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Storage and processing evaluation of advanced potato breeding clones.

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The concentration of reducing sugars (glucose and fructose) that accumulate in a potato cultivar during storage determines its marketing potential for chips, fries, or fresh markets (Sowokinos and Glynn, 2000). The undesirable effect that reducing sugars have on the color of chip and fry products is well known. Potatoes clones that are desirable have a greater ability to resist sweetening when subjected to field stresses such as temperature, moisture, fertility and early dying (Sowokinos et al., 2000).

Potato breeding is an expensive and labor-intensive process. Tens of thousands of potato clones are grown annually by breeders in an effort to find a “single clone” that may meet all of the horticultural requirements necessary to make a successful cultivar (i.e., high yield and solids, disease resistance, etc.). Once a new clone has undergone several years of field trials, it often fails because of storage- and marketing-related problems. This report describes the storage characteristics of advanced potato clones provided by state and federal breeders and is funded, in part, by the Northern Plains Potato Growers Association.

Materials and Methods:

1. Sixty- eight advanced clones from Idaho, Maine, Michigan, Minnesota, New York, North Dakota, Oregon, Texas, Wisconsin and Canada were grown under irrigation south of Larimore, ND. All potatoes were harvested mid-September, suberized two weeks at room temperature and then placed into 45^0 F, 42^0 F and 38^0 F storage. Several tubers of each clone were evaluated for sugar content, Agtron color values and chip appearance at three intervals (i.e., harvest, three and seven month’s storage). Potatoes were also reconditioned at 55^0 F for two weeks following storage at 42^0 F and 38^0 F for five months. All storage and processing evaluations were conducted at the USDA/ARS Potato Research Worksite, East Grand Forks, Mn.

Results

The individual clones demonstrated a wide range of glucose (Glc) accumulation when subjected to cold stress. At 42^0 F storage, the concentration of glucose ranged from 0.03 mg/g in NY 145(Table 1) to 6.93 mg/g in Viking (Table 3). Based on sugar content and chip appearance, the clones were categorized into three classes based on their storage performance.

- Class A: Clones that can be chipped directly from 42^0 F storage (Table 1).
- Class B: Clones that chip from 45^0 F but not from 42^0 F storage (Table 2).
- Class C: Clones that chip from neither 45^0 F nor 42^0 F storage (Table 3).

Table 1 shows fourteen 'Class A' clones that chipped successfully from 42^0 F without reconditioning. Reconditioning, however, did improve most of the Agtron scores (data not shown). Seven of the top performers were from North Dakota, (ND 7519-1, ND 8331CB-2, ND 8-14, ND 860-2, Sport 860, ND 8305-1 and ND 8331CB-2,). Three were from Wisconsin (W 5015-12, W 2717-5, and W 2310-3,). Four were from Michigan (MSJ 147-1, MSP 459-5, MSQ 070-1 and MSJ 126-9Y). One was from New York (NY 145).

Table 2 shows the 'Class B' clones that chip from 45^0 F but not 42^0 F. There are fourteen clones represented. They were from North Dakota, Wisconsin, Colorado, ,and Michigan. Although these clones do not have the low glucose forming potential (GFP) of clones listed in Table 1 (Class A), their storage performance was still superior to the original chipping standard, Norchip. Consequently, the clones listed in Table 2, can potentially play an important role in meeting grower and industry needs.

Table 3 lists 'Class C' clones that chip neither from 42^0 F or 45^0 F storage. Cultivars such as Russet Burbank, Shepody and Viking fall into this class. Their higher inherent GFP serves to direct their end use more towards french fry and fresh markets.

Discussion
All sixty eight of the potato clones failed to produced acceptably colored chips following storage at 38^0 F for seven months. Three Class A clones listed in Table 1 did, however, chip successfully after storage at 38^0 F following a reconditioning period at 55^0 F. These included W 7124-9, NY 145, and MSP 459-5. The first clone listed in Table 1 was W 7124-9. Interestingly, its parents were White Pearl and Dakota Pearl. The next Wisconsin clone was 5015-12. Its parents were Brodick x White Pearl. W 2717-5 (recently named cv.Lelah; S440 x ND3828-15) and W2310-3 (cv.Tundra, Pike x S440) both had S440 as one of the parents.The second rated clone in Table 1 was ND 8305-1. It also had White Pearl as a parent (ND 2471-8 x White Pearl). Previously, White Pearl demonstrated superior long-term cold chipping quality compared to commonly used U.S. chipping clones i.e., Atlantic, Snowden, Dakota Pearl, and NorValley (Groza, et.al., 2006). The thrid clone listed in Table 1 was NY145. Its parents were NY121 x NY 115. The parents of the clone MSP 459-5, that also reconditioned from 38^0 F storage, were Marcy X NY 121. It is noted that previously highly rated clones, identified through these annual storage evaluations, have gone on to become leading U.S. chipping cultivars as well as to serve as valuable parents for future crossings. Six of the Class A clones listed in Table 1 are also included in the past years Snack Food Association National Chipping Trials i.e.,ND 7519-1, ND 8305-1, W 2310-3, ND 8331CB-2, W 5015-12

and MSJ 126-9Y. (Contact Charllie Higgins, Snack Food Association Storage Trials at 719-588-2388 or chiggins@hfinc.biz).

Summary

The Class A' clones listed in Table 1 provide the quality advantages from storage as listed below.

- Decreased microbial spoilage.
- Retention of dry matter
- Reduced shrinkage
- Decreased need for sprout inhibition
- Decreased physiological aging
- Increased marketing window.
- Negligible acrylamide formation

For a new potato cultivar to be successful, it must also demonstrate a variety of other horticultural and marketing qualities that are required by the producer and consumer. Contact the respective potato breeder (listed below) if you are interested in any additional quality traits demonstrated by the potato clones listed.

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2011 - 2012 Class A: Potato Clones that chip following 7 months at 42° F.
Clones are aligned in order of decreasing agtron values from 42° F.

			CC	AGT	SUCROSE	GLUCOSE	CC	AGT	SUCROSE	GLUCOSE
			45°F				42°F			
	Clone	Source			(mg/g)	(mg/g)			(mg/g)	(mg/g)
48	NY 145	ND	1	68	0.62	0.01	1	67	1.02	0.04
37	ND 7519-1	ND	1	67	1.00	0.03	1	65	1.19	0.03
39	ND 8-14	ND	1	64	1.69	0.66	1	65	1.14	0.04
63	W 5015-12	WI	1	67	1.70	0.03	1	64	1.21	0.12
60	W 2717-5	WI	1	65	0.82	0.08	1	64	0.91	0.10
59	W 2310-3	WI	1	64	0.86	0.03	1	64	1.22	0.05
24	NYE 106-4	NY	1	65	0.91	0.03	1	63	2.86	0.16
46	ND 860-2	ND	1	65	0.65	0.05	1	62	1.09	0.10
56	Sport 860	ND	2	62	0.94	0.04	1	62	0.76	0.19
22	Dakota Pearl	ND	1	65	0.81	0.07	1	61	1.05	0.09
42	ND 8305-1	ND	1	66	1.21	0.01	1	61	2.63	0.08
5	AO 1143-3C	ID	1	65	0.81	0.06	2	60	2.21	0.09
25	Ivory Crisp	ND/OR/ID/USDA	2	62	1.28	0.08	2	60	1.00	0.14
44	ND 8331CB-2	ND	1	64	1.72	0.28	2	59	2.19	0.34

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[1]CC = Represents chip color relating to the Potato Chip/Snack Food Association five-code color chart: 1 and 2 are acceptable, 3 is marginal, 4 and 5 are unacceptable.
[2]Agtron values of 60 or greater yield acceptable colored chips.
[3]Acceptable values for Glc (glucose) are 0.25 mg/g (0.025%) or less.
******* Denotes no data.**

Table 2: 2011 - 2012 Class B: Potato Clones that chip following 7 months at 45° F, but not 42° F Clones are aligned in order of decreasing agtrons from 42° F storage.

			45°F				42°F			
			CC	AGT	SUCROSE (mg/g)	GLUCOSE (mg/g)	CC	AGT	SUCROSE (mg/g)	GLUCOSE (mg/g)
	Clone	Source								
47	Norvalley	ND	2	61	1.17	0.19	3	57	0.79	0.64
33	MSR 127-2	MI	2	55	1.99	0.60	3	56	1.65	0.54
21	Dakota Crisp	ND	2	57	1.14	0.09	3	55	1.12	0.68
41	ND 8304-2	ND	1	64	1.88	0.56	2	55	2.31	0.99
55	Snowden	WI	2	60	1.39	0.59	3	55	0.92	0.50
29	MSL 292-A	MI	2	60	1.40	0.41	3	55	1.08	0.69
9	Atlantic	USDA	2	59	1.94	0.62	3	55	1.10	0.88
15	CO 0197-3W	CO	2	62	0.51	0.14	3	55	0.62	2.30
64	W 5955-1	WI	2	62	0.96	0.07	3	54	1.05	0.60
28	MSL 007-B	MI	2	59	0.74	0.24	3	54	0.84	0.59
61	W 2978-3	WI	2	58	0.78	0.32	3	53	1.22	0.88
31	MSQ 086-3	MI	2	60	0.64	0.11	3	53	0.98	1.04
27	MSJ 126-9Y	MI	2	61	0.74	0.51	3	53	1.16	0.73
30	MSQ 070-1	MI	2	58	1.59	0.34	3	52	1.11	0.99

[1]CC = Represents chip color relating to the Potato Chip/Snack Food Association five-code color chart: 1 and 2 are acceptable, 3 is marginal, 4 and 5 are unacceptable.
[2]Agtron values of 60 or greater yield acceptable colored chips.
[3]Acceptable values for Glc (glucose) are 0.25 mg/g (0.025%) or less.
******* Denotes no data.**

Table 3 2011 - 2012 Class C:

Potato Clones that do not chip following 7 months storage from either 45° F or 42° F storage.
Clones are aligned in order of decreasing agtrons from 42° F storage.

	Clone	Source	CC	AGT	SUCROSE 45°F (mg/g)	GLUCOSE 45°F (mg/g)	CC	AGT	SUCROSE 42°F (mg/g)	GLUCOSE 42°F (mg/g)
14	CO 0188-4W	CO	3	55	0.52	0.07	3	53	0.99	0.79
62	W 4980-1	WI	3	53	0.97	0.27	3	52	0.83	0.91
8	AOTX 98152-3RU	ID/OR/TX	3	53	0.71	0.33	3	52	0.97	1.33
23	Dakota Trailblazer	ND	3	52	0.93	0.44	3	52	1.36	0.70
32	MSR 061-1	MI	3	57	1.71	0.45	3	52	1.63	1.13
43	ND 8307C-3	ND	1	64	1.43	0.37	2	52	2.02	0.60
6	AOND 95292-3RUSS	ID/OR/ND	3	52	0.99	0.89	3	51	2.81	2.12
19	CO 99100-1RU	CO	3	54	1.07	0.45	3	51	1.14	1.19
35	NCB 2497-17	NC					3	51	2.09	1.50
67	W 8946-1RUS	WI	3	52	0.78	1.01	3	50	0.10	1.72
36	NCO 349-3	NC	2	53	1.22	0.45	3	50	0.65	2.64
1	A 98345	ID	3	52	0.66	1.11	3	50	1.32	1.52
17	CO 99053-3RU	CO	3	52	0.70	1.13	3	50	0.33	2.92
40	ND 8229-3	ND	3	48	1.66	0.59	3	50	1.68	1.24
68	Yukon Gem	ID	2	59	1.23	0.30	2	50	0.47	1.96
65	W 6234-4RUS	WI	3	58	0.69	0.10	3	49	0.85	1.15
10	ATX 9202-3RUS	ID/TX	3	48	1.11	0.94	3	47	0.84	2.32
26	MSH 228-6	MI	***	***	***	***	3	47	1.09	1.04
45	ND 8331-CB-3	ND	3	50	1.20	1.79	3	47	2.07	3.55
3	AO 02060-3TE	ID/OR	***	***	***	***	3	46	1.77	2.81
4	AO 1010-1	ID/OR	2	57	0.46	1.11	3	46	0.79	3.10
20	COTX 90046-1W	CO/TX	3	52	1.24	1.11	3	46	2.30	3.63
50	Red Norland	ND	3	50	0.35	1.35	3	46	1.15	4.53
57	Umatilla	ID/OR	3	52	1.18	1.58	3	46	0.76	1.91
13	CO 001399-10P/Y	CO	3	45	0.07	0.99	3	45	0.00	2.70
12	CO 000270-7W	CO	3	53	2.15	0.91	3	45	3.30	3.03
18	CO 99053-4RU	CO	3	51	0.63	2.90	4	44	1.38	5.66

	Clone	Source	CC	AGT	SUCROSE 45°F (mg/g)	GLUCOSE (mg/g)	CC	AGT	SUCROSE 42°F (mg/g)	GLUCOSE (mg/g)
7	AOTX 96216-2RU	ID/OR/RX	***	***	***	***	4	43	0.85	5.07
49	Ranger Russ	ID/OR/WA/CO	3	45	0.00	2.56	4	43	0.10	5.91
52	Russ Norkotah	ND/TX	3	50	1.54	0.79	4	43	1.29	2.92
34	NC 182-5	NC	3	50	1.40	0.53	3	42	2.29	3.17
11	Classic Russ	ID	3	46	0.70	1.61	4	42	1.14	3.94
51	Russ Burbank	CO	3	48	0.63	2.93	4	42	0.85	3.77
69	Yukon Gold	CAN	3	50	0.90	2.84	4	42	1.38	2.39
16	CO 98067-7RU	CO	3	53	0.94	0.91	4	41	2.09	3.84
66	W 6360-1RUS	WI	3	50	1.40	0.93	4	41	0.14	2.31
54	Shepody	CAN/NB	4	39	0.31	2.04	4	40	0.69	3.97
53	Sangre	ID/CO	4	36	1.63	5.96	4	37	1.75	6.57
2	AO 008-1TE	ID/OR	4	45	1.40	1.76	5	34	2.06	4.34
58	Viking	ID/OR/CO/WA	4	39	1.57	3.46	5	34	2.85	6.93

[1]CC = Represents chip color relating to the Potato Chip/Snack Food Association five-code color chart: 1 and 2 are acceptable, 3 is marginal, 4 and 5 are unacceptable.
[2]Agtron values of 60 or greater yield acceptable colored chips.
[3]Acceptable values for Glc (glucose) are 0.25 mg/g (0.025%) or less.
*** denotes no data .

Title: Management of Powdery Scab and *Potato Mop Top Virus* Using Genetic Resistance

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Submitted to MN Area II and NPPGA

Executive Summary:

Soilborne diseases of potato are generally regarded as the one of the most serious economic constraints facing the potato industry when disease losses are coupled with the cost of control. The principle soil borne pathogens affecting potato are *Verticillium dahliae, Colletotrichum coccodes, Rhizoctonia solani,* and most recently *Spongospora subterranea,* the cause of powdery scab. The powdery scab pathogen is also the vector of *potato mop top virus*. Powdery scab was first reported in North Dakota in 1997 (Draper, et al., 1997) and has since emerged as one of the most important soil borne diseases of potato in the region affecting every market sector. This tuber necrosis virus was first reported in Maine in 2003, (Lambert, et al., 2003) and subsequently in North Dakota in 2010 (David et al., 2010), Washington in 2011 (Crosslin, 2011), and in Idaho in 2012 (Whitworth and Crosslin, 2013). It is evident that PMTV incidence is increasing in the US.

Additionally, potato tubers from Colorado and New Mexico with tuber necrosis symptoms have recently been confirmed to be infected with PMTV (Gudmestad, unpublished). Furthermore, a survey for PMTV in certified seed lots conducted in the USA and Canada in 2001 and 2002 found the virus present in 4.3% of the 3,221 seed lots tested (Xu, et al., 2004). Although individual states and provinces were not identified, PMTV was found in all of the Western, Central, and Eastern zones of both countries, clearly demonstrating that the virus is widespread in both countries. Seed tubers from a number of certified seed lots produced in the US have tested positive for PMTV the past two years (Gudmestad, unpublished), which suggests that the virus is being spread across the country. It is only a matter of time before PMTV is as economically damaging in the USA as it is in Europe (Santala, et al., 2010).

