Progress Report to the Maine Potato Board Research Subcommittee
January 31, 2019

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 AF5071-2 (a candidate processing variety) was studied during 2018 with particular emphasis on yield, fry color, fry color uniformity, internal quality, specific gravity, size profile, skinning susceptibility, and bruise resistance. Weather conditions were unusual during 2018 (cool and dry followed by a very warm period, good shower activity in August, very wet and cold in the 10 days prior to harvest). AF5071-2 had the highest yields, highest specific gravity, and the lightest fry color. Caribou Russet had the second highest yield and had a larger tuber size profile than Russet Burbank. Specific gravity of Caribou Russet was equal to Russet Burbank and fry color was much better. Due to the unusual growing conditions, yields were much less responsive to N than usual. Total and US#1 yields of all three varieties were highest at the 100 lbs N/A rate, rather than the more typical maximum yield at ~ 200 lbs N/A. As expected, tuber size increased with N rate, while specific gravity decreased. Hollow heart incidence was lowest for the 300 lbs/A treatment. Incidence of misshapen tubers for Russet Burbank generally increased with N rate, while this was not observed for the other varieties. Nitrogen rate did not significantly affect fry color uniformity in the December fry evaluations.

Yield and quality effects potassium, calcium, and boron treatments on were studied in a field experiment using Russet Burbank potatoes. 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. Two additional treatments with CAN applied at 60 lbs N/A following 180 lbs of at-planting N per acre combined with the two potash rates. Russet Burbank did not like the combination of soil and weather conditions that occurred in this experiment. Even though stands were very good, crop vigor was excellent from mid-season onward and no significant disease pressure was noted, yields were low on this site, tuber type was poor, and there was an unusual amount of plot-to-plot variation. For these reasons, the experiment was inconclusive and should be repeated during 2019. Despite the difficult conditions, specific gravity significantly decreased in response to the high potash rate (1.077 vs. 1070) and hllow heart incidence in large-sized tubers was also reduced by the high potash rate (40.0 vs. 13.2 %). Yield was significantly improved by removing some N fertilizer from the band and applying a sidedressed CAN treatment (206 vs 255 cwt/A). Yield was also significantly improved by the foliar B application (215 vs 248 cwt/A). Fry color and fry color uniformity results will be available after the March 2019 fry evaluation.

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 a very strange growing season and that they could have been influenced by these usual conditions. As a result these experiments should be repeated during 2019.

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 AF5071-2-2 (a candidate processing variety) was studied during 2018 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 5.6 and soil organic matter was 2.4% based UM soil testing procedures. The field was in timothy and clover during 2017 and in oats underseeded to timothy and clover during 2016. Soil test K was high (345 lbs/A, 7.2% saturation), soil P was medium-high (18.9 lbs/A available P by Modified Morgan), soil test Ca was medium-low (1258 lbs/A, 50.2% saturation) and soil test Mg was high (345 lbs/A, 12.4% 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 29, vinekilled on September 24 (118 days after planting), and harvested on October 18. The in-row seedpiece spacing was 16 inches for Russet Burbank, while Caribou Russet and AF5071-2 were spaced at 10 inches. May, June, and early July were relatively cool and dry at the research farm, while August had adequate rainfall from August 9 onward. Late July and early August were unusually warm, while very cold conditions prevailed in the 10 days prior to harvest. Rainfall totals for May, June, and July were only 2.33, 3.16, and 2.19 inches, respectively, while 3.87 inches were recorded in August. No supplemental irrigation was available at the research site. No significant pest problems were observed. Early-season growth was slow due to the cool, dry conditions; however, late-season growth and vigor was excellent.

This report provides a summary of the yield and quality results including the December 50F storage fry color (see example 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.

AF5071-2 had the highest yields and its tuber size profile was equal to Russet Burbank. AF5071-2 had the highest specific gravity and the lightest fry color. Caribou Russet had the second highest yield and had a larger tuber size profile than Russet Burbank. Specific gravity of Caribou Russet was equal to Russet Burbank and fry color was much better. Russet Burbank and AF5071-2 had high incidences of hollow heart in large-sized tubers, while Caribou Russet had much lower incidence. Due to the unusual growing conditions, yields were much less responsive to N than usual. Total and US#1 yields of all three varieties were highest at the 100 lbs N/A rate, rather than the more typical maximum yield at ~ 200 lbs N/A. As expected, tuber size increased with N rate, while specific gravity decreased. Hollow heart incidence was lowest for the 300 lbs/A treatment. Incidence of misshapen tubers for Russet Burbank generally increased with N rate, while this was not observed for the other varieties. Nitrogen rate did not significantly affect fry color uniformity in the December fry evaluations. The results differed from the 2017 results in that: 1) during 2018 the varieties had a similar and much less dramatic yield response to N than during 2017; 2) all three varieties had their highest yield at 100 lbs N/A during 2018, while during 2017 the yield of Caribou Russet was maximized at a lower N rate (200 lbs/A) than was observed for Russet Burbank (300 lbs/A); 3) fry color uniformity was not greatly affected by N during 2018, while it showed a strong variety x N rate interaction during 2017. During 2017 all three varieties had light fry color; however, fry color uniformity of Russet Burbank was best at the low N rate and poorer uniformity occurred as the N rate increased. During 2017, 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.

