Processing Potato Trial
Larimore, North Dakota
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The northern plains potato production areas of Minnesota and North Dakota produce potatoes for all markets, including tablestock, seed, and processing. About 60% of production is for processing (chips and frozen, including French fries). Russet Burbank is grown on about 35% of the acreage in North Dakota, with Prospect Russet being grown on about 15%. Russet Burbank, while the industry standard, has several shortcomings: it is a long-season cultivar, it requires high amounts of inputs including fertilizer and water, and it is susceptible to many pests, but more importantly to many stresses including temperature and moisture. Cultivars possessing excellent processing quality including low sugar accumulation and high specific gravity, and that are more environmentally and economically sustainable, are of interest to producers, processors and consumers.

In order to identify superior genotypes, the North Dakota State University (NDSU) potato breeding program conducts crossing, selection, evaluation, and cultivar development activities across North Dakota and western Minnesota. In 2015, field research trials were grown at eight sites. Five were irrigated (Larimore, Oakes, Inkster, Williston, and Park Rapids) and three were non-irrigated (Hoople, Crystal and Grand Forks) sites. These trials are important in identifying selections with high yield potential, disease and pest resistance, stress tolerance, and consumer quality attributes for tablestock and processing genotypes. This report summarizes the results from the Larimore Processing Trial.

Twenty-four advancing dual-purpose russet selections and commercially acceptable cultivars were included in the trial planted on April 25. The field plot design was a randomized complete block with four replicates; cultural practices typical of the growing area were used during the growing season, including sprinkler irrigation. Rows were 36 inches apart, with a 12-inch within-row spacing. Vines were flailed on September 16 and the trial was harvested on September 24. Typically, we flail within a day or two of harvest in order to mimic what many process growers are doing in terms of green digging. Days to vine kill were 144, while days to harvest totaled 152.

Agronomic and quality evaluations, yield and grade, and French fry quality are summarized in Tables 1, 2 and 3, respectively. Percentage stand ranged from 89 to 100% (Table 1). Many entries, particularly those with Dakota Trailblazer as a parent, tend to have strong dormancy. Vine sizes significantly differed, as expected, and ranged from very small for ND091933ABCR-7Russ, ND8068-5Russ and ND102647-3Russ, to very large for Dakota Trailblazer and ND113174B-2Russ. Vine maturity ranged from 1.0 (very early) for ND8068-5Russ and ND091933ABCR-7Russ, to 4.3 (medium late) for ND113174B-2Russ. Stems per plant is indicative of seed quality (physiological age and seed size), tuber eye number (genetic), and length of dormancy (genetic). Stem numbers ranged from 1.1 for Dakota Russet to 2.0 for

ND8068-5Russ. Seed quality was excellent in 2015 and this was reflected in the stem numbers. Most cultivars peak performance will be in the 1.5 to 3.0 stem range.

Total yields were significantly different, ranging from 222 cwt./acre for ND049546b-10Russ to 488 cwt./acre for Alpine Russet (Table 2). Yield of US No. 1s ranged from 202 for ND091933ABCR-7Russ to 446 for Alpine Russet. Percentage US No. 1s ranged from 65% for Shepody, to 92% for Dakota Russet and WND8624-2Russ. Due to a more normal growing season (late April through mid-September) the tuber size profile for all clones tended to be larger than in 2014, when we experienced a very short growing season and the size profile was small. The percentage of 6 to 12 ounce size tubers for most clones was in the upper 40 to mid-50 percentage range. Several clones could have perhaps been vine killed earlier because they had an excessively high percentage of oversized tubers; ND019194AB-1Russ, ND049251B-9Russ, ND060761B-3Russ, ND081764B-4Russ, ND091938BR-2Russ, ND113174B-2Russ, Dakota Trailblazer, Bannock Russet and Shepody are some entries with a high propensity for over-sized tubers. Some of these entries do not set many tubers per plant (data not presented here), so within-row spacing may need to be tightened up (perhaps to 10 inches) to allow for development of a smaller tuber size profile. ND113100-1Russ, ND113174B-2Russ and Shepody produced more than 10% US No. 2 tubers. Tubers were generally culled due to misshapen tubers or growth cracks; ND113174B-2Russ and Shepody had a high propensity for culls.