Rationale:

A number of important soilborne pathogens affect potato development and tuber quality. Among the most important of these diseases is powdery scab, caused by *Spongospora subterranea*, The powdery scab pathogen forms galls on the roots of infected plants which can girdle the roots and compromise their function in water and nutrient uptake. However, the tuber lesion phase of this disease is the most recognizable since infected tubers are unmarketable. Powdery scab has been particularly troublesome in some red potato production areas of MN. When the powdery scab pathogen carries the *potato mop top virus* (PMTV) and transmits it to potato plants, the resulting tuber necrosis exacerbates the yield loss potential from this pathogen causing a disease the potato industry in the United Kingdom refer to as 'spraing'. The occurrence of spraing in several French fry processing fields in North Dakota caused significant economic hardship for one grower but the threat to other growers in the region is real.

At current time, the only method of controlling powdery scab in potato is to avoid it. The methods to determine the presence and concentration of important soil borne potato pathogens have historically been costly, time-consuming, and in the case of powdery scab, nonexistent. The development of a multiplex real-time PCR method in my research laboratory capable of detecting and quantifying soil inocula of three soilborne pathogens has assisted growers in making management decisions. The NPPGA and MN Area II Potato Growers supported this research in previous years and, as a result, growers are testing soils before planting in order to avoid planting potatoes into soils with high levels of powdery scab. The red growers in MN and ND have been particularly supportive of this testing method.

Unfortunately, many potato soils in our region are already contaminated with high levels of powdery scab and, in some cases, PMTV also exists. There are currently no disease management strategies available for these producers. Research proposed here would provide short and intermediate control strategies for potato producers already faced with serious powdery scab and mop top disease problems.

The goal of the research proposed here is to evaluate cultivars and potato germplasm for susceptibility to PMTV. Some funding was provided for PMTV research in 2011 and 2012 to support chloropicrin trials, but that soil fumigant proved to be ineffective in managing PMTV tuber necrosis. We also initiated the screening of commercial varieties for susceptibility in the expression of the tuber necrosis phase of PMTV that renders tubers unmarketable and that has shown great potential. The research proposed here proposes to build on this later work.

Current Research:

Field trials were established in 2011 and 2012 to evaluate and screen a variety of potato cultivars and germplasm representing all market classes for resistance to powdery scab and mop top virus. We have detected wide variability in susceptibility of potato cultivars and germplasm to both powdery scab and PMTV. We also observed wide variation in the incidence of tuber necrosis caused by PMTV among all cultivars and selections in each market class in the screening trial. Tuber necrosis ranged from zero in some cultivars to over 45% in some advanced breeding selections. Based on these data, we believe we can use field trials to develop reliable susceptibility rankings for potato cultivars and provide growers with useful disease management information. We envision that growers who have PMTV tuber necrosis issues will be able to avoid the most susceptible cultivars but will still be able to plant a variety within the same market class (such as red-skinned potatoes) that do not express PMTV tuber necrosis. Furthermore, we believe we can begin to develop PMTV resistant germplasm that can be utilized in further breeding strategies.

Research Objectives:

1) Screen commercially acceptable red, white, and russet-skinned potato cultivars for susceptibility to powdery scab and mop top virus.
2) Screen potato germplasm for susceptibility to powdery scab and mop top virus.

Research Plan:

Two field trials were established in two fields with a history of potato production and with known infestations of powdery scab. These field trials were set up very similar to those conducted in 2011 and 2012. In the experiments conducted in 2013 we will continue to assess cultivar and germplasm susceptibility to powdery scab and in one trial in ND we will assess susceptibility to mop top virus. We will screen all skin types, varieties and advanced selections, discussed above but will emphasize chip varieties (courtesy USPB) and French fry germplasm (courtesy R. Novy, USDA-ARS at the trial site in which mop top virus exists. Varietal susceptibility will be assessed by determining the severity of galls that form on roots and the severity of tuber lesion development. Mop top susceptibility will be determined by the degree of internal tuber necrosis that develops.

Results:

The French fry germplasm trial was planted with 531 selections from five families and PMTV tuber necrosis was evaluated 71-88 days after harvesting. Significant differences were found in the incidence of PMTV-induced tuber necrosis among selections ($p < 0.038$). PMTV tuber necrosis was not observed in any of the selections from families A09059 and A09073 (Table 1). For family A09073, 248 selections were planted but only 191 produced tubers. For family A09059, 178 selections produced tubers out of 248 planted.

Selections within the family A10384 had the highest incidence of PMTV-induced tuber necrosis with an overall family mean of 1.16%. Within family A10384, PMTV tuber necrosis was observed in 13 out of 178 selections evaluated from 242 selections planted. PMTV incidence ranged from zero in several selections to 17.50% in selection 135 over two replications. Selections 135, 45, 9, 13, 92, and 93 had PMTV tuber necrosis incidence of 10% or more (10% in selections 13 and 93 to 17.5% in selection 135) while selections 63, 125, 83, 17, 140 and 101 had PMTV tuber necrosis incidence below 10%.

Within family A09250, PMTV-induced tuber necrosis was observed in 5 out of 108 selections evaluated from 146 selections planted. PMTV incidence ranged from zero in several selections to 25% in selection 10 over two replications. Selection 27 had PMTV tuber necrosis incidence of 16.67% while selections 48, 9 and 24 had PMTV tuber necrosis incidence below 10%. The overall mean of PMTV tuber necrosis incidence for the family A09250 was 1.11%.

Within family A09094, PMTV tuber necrosis was observed in 4 out of 100 selections evaluated from 178 selections planted. PMTV incidence ranged from zero in several selections to 16.67% in selections 47 and 80 over two replications. Selections 79 and 45 had PMTV tuber necrosis incidence below 10%. The overall mean of PMTV tuber necrosis incidence for the family A09094 was 0.89%.

Table 1. PMTV tuber necrosis incidence within French fry germplasm families

Family	PMTV tuber necrosis incidence (%)	Duncan Grouping
Control*	8.6555	a
A10384	1.1587	b
A09250	1.1093	b
A09094	0.8928	b
A09059	0	b
A09073	0	b

*Dakota Crisp and Ivory Crisp are included as susceptible controls for comparison.

Significant differences ($p < 0.0001$) were found in PMTV tuber necrosis incidence and severity among chip varieties and germplam at 63 to 89 days after harvesting (Table 2). Dakota Crisp is the susceptible standard based on previous research reported to MN Area II and the NPPGA in 2011 and 2012. A new chip cultivar, Nicolet, appears to be as or more susceptible than Dakota Crisp to PMTV-induced tuber necrosis, although not significantly so. In contrast, chip cultivar Lamoka is significantly less susceptible to PMTV necrosis than Nicolet, Snowden, or Ivory Crisp. Several chip advanced clones appear to be less susceptible to PMTV-induced tuber necrosis than the susceptible controls.

Table 2. PMTV tuber necrosis incidence and severity chip clones and cultivars

Clone/Cultivar	**PMTV tuber necrosis incidence (%)**		**PMTV tuber necrosis severity**	
Nicolet	50.857	a*	0.5793	a
W2324-1	41.077	ab	0.5727	a
Snowden	39.777	ab	0.4457	ab
Dakota Crisp	39.047	ab	0.4287	abc
MSL292-A	28.503	b	0.3103	bcd
W2717-5	28.063	b	0.3413	abc
MSK061-4	25.547	bc	0.1777	cde
Atlantic	10.13	cd	0.0267	e
NY138	8.66	dc	0.038	e
Ivory Crisp	5.93	d	0.0457	e
W5015-12	5.823	d	0.0583	de
MSL007-B	2.623	d	0.003	e
MSH228-6	1.15	d	0.0057	e
Lamoka	0.953	d	0.002	e
MSR061-1	0.833	d	0.003	e

*****Numbers followed by the same letter are not significantly different.

Discussion:

There is a high degree of variability in the expression of PMTV-induced tuber necrosis among commercially acceptable potato cultivars. In previous studies supported by the NPPGA and MN Area II in 2011 and 2012 we found a range of susceptibility among potato cultivars of all market classes from highly susceptible to those displaying some form of resistance to the expression of PMTV tuber necrosis. These observations were confirmed in 2013 in more advanced breeding selection and varieties of potato chip type clones. This further demonstrates the utility of these type of studies in providing the information necessary for potato growers to make informed decisions on their choice of potato cultivar should they be unfortunate enough to have PMTV introduced onto their farm.

In the current study, we further demonstrate also that among breeding families of French fry cultivars, resistance to PMTV-induced tuber necrosis is heritable. Future studies will determine if PMTV resistance is to the expression of PMTV necrosis in a potato tuber or whether or not the clone is able to resist infection by the virus.

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Title: Prevalence of SDHI Resistance in Minnesota and North Dakota

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Submitted to MN Area II and NPPGA

Executive Summary:

Early blight, caused by *Alternaria solani* Sorauer is an important chronic foliar disease of potato present every growing season in the Midwestern United States. Most currently grown potato cultivars lack resistance to early blight, therefore, foliar fungicides are relied upon for disease management. Foliar fungicides with high efficacy against the pathogen frequently are used under high disease pressure situations, such as, potatoes grown under overhead irrigation. *A. solani* has been demonstrated previously to have developed resistance to quinone outside inhibiting (QoI) fungicides (strobilurins such as Quadris® and Headline®) rendering them of little use for the management of early blight throughout much of the United States. QoI resistance was detected only two years after this chemistry was introduced into the marketplace.

After the development of resistance to QoI fungicides, boscalid (Endura®) was demonstrated to be the most efficacious fungicide for the control of early blight. Boscalid is a member of the succinate dehydrogenase inhibiting (SDHI) fungicide group and was registered for use on potato in 2005. Resistance to boscalid in *A. solani* has recently been detected in the states of North Dakota, Minnesota, Nebraska, Texas, Idaho, Wisconsin and Florida from early blight samples collected in 2010 and 2011. Two phenotypes of boscalid resistance were detected. Approximately 80% of all *A. solani* assayed were found to have some level of resistance to boscalid with about 5% and 75% of the population moderately resistant and highly resistant, respectively, to the fungicide. Nearly 99% of all boscalid resistant isolates possessed the F129L mutation, indicating that an *A. solani* population with dual fungicide resistance predominates in the states surveyed.

An interesting attribute to the SDHI resistance situation is that *A. solani* isolates resistant to boscalid remained sensitive to fluopyram (Luna®)and a large proportion of moderately resistant and resistant isolates were sensitive to penthiopyrad (Vertisan®). We have now cloned and sequenced the SDH gene of *A. solani* and have identified five point mutations responsible for conveying resistance to boscalid, two of which convey a high level of resistance to the fungicide, the other three moderate levels of resistance. This molecular study has provided the opportunity to develop PCR assays that can detect each mutation rapidly and efficiently.

Although we know boscalid resistance in the early blight fungus exists, we do not know what farms and production areas are affected. The limited survey conducted on *A. solani* from ND and MN included only 26 and 29 isolates, respectively, and resistance is not prevalent on every farm. We have detected farms in some areas of the Midwest were the early blight fungus is 100% sensitive to boscalid and others where it is completely resistant. We propose to do a more systematic and comprehensive survey of

boscalid resistance in *A. solani* to help growers make informed decisions on their fungicide choice.

Rationale:

Early blight of potato, caused by *Alternaria solani* Sorauer, is a chronic foliar disease of potato present every growing season, particularly in the Midwestern portion of the United States. This disease is characterized by relatively small, discrete lesions with a concentric ring pattern. Early blight lesions tend to be evident initially on the older leaves as they senesce, eventually spreading to other foliage in the plant canopy under conditions conducive for disease development. Periods of free moisture from rain, dew or overhead irrigation are required for spore germination and infection, and temperatures ranging from 42 to 86F favor pathogen sporulation and disease development. Most currently grown potato cultivars are susceptible to early blight to varying degrees, thus, foliar fungicides are frequently used to manage the disease

A number of foliar fungicides can be used to manage early blight in potato. Mancozeb and chlorothalonil are perhaps the most frequently used protectant fungicides for early blight management but provide insufficient control under high disease pressure. QoI fungicides were used successfully after their introduction in 1999, and provided a very high level of disease control (Pasche et al., 2004; 2005; Pasche and Gudmestad, 2008). Unfortunately, QoI resistance due to the F129L mutation was detected first in North Dakota and Nebraska in 2001 (Pasche et al., 2004; 2005) and was prevalent throughout much of the United States by 2006 (Pasche and Gudmestad, 2008). The F129L mutation conveys a moderate level of resistance to QoI fungicides such as azoxystrobin and pyraclostrobin. The reduced efficacy of these two fungicides to levels of disease control provided by mancozeb and chlorothalonil makes them less attractive for early blight disease management due to their increase cost compared to standard protectants. Boscalid was registered in the United States for use on potato in 2005 and proved to be an excellent fungicide for early blight disease management (Pasche and Gudmestad, 2008). As a result, throughout much of the potato growing regions of the United States where early blight is an important foliar disease, boscalid replaced the QoI fungicides in the foliar fungicide program.

Boscalid belongs to a class of fungicide referred to as succinate dehydrogenase inhibitors (SDHI). The primary target of SDHI fungicides is in the complex II electron transport system known as the succinate dehydrogenase (SDH) complex or the succinate:ubiquinone oxidoreducate respiratory chain. Molecules belonging to this class of fungicide bind to the ubiquinone-binding site of the mitochondrial complex II, thereby inhibiting fungal respiration. Despite having a similar biological mode of action, SDHI fungicides show no cross resistance to QoI fungicides, which inhibit fungal respiration at mitochondrial complex III. This makes them excellent candidates for alternating with, or mixing with, QoI fungicides to manage fungicide resistance development while also providing superior disease control. Unfortunately, resistance to boscalid has developed quite readily and has been reported in *Alternaria alternata* of pistachio, *Botrytis cinerea* in several crops, *Corynespora cassiicola* of cucumber, *Didymella broyniae* of cucurbits, *Monilinia fructicola* of peach, *Podosphaera xanthii* of cucumber, and *A. solani* of potato

(Avenot and Michailides, 2010; Avenot, et al., 2012; Ishii, et al., 2011; Wharton, et al., 2012). Boscalid resistance in *A. solani* was first detected in 2009 and 2010 in Idaho with 15 and 62% of the isolates found to be insensitive to the fungicide. The prevalence of boscalid resistance in MN and ND is very similar with approximately 70% of the isolates demonstrating insensitivity to the fungicide in *A. solani* collected in 2010 and 2011, however, those numbers are based on collections from two farms in each state and only 26-29 isolates (Gudmestad, et al., 2013).

The objectives of the research reported here were to determine the prevalence and distribution of boscalid resistance in North Dakota and Minnesota by sampling a widely distributed population of *A. solani* in both states. The development of these molecular diagnostic assays will allow us to determine the prevalence of SDHI resistance in MN and ND and will provide valuable information on the appropriate use of fungicides. While boscalid is affected by all of these mutations, penthiopyrad is affected by only two of them, and fluopyram is not affected by any of the mutations. Decisions on which fungicide is appropriate and most economically feasible can be made with the information generated by this research.

Current Research:

During our initial studies on the development of resistance to boscalid, we detected two phenotypes in the early blight pathogen, one in which *A. solani* isolates appear to be moderately resistant to boscalid, the other in which isolates of were highly resistant to the fungicide (Gudmestad, et al., 2013). Resistance to SHDI fungicides is known to occur in one of the soluble subunits of succinate dehydrogenase (SDH) protein SdhB. In our previous study, the *sdhB* gene was analyzed and compared in some sensitive, moderate and highly resistant *A. solani* isolates (Mallik, et al., 2014). Sequencing of *sdhB* gene revealed two point mutations, one conveying high level or resistance to boscalid, the other moderate levels of resistance. A mismatch amplification mutation assay (MAMA) PCR was developed to differentiate between the isolates with these two mutations (Mallik, et al., 2014).

