AF4172-2	100	187	181	36	6	1.099	2.9	0.0	0.12	100.0	95.0	0.0
AF4172-2	200	208	196	27	7	1.096	6.4	0.0	0.31	92.5	77.5	2.5
AF4172-2	300	227	209	29	12	1.094	7.9	0.0	0.12	100.0	87.5	2.5
AOV results[3]:												
Variety (V)		**	**	**	**	**	**	ns	**	**	**	**
Nitrogen (N)		**LQ	**LQ	**LQ	**LQ	*L	*LQC	ns	ns	ns	ns	ns
V * N		ns	ns	ns	.08	ns	**	ns	ns	ns	**	**

[1]The experimental design was a randomized block design with four blocks as replicates. Three potato varieties and four nitrogen rates were used in factorial combination. All plots were hand planted on May 23. Nitrogen was applied in bands at planting using DAP, ammonium nitrate, and ammonium sulfate as the blended nitrogen source. P_2O_5 and K_2O rates were held constant at 150 and 180 lbs/A, respectively. The seedpiece spacings were: Russet Burbank, 16"; Caribou Russet, 10"; AF4172-2, 16". The plots were vinekilled on September 15 (115 days after planting) and harvested on October 4.

[2]Samples were fried from 50F in December. Ten tubers per treatment, 1 fry slice per tuber. Index is a weighted fry color index based on the number of fry slices in each USDA fry color category from OOO to 4. Lower numbers indicate lighter fry color where index would be 0.1 if all slices fried in color chart category OO, 0.5 if all slices fried O, 1 if all slices fried 1, etc . %VG is the percentage of slices that were color category O or lighter. % Uniform fries is the percentage of fry slices that had no slight or moderate stem end or other color defects. % Stem defs. is the percentage of slices with moderate to severe stem end color observed after frying. Data from 45F are also available and fry quality will be evaluated again in March.

[3]Analysis of variance F-test results for treatment main effects and interactions: ns=no significant effect, *=significant at 5%, **=significant at 1%. The p-value is reported when significant at 10% level only. Trend analysis was used to document the N main effect response (L=linear; Q=quadratic; C=cubic. Mean separation for variety main effect was conducted with the Waller-Duncan LSD Test (k=100) which approximates α=0.05.

Table 2. Response of Russet Burbank to potassium fertilizer rate, CAN application, and foliar B treatments. Aroostook Research Farm, 2017.

Treatments[1]	Yield (cwt/A)		% of Yld.		Spec	% Ext.	% HH	Fry Color[2]			
	Total	US#1	<2"	≥10oz	Grav.	Defects	≥10 oz.	Color Index	% VG, Color	% Unif. Fries	%Stem Defs.
K_2O Rate:											
150 lbs/A	317	298	15	11	1.081	6.1	5.6	0.55	86.2	52.0	2.9
300 lbs/A.	344	325	11	14	1.079	5.7	1.7	0.56	85.0	62.5	2.9
CAN Rate:											
0 lbs/A	324	308	13	12	1.080	5.2	0.4	0.55	87.1	59.9	2.5
60 lbs N per A	337	315	13	14	1.079	6.6	6.8	0.56	84.2	54.6	3.3
Foliar B:											
0 lbs/A	325	306	13	12	1.079	6.0	2.2	0.54	88.8	62.9	2.5
1 lbs/A	336	317	12	13	1.080	5.8	5.0	0.57	82.5	51.6	3.3
Potash x CAN Rate:											
150 lbs/A 0 lbs/A	323	304	14	9	1.081	5.9	0.0	0.53	89.2	58.2	3.3
150 lbs/A 60 lbs N/A	312	292	16	14	1.081	6.2	11.1	0.56	83.3	45.8	2.5
300 lbs/A 0 lbs/A	326	312	12	15	1.080	4.4	0.8	0.56	85.0	61.7	1.7
300 lbs/A 60 lbs N/A	363	338	10	14	1.078	7.0	2.5	0.56	85.0	63.3	4.2
Potash x B Rate:											
150 lbs/A 0 lbs/A	304	282	16	11	1.080	7.0	2.7	0.52	90.8	60.0	1.7
150 lbs/A 1 lbs/A	331	314	14	12	1.082	5.1	8.4	0.57	81.7	44.0	4.2
300 lbs/A 0 lbs/A	347	330	11	14	1.079	5.0	1.7	0.55	86.7	65.8	3.3
300 lbs/A 1 lbs/A	342	319	11	15	1.079	6.5	1.7	0.56	83.3	59.2	2.5
AOV results[3]:											
Potash (K)	**	*	*	.09	*	ns	.11	ns	ns	*	ns
Ca. Nitrate (CAN)	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
Boron (B)	ns	ns	ns	ns	ns	ns	ns	.1	.07	*	ns
K x CAN	*	.07	ns	ns	ns	ns	.053	ns	ns	ns	ns
K x B	.1	*	ns	ns	ns	ns	ns	ns	ns	ns	ns
CAN x B	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
K x CAB x B	ns	ns	ns	ns	.11	ns	ns	ns	ns	ns	ns
Interaction LSD:											
$LSD_{0.05}$	38	41	7	ns	0.003	ns	9.6	0.08	13.8	19.1	ns

[1]The experimental design was a randomized block design with four blocks as replicates. Russet Burbank was the potato variety. The eight treatments consisted of high versus low K_2O (150 versus 300 lbs/A), no calcium nitrate (CAN) sidredress versus 60 lbs of N per acre from CAN sidedress, and no foliar B versus 1 lb/A foliar B arranged in factorial combination to allow tests for interactions. All plots were hand planted on June 1. At planting fertilizer was applied in bands using DAP (constant amount), ammonium nitrate (constant amount), and ammonium sulfate (variable due to the CAN sidress treatment) as the blended nitrogen source. Total N and P_2O_5 rates were held constant at 180 and 150 lbs/A, respectively. To maintain constant N while sidedressing 60 lbs N per acre as CAN, we removed an equivalent amount of ammonium sulfate N from the fertilizer band. The seedpiece spacing for Russet Burbank was 16 inches. The plots were vinekilled on September 22 (113 days after planting) and harvested on October 5 and 6.

[2]Samples were fried from 50F in December. Ten tubers per treatment, 1 fry slice per tuber. Index is a weighted fry color index based on the number of fry slices in each USDA fry color category from OOO to 4. Lower numbers indicate lighter fry color where index would be 0.1 if all slices fried in color chart category OO, 0.5 if all slices fried O, 1 if all slices fried 1, etc . %VG is the percentage of slices that were color category O or lighter. % Uniform fries

is the percentage of fry slices that had no slight or moderate stem end or other color defects. % Stem defs. is the percentage of slices with moderate to severe stem end color observed after frying. Fry quality will be evaluated again in March.

[3]Analysis of variance F-test results for treatment main effects and interactions: ns=no significant effect, *=significant at 5%, **=significant at 1%. The p-value is reported when significant at 10% level. Mean separation for the individual treatments when significant interactions were observed was conducted with the LSD Test at α=0.05.