Several advancing selections and industry standards had outstanding French fry color when fried at harvest and after storage at 45F for 8 weeks (Table 3). Many demonstrate sugar end resistance, and while most clones considered resistant to sugar ends had some, they were light enough to be manageable during processing. ND8068-5Russ, ND091938BR-2Russ, ND102647-3Russ, ND102719B-1Russ, Dakota Russet and Dakota Trailblazer would be considered resistant. ND113174B-2 Russ and Russet Burbank had the most severe and the most sugar ends as defined by the industry. Our program assesses a sugar end as any color deviation from the main fry. This is more stringent than the processing industry that requires a score of a 3 or 4 on the color chart to be called a sugar end. Clones with stem end colors 2 or less can usually be managed during processing. Our research efforts are designed to identify processing (both chip and frozen) germplasm that will reliably and consistently process from long-term cold 38F and 42F (3.3C and/or 5.5C) storage. As we grade, a field (zero time) sample is collected for immediate French fry processing. French fry/frozen processing selections are also evaluated from 45F (7.2C) storage after eight weeks, and again the following May or June for fry color, stem end fry color, sugar ends, and other defects. All clones with processing potential (chip and frozen) are chipped from 38F after 8 weeks of storage as we seek genotypes that will reliable process from that temperature.

Trial entries were evaluated for internal defects. ND102647-3Russ, Bannock Russet, Dakota Trailblazer and Russet Burbank had high percentages of hollow heart (Table 1). The latter three had a high percentage of oversized tubers, while the ND102647-3Russ tended to have a smaller profile. This selection will need to be monitored to see if it is susceptible to hollow heart due to cool temperatures during early tuber bulking as Russet Burbank is, or if it is more similar to Norgold Russet, and thus is more susceptible to late season manifestations. Trial entries are also evaluated for blackspot and shatter bruise potential. Blackspot bruise (Table 1) results when polyphenol oxidase and tyrosine combine within damaged cells due to tubers bumping around

during harvest and handling. Usually the skin is not broken and bruises are difficult to detect without peeling. Based on our ratings, producers should use management practices to maximize the marketing of bruise-free tubers, including a pre-harvest irrigation if appropriate, maintain belts and conveyors full of tubers and soil as the potatoes move through the harvester, limit drops, and utilize padding on harvesters, in trucks, and on conveyors going into storage. Shatter bruise potential was evaluated following storage at 45F. No clone stood out as having significant potential for shatter, however, keeping tubers properly hydrated, using bruise-free management techniques, and minimizing damage limit shatters. Shatter bruises may be a possible entrance point for pathogens such as *Fusarium graminearum*, *Fusarium sambucinum* and *Fusarium coeruleum*.

The most promising advancing dual-purpose (frozen processing and tablestock) russet selections included AND97279-5Russ, ND8068-5Russ, ND039194AB-1Russ, ND060761B-3Russ, and ND102719B-1Russ. The most advanced is ND8068-5Russ. ND8068-5Russ has very early maturity, about seven to ten days earlier than standard Russet Norkotah, thus will not compete with late season cultivars for yield; however, it sizes early and has potential as an early russet for packing or may be used in place of Shepody or Ranger Russet as a clone for opening processing plants in mid-July.

The NDSU potato improvement team wishes to express our gratitude to Hoverson Farms for hosting this research trial. We are appreciative of the opportunity to conduct cooperative and interdisciplinary research efforts, and are grateful to our many grower, industry, and research cooperators in North Dakota, Minnesota, and beyond, for funding and certified seed potatoes in support of our processing research.

Table 1. Agronomic and quality evaluations for advanced processing selections and cultivars, full season, Larimore, 2015.