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 2.6% based UM soil testing procedures. The field was in timothy and clover during 2017 and in oats underseeded to timothy and clover during 2016. Soil test K was high (318 lbs/A, 6.8% saturation), soil P was medium-high (21.1 lbs/A available P by Modified Morgan), soil test Ca was high (1796 lbs/A, 60.0% saturation) and soil test Mg was high (255 lbs/A, 17.4% saturation). The recommended P_2O_5 and K_2O rates based on the soil test results were 120 and 132 to 182 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 0.18 ppm. The experimental design was a randomized block design with six blocks as replicates. 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. Two additional treatments with CAN applied at 60 lbs N/A following 180 lbs of at-planting N per acre combined with the two potash rates. All plots were hand planted on May 31. 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 in most of the CAN-treated plots. Two additional treatments with CAN applied at 60 lbs N/A following 180 lbs of at-planting N per acre were included to determine if remving N from the fertilizer band created problems. The plots were vinekilled on September 24 (116 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 will be evaluated from 50F storage in March.

May, June, and early July were relatively cool and dry at the research farm, while August had adequate rainfall from August 9 onward. Late July and early August were unusually warm, while very cold conditions prevailed in the 10 days prior to harvest. Rainfall totals for May, June, and July were only 2.33, 3.16, and 2.19 inches, respectively, while 3.87 inches were recorded in August. No supplemental irrigation was available at the research site. No significant pest problems were observed. Early-season growth was slow due to the cool, dry conditions; however, late-season growth and vigor was excellent. This report provides a summary of the yield and quality results (see example 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 report.

Russet Burbank did not like the combination of soil and weather conditions that occurred in this experiment. Even though stands were very good, crop vigor was excellent from mid-season onward and no significant disease pressure was noted, yields were low on this site, tuber type was poor, and there was an unusual amount of plot-to-plot variation. For these reasons, the experiment was inconclusive and should be repeated during 2019. Despite the difficult conditions, some interesting results were observed (Table 2). Specific gravity significantly decreased in response to the high potash rate (1.077 vs. 1070). The high potash rate results in particularly low gravity when combined with the high N rate (e.g. 1.067). Hollow heart incidence in large-sized tubers was lower at the high rate of potash (40.0 vs. 13.2 %). Yield was significantly improved by removing some N fertilizer from the band and applying a sidedressed CAN treatment (206 vs 255 cwt/A). Yield was significantly improved by the foliar B application (215 vs 248 cwt/A). Foliar B also tended to decrease hollow heart incidence in this study (42.2 vs. 15.8%). During 2017, the higher potash rate resulted in a 27 cwt/A yield and US#1 yield increase, while also slightly increasing tuber size and decreasing specific gravity by 0.002. We did not observe a positive yield response during 2018. The higher potash rate also tended to decrease hollow heart incidence in large-sized tubers during both years (5.6 vs 1.7%, $p<0.11$ during 2017; 40.0 vs. 13.2% during 2018). The CAN treatment did not significantly affect hollow heart incidence during 2018, while it increased hollow heart incidence in large-sized tubers during 2018 (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).

Fry color and fry color uniformity results will be available after the March 2019 fry evaluation. During 2017, fry color was not strongly affected by the K, CAN, and B treatments and no significant interactive effects of treatments were detected; however, the higher K rate resulted in an increased percentage of uniform fry slices (62.5 versus 52.0%) and the foliar B treatment resulted in a decreased percentage of uniform fry slices (62.9 versus 51.6%). While these nutrient management treatments did not have huge effects on fry color during 2017, they did have enough influence to warrant further study.

Table 1. Response of Russet Burbank, Caribou Russet, and AF5071-2 potatoes to nitrogen fertilizer rate, Aroostook Research Farm, 2018.