Interestingly, some *A. solani* isolates with moderate and very high EC_{50} values did not amplify with sensitive MAMA primers, suggesting that there might be additional mutations elsewhere in the protein. Further investigation revealed the presence of other mutations in the membrane anchored subunits SdhC and SdhD. Sequencing the *sdhC* and *sdhD* genes in those isolates confirmed the presence of point mutations in either SdhC or SdhD subunits respectively. A multiplex PCR to detect and differentiate the sensitive and resistant isolates was designed based on the single nucleotide polymorphisms (SNPs) present in all three genes. The multiplex and MAMA PCR facilitated the screening and identification of the mutations in additional *A solani* isolates with varied boscalid resistant phenotypes. The mutation in *sdhC* was more commonly observed in *A. solani* isolates with moderately resistant boscalid EC_{50} values and the *sdhD* mutation was observed in isolates with both moderate and very high EC_{50} values (Mallik, et al., 2014).

Research Objectives:

1) Collect *A. solani* isolates from all potato production areas of North Dakota and Minnesota.
2) Determine the presence or absence of SDHI resistance genes using PCR.
3) Provide recommendations on SDHI fungicide efficacy based on the presence or absence of SDH point mutations.

Research Plan:

A multiplex PCR will be used to detect and differentiate the sensitive and resistant isolates was designed based on the single nucleotide polymorphisms (SNPs) present in all three genes (Mallik, et al., 2014). The multiplex and MAMA PCR will facilitate the screening and identification of the mutations in additional *A solani* isolates with varied boscalid resistant phenotypes. The mutation in *sdhC* was more commonly observed in *A. solani* isolates with moderately resistant boscalid EC_{50} values and the *sdhD* mutation was observed in isolates with both moderate and very high EC_{50} values (Mallik, et al., 2013).

The 2013 growing season was characterized by late planting and development of the potato crop. As a result, early blight pressure was unusually light in 2013. Nonetheless, potato leaves infected with early blight were collected, either by growers or by staff from the Gudmestad lab, and brought back to NDSU for isolation and long term storage. DNA will be extracted from 10 day old cultures of *A. solani* and tested in PCR assays using MAMA and multiplex primers to detect point mutations in the *sdh*B, *sdh*C, and *sdh*D gene (Mallik, et al., 2014).

Results:

A total of 79 and 51 isolates of *A. solani* were collected from potato fields in North Dakota and Minnesota, respectively. These isolates were purified and placed into long term storage for further study. Cultures of each isolate were removed from storage and grown in vitro. After ten days of grown, DNA was extracted and tested with multiplex and MAMA-based PCR to determine the presence of SDHI/boscalid resistance mutations (Mallik, et al., 2014). *A. sol*ani isolates collected from North Dakota and Minnesota were found to be 98.7 and 100% resistant to boscalid (Table 1).

In contrast to the rest of the USA, the SDHI mutations in the *A. solani* population recovered from North Dakota and Minnesota are dominated by the H134R mutation. The H134R mutation is in the *AsSDHC* gene but elsewhere in the potato industry mutations in the *AsSDHB* gene dominate the population.

Table 1. Frequency of SDHI mutations conveying resistance to boscalid in isolates of *Alternaria solani*, cause of potato early blight, recovered from North Dakota and Minnesota in 2013.

State	**No. of Isolates**	**H278Y**[@]	**H278R**[#]	**H134R**[+]	**H133R**[*]	**SDHI Sensitive**
ND	79	14	18	63	4	1
MN	51	4	2	53	41	0

[@]H278Y is a SDHI mutation in the *AsSDHB* gene conveying very high resistance to boscalid.
[#]H278R is a SDHI mutation in the *AsSDHB* gene conveying moderate resistance to boscalid.
[+]H134R is a SDHI mutation in the *AsSDHC* gene conveying high resistance to boscalid.
[*]H133R is a SDHI mutation in the *AsSDHD* gene conveying very high resistance to boscalid.

Discussion:

Isolates of *A. solani* collected from North Dakota and Minnesota in 2010 and 2011 indicated that the prevalence of boscalid resistance was spatially distributed (Gudmestad, et al., 2013). In other words, some farms had a population of the early blight pathogen that was sensitive to boscalid while others did not. This meant that the use of Endura® was an option for early blight disease control for some potato growers but not for others. Since this fungicide is less expensive than other SDHI fungicides in the same class, this was an attractive option for early blight disease control on potato farms with an A. solani population that was sensitive to Endura®.

Unfortunately, results of the current survey conducted in 2013 suggests that the distribution of SDHI resistance is much more uniform across the two states than it was 2-3 years prior. Although the number of isolates characterized is still quite low, the distribution of isolates collected from both states was fairly wide and representative of all irrigated potato production areas in both states. Therefore, we can no longer recommend the use Endura® of for the control of early blight of potato in North Dakota and Minnesota.

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MN Area II Potato Research and Promo Council and the Northern Plains Potato Growers Association (NPPGA) FY 2013 Progress Report.

TITLE: Screening promising germplasm for cold-induced sweetening (CIS) resistance and improved nutritional quality to compliment potato breeding programs and new variety development.

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BACKGROUND:
Biochemical markers to predict cold sweetening resistance in stored potatoes are reliable selection tools for potato breeding because they have the capacity to predict a clone's ability to process from long term cold storage. These biochemical markers Acid Invertase (AcInv) and UGPase have been used to characterize a diverse set of breeding clones from US potato breeding programs, as well as the segregating progeny population from the cross of Premier Russet (PR) x Rio Grande Russet (RGR); that was subsequently genotyped in the NIFA funded SolCAP mapping study. In addition to genotyping, the 124 clones from PR X RGR population were characterized for AcInv and UGPase (biochemical markers), sucrose and glucose (sugars), and sugar end defects. Results showed wide variation in acid invertase activity in the population. Most of the clones had enzyme activity values ranging between the two parents. However, some progeny performed better than the parents, thus transgressive segregation was observed in these progeny. Similar patterns were observed in terms of reducing sugar accumulation and other parameters. In the segregating population only a small portion of clones had desirable range for processing. Higher storage temperature increased the portion of desirable clones. These results set the stage for the current study to screen promising potato germplasm for resistance to cold sweetening.

PROGRESS: Promising clones from the North Central Region (NCR) were planted in Becker, MN in April 2013 and tubers were harvested in mid-September 2013. After suberization for 3 weeks at 58F the tubers were sorted, sampled and stored at 40F and 45F storage. For the 0 time biochemical analysis, 10 grams of fresh tuber tissue was collected, frozen in dry ice and stored at -80°C for analysis at later time. An additional biochemical analysis and tuber tissue sampling will be performed after 3 months storage.

In order to have better understanding of how these biochemical markers can be used to predict chip processing from cold storage, breeding clones used in the Minnesota Potato Breeding program were sampled and subsequently divided into 3 main categories (category A, B, or C) based on AcInv activity. Category A has < 1 unit, B has 1-3 units, and C has > 3 units of activity. Then, each category was further sub-divided into 2 categories (UGPase +) having favorable A II isozymes of UGPase and (UGP -) those lacking favorable alleles of A II isozymes (see Appendix I, Figure 1). Crosses among these parents were made resulting in 39 families and 1124 progeny that were categorized as per their cold-sweetening resistance category. Some examples of crosses made are shown in Appendix I, Figure 2. Clones from these families have been sampled and will be characterized for biochemical markers to study the inheritance of the cold sweetening resistance trait. This is the middle of storage season. Full biochemical analysis will be done by summer 2014.

FUTURE PLAN:
NCR clones from UM, NDSU, UW, and MSU will be planted next year for evaluations. Additional promising clones will be selected for cold-induced sweetening resistance evaluation. The families established this year will be planted in 2014 to increase tuber number and will be evaluated for biochemical markers, sugar and chip color. A predictive model will be developed that will determine processing quality of progeny based on parent clone performance.

APPENDIX 1:

Figure1: Potato clones were divided into three different main classes based on the expression of marker enzymes.

A. Clones with up to 1 unit of Acid Invertase Activity
    a. Clones with A-II isozyme of UGPase (A+)
    b. Clones without A-II isozyme of UGPase (A-)

B. Clones with 1 – 3 Units of Acid Invertase Activity
    a. Clones with A-II isozyme of UGPase (B+)
    b. Clones without A-II isozyme of UGPase (B-)

C. Clones with more than 3 units of Acid Invertase Act.
    a. Clones with A-II isozyme of UGPase (C+)
    b. Clones without A-II isozyme of UGPase (C-)

Figure 2: Parents in 39 diverse families were categorized according to the biochemical markers. Here are some examples

Family Selection

FRY (3 Families, 150 Clones)

- Premier Rus X AF4526-2 (Class A- x __)
- Premier Rus X AOND95249-1 (Class A- x C)
- Premier Rus X MN 18747 (Class A- x C)

CHIP (39 Families, 1124 Clones)

- Dakota Pearl X Atlantic (Class B- x B+)
- Dakota Pearl X MN02696 (Class B- x A-)
- Atlantic X Dakota Pearl (Class B+ x B-)
- Atlantic X ND860-2 (ClassB+ x A-)
- Atlantic X NY138 (Class B+ x A+)
- Atlantic X NY139 (Class B+ x A+)
- OTHERS

2013 Irrigated Starter Fertilizer Trial. Harlene Hatterman-Valenti and Collin Auwarter.
This study was conducted at the Oakes Irrigation Research Station to evaluate various rates of in-furrow starter fertilizer on Russet Burbank potato. Plots were 4 rows by 17 feet arranged in a randomized complete block design with four replicates. Starter fertilizers, fert-A and fert-B, was tank-mixed and applied at different rates (shown below). There was also a grower standard application with 10-34-0 at 25 gal/A and an untreated that didn't receive any starter fertilizer. Soil tests taken prior to trial showed 22 lb N, 15 ppm P, and 140 ppm K. Pre-plant applications of 50 lbs N as 46-0-0 and 200 lbs K (grower standard application, treatment 2) and 140 lbs K (treatments 3-6) as 0-0-60 were applied and incorporated on May 15, 2012. Closing disks were removed from the planter as we planted potatoes to expose seed piece in-furrow and applied starter fertilizer. In addition to fert-A and fert-B, 28% urea was tank mixed to bring the total N to 100 lbs in each treatment. At this point, 100 lbs N, various lbs P, 200 lbs K in treatment 2, and 140 lbs K in treatments 3-6. Nitrogen, as 28-0-0 was stream barred and immediately irrigated with 0.30" irrigation on June 6 (50 lbs), July 11 (50 lbs) and July 20 (34 lbs). Potatoes were harvested October 29 with a single-row digger and graded in Fargo.

Trt	Form	Rate	App	----------------------------CWT/A-----------------------------						--Tuber Count in 20 feet--				
Name	Conc	Unit	Code	Total	0-4oz	4-6oz	6-10oz	>10oz	>4oz	Total	0-4oz	4-6oz	6-10oz	>10oz
1 N	28%	50 lb ai/a	A	431	36	41	139	216	395	120	39	18	35	28
N	28%	50 lb ai/a	C											
N	28%	50 lb ai/a	D											
N	28%	34 lb ai/a	E											
2 N	46%	50 lb ai/a	A	413	37	44	131	200	375	120	41	19	33	27
K	60%	200 lb ai/a	A											
10-34-0	10,34%	25 gal/a	B											
N	28%	50 lb ai/a	C											
N	28%	50 lb ai/a	D											
N	28%	34 lb ai/a	E											
3 N	46%	50 lb ai/a	A	418	31	39	146	202	386	118	37	17	37	27
K	60%	140 lb ai/a	A											
^Fert-A	na	15 gal/a	B											
^Fert-B	na	3 gal/a	B											
N	28%	50 lb ai/a	C											
N	28%	50 lb ai/a	D											
N	28/%	34 lb ai/a	E											
4 N	46%	50 lb ai/a	A	469	39	54	155	222	431	133	42	24	39	28
N	60%	140 lb ai/a	A											
^Fert-A	na	10 gal/a	B											
^Fert-B	na	2 gal/a	B											
N	28%	50 lb ai/a	C											
N	28%	50 lb ai/a	D											
N	28%	34 lb ai/a	E											
5 N	46%	50 lb ai/a	A	484	37	40	175	232	446	137	42	18	45	32
K	60%	140 lb ai/a	A											
^Fert-A	na	20 gal/a	B											
^Fert-B	na	3 gal/a	B											
N	28%	50 lb ai/a	C											
N	28%	50 lb ai/a	D											
N	28%	34 lb ai/a	E											
6 N	46%	50 lb ai/a	A	428	39	39	130	221	390	120	41	17	33	29
K	60%	140 lb ai/a	A											
^Fert-A	na	10 gal/a	B											
^Fert-B	na	5 gal/a	B											
N	28%	50 lb ai/a	C											
N	28%	50 lb ai/a	D											
N	28%	34 lb ai/a	E											
LSD 0.05				222	20	23	89	131	214	57	21	10	23	19

^Fert –A & B – Confidential data

Fertilizer applications:

A = 5/15/12 – Treatments 1-6 @ Pre-plant
B = 5/15/12 – Treatments 2-6 @ Planting
C = 6/6/12 – Treatments 1-6 @ Tuber hooking
D = 7/11/13 – Treatment s 1-6 @ Early tuber bulking
E = 7/20/12 – Treatments 1-6 @ Tuber bulking

All treatments had total yields over 400 cwt/A. The highest yielding treatment had the highest amount of Fert-A at 20gal/a (trt 5) with a total yield of 484 cwt/A. The lowest yielding treatment was the grower's standard practice (trt 2) with 413 cwt/a. Treatments 4 and 5 were the only treatments with over 400 cwt/A of marketable tubers. These two treatment also had the most harvested tubers with 133 and 137 in 20 ft of row, respectively.

Dessication in Red Norland Potatoes – Harlene Hatterman-Valenti and Collin Auwarter.

This study was conducted in Fargo, ND to compare Scythe and Reglone herbicides as desiccants on Red Norland potatoes. Seed pieces (2 oz) were planted on July 2, 2013. Plots were 4 rows by 20 feet arranged in a randomized complete block design with four replicates. The potato seed pieces were planted on 36 inch rows at 12 inch spacing with-in row. Extension recommendations were used for cultural practices. The desiccant treatments were applied using a CO2 backpack sprayer equipped with 8002 flat fan nozzles with an output of 20 GPA and a pressure of 40 psi.

Application Date:	9/18/13
Time of Day:	8:00 AM
Air Temp. (F):	62
Rel. Hum. (%):	95
Wind (mph)	6
% Cloud Cover:	100

Potato dessication with Scythe and Reglone.

Rating date:				------9/23/13------		------9/30/13------		------10/8/13------	
				leaves	stems	leaves	stems	leaves	stems
				5 DAA	5 DAA	12 DAA	12 DAA	20 DAA	20 DAA
		Rate	Rate						
			Unit						
1	Scythe	10	% v/v	50.0 a	20.0 b	82.5 ab	53.8 a	100.0 a	97.5 a
2	Scythe	8	% v/v	46.3 a	20.0 b	78.8 bc	45.0 b	100.0 a	95.0 a
3	Scythe	6	% v/v	36.3 b	13.8 b	75.0 c	42.5 b	`100.0 a	90.0 b
4	Reglone	1.5	pt/a	51.3 a	28.8 a	86.3 a	56.3 a	100.0 a	98.8 a
5	Untreated			0.0 c	0.0 c	0.0 d	0.0 c	0.0 b	0.0 c

The treatments were applied when the plants were beginning to senescence. The higher the rate of Scythe the quicker and more complete the desiccation. Scythe @ 10% and 8% v/v were similar, while Scythe @ 6% v/v was a little slower. By the end of the trial (20 DAA), Scythe @ 10% and 8% v/v showed similar desiccation as Reglone.

Effect of Simulated Glyphosate Drift to Four Potato Processing Cultivars. Harlene Hatterman-Valenti Collin Auwarter and Andrew Robinson.