Clone	% Stand	Vine Size[1]	Vine Maturity[2]	Stems per Plant	Specific Gravity[3]	% Hollow Heart[4]	Black-spot Bruise[5]
1. AND97279-5Russ	98	3.8	2.3	1.9	1.1041	6	4.7
2. ND8068-5Russ	96	1.5	1.0	2.1	1.0962	3	5.0
3. ND039194AB-1Russ	96	3.5	3.0	1.4	1.0911	2	3.8
4. ND049251B-9Russ	90	4.0	2.8	1.7	1.0895	3	3.6
5. ND049546b-10Russ	96	3.0	1.5	1.3	1.0885	11	4.2
6. ND060761B-3Russ	91	3.3	2.3	1.4	1.0899	3	4.7
7. ND081764B-4Russ	90	3.3	3.3	1.2	1.0917	9	4.2
8. ND091933ABCR-7Russ	91	1.3	1.0	1.7	1.0896	10	4.0
9. ND091938BR-2Russ	96	4.0	3.5	1.8	1.0933	1	3.0
10. ND102647-3Russ	95	1.5	1.8	2.0	1.0836	33	3.8
11. ND102719B-1Russ	96	4.3	4.0	1.3	1.1030	3	4.2
12. ND113100-1Russ	93	4.5	2.0	1.8	1.0888	1	3.9
13. ND113174B-2Russ	99	5.0	4.3	1.4	1.0940	5	4.3
14. WND8624-2Russ	89	2.8	2.5	1.4	1.0912	4	4.0
15. WND8625-2Russ	91	3.8	1.1	1.6	1.0920	9	4.2
16. Alpine Russet	96	4.3	3.0	1.6	1.0942	0	4.4
17. Bannock Russet	100	4.0	3.9	1.8	1.0928	28	3.5
18. Dakota Russet	94	3.8	3.3	1.1	1.0976	13	3.2
19. Dakota Trailblazer	96	4.8	4.0	1.3	1.1112	20	3.6
20. Ranger Russet	96	4.0	3.5	1.9	1.0993	3	4.9
21. Russet Burbank	99	4.0	2.9	1.8	1.0850	21	4.2
22. Russet Norkotah	99	2.8	1.0	1.8	1.0875	11	4.4
23. Shepody	96	3.8	2.3	1.8	1.0893	8	3.7
24. Umatilla Russet	98	3.5	2.5	1.9	1.0968	8	3.2
Mean	95	3.5	2.6	1.6	1.0933	9	4.0
LSD ($\propto$=0.05)	7	0.9	0.7	0.3	0.0078	10	1.6

[1] Vine size – scale 1-5, 1 = small, 5 = large.
[2] Vine maturity – scale 1-5, 1 = early, 5 = late.
[3] Determined using weight-in-air, weight-in-water method.
[4] Hollow heart includes brown center.
[5] Blackspot bruise determined by the abrasive peel method, scale 1-5, 1=none, 5=severe.

Table 2. Yield and grade for advanced processing selections and cultivars, full season, Larimore, 2015.

Clone	Total Yield Cwt./A	US No. 1 Cwt./A	US No. 1 %	0-4 oz. %	4-6 oz. %	6-12 oz. %	>12 oz. %	US No. 2 %	Culls %
1. AND97279-5Russ	347	276	79	16	19	50	10	2	3
2. ND8068-5Russ	259	211	81	17	23	56	2	1	1
3. ND039194AB-1Russ	375	338	90	6	11	46	33	4	0
4. ND049251B-9Russ	313	272	87	9	14	48	25	3	1
5. ND049546b-10Russ	222	200	88	10	21	51	17	2	0
6. ND060761B-3Russ	361	303	85	5	8	42	34	9	2
7. ND081764B-4Russ	332	299	90	10	13	49	28	0	0
8. ND091933ABCR-7Russ	289	202	69	30	32	37	0	1	0
9. ND091938BR-2Russ	391	339	87	3	7	41	39	7	2
10. ND102647-3Russ	281	225	80	17	32	43	4	2	0
11. ND102719B-1Russ	371	316	84	5	8	48	28	7	4
12. ND113100-1Russ	310	243	78	7	10	47	21	14	1
13. ND113174B-2Russ	404	290	71	2	6	31	35	12	14
14. WND8624-2Russ	263	243	92	6	16	51	25	1	0
15. WND8625-2Russ	275	248	90	5	9	50	31	3	1
16. Alpine Russet	488	446	91	3	9	38	45	5	1
17. Bannock Russet	309	279	90	9	13	45	32	0	0
18. Dakota Russet	335	311	92	6	8	59	25	1	1
19. Dakota Trailblazer	321	268	84	6	9	42	32	6	4
20. Ranger Russet	390	310	79	7	11	42	27	5	9
21. Russet Burbank	423	315	74	10	14	35	25	7	8
22. Russet Norkotah	345	296	86	14	18	47	20	0	1
23. Shepody	358	230	65	4	7	29	29	15	16
24. Umatilla Russet	394	297	75	12	11	44	21	8	5
Mean	340	282	83	9	14	45	25	5	3
LSD ($\propto$=0.05)	79	76	9	5	5	10	11	5	5