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		250	201	16	19	1.081	20.1	34.9	1.29	16.9	70.6	2.0
Caribou R.		303	273	8	46	1.080	10.5	13.6	0.72	67.0	66.3	2.5
AF5071-2		338	310	22	20	1.094	8.6	41.6	0.44	90.0	58.8	1.3
W-D LSD $_{0.05}$		47	44	6	6	0.004	3.0	14.3	0.17	11.6	ns	ns
Nitrogen Rate Averages:												
0 lbs/A		266	246	24	9	1.092	7.9	32.8	0.85	54.2	67.5	2.5
100 lbs/A		348	311	13	29	1.087	12.0	31.9	0.89	52.5	57.5	3.3
200 lbs/A		298	257	12	37	1.079	14.8	34.4	0.76	64.9	70.5	0.9
300 lbs/A		275	230	12	49	1.081	17.4	20.5	0.72	64.3	65.3	0.8
Variety x Nitrogen Rate:												
R. Burbank	0	234	208	26	9	1.087	11.7	50.6	1.54	7.5	72.5	2.5
R. Burbank	100	282	228	14	22	1.080	20.6	30.6	1.44	7.5	55.0	5.0
R. Burbank	200	245	194	12	21	1.075	21.0	41.7	1.10	30.3	93.3	0.0
R. Burbank	300	238	174	12	25	1.082	27.0	20.5	1.05	25.8	67.2	0.0
Caribou R	0	277	258	11	14	1.086	7.0	0.0	0.60	67.5	55.0	5.0
Caribou R	100	380	348	6	48	1.082	8.8	15.0	0.80	57.5	67.5	0.0
Caribou R	200	325	294	6	59	1.075	9.3	32.5	0.73	68.3	68.8	2.5
Caribou R	300	230	191	8	64	1.075	17.0	0.0	0.74	74.8	73.8	2.5
AF5071-2	0	287	273	35	4	1.104	5.0	58.9	0.42	87.5	75.0	0.0
AF5071-2	100	382	357	20	17	1.099	6.8	50.0	0.43	92.5	50.0	5.0
AF5071-2	200	326	283	17	31	1.088	14.2	27.4	0.54	87.5	55.0	0.0
AF5071-2	300	357	326	16	29	1.085	8.4	30.8	0.38	92.5	55.0	0.0
AOV results[3]:												
Variety (V)		**	**	**	**	**	**	**	**	**	ns	ns
Nitrogen (N)		*Q	*Q	**LQ	**LQ	**L	**L	.09L	.14L	.09L	.07C	.16L
V * N		ns	ns	ns	**	ns	.06	ns	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 29. 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"; AF5071-2, 10". The plots were vinekilled on September 24 (118 days after planting) and harvested on October 18.

[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, 2018.

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	240	195	9	31	1.077	18.9	40.0				
300 lbs/A.	224	179	11	27	1.070	20.7	13.2				
CAN Rate:											
0 lbs/A	206	163	9	28	1.073	21.1	27.8				
60 lbs N per A	255	208	11	29	1.075	18.7	27.9				
Foliar B:											
0 lbs/A	215	174	10	32	1.075	18.9	42.2				
1 lbs/A	248	199	10	26	1.073	20.6	15.8				
Potash x CAN Rate:											
150 lbs/A 0 lbs/A	217	171	9	30	1.078	20.7	46.0				
150 lbs/A 60 lbs N/A	261	216	9	32	1.077	17.4	35.7				
150 lbs/A 60 lbs N*/A	207	160	13	20	1.072	21.9	25.0				
300 lbs/A 0 lbs/A	196	156	9	27	1.069	21.5	5.0				
300 lbs/A 60 lbs N/A	249	199	13	26	1.072	20.0	18.7				
300 lbs/A 60 lbs N*/A	225	205	10	33	1.067	9.5	0.0				
Potash x B Rate:											
150 lbs/A 0 lbs/A	219	176	10	37	1.077	7.0	2.7				
150 lbs/A 1 lbs/A	260	212	8	26	1.077	5.1	8.4				
300 lbs/A 0 lbs/A	211	171	11	28	1.073	5.0	1.7				
300 lbs/A 1 lbs/A	236	185	12	26	1.069	6.5	1.7				
AOV results[3]:											
Potash (K)	ns	ns	ns	ns	**	ns	*				
Ca. Nitrate (CAN)	**	*	*	ns	ns	ns	ns				
Boron (B)	*	.12	.15	.1	.06	ns	.07				
K x CAN	ns	ns	ns	ns	.06	ns	ns				
K x B	ns	ns	ns	ns	*	ns	ns				
CAN x B	ns	ns	ns	ns	.07	ns	ns				
K x CAB x B	.15	ns	ns	ns	.11	ns	ns				
Interaction LSD:											
W-D LSD $_{0.05}$	85	ns	ns	ns	0.004	ns	ns				
W-D LSD $_{0.10}$	71	74	ns	18	0.003	ns	80				

[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 May 31. 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. 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. For comparison, the 60 lbs N*/A has the full 180 lbs/A N rate in the band plus the 60 lbs/A CAN sidedress. The seedpiece spacing for Russet Burbank was 16 inches. The plots were vinekilled on September 24 (116 days after planting) and harvested on October 22 and 23.

[2]Samples will be fried from 50F in March. 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.