Field research was conducted at the Northern Plains Potato Grower's Association irrigation research site near Inkster, ND to evaluate the injury from glyphosate applied at the tuber initiation (TI), early tuber bulking (EB), and late tuber bulking stage (LB) on yield and carryover of daughter tubers that will be planted in 2014. Russet Burbank, Umatilla, Ranger Russet and Bannock were planted on June 12. Glyphosate was applied at rates one-quarter, one-eighth, and one-sixteenth the standard use rate of 0.95 lb/A. Ammonium sulfate was tank mixed at a rate of 4 lbs/100 gal. The treatments were applied using an ATV with a spray boom extended out to cover treated rows with 8002 flat fan nozzles, 20 GPA, and CO_2 at 40 psi.

Trt No	Trt Name	Rate	Rate Unit	AI	Rate	Rate Unit	App Code
1	Untreated						
2	Roundup WeatherMax	5.5	floz/a	glyphosate	0.19	lb ae/A	A
	AMS	4	lbs/100 gal				A
3	Roundup WeatherMax	2.75	floz/a	glyphosate	0.095	lb ae/A	A
	AMS	4	lbs/100 gal				A
4	Roundup WeatherMax	1.375	floz/a	glyphosate	0.048	lb ae/A	A
	AMS	4	lbs/100 gal				A
5	Roundup WeatherMax	5.5	floz/a	glyphosate	0.19	lb ae/A	B
	AMS	4	lbs/100 gal				B
6	Roundup WeatherMax	2.75	floz/a	glyphosate	0.095	lb ae/A	B
	AMS	4	lbs/100 gal				B
7	Roundup WeatherMax	1.375	floz/a	glyphosate	0.048	lb ae/A	B
	AMS	4	lbs/100 gal				B
8	Roundup WeatherMax	5.5	floz/a	glyphosate	0.19	lb ae/A	C
	AMS	4	lbs/100 gal				C
9	Roundup WeatherMax	2.75	floz/a	glyphosate	0.095	lb ae/A	C
	AMS	4	lbs/100 gal				C
10	Roundup WeatherMax	1.375	floz/a	glyphosate	0.048	lb ae/A	C
	AMS	4	lbs/100 gal				C

Application Information.

Date:		8/4/2013	8/22/2013	9/11/2013
Time:		A	B	C
Sprayer:	GPA:	20	20	20
	PSI:	40	40	40
	Nozzle:	8002	8002	8002
Air Temperature (F):		62	73	70
Relative Humidity (%):		65	6338	68
Wind (MPH):		11	5	12
Cloud Cover (%):		100	25	25
Potato Stage:		Tuber Initiation	Early Tuber Bulking	Late Tuber Bulking

Bannock Yield.

Trt	Glyphosate	Rate	App	--------------------------------CWT/A--------------------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				46 c	61 a	189 a	163 a	459 a	413 a
2	0.19	lb ae	A	62 c	8 b	13 c	6 c	89 c	27 c
3	0.095	lb ae	A	167 a	50 a	29 c	6 c	251 b	85 c
4	0.048	lb ae	A	110 b	70 a	109 b	34 bc	323 ab	212 b
5	0.19	lb ae	B	43 c	48 a	161 a	127 ab	379 ab	336 a
6	0.095	lb ae	B	42 c	53 a	186 a	168 a	448 a	406 a
7	0.048	lb ae	B	43 c	53 a	153 a	120 ab	367 ab	325 a
8	0.19	lb ae	C	54 c	60 a	164 a	62 abc	340 ab	286 ab
9	0.095	lb ae	C	45 c	50 a	175 a	129 ab	399 ab	354 a
10	0.048	lb ae	C	38 c	55 a	186 a	133 ab	413 a	375 a
			LSD (P=.05)	30	17	35	73	100	92

Bannock Tuber Counts.

Trt	Glyphosate	Rate	App	-----------------------Tuber Counts/20'-----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				51 c	27 a	48 a	23 a	147 b	66 a
2	0.19	lb ae	A	125 b	4 b	4 c	1 c	134 b	5 c
3	0.095	lb ae	A	225 a	22 a	8 c	1 c	256 a	12 c
4	0.048	lb ae	A	127 b	31 a	30 b	5 bc	192 b	35 b
5	0.19	lb ae	B	46 c	21 a	42 a	18 ab	126 b	63 a
6	0.095	lb ae	B	45 c	23 a	48 a	22 a	138 b	67 a
7	0.048	lb ae	B	43 c	24 a	40 a	17 ab	124 b	66 a
8	0.19	lb ae	C	59 c	27 a	43 a	9 abc	137 b	57 a
9	0.095	lb ae	C	45 c	22 a	47 a	18 ab	130 b	66 a
10	0.048	lb ae	C	40 c	24 a	48 a	17 ab	129 b	69 a
			LSD (P=.05)	41	7	9	9	48	9

Ranger Russet Yields.

Trt	Glyphosate	Rate	App	-------------------------------CWT/A-------------------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				118 b	105 ab	144 a	26 a	393 ab	274 a
2	0.19	lb ae	A	180 a	70 b	54 b	13 a	317 b	137 b
3	0.095	lb ae	A	160 ab	86 ab	86 ab	18 a	350 ab	190 b
4	0.048	lb ae	A	136 ab	103 ab	140 a	37 a	416 a	280 a
5	0.19	lb ae	B	97 b	99 ab	153 a	41 a	390 ab	293 a
6	0.095	lb ae	B	118 b	112 a	142 a	47 a	419 a	300 a
7	0.048	lb ae	B	121 b	113 a	151 a	43 a	427 a	307 a
8	0.19	lb ae	C	119 b	98 ab	150 a	34 a	401 a	282 a
9	0.095	lb ae	C	123 b	118 a	134 a	46 a	421 a	298 a
10	0.048	lb ae	C	109 b	117 a	156 a	36 a	417 a	308 a
			LSD (P=.05)	38	25	45	29	57	66

Ranger Russet Tuber Counts.

Trt	Glyphosate	Rate	App	-----------------------Tuber Counts/20'-----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				117 bc	46 ab	40 a	4 a	206 b	45 a
2	0.19	lb ae	A	241 a	32 b	16 b	2 a	290 a	17 c
3	0.095	lb ae	A	170 b	38 ab	24 ab	3 a	235 b	28 c
4	0.048	lb ae	A	128 bc	46 ab	39 a	5 a	218 b	42 a
5	0.19	lb ae	B	95 c	44 ab	44 a	6 a	188 b	50 a
6	0.095	lb ae	B	115 bc	50 a	40 a	7 a	211 b	47 a
7	0.048	lb ae	B	114 bc	51 a	42 a	6 a	213 b	47 a
8	0.19	lb ae	C	116 bc	44 ab	41 a	5 a	205 b	44 a
9	0.095	lb ae	C	116 bc	52 a	37 a	7 a	212 b	45 a
10	0.048	lb ae	C	104 bc	52 a	43 a	5 a	203 b	49 a
LSD (P=.05)				43	11	12	4	39	10

Umatilla Yields.

Trt	Glyphosate	Rate	App	------------------------------CWT/A------------------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				54 bc	60 a	153 a	99 a	366 a	313 a
2	0.19	lb ae	A	28 c	2 b	10 b	0 b	39 b	11 b
3	0.095	lb ae	A	100 ab	9 b	7 b	0 b	116 b	16 b
4	0.048	lb ae	A	134 a	36 a	43 b	18 b	231 a	97 b
5	0.19	lb ae	B	51 bc	70 a	152 a	102 a	375 a	324 a
6	0.095	lb ae	B	47 bc	47 a	147 a	108 a	349 a	302 a
7	0.048	lb ae	B	67 bc	67 a	133 a	69 ab	336 a	269 a
8	0.19	lb ae	C	64 bc	53 a	158 a	53 ab	328 a	264 a
9	0.095	lb ae	C	60 bc	57 a	131 a	51 ab	298 a	238 a
10	0.048	lb ae	C	53 bc	61 a	133 a	73 ab	320 a	267 a
LSD (P=.05)				34	26	59	49	95	91

Umatilla Tuber Counts.

Trt	Glyphosate	Rate	App	----------------------Tuber Counts/20'----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				53 b	27 a	41 a	14 a	134 bc	60 a
2	0.19	lb ae	A	77 b	1 b	3 b	0 c	81 c	2 b
3	0.095	lb ae	A	213 a	4 b	2 b	0 c	219 ab	3 b
4	0.048	lb ae	A	222 a	16 a	12 b	3 bc	252 a	14 b
5	0.19	lb ae	B	52 b	31 a	40 a	15 a	137 bc	62 a
6	0.095	lb ae	B	48 b	21 a	37 a	15 a	121 bc	59 a
7	0.048	lb ae	B	68 b	30 a	34 a	10 ab	141 bc	52 a
8	0.19	lb ae	C	70 b	24 a	41 a	8 abc	143 bc	51 a
9	0.095	lb ae	C	63 b	25 a	34 a	8 abc	129 bc	52 a
10	0.048	lb ae	C	52 b	27 a	35 a	11 ab	124 bc	59 a
LSD (P=.05)				62	11	15	6	65	11

Russet Burbank Yields.

Trt No	Glyphosate Rate	Rate Unit/a	App Code	---CWT/A--- <4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				129 ab	97 a	126 a	61 a	413 a	284 a
2	0.19	lb ae	A	131 ab	30 c	17 b	0 b	178 b	48 c
3	0.095	lb ae	A	189 a	49 bc	38 ab	1 b	277 ab	88 bc
4	0.048	lb ae	A	139 ab	73 ab	100 ab	21 ab	333 a	194 ab
5	0.19	lb ae	B	105 b	101 a	144 a	32 ab	381 a	276 a
6	0.095	lb ae	B	116 b	106 a	140 a	40 ab	401 a	286 a
7	0.048	lb ae	B	131 ab	110 a	150 a	42 ab	432 a	302 a
8	0.19	lb ae	C	130 ab	87 a	104 ab	32 ab	353 a	222 a
9	0.095	lb ae	C	123 ab	94 a	131 a	39 ab	387 a	265 a
10	0.048	lb ae	C	109 b	102 a	134 a	60 a	405 a	296 a
LSD (P=.05)				44	30	75	33	107	111

Russet Burbank Tuber Counts.

Trt No	Glyphosate Rate	Rate Unit/a	App Code	---Tuber Counts/20'--- <4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				137 c	43 a	34 a	9 a	223 b	39 ab
2	0.19	lb ae	A	221 b	14 c	5 b	0 b	240 b	8 c
3	0.095	lb ae	A	271 a	23 bc	11 ab	0 b	305 a	11 c
4	0.048	lb ae	A	164 c	33 ab	27 ab	3 ab	227 b	28 b
5	0.19	lb ae	B	103 c	45 a	39 a	5 ab	192 b	46 a
6	0.095	lb ae	B	119 c	47 a	39 a	5 ab	210 b	43 ab
7	0.048	lb ae	B	133 c	49 a	43 a	7 ab	231 b	42 ab
8	0.19	lb ae	C	136 c	39 a	29 ab	5 ab	208 b	36 ab
9	0.095	lb ae	C	131 c	42 a	37 a	6 ab	216 b	41 ab
10	0.048	lb ae	C	111 c	45 a	36 a	9 a	201 b	44 ab
LSD (P=.05)				45	14	20	5	50	11

Bannock

Simulated glyphosate drift to Bannock during tuber initiation (A) reduced marketable yield compared to the untreated regardless of the sub-lethal rate that was applied. This was due to a reduction in tuber size instead of a reduction in tuber number. The number of tubers produced actually increased when Bannock plants were spray with 0.095 lb ae/A glyphosate at t compared to the untreated. Sub-lethal rates of glyphosate applied to Bannock plants in the early tuber bulking (B) or late tuber bulking (C) stages did not affect marketable tuber yield or tuber number compared to the untreated.

Ranger Russet

Simulated glyphosate drift to Ranger Russet during tuber initiation (A) reduced marketable yield compared to the untreated only when sub-lethal rates of 0.19 and 0.095 lb ae/A were applied. This was due to a reduction in tuber size instead of a reduction in tuber number, even though tuber number were numerically less when sub-lethal rates of 0.19 and 0.095 lb ae/A glyphosate were applied compared to the untreated. The number of tubers produced actually increased when Ranger Russet plants were spray with 0.19 lb ae/A glyphosate at tuber initiation compared to the untreated. Sub-lethal rates of glyphosate applied to Ranger Russet plants in the early tuber bulking (B) or late tuber bulking (C) stages did not affect marketable tuber yield or tuber number compared to the untreated.

<u>Umatilla</u>
Simulated glyphosate drift to Umatilla during tuber initiation (A) reduced marketable yield compared to the untreated regardless of the sub-lethal rate that was applied. This was due to a reduction in tuber size instead of a reduction in tuber number. The number of tubers produced actually increased when Bannock plants were spray with 0.048 lb ae/A glyphosate at tuber initiation compared to the untreated. Sub-lethal rates of glyphosate applied to Umatilla plants in the early tuber bulking (B) or late tuber bulking (C) stages did not affect marketable tuber yield or tuber number compared to the untreated.

<u>Russet Burbank</u>
Simulated glyphosate drift to Russet Burbank during tuber initiation (A) reduced marketable yield compared to the untreated only when sub-lethal rates of 0.19 and 0.095 lb ae/A were applied. This was due to a reduction in tuber size instead of a reduction in tuber number. The number of tubers produced actually increased when Russet Burbank plants were spray with 0.095 lb ae/A glyphosate at tuber initiation compared to the untreated. Sub-lethal rates of glyphosate applied to Russet Burbank plants in the early tuber bulking (B) or late tuber bulking (C) stages did not affect marketable tuber yield or tuber number compared to the untreated.

Glyphosate Carryover Effect to Daughter Tubers from Simulated Glyphosate Drift to Four Potato Processing Cultivars. Harlene Hatterman-Valenti, Collin Auwarter, and Andrew Robinson.

Field research was conducted in 2012 at the Northern Plains Potato Grower's Association irrigation research site near Inkster, ND to evaluate the injury from glyphosate applied at the tuber initiation (TI), early tuber bulking (EB), and late tuber bulking stage (LB) on yield and carryover of daughter tubers that were planted in 2013. Russet Burbank, Umatilla, Ranger Russet and Bannock were planted on May 24, harvested October 4, and stored October 31, 2012. Glyphosate was applied at rates one-quarter, one-eighth, and one-sixteenth the lowest labeled rate of 0.47 lb/A during the TI and EB stages. During the LB stage glyphosate was applied at the one-quarter, one-eighth, and one-sixteenth the standard use rate of 0.95 lb/A. Ammonium sulfate was tank mixed at a rate of 4 lbs/100 gal. The treatments were applied using an ATV with a spray boom extended out to cover treated rows with 8002 flat fan nozzles, 20 GPA, and CO_2 at 40 psi.

Daughter tubers were planted June 12 and harvested October 25, 2013.