Table 3. Shatter bruise potential and French fry evaluations following harvest and after 8 weeks storage at 45F, full season trial, Larimore, 2015.

Clone	Shatter Bruise[1]	Fry Color[2]	Stem-end Color	% Sugar End[3]	Fry Color[2]	Stem-end Color	% Sugar End[3]
		Field Fry			Following 8 wks. at 45F		
1. AND97279-5Russ	1.5	1.0	2.2	75	1.0	1.8	58
2. ND8068-5Russ	1.7	0.6	1.1	50	0.5	0.9	33
3. ND039194AB-1Russ	2.4	1.3	2.0	75	1.4	2.0	59
4. ND049251B-9Russ	2.5	1.0	2.2	75	1.1	2.4	84
5. ND049546b-10Russ	1.4	0.5	1.2	83	0.9	1.8	58
6. ND060761B-3Russ	1.4	0.6	1.7	59	0.6	1.7	59
7. ND081764B-4Russ	2.0	0.9	2.6	83	1.6	2.9	50
8. ND091933ABCR-7Russ	1.7	0.5	0.8	33	1.4	1.8	25
9. ND091938BR-2Russ	1.6	0.8	1.2	42	1.2	1.5	25
10. ND102647-3Russ	1.3	0.5	1.1	25	0.4	1.2	33
11. ND102719B-1Russ	1.4	0.5	1.1	46	0.6	1.4	50
12. ND113100-1Russ	1.2	0.7	2.0	83	0.6	2.3	67
13. ND113174B-2Russ	1.7	1.4	3.2	67	1.0	3.8	88
14. WND8624-2Russ	2.5	2.3	2.6	17	2.6	2.9	17
15. WND8625-2Russ	1.9	1.0	1.7	50	2.0	2.4	33
16. Alpine Russet	2.0	1.0	1.6	42	1.0	1.8	42
17. Bannock Russet	1.4	0.8	2.0	75	1.3	2.1	75
18. Dakota Russet	1.5	0.7	0.9	25	0.7	0.8	17
19. Dakota Trailblazer	1.3	0.7	1.6	67	0.6	1.1	50
20. Ranger Russet	1.8	0.9	2.4	100	1.1	2.4	67
21. Russet Burbank	1.3	1.3	3.3	84	1.0	3.1	84
22. Russet Norkotah	1.4	1.6	2.2	50	1.9	2.4	42
23. Shepody	2.0	1.6	2.5	42	1.0	2.3	67
24. Umatilla Russet	1.3	1.3	2.9	67	1.0	2.0	75
Mean	1.6	1.0	1.9	59	1.1	2.0	52
LSD ($\propto$=0.05)	1.6	0.6	0.9	45	0.7	0.8	43

[1]Shatter bruise is evaluated using a bruising chamber with digger chain link baffles. Tubers are stored at 45F prior bruising. Shatter bruises are rated on a scale of 1-5, with 1 = none and 5 = many and severe.

[2] Fry color scores: 0.1 corresponds to 000, 0.3 corresponds to 00, 0.5 corresponds to 0, 1.0 equals 1.0; subsequent numbers follow French fry rating scale 000 to 4.0. Scores of 3.0 and above are unacceptable because adequate sugars cannot be leached from the tuber flesh to make an acceptable fry of good texture.

[3] Any stem end darker than the main fry is considered a sugar end in these evaluations, thus mirroring the worst case scenario. The processing industry defines a sugar end as a 3.0 or darker.