2012 Treatments.

Trt No	Trt Name	Rate	Rate Unit	AI	Rate	Rate Unit	App Code
1	Untreated						
2	Roundup WeatherMax	2.75	fl oz/A	glyphosate	0.095	lb ae/A	A
	AMS	4	lbs/100 gal				A
3	Roundup WeatherMax	1.375	fl oz/A	glyphosate	0.048	lb ae/A	A
	AMS	4	lbs/100 gal				A
4	Roundup WeatherMax	0.6875	fl oz/A	glyphosate	0.024	lb ae/A	A
	AMS	4	lbs/100 gal				A
5	Roundup WeatherMax	2.75	fl oz/A	glyphosate	0.095	lb ae/A	B
	AMS	4	lbs/100 gal				B
6	Roundup WeatherMax	1.375	fl oz/A	glyphosate	0.048	lb ae/A	B
	AMS	4	lbs/100 gal				B
7	Roundup WeatherMax	0.6875	fl oz/A	glyphosate	0.024	lb ae/A	B
	AMS	4	lbs/100 gal				B
8	Roundup WeatherMax	5.5	fl oz/A	glyphosate	0.19	lb ae/A	C
	AMS	4	lbs/100 gal				C
9	Roundup WeatherMax	2.75	fl oz/A	glyphosate	0.095	lb ae/A	C
	AMS	4	lbs/100 gal				C
10	Roundup WeatherMax	1.375	fl oz/A	glyphosate	0.048	lb ae/A	C
	AMS	4	lbs/100 gal				C

2012 Application Information.

Date:		7/24/2012	8/9/2012	9/4/2012
Time:		A	B	C
Sprayer:	GPA:	20	20	20
	PSI:	40	40	40
	Nozzle:	8002	8002	8002
Air Temperature (F):		78	69	80
Relative Humidity (%):		53	63	46
Wind (MPH):		10	7	9

Cloud Cover (%):		25	10	10
Potato Stage:		Tuber Initiation	Early Tuber Bulking	Late Tuber Bulking

2013 Bannock Yield.

Trt	Glyphosate	Rate	App	# Emg.	--------------------------------CWT/A--------------------------------					
No	Rate	Unit/a	Code	Plants/20'	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				20 a	52 a	78 a	227 a	121 ab	491 a	440 a
2	0.095	lb ae	A	12 ab	43 a	42 b-e	122 bc	66 abc	279 bcd	236 bcd
3	0.048	lb ae	A	20 a	45 a	55 a-d	222 a	100 ab	426 ab	381 ab
4	0.024	lb ae	A	20 a	37 a	56 a-d	229 a	161 a	484 a	447 a
5	0.095	lb ae	B	2 c	21 a	17 e	44 d	14 c	101 e	80 e
6	0.048	lb ae	B	7 bc	46 a	38 cde	125 bc	39 bc	249 cd	203 cde
7	0.024	lb ae	B	17 a	57 a	64 abc	170 ab	91 ab	388 abc	331 abc
8	0.19	lb ae	C	5 bc	32 a	24 de	68 cd	49 abc	176 de	144 de
9	0.095	lb ae	C	14 a	49 a	57 a-d	151 ab	66 abc	328 a-d	279 bcd
10	0.048	lb ae	C	18 a	43 a	74 ab	203 a	85 ab	409 abc	366 ab
LSD (P=.05)				6	20	22	55	4	116	109

2013 Bannock Tuber Counts.

Trt	Glyphosate	Rate	App	-----------------------Tuber Counts/20'-----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				55 a	35 a	58 a	18 ab	165 a	67 a
2	0.095	lb ae	A	49 a	18 bcd	31 bc	10 bc	109 abc	56 ab
3	0.048	lb ae	A	45 a	24 abc	57 a	15 abc	142 ab	68 a
4	0.024	lb ae	A	39 a	24 abc	59 a	24 a	145 ab	74 a
5	0.095	lb ae	B	24 a	8 d	11 d	3 c	46 d	38 b
6	0.048	lb ae	B	45 a	17 bcd	32 bc	6 bc	100 bc	55 ab
7	0.024	lb ae	B	54 a	29 ab	43 ab	13 abc	139 ab	61 a
8	0.19	lb ae	C	34 a	11 cd	18 cd	7 bc	70 cd	52 ab
9	0.095	lb ae	C	49 a	25 abc	39 ab	10 bc	123 ab	60 a
10	0.048	lb ae	C	46 a	32 a	52 a	13 abc	143 ab	67 a
LSD (P=.05)				19	9	14	8	36	15

2013 Ranger Russet Yields.

Trt	Glyphosate	Rate	App	# Emg.	--------------------------------CWT/A--------------------------------					
No	Rate	Unit/a	Code	Plants/20’	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				20 a	98 a	112 a	225 a	95 a	536 a	438 a
2	0.095	lb ae	A	20 a	97 a	106 a	225 a	80 a	510 a	412 a
3	0.048	lb ae	A	20 a	107 a	116 a	213 a	72 a	512 a	405 a
4	0.024	lb ae	A	19 a	95 a	106 a	215 a	65 a	482 a	388 a
5	0.095	lb ae	B	20 a	85 a	92 a	197 a	68 a	451 a	366 a
6	0.048	lb ae	B	20 a	91 a	103 a	207 a	54 a	462 a	371 a
7	0.024	lb ae	B	20 a	104 a	100 a	202 a	75 a	485 a	381 a
8	0.19	lb ae	C	19 a	95 a	91 a	170 a	70 a	432 a	337 a
9	0.095	lb ae	C	20 a	86 a	97 a	188 a	77 a	451 a	365 a
10	0.048	lb ae	C	20 a	88 a	88 a	225 a	82 a	499 a	411 a
			LSD (P=.05)	1	28	27	56	3	74	69

2013 Ranger Russet Tuber Counts.

Trt	Glyphosate	Rate	App	-----------------------Tuber Counts/20’-----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				100 a	50 a	59 a	15 a	223 a	56 a
2	0.095	lb ae	A	107 a	46 a	60 a	11 a	224 a	54 a
3	0.048	lb ae	A	118 a	51 a	58 a	10 a	237 a	52 a
4	0.024	lb ae	A	101 a	47 a	58 a	10 a	215 a	55 a
5	0.095	lb ae	B	90 a	41 a	52 a	11 a	194 a	55 a
6	0.048	lb ae	B	101 a	45 a	55 a	9 a	209 a	53 a
7	0.024	lb ae	B	108 a	45 a	55 a	11 a	218 a	50 a
8	0.19	lb ae	C	100 a	41 a	45 a	11 a	196 a	50 a
9	0.095	lb ae	C	96 a	43 a	50 a	11 a	201 a	53 a
10	0.048	lb ae	C	97 a	39 a	61 a	13 a	209 a	57 a
			LSD (P=.05)	30	12	14	6	37	9

2013 Umatilla Yields.

Trt	Glyphosate	Rate	App	# Emg.	--------------------------------CWT/A--------------------------------					
No	Rate	Unit/a	Code	Plants/20'	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				20 a	113 ab	113 a	201 a	44 a	473 a	360 a
2	0.095	lb ae	A	20 a	116 ab	120 a	209 a	21 a	472 a	357 a
3	0.048	lb ae	A	19 a	93 ab	111 a	200 a	53 a	459 a	366 a
4	0.024	lb ae	A	20 a	131 a	122 a	186 a	26 a	469 a	338 a
5	0.095	lb ae	B	7 c	72 b	63 b	84 b	16 a	236 b	164 b
6	0.048	lb ae	B	19 a	88 ab	104 a	186 a	39 a	420 a	332 a
7	0.024	lb ae	B	20 a	111 ab	113 a	186 a	27 a	451 a	340 a
8	0.19	lb ae	C	11 b	84 ab	61 b	115 ab	46 a	308 b	224 ab
9	0.095	lb ae	C	19 a	97 ab	115 a	187 a	36 a	438 a	341 a
10	0.048	lb ae	C	19 a	110 ab	117 a	190 a	37 a	458 a	348 a
			LSD (P=.05)	2	34	31	64	3	97	101

2013 Umatilla Tuber Counts.

Trt	Glyphosate	Rate	App	-----------------------Tuber Counts/20'-----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				111 a	50 a	56 a	7 a	224 a	51 a
2	0.095	lb ae	A	111 a	53 a	57 a	4 a	226 a	52 a
3	0.048	lb ae	A	91 a	49 a	55 a	8 a	203 a	55 a
4	0.024	lb ae	A	127 a	54 a	52 a	5 a	238 a	47 a
5	0.095	lb ae	B	75 a	28 b	23 b	3 a	128 b	43 a
6	0.048	lb ae	B	86 a	46 a	52 a	6 a	190 a	54 a
7	0.024	lb ae	B	110 a	50 a	51 a	6 a	217 a	50 a
8	0.19	lb ae	C	86 a	27 b	31 ab	7 a	151 b	42 a
9	0.095	lb ae	C	102 a	50 a	51 a	5 a	208 a	51 a
10	0.048	lb ae	C	122 a	52 a	51 a	6 a	231 a	48 a
			LSD (P=.05)	33	13	16	5	37	12

2013 Russet Burbank Yields.

Trt	Glyphosate	Rate	App	# Emg.	--------------------------------CWT/A--------------------------------					
No	Rate	Unit/a	Code	Plants/20'	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	>4 oz
1				20 a	80 a	76 a	173 a	42 a	385 a	305 a
2	0.095	lb ae	A	20 a	78 a	77 a	109 a	26 a	297 a	219 a
3	0.048	lb ae	A	20 a	70 a	78 a	193 a	98 a	441 a	370 a
4	0.024	lb ae	A	20 a	93 a	83 a	173 a	83 a	442 a	349 a
5	0.095	lb ae	B	13 b	69 a	68 a	67 a	12 a	224 a	155 a
6	0.048	lb ae	B	19 a	94 a	92 a	121 a	12 a	321 a	227 a
7	0.024	lb ae	B	20 a	106 a	91 a	178 a	20 a	396 a	290 a
8	0.19	lb ae	C	10 b	61 a	65 a	100 a	13 a	244 a	183 a
9	0.095	lb ae	C	18 a	91 a	89 a	100 a	22 a	315 a	224 a
10	0.048	lb ae	C	19 a	85 a	88 a	153 a	48 a	380 a	294 a
			LSD (P=.05)	4	32	41	80	5	133	129

2013 Russet Burbank Tuber Counts.

Trt	Glyphosate	Rate	App	-----------------------Tuber Counts/20'-----------------------					
No	Rate	Unit/a	Code	<4 oz	4-6 oz	6-10 oz	>10 oz	Total	% >4 oz
1				84 a	34 a	46 a	8 a	172 a	51 a
2	0.095	lb ae	A	79 a	34 a	30 a	5 a	148 a	47 a
3	0.048	lb ae	A	73 a	35 a	51 a	14 a	173 a	58 a
4	0.024	lb ae	A	101 a	37 a	46 a	13 a	198 a	49 a
5	0.095	lb ae	B	75 a	31 a	19 a	3 a	127 a	41 a
6	0.048	lb ae	B	100 a	41 a	35 a	2 a	177 a	42 a
7	0.024	lb ae	B	110 a	39 a	50 a	3 a	201 a	45 a
8	0.19	lb ae	C	60 a	29 a	28 a	3 a	120 a	48 a
9	0.095	lb ae	C	102 a	39 a	27 a	6 a	174 a	42 a
10	0.048	lb ae	C	89 a	40 a	41 a	8 a	177 a	50 a
			LSD (P=.05)	33	18	21	8	53	14

Bannock showed the greatest difference among yield, tuber counts and plant emergence. The lowest yielding treatment was glyphosate applied during the ETB stage at 0.095 lb ae/A with 80 CWT/A. Glyphosate applied at 0.048 and 0.024 lb ae/A during the ETB stage had yields of 203 and 331 CWT/A, respectively. The untreated had a yield of 440 CWT/A. Tuber counts showed the lowest count with 46 total tubers, 38% marketable, during the ETB stage at 0.095 lb ae/A. The untreated had 165 tubers and 67% marketable. Only 10% of plants emerged during the ETB stage at a rate of 0.095 lb ae/A. 60% and 25% of plants emerged at the 0.095 lbae/A rate during the TI and 0.19 lb ae/A LTB stages, respectively. During 2012, Bannock potatoes showed the greatest injury of tubers during the ETB stage at the 0.095 lb ae/A rate with 32% of total tubers showing symptoms of glyphosate. The other stages at the high rate, TI stage at 0.095 lb ae/A showed 16% injury and the LTB stage at 0.19 lb ae/A had 3% injury. Only 34% of tubers were >4 oz during the ETB stage at 0.095 lb ae/A. Also, during this stage and rate, it had the lowest yield with 194 CWT/A. All other treatments had at least 295 CWT/A. The ETB stage showed the greatest impact of daughter tubers from glyphosate in Bannock potatoes.

Ranger showed very little difference among treatments. There were at least 95% of plants emerged in all treatments. All yielded greater than 337 CWT/A, which was during the LTB stage at 0.19 lb ae/A. The untreated had a yield of 438 CWT/A. All treatments had between 50% and 57% of marketable tubers. During 2012, Ranger potatoes showed the most injury during the ETB stage. There was 12% injury at the 0.095 lb ae/A rate and 9% injury at the 0.048 lb ae/A rate. All other treatments showed injury, including the untreated, but none more than 5%. The same potatoes that showed signs of injury during 2012 during ETB, yielded well in 2013. The 0.095 lb ae/A rate at the ETB stage had a yield of 381 CWT/A during 2012 and a yield of 366 CWT/A in 2013.

Umatilla potatoes showed similar results as Bannock, as potatoes treated during the ETB stage had the greatest impact on yield, tuber counts and plant emergence. The lowest yielding treatment was at 0.095 lb ae/A with 164 CWT/A at the ETB stage, while the untreated had 360 CWT/A. 35% of plants emerged at this stage, and produced the least amount of tubers, 57% of what the untreated produced. During the LTB stage at the 0.19 lb ae/A only 55% of plants emerged. All other treatments had at least 95% emergence of plants.
During 2012, Umatilla potatoes had 49% injury during the ETB stage at the 0.095 lb ae/A rate. However, it still yielded well with 277 CWT/A. The untreated had a yield of 283 CWT/A. In 2013, daughter tubers from this treatment yielded 164 CWT/A while the untreated had 360 CWT/A. During the LTB stage at 0.19 lb ae/A in 2012, only 5% of tubers showed injury. When daughter tubers were planted in 2013, only 55% if the tubers emerged.

Russet Burbank showed similar results as the Ranger potatoes in regards to no significant differences among yields and tuber counts. Plant emergence showed during the ETB stage at the 0.095 lb ae/A rate produced 65% plants and at the LTB stage at the rate of 0.19 lb ae/A only had 50% of emerged plants. All other treatments had at least 90% emerged plants. Yield varied between 155 and 370 CWT/A and 41% - 58% of tubers marketable.
During 2012, Russet Burbank showed the greatest injury symptoms during the ETB stage. There was 41% and 23% injury at the 0.095 and 0.048 lb ae/A, respectively. Those same daughter tubers planted in 2013 had significantly less plant emergence however no differences in yield and tuber counts.

Ranger Russet daughter tubers showed the least injury when plants were sprayed with glyphosate among the four cultivars that were studied. Russet Burbank fared well, but showed more injury than Ranger Russet potatoes even though there were no significant differences in yield or tuber counts. Bannock showed the greatest effect from glyphosate injury. It had a greater difference in yield and number of plants to emerge among the entire cultivar. Umatilla was more similar to Bannock than Russet Burbank. It showed a difference in yield and emergence, but not to the extent of Bannock. Potatoes applied with glyphosate during the ETB stage had the greatest effect on daughter tubers, followed by LTB. TI stage shows the greatest sign of glyphosate injury in the field, but carryover to the following year had the least effect compared to the other stages.

Red Norland in-furrow fertilizer trial – Harlene Hatterman-Valenti and Collin Auwarter.

This study was conducted at the Northern Plains Potato Grower's Association non-irrigation research site near Grand Forks, ND to evaluate of in-furrow fertilizer on Red Norland potato. Soil tests showed 20 lbs N, 26 ppm P (very high on the Olsen soil test method), and 184 ppm K (very high on the Olsen soil test method). Soybeans were grown during 2012. Plots were 4 rows by 20 ft arranged in a randomized complete block design with four replicates. 50 lbs N as 46-0-0 and 50 lbs K as 0-0-60 was pre-plant incorporated prior to planting on entire plot. Seed pieces (2 oz) were planted on 36-inch rows and 12-inch spacing within the row on June 3, 2013. Fertilizer was applied in-furrow at 15 gpa as a stream on both sides of the seed piece.

After planting:

Treatment 1: 100 lbs N (20 lb soil test, 50 lb ppi, 30 lb @ planting as 28-0-0), 0 P

Treatment 2: 103.4 lbs N, 110.5 lbs P (3.6 lb as WC139, 106.9 lb as 10-34-0)

Treatment 3: 102.3 lbs N, 105.1 lbs P

Treatment 4: 99.4 lbs N, 91.3 lbs P

Treatment 5: 102.5 lbs N, 118.8 lbs P

Treatment 6: 100 lbs N + WC041 @ 1 lb/A

Hilling and an additional 50 lbs N as 46-0-0 occurred on June 20 (17 DAP). Maintenance sprays occurred when needed. All plots received 50 lbs N as 46-0-0 on July 19 (46 DAP). Next significant rain after fertilizer application occurred on July 21 with .50 inch. Plots had 50% emergence on June 27 (24 DAP). Each plot was 4 rows and fertilizer was only applied to the middle 2 rows. The day after planting, the trial received almost 2 inches of rain, which led to some seed piece rot issues. Stand counts represent a decrease in plants as only 1 row had all 20 seed pieces germinate and plants successfully emerge. Potatoes were harvested on November 4 and graded November 19.

Treatment 2, 3 gal/A WCI139 (3.6 lbs P) + 27 gal/A 10-34-0 (106.9 lbs P) was the highest yielding treatment with a total yield of 309 cwt/A, while treatment 1 with no P applied had the lowest total yield with 204 cwt/A. The same was true with the marketable yield (>4 oz).

Treatment 6, 1 lb/A WCI041 had less than 25% of total tubers of marketable size. Treatment 1 had 28% of total tubers marketable. Treatments 2-4 had 42, 40, and 43%, marketable tubers, respectively. Treatment 5, 30 gal/A 10-34-0 (118.8 lbs P) had 33% of its tubers marketable.

Russet Burbank in-furrow fertilizer trial – Harlene Hatterman-Valenti and Collin Auwarter.

This study was conducted at the Oakes Irrigation Research Extension Center near Oakes, ND to evaluate rates of in-furrow fertilizer on Russet Burbank potato. Soil tests showed 22 lbs N, 15 ppm P (high on the Olsen soil test method), and 140 K (high on the Olsen soil test method). Corn was grown during 2012. Plots were 4 rows by 20 ft arranged in a randomized complete block design with four replicates. 50 lbs N as 46-0-0 and 50 lbs K as 0-0-60 was pre-plant incorporated prior to planting on entire plot. Seed pieces (2 oz) were planted on 36 inch rows and 12 inch spacing on May 15, 2013. Fertilizer was applied in-furrow at 15 gpa as a stream on both sides of the seed piece.

After planting:

Treatment 1: 102 lbs N (22 lb soil test, 50 lb ppi, 30 lb @plant as 28-0-0), 0 P

Treatment 2: 105.4 lbs N, 110.5 lbs P (3.6 lb as WC139, 106.9 lb as 10-34-0)

Treatment 3: 104.3 lbs N, 105.1 lbs P

Treatment 4: 101.4 lbs N, 91.3 lbs P

Treatment 5: 104.5 lbs N, 118.8 lbs P

Treatment 6: 102 lbs N + WC041 @ 1 lb/A

Maintenance sprays, hilling, irrigation and additional N were applied as needed. N was applied once in late June and late July @ 50 lbs each time. 50% emergence occurred on June 7 (23 DAP) among all treatments. Each plot was 4 rows, however, fertilizer was only applied on the middle 2 rows. 50% row closure occurred on July 16 (62 DAP). Potatoes were harvested on October 29 and graded November 19.

The highest yielding treatment occurred with 5 gal/A WCI139 (6.1 lbs P) + 25 gal/A 10-34-0 (99 lbs P) (treatment 3) with a total yield of 544 cwt/A. The lowest yielding treatment was treatment 1 with no P applied, at 396 cwt/A. Marketable yield (>4oz) showed the same trend with treatment 3 having the highest (504 cwt/A) and treatment 1 the least (364 cwt/A).

Tuber counts in 20 feet of row showed treatment 3 with the highest count (154 tubers) and treatment 1 with the least (111 tubers). Treatment 2, 3 gal/A WCI139 (3.6 lbs P) + 27 gal/A 10-34-0 (106.9 lbs P) had the second lowest number of tuber with 123 tubers. Treatments 4-6 had between 143 and 148 tubers. Treatment 3 also had the highest percentage of marketable tubers with 72% of all tubers being greater than 4 oz. Treatment 6, 1 lb/A WCI041 had the lowest percentage of marketable tubers with only 64% of all tubers being marketable. Treatment 1 had 67% marketable tubers.

Aphid Alert II – Monitoring Aphid Vectors of Virus in Potato

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Executive Summary – This is a continuing project designed to initiate and maintain an aphid trapping and monitoring network for aphid vectors of virus disease in potatoes (focusing on PVY) and provide near real-time maps of aphid population distribution.

Rationale – The Minnesota and North Dakota seed potato industry is at a critical juncture. Seed production acreage has suffered a significant decrease since 1995 in part because of aphid vectored viral diseases of seed potato, notably Potato Leaf Roll Virus (PLRV) and Potato Virus Y (PVY). While PLRV is a non-persistent (circulative) virus which takes a comparatively lengthy time to be transferred to a plant and can be controlled by well-timed insecticide applications against the vector, PVY is a non-persistent and is transferred to the plant within moments of the aphid probing the plant. Consequently, controlling PVY through vector control using insecticides is more problematic. Aphid dynamics in potato fields indicate that aphid populations develop in other host plant systems through the early summer, moving into potatoes usually after mid-July. When first colonizing fields, most aphid species first settle at the edge for 7-10 days before dispersing throughout the rest of the field. This colonization behavior facilitates the targeted application of insecticide at the field edge. When combined with other techniques, such as border plantings of non-PVY hosts (e.g. soybeans), to clean virus from the mouthparts of infected aphids, these techniques can significantly contribute to PVY control.

Certification programs in Minnesota and North Dakota are operationally excellent, but it is difficult to turn the corner on potato virus epidemics because large amounts of virus-inoculum must be flushed from the seed production system. This is an increasingly difficult proposition with Potato Virus Y (PVY). New virus strains with variable levels of expression and a new vector species have resulted in what appears to be a change in the epidemiology of this viral disease.

The ordinary (common) strain of PVY is PVY^{o}, which is present in all potato growing areas, causes mild to severe mosaic, leaf drop and leaf and stem necrosis. Of greater concern are PVY^{N} (tobacco veinal necrosis) and the relatively new strain PVY^{NTN}. While PVY^{N} produces mild to severe mild to severe mosaic symptoms, PVY^{NTN} potato tuber necrotic ringspot disease (PTNRD). Visible symptoms of infection of either strain vary according to potato cultivar with some cultivars being nearly or completely asymptomatic making within season diagnosis difficult.

In past years, the most important vector of PVY has been green peach aphid, *Myzus persicae* (Sulzer). It is by far the most efficient vector of PLRV and of PVY in the northern Great Plains. Green peach aphid doesn't overwinter in the Red River Valley and populations are reestablished each year by spring immigrants so there is great annual variation in abundance. Distributions of *M. persicae* are concentrated within a few meters of field margins in the days immediately following inflights but this edge distribution is temporally limited with aphid colonies eventually dispersing across fields (Suranyi et al. 2004, Carroll et al. 2004). This alighting preference is likely a response to the contrast provided by the interface of fallow and crop border. This facilitates the use of targeted border applciations to control aphid vectors. Treating just the 18 m adjacent to the fallow headlands resulted in spraying only 38.5 of 730 hectares saving an estimated 93% (mean savings of $58.29 per hectare, application costs included) compared to treating the entire field (Carroll et al. 2004, Olson et al. 2004). For this technique to be successful, application timing is critical and treatments must be applied prior to aphid populations dispersing across the field. Consequently, an accurate method of monitoring the arrival of aphids within the fields is essential. From 1992 to 1994 and from 1998 to 2003, this monitoring was delivered by a regional aphid trapping network, *Aphid Alert*, which provided Minnesota and North Dakota seed potato growers with real-time information on virus vector flight activity.

In recent years, however, there have been high rates of certification failure, despite low populations of aphids typically associated as virus vectors. In 2011, for example, MN and ND had extremely high rates of PVY infection in seed potato fields, resulting in one of the lowest annual acreages of certified seed. However, a 9m suction trap, established as part of a multi-state aphid monitoring effort,

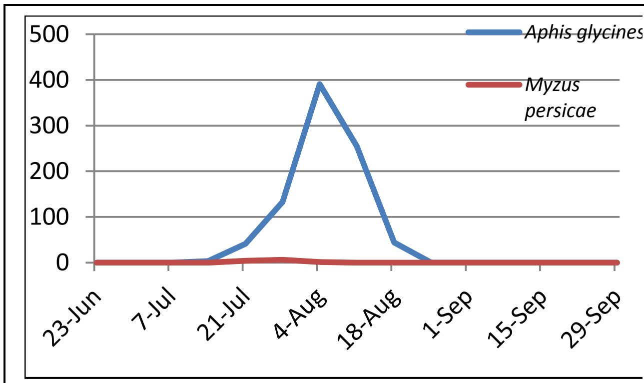

Figure 1. Seasonal dynamics of immigrating soybean aphid, *Aphis glycines* Matsumara, and green peach aphid, *Myzus persicae* Sulzer. Note that while very high numbers of soybean aphid were recovered approximately at the same time as aphids would be colonizing seed potato fields, there were only negligible numbers of green peach recorded.

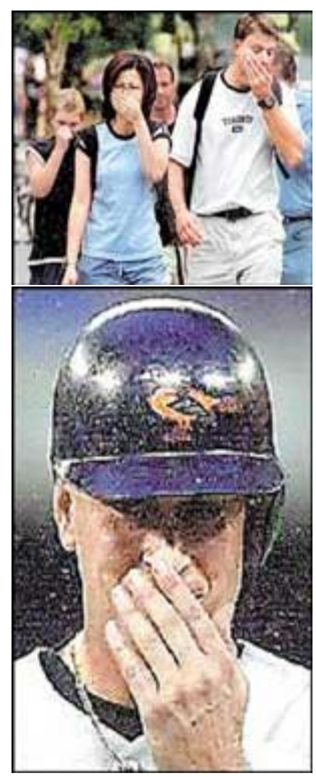

Figure 2. High soybean populations in Toronto as a result of a dispersal event from SE Minnesota and SW Wisconsin in 2001. These populations disrupted pedestrian traffic and caused a delay in a Toronto Blue Jays professional baseball game. Photo Credit: Toronto Star Newspaper,

indicated low populations of *M. persicae* but extremely high numbers of the invasive soybean aphid, *Aphis glycines* Matsumura (Fig. 1).

Soybean aphid was first recorded in the U.S. in 2000 and in Minnesota in 2001 (Rasgdale 2004). Since then, this invasive species has spread to all of the soybean producing states in the North Central region becoming the most important insect pest of soybeans in those states. Of all of the states in the NC plains, Minnesota has the most consistent populations, with some area of the state requiring insecticide treatment every year since 2001. Soybean aphid overwinter as eggs on species of Buckthorn, notably glossy buckthorn, *Rhamnus cathartica*, spend several generations as wingless forms, building numbers. Eventually a winged, dispersive generation is formed and the aphids then move to soybeans, its only acceptable summer host. As a species, soybean aphid is prone to large scale dispersal events. If food quality falls or host plants become too crowded, a winged generation develops and a dispersal event occurs. While these dispersal events occur as a response to host conditions, a late summer dispersal (Ragsdale 2004), probably in response to environmental (i.e. daylength) occurs in late July-early August. Although they do not occur every year, when they do, soybean aphid dispersal events can be almost locust like in scale (Fig. 2). When colonizing a field, soybean aphid do show some tendency to alight on the edge but not for an extended period of time (Hodgson et al. 2005). In addition, individual soybean aphids will continue into the field, colonizing the interior. Late in August, soybean aphids develop a winged generation that returns to buckthorn to mate, lay eggs and overwinter. Soybean aphid vectors a number of virus diseases to soybean and has been shown to vector PVY to potatoes although not as effectively as green peach aphid (Davis et al. 2005).

The technique of targeted application of insecticide works well with green peach aphid and a number of other aphids that are traditionally important in vectoring PVY into potatoes. This control tactic, however, will not control the colonization of a field by soybean aphid. Soybean aphid will attempt to colonize a number of host plants during summer dispersal events, but will only colonize soybeans. When testing the suitability of a host aphids probe to sample plant fluids, in the process they will transfer any non-persistent virus on their mouthparts (Fig. 3. Even if a low number of soybean aphids are viruliferous, and even if only a subset of these can efficiently vector the virus, the sheer numbers of soybean aphids entering fields during a large dispersal event means indicates these insects may be a significant driver in PVY epidemiology.

Figure 3. Aphids on a potato leaf.

There are other tactics that may prove much more effective in controlling soybean aphid. The use of crop oils has been demonstrated as an effective method of preventing aphids from feeding on plants and thereby preventing the transmission of virus. While inexpensive, crop oils must be applied 1-2 times per week, beginning prior to the arrival of aphids in the field. Consequently, this method relies heavily on application timing and requires accurate monitoring (DiFonzo et al. 1997).

Regardless of the vector involved in any particular year, monitoring populations and determining where and when aphids are occurring in the region and what species are involved is essential in applying appropriate management tactics. There are a number of methods to trap and monitor aphids but the most effective is using suction traps.

Procedures – A program will be initiated to assess the seasonal populations of aphid vector species. Buckthorn will be sampled in early summer to assess the potential for regional soybean aphid populations. In addition, information on soybean aphids will be obtained from other extension entomologists across the North Central region. To monitor aphids colonizing potato fields, a network of 2m tall suction traps will be established in the seed potato production areas of Minnesota and North Dakota. These traps consist of a fan drawing air down in through the trap and trapping the incoming aphids in a sample jar which is changed weekly. Sample jars will be sorted, aphids identified to species and aphid population dynamics at sample locations will be determined. Maps are prepared weekly showing these dynamics. This information is made available to growers on a website (aphidalert.blogspot.com). Hard copy publication will not be utilized in Aphid Alert II due to publication and mailing costs. Recommendations for beginning oil treatments or targeted edge applications can be made based on the information obtained from the regional monitoring system.

***For 2013**, we proposed expanding the Aphid Alert II network to 15-18 traps providing better coverage of the RRV seed producing area. Funding for this expansion was obtained from a Minnesota State Specialty Crops Block Grant in collaboration with the Minnesota Dept. of Agriculture. In addition, traps were established earlier in the year as aphid flights in 2012 began earlier than expected. While this was probably the result of unusual climatic conditions, early flights must be monitored.*

The Network

Sixteen suction traps were emplaced next to potato fields in Minnesota and North Dakota during the 2013 growing season (Fig 4). Traps consisted of a 1.5 meter vertical PVC pipe housing a fan powered by a solar panel. The fan sucks passing insects into the trap and deposits them into a collection jar filled with a water / ethylene glycol mixture (antifreeze). Cooperators replaced collection jars weekly and mailed them to the lab for identification and counting. Number of each species of aphid collected by location were posted to

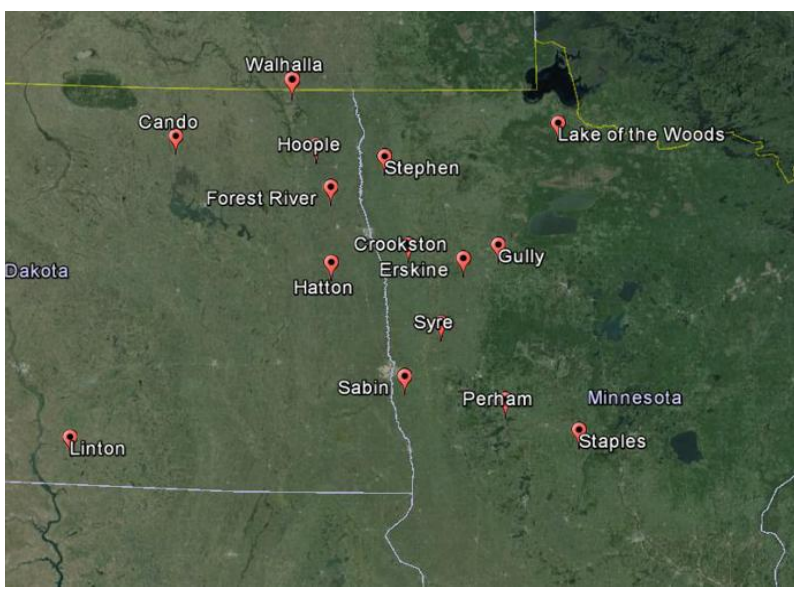

Figure 4. Location of suction traps in 2013 AphidAlert II network.

the web (http://aphidalert.blogspot.com/) and emailed to cooperators once or twice a week.

Results

A total of 2543 aphids representing 14 vector species were collected from June 21 through September 26 (Table 1). Of these, 1854 were vectors of PVY. Number of vector aphids varied widely by location with the Linton II site collecting 288 vectors and the Syre site collecting only 3 vectors (Fig 5). Four sites observed high aphid numbers, totaling more than 200 vectors at each site (Linton II, Hatton, Walhalla, and Staples). Eight sites had moderate aphid levels collecting between 50 and 150 vectors (Gully, Hoople, Forest River, Linton I, Crookston, Lake of the Woods, Perham, and Sabin). Finally, four sites had low vector counts, collecting less than 50 throughout the season (Syre, Stephen, Cando, and Erskine). No trend was observed that would indicate geographic location affected the number of aphids collected; some of the sites nearest to each other had dramatically different vector counts. While this may have been simply a reflection of wind events, which experience significant local variation, local alternate hosts may have had some influence on local aphid populations. Analyses examining the possible influence of neighboring cropping systems will be examined.

Table 1. Cumulative seasonal trap capture by location, 2013.

	Aphid Species Captured (per suction trap Jun 14-Oct 02)															
	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	2	19	8	3	11	0	4	0	0	0	3	0	0	0	1	1
Soybean aphid	3	8	10	23	21	3	13	2	1	9	21	0	0	8	17	23
Bird cherry oat aphid	6	31	41	25	32	15	45	25	3	48	6	5	0	6	3	27
Corn leaf aphid	0	9	2	0	6	6	13	3	0	2	0	2	0	0	3	2
English grain aphid	3	24	25	16	12	28	109	7	3	11	18	14	0	15	22	28
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	2	2	1	22	56	5	12	1	0	21	1	5	0	1	6	2
Sunflower aphid	0	14	11	1	2	2	9	0	2	3	3	3	0	0	1	18
Thistle aphid	1	26	1	1	2	0	9	0	1	6	1	0	0	0	0	0
Turnip aphid	3	0	0	1	2	1	2	0	0	7	0	0	1	0	2	3
Cotton/melon aphid	6	41	25	8	31	7	24	15	0	15	4	3	0	7	10	51
Pea aphid	0	3	2	3	1	8	11	2	5	3	2	1	0	3	0	2
Cowpea aphid	0	2	6	13	29	8	20	13	4	10	1	1	2	2	4	15
black bean aphid	1	3	1	13	16	6	9	1	0	3	4	5	0	9	2	3
Buckthorn aphid	0	44	10	5	21	3	7	2	0	9	10	2	0	5	5	38
Identified non-vectored species	21	80	48	82	146	32	109	22	10	43	25	17	1	15	7	21
No ID'd	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0
Total # captured	48	306	191	216	390	125	397	93	29	190	99	58	4	71	83	234
Total Vectors	27	226	143	134	244	93	288	71	19	147	74	41	3	56	76	213

Aphid flight increased gradually throughout the beginning of the season then dramatically in August, peaking the week of August 23rd (Fig 5&6). This supports the idea that most of our aphid flight, and therefore most of our vectored inoculum movement, occurs later in the season. The total number of green peach aphid, the most efficient vector of PVY, remained low throughout the season. While not as efficient a vector, soybean aphid have the capacity to develop very high populations in which case the sheer number of aphids increases the amount of virus transmitted. However, in 2013 we did not see large outbreaks in soybean aphid populations.

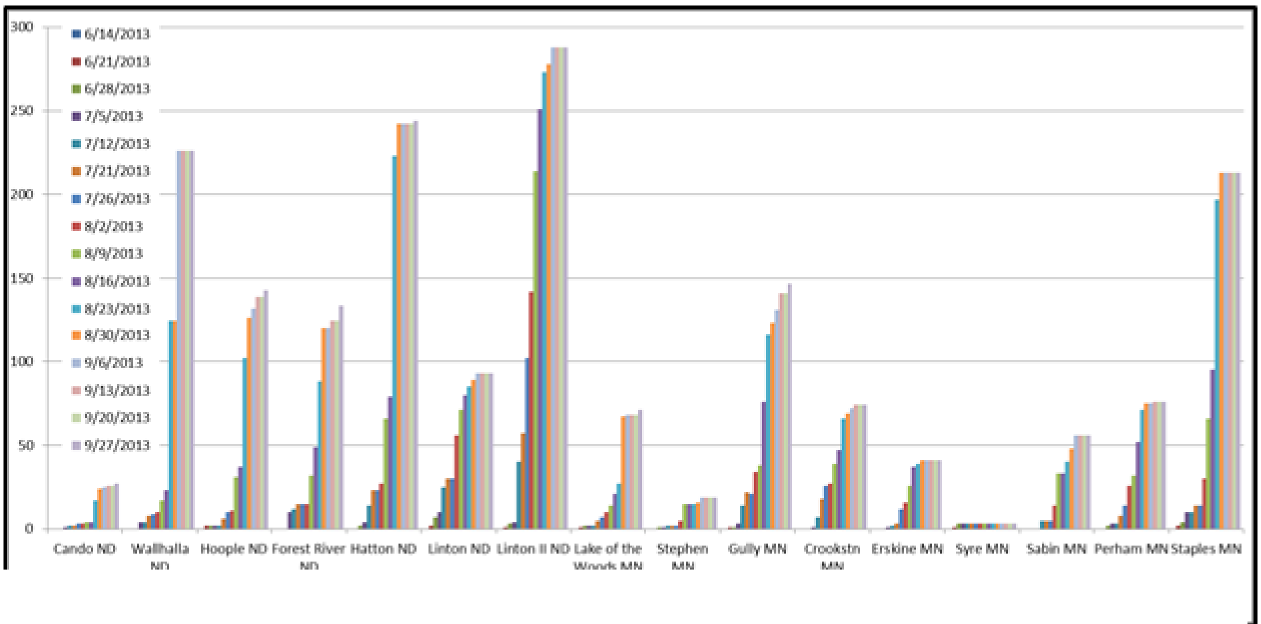

Figure 5. Cumulative vector counts at each location in the AphidAlert trapping network, 2013.

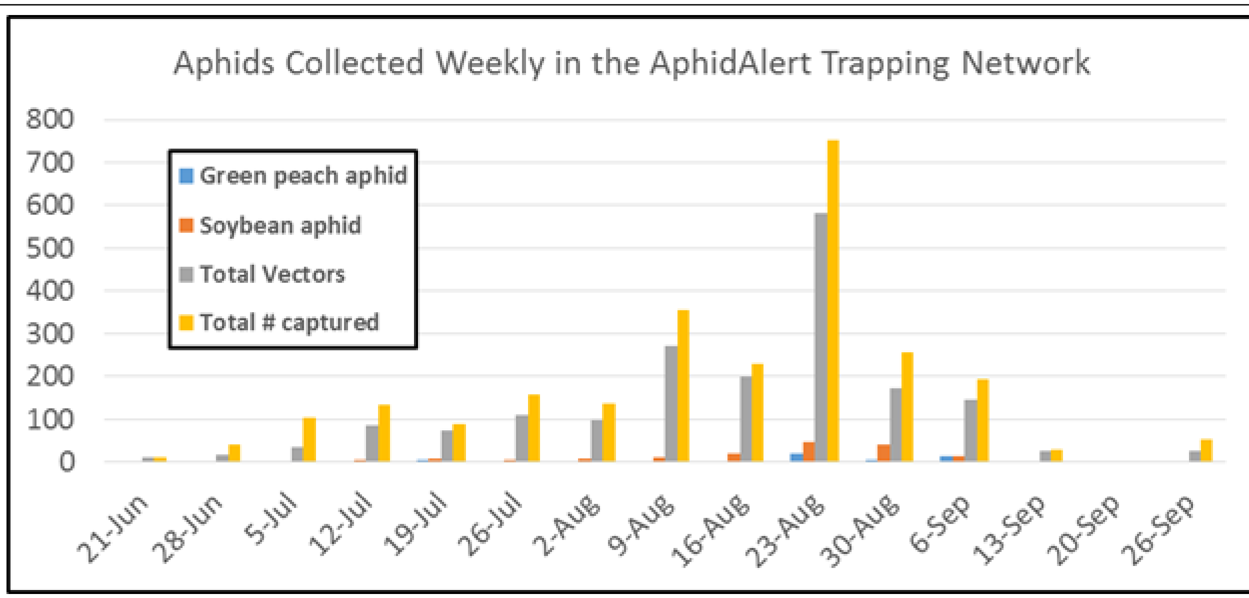

Figure 6. Total network catch of Green peach aphid, soybean aphid, total vectors, and total aphids.

The AphidAlert II network will be in operation again next year with a greater number of traps to refine the resolution. We would like to thank all cooperators participating in the project and thank our funding sources.

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Aphid Species Captured - 6/21/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird cherry oat aphid	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Corn leaf aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
English grain aphid	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Sunflower aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thistle aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turnip aphid	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Cotton/melon aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pea aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cowpea aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
black bean aphid	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Buckthorn aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-vectored species	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
No ID'd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # captured	0	0	2	0	0	2	1	1	0	1	0	0	2	0	0	2
Total Vectors	0	0	2	0	0	2	1	1	0	1	0	0	1	0	0	2

Aphid Species Captured - 6/28/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Soybean aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird cherry oat aphid	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0
Corn leaf aphid	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
English grain aphid	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Sunflower aphid	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Thistle aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turnip aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton/melon aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pea aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cowpea aphid	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0
black bean aphid	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	2
Buckthorn aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-vectored species	0	0	3	0	9	2	6	1	0	0	0	1	0	0	1	0
No ID'd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # captured	0	0	3	0	11	7	8	2	1	0	0	1	2	0	3	2
Total Vectors	0	0	0	0	2	5	2	1	1	0	0	0	2	0	2	2

Aphid Species Captured - 7/05/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bird cherry oat aphid	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1
Corn leaf aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
English grain aphid	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Sunflower aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Thistle aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turnip aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton/melon aphid	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	1
Pea aphid	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cowpea aphid	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0	3
black bean aphid	0	2	0	4	1	1	0	0	0	0	0	0	0	0	0	0
Buckthorn aphid	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Non-vectored species	1	1	2	30	3	2	3	0	2	19	0	3	0	3	0	2
No ID'd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # captured	2	5	2	42	5	5	4	0	2	21	1	4	0	3	1	8
Total Vectors	1	4	0	12	2	3	1	0	0	2	1	1	0	0	1	6

Aphid Species Captured - 7/12/2013 (aphids/trap)	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Soybean aphid	0	0	0	0	0	0	1	0	0	1	3	0	0	0	0	0
Bird cherry oat aphid	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0
Corn leaf aphid	0	0	0	0	0	2	1	0	0	0	0	1	0	0	0	0
English grain aphid	0	0	0	0	0	5	3	0	0	2	0	0	0	0	0	0
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	0	2	0	5	0	0	1	0	0	0	0	0	0
Sunflower aphid	0	0	0	0	0	0	3	0	1	0	2	0	0	0	0	0
Thistle aphid	1	0	0	0	1	0	4	0	0	1	0	0	0	0	0	0
Turnip aphid	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Cotton/melon aphid	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Pea aphid	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Cowpea aphid	0	0	0	0	1	5	5	0	0	3	0	0	0	0	0	0
black bean aphid	0	0	0	0	6	3	5	0	0	2	1	0	0	2	0	0
Buckthorn aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Non-vectored species	0	0	0	0	0	7	33	0	0	4	0	0	0	3	0	0
No ID'd	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Total # captured	1	0	0	0	10	22	69	0	1	15	6	1	0	8	0	0
Total Vectors	1	0	0	0	10	15	35	0	1	11	6	1	0	5	0	0

Aphid Species Captured - 7/19/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1
Soybean aphid	0	1	0	0	0	0	1	0	0	1	4	0	0	0	0	0
Bird cherry oat aphid	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Corn leaf aphid	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
English grain aphid	0	0	0	0	2	3	3	0	0	0	3	0	0	0	1	0
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1
Sunflower aphid	0	0	0	1	2	0	1	0	0	0	0	0	0	0	0	1
Thistle aphid	0	1	0	1	0	0	5	0	0	4	1	0	0	0	0	0
Turnip aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton/melon aphid	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
Pea aphid	0	1	0	0	0	0	3	0	0	2	0	0	0	0	0	0
Cowpea aphid	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0
black bean aphid	1	1	1	0	4	0	1	0	0	0	1	0	0	0	2	1
Buckthorn aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-vectored species	0	2	1	1	0	0	2	1	1	0	3	0	0	0	1	3
No ID'd	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Total # captured	1	6	5	4	9	5	19	4	1	8	14	1	0	0	6	7
Total Vectors	1	4	4	3	9	5	17	3	0	7	11	1	0	0	5	4

Aphid Species Captured - 7/26/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean aphid	0	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0
Bird cherry oat aphid	0	1	2	0	0	0	4	0	0	0	0	0	0	2	1	0
Corn leaf aphid	0		0	0	0	0	1	1	0	0	0	0	0	0	0	1
English grain aphid	0	0	1	0	3	4	34	0	0	2	3	5	0	5	3	1
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	0	0	0	0	0	0	7	0	0	0	0	1	0
Sunflower aphid	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Thistle aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turnip aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cotton/melon aphid	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pea aphid	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cowpea aphid	0	0	0	0	0	1	4	0	0	1	0	1	0	0	0	0
black bean aphid	0	0	0	0	0	2	2	0	0	0	0	3	0	0	0	0
Buckthorn aphid	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Non-vectored species	0	0	1	0	1	0	29	5	1	1	5	4	0	1	0	0
No ID'd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # captured	0	1	5	0	5	9	74	7	1	12	13	13	0	8	6	4
Total Vectors	0	1	4	0	4	9	45	2	0	11	8	9	0	7	6	4

Aphid Species Captured - 8/02/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0			0	0	0	0	0	0	0		0	0	0
Soybean aphid	0	0	0			1	5	1	0	0	0	0		0	0	1
Bird cherry oat aphid	0	0	0			4	2	0	0	0	0	1		0	0	0
Corn leaf aphid	0	0	0			1	4	0	0	2	0	0		0	0	1
English grain aphid	0	1	1			5	22	0	3	0	0	2		2	10	5
Green bug	0	0	0			0	0	0	0	0	0	0		0	0	0
Potato aphid	0	0	0			1	2	0	0	0	0	0		0	0	0
Sunflower aphid	0	0	0			0	0	0	0	0	0	1		0	0	0
Thistle aphid	0	0	0			0	0	0	0	0	0	0		0	0	0
Turnip aphid	0	0	0			0	0	0	0	0	0	0		0	0	0
Cotton/melon aphid	0	0	0			3	1	0	0	0	0	0		0	1	0
Pea aphid	0	0	0			0	1	1	0	0	0	0		0	0	0
Cowpea aphid	0	0	0			2	3	1	0	0	0	0		0	0	5
black bean aphid	0	0	0			0	0	0	0	0	1	0		0	0	0
Buckthorn aphid	0	0	0			0	0	0	0	0	0	0		0	1	0
Non-vectored species	1	5	3			10	4	2	1	0	2	2		4	1	3
No ID'd	0	0	0			0	0	0	0	0	0	0		0	0	0
Total # captured	1	6	4	0	0	27	44	5	4	2	3	6	0	6	13	15
Total Vectors	0	1	1	0	0	17	40	3	3	2	1	4	0	2	12	12

Aphid Species Captured - 8/09/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
Soybean aphid	0	0	0	1	6	0	0	0	1	0	1	0	0	0	1	1
Bird cherry oat aphid	1	0	8	0	6	3	12	0	0	0	1	3	0	1	0	15
Corn leaf aphid	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0
English grain aphid	0	5	9	5	2	3	31	3	0	0	5	5	0	7	3	7
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1
Sunflower aphid	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	5
Thistle aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turnip aphid	0	0	0	0	0	1	1	0	0	3	0	0	0	0	0	2
Cotton/melon aphid	0	0	0	1	3	2	13	0	0	0	2	0	0	0	0	3
Pea aphid	0	0	1	0	0	4	5	1	5	0	1	0	0	3	0	2
Cowpea aphid	0	2	1	0	16	0	5	0	4	0	0	0	0	0	0	0
black bean aphid	0	0	0	9	0	0	0	0	0	0	1	0	0	5	0	0
Buckthorn aphid	0	0	0	0	5	0	3	0	0	0	1	1	0	3	0	0
Non-vectored species	0	5	7	6	23	4	15	2	1	4	3	1	0	3	0	8
No ID'd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # captured	1	12	27	23	62	19	87	6	11	8	15	11	0	22	6	44
Total Vectors	1	7	20	17	39	15	72	4	10	4	12	10	0	19	6	36

Aphid Species Captured - 8/16/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	0	0	2	0	0	0	0	0	0	0	0			0	0
Soybean aphid	0	0	1	3	3	1	3	0	0	0	0	0			4	5
Bird cherry oat aphid	0	3	3	4	0	1	7	1	0	23	0	0			0	9
Corn leaf aphid	0	1	0	0	1	0	4	1	0	0	0	0			0	0
English grain aphid	0	2	1	6	0	5	7	0	0	2	4	1			4	12
Green bug	0	0	0	0	0	0	0	0	0	0	0	0			0	0
Potato aphid	0	0	0	0	1	0	3	0	0	5	1	4			0	0
Sunflower aphid	0	0	0	0	0	0	4	0	0	0	1	2			0	0
Thistle aphid	0	0	0	0	1	0	0	0	0	0	0	0			0	0
Turnip aphid	0	0	0	0	0	0	0	0	0	3	0	0			0	0
Cotton/melon aphid	0	0	0	0	0	0	8	3	0	4	1	1			8	3
Pea aphid	0	0	0	2	0	2	1	0	0	0	1	1			0	0
Cowpea aphid	0	0	1	0	2	0	0	2	0	1	0	0			4	0
black bean aphid	0	0	0	0	3	0	0	0	0	0	0	2			0	0
Buckthorn aphid	0	0	0	0	0	0	0	0	0	0	0	0			0	0
Non-vectored species	0	0	3	3	1	3	7	2	0	4	3	0			2	1
No ID'd	0	0	0	0	2	0	0	0	0	0	0	0			0	0
Total # captured	0	6	9	20	14	12	44	9	0	42	11	11	0	0	22	30
Total Vectors	0	6	6	17	11	9	37	7	0	38	8	11	0	0	20	29

Aphid Species Captured - 8/23/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	1	8	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Soybean aphid	0	4	4	2	11	0	1	0	0	3	8	0	0	0	8	7
Bird cherry oat aphid	4	9	18	4	25	0	4	0	0	6	4	1	0	1	1	1
Corn leaf aphid	0	8	1	0	5	0	3	0	0	0	0	0	0	0	1	0
English grain aphid	3	14	10	3	5	1	9	0	0	5	2	1	0	1	1	2
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	1	0	18	41	0	1	0	0	8	0	0	0	0	2	0
Sunflower aphid	0	14	11	0	0	0	1	0	0	2	0	0	0	0	0	9
Thistle aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turnip aphid	2	0	0	1	2	0	0	0	0	0	0	0	0	0	1	0
Cotton/melon aphid	3	14	11	6	24	0	0	1	0	5	0	0	0	2	1	42
Pea aphid	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Cowpea aphid	0	0	0	4	8	0	2	4	0	4	0	0	0	2	0	3
black bean aphid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buckthorn aphid	0	28	10	0	12	3	1	1	0	7	5	0	0	1	4	38
Non-vectored species	5	37	11	11	73	2	7	3	0	4	3	6	0	0	1	4
No ID'd	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Total # captured	18	138	76	50	217	7	29	9	0	44	22	8	0	7	20	106
Total Vectors	13	101	65	39	144	4	22	6	0	40	19	2	0	7	19	102

Aphid Species Captured - 8/30/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	1		3	0	0	0	0	0	0	0	1	0	0	0	0	0
Soybean aphid	3		5	16	1	0	0	0	0	0	0	0	0	4	4	9
Bird cherry oat aphid	0		6	4	0	2	5	24	0	5	0	0	0	0	0	0
Corn leaf aphid	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0
English grain aphid	0		1	0	0	0	0	3	0	0	0	0	0	0	0	1
Green bug	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	2		0	2	12	1	0	0	0	0	0	0	0	1	0	0
Sunflower aphid	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thistle aphid	0		0	0	0	0	0	0	1	0	0	0	0	0	0	0
Turnip aphid	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton/melon aphid	1		7	0	4	1	0	8	0	1	0	2	0	1	0	2
Pea aphid	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cowpea aphid	0		0	5	0	0	0	5	0	0	0	0	0	0	0	4
black bean aphid	0		0	0	0	0	0	0	0	0	0	0	0	2	0	0
Buckthorn aphid	0		0	5	2	0	0	0	0	1	2	0	0	0	0	0
Non-vectored species	7		14	9	36	2	1	3	0	5	5	0	0	1	1	0
No ID'd	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total # captured	14	0	38	41	55	6	6	43	1	12	8	2	0	9	5	16
Total Vectors	7	0	24	32	19	4	5	40	1	7	3	2	0	8	4	16

Aphid Species Captured - 9/06/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	11	2			0	0	0	0	0	0		0	0	0	
Soybean aphid	0	3	0			1	2	0	0	3	0		0	4	0	
Bird cherry oat aphid	0	18	2			3	5	0	3	5	1		0	0	0	
Corn leaf aphid	0	0	0			0	0	0	0	0	0		0	0	0	
English grain aphid	0	2	0			0	0	0	0	0	0		0	0	0	
Green bug	0	0	0			0	0	0	0	0	0		0	0	0	
Potato aphid	0	1	0			0	0	0	0	0	0		0	0	0	
Sunflower aphid	0	0	0			0	0	0	0	0	0		0	0	0	
Thistle aphid	0	25	0			0	0	0	0	0	0		0	0	0	
Turnip aphid	1	0	0			0	0	0	0	0	0		0	0	0	
Cotton/melon aphid	0	27	2			0	0	0	0	0	0		0	4	0	
Pea aphid	0	0	0			0	0	0	0	0	0		0	0	0	
Cowpea aphid	0	0	0			0	0	0	0	0	0		0	0	0	
black bean aphid	0	0	0			0	0	0	0	0	0		0	0	0	
Buckthorn aphid	0	15	0			0	3	1	0	0	2		0	0	0	
Non-vectored species	6	30	2			0	2	2	4	2	0		0	0	0	
No ID'd	0	0	0			0	0	0	0	0	0		0	0	0	
Total # captured	7	132	8	0	0	4	12	3	7	10	3	0	0	8	0	0
Total Vectors	1	102	6	0	0	4	10	1	3	8	3	0	0	8	0	0

Aphid Species Captured - 9/13/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0		1	0						0	1		0		0	
Soybean aphid	0		0	0						1	0		0		0	
Bird cherry oat aphid	0		1	3						3	0		0		0	
Corn leaf aphid	0		0	0						0	0		0		1	
English grain aphid	0		0	0						0	1		0		0	
Green bug	0		0	0						0	0		0		0	
Potato aphid	0		1	0						0	0		0		0	
Sunflower aphid	0		0	0						0	0		0		0	
Thistle aphid	0		1	0						1	0		0		0	
Turnip aphid	0		0	0						1	0		0		0	
Cotton/melon aphid	1		3	1						3	0		0		0	
Pea aphid	0		0	0						0	0		0		0	
Cowpea aphid	0		0	0						1	0		0		0	
black bean aphid	0		0	0						0	0		0		0	
Buckthorn aphid	0		0	0						0	0		0		0	
Non-vectored species	1		0	1						0	1		0		0	
No ID'd	0		0	0						0	0		0		0	
Total # captured	2	0	7	5	0	0	0	0	0	10	3	0	0	0	1	0
Total Vectors	1	0	7	4	0	0	0	0	0	10	2	0	0	0	1	0

Aphid Species Captured - 9/20/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid										0			0			
Soybean aphid										0			0			
Bird cherry oat aphid										3			0			
Corn leaf aphid										0			0			
English grain aphid										0			0			
Green bug										0			0			
Potato aphid										0			0			
Sunflower aphid										0			0			
Thistle aphid										0			0			
Turnip aphid										0			0			
Cotton/melon aphid										0			0			
Pea aphid										0			0			
Cowpea aphid										0			0			
black bean aphid										0			0			
Buckthorn aphid										0			0			
Non-vectored species										0			0			
No ID'd										0			0			
Total # captured	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Total Vectors	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0

Aphid Species Captured - 9/27/2013 (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0		1	0	0			0		0	0					
Soybean aphid	0		0	1	0			0		0	0					
Bird cherry oat aphid	0		0	7	1			0		4	0					
Corn leaf aphid	0		0	0	0			0		0	0					
English grain aphid	0		1	0	0			0		0	0					
Green bug	0		0	0	0			0		0	0					
Potato aphid	0		0	0	0			0		0	0					
Sunflower aphid	0		0	0	0			0		0	0					
Thistle aphid	0		0	0	0			0		0	0					
Turnip aphid	0		0	0	0			0		1	0					
Cotton/melon aphid	1		1	0	0			2		1	0					
Pea aphid	0		0	0	0			0		0	0					
Cowpea aphid	0		1	2	0			1		0	0					
black bean aphid	0		0	0	0			0		0	0					
Buckthorn aphid	0		0	0	1			0		0	0					
Non-vectored species	0		1	21	0			1		5	0					
No ID'd	0		0	0	0			0		0	0					
Total # captured	1	0	5	31	2	0	0	4	0	11	0	0	0	0	0	0
Total Vectors	1	0	4	10	2	0	0	3	0	6	0	0	0	0	0	0

Aphid Species Captured - Entire Season (aphids/trap)

	Cando ND	Wallhalla ND	Hoople ND	Forest River ND	Hatton ND	Linton ND	Linton II ND	Lake of the Woods MN	Stephen MN	Gully MN	Crookstn MN	Erskine MN	Syre MN	Sabin MN	Perham MN	Staples MN
Green peach aphid	0	8	1	3	1	0	4	0	0	0	1	0	0	0	1	1
Soybean aphid	0	5	1	6	9	2	10	2	1	2	21	0	0	0	5	23
Bird cherry oat aphid	2	13	14	11	6	10	31	1	0	23	5	5	0	6	2	27
Corn leaf aphid	0	9	0	0	1	6	10	3	0	2	0	2	0	0	1	2
English grain aphid	0	22	13	16	7	27	100	4	3	6	17	14	0	15	21	28
Green bug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potato aphid	0	1	0	20	3	4	11	1	0	13	1	5	0	0	4	2
Sunflower aphid	0	14	0	1	2	2	8	0	2	1	3	3	0	0	1	18
Thistle aphid	1	1	0	1	2	0	9	0	0	5	1	0	0	0	0	0
Turnip aphid	0	0	0	1	0	1	2	0	0	6	0	0	1	0	1	3
Cotton/melon aphid	0	14	1	7	3	6	24	5	0	6	4	1	0	2	9	51
Pea aphid	0	3	1	3	0	8	11	2	5	3	2	1	0	3	0	2
Cowpea aphid	0	2	5	6	21	8	18	7	4	5	1	1	2	2	4	15
black bean aphid	1	3	1	13	16	6	9	1	0	3	4	5	0	7	2	3
Buckthorn aphid	0	29	0	0	6	0	3	1	0	1	6	2	0	5	1	38
Non-vectored species	2	50	20	51	37	28	99	16	6	32	19	17	1	14	5	21
No ID'd	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
Total # captured	6	174	57	139	116	108	350	43	21	108	85	56	4	54	57	234
Total Vectors	4	124	37	88	79	80	251	27	15	76	66	39	3	40	52	213

NPPGA/Area II Potato Insect Research Report 2013 - Establishing a Resistance Monitoring Program for Neonicotinoid Insensitive Colorado Potato Beetle in Minnesota and North Dakota

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Rationale – Colorado Potato Beetle (CPB), *Leptinotarsa decimlineata* Say is one of the most damaging insect pests of potatoes in Minnesota and North Dakota. Typically this defoliating insect has required intensive chemical management with broad spectrum insecticides. This, combined with the detoxification systems which permit the insect to feed on the foliage of potato plants, high in toxic alkyloids, has led to CPB developing resistance to essentially every insecticide ever used against it (Weisz et al. 1994, Alyokhin et al. 2007). This continues to be a significant problem in managing CPB (Jorg et al. (2007). The rapidity with which CPB can develop resistance is remarkable; some insecticides (e.g. oxymyl) have even lost effectiveness within their first season of use (Forgash 1985). In some cases, the development of resistance to insecticides by a local population of CPB results in its 'appearance' as a pest in areas where it has not previously been a problem. This may result from these beetle populations losing their susceptibility to insecticides used in the production system that had previously been suppressing their populations. The introduction of the neonicotinoid insecticides initially provided some alternatives to existing classes of insecticides. The systemic abilities of these insecticides made them especially efficacious for whole field treatment and provided excellent protection. It was, however, recognized that resistance would develop and their effectiveness would eventually fade.

In 2000, the first reports of resistance to the neonicotinoid insecticide Imidacloprid (Admire, Bayer Crop Science) was reported in New York (Olson et al. 2000, Zhang et al. 2000) and later from Maine (Alyokhin & Dwyer 2005). This resistance was later linked to cross-resistance to the neonicotinoid insecticide Thiamethoxam (Platinum, Cruiser, Syngenta Crop Protection) (Alyokhin et al 2007); these insecticides are used on ~70% of all potatoes grown from Maine to North Dakota, belong to the same class of insecticides and have the same mode of action. The development of cross-resistance refers to a population of insects that develop resistance to an insecticide with a specific mode of action are then resistant, or partially resistant, to all other insecticides with the same mode of action (which may include all insecticides in that class).

This situation was reported from a number of field locations in Minnesota in 2007. In certain locations, populations of CPB were not controlled by field rate applications of imidacloprid. It was subsequently learned that an associated cross resistance to thiamethoxam was also present in these populations. Although not a linear relationship (a 15 fold resistance to thiamethoxam was associated with a 100 fold resistance to imidacloprid), the presence of this cross-resistance does suggest that the future use of these and other neonicotinoids to control CPB in Minnesota and North Dakota may be problematic. In addition, research indicates CPB resistant to imidacloprid will be partially resistant to new neonicotinoids, such as acetamiprid introduced in 2005 (Assail, Cerexagri) and dinotefuran (Venom, Valent Corp.) even prior to their use in the field (Grafius & Byrne, 2005).

Recently, populations of CPB that are insensitive to neonicotinoid insecticides have been reported from Central Minnesota and this insensitivity may be spreading geographically. This has resulted in a significant increase in control costs for this insect pest. The initial response to this situation is to identify alternative chemistries and application methods that remain effective or may either alleviate insensitivities in CPB. In 2010, populations were sampled in 3 different locations in Minnesota and sent to University of Michigan to evaluate levels of resistance (Table 1). It was found that populations in Becker and Long Prairie were marginally less susceptible but that populations in Perham were low to moderately resistant to neonicotinoid insecticides. Considering neonicotinoid insecticides were effective in these locations only 10 years ago, it can be assumed we are seeing an increase in resistance to neonicotinoids in CPB in Minnesota. The current and future geographic distribution of resistant CPB in Minnesota and North Dakota would be useful to estimate rates of spread of neonicotinoid resistance to other potato producing areas in the states and facilitate the development of resistance management programs. Unfortunately the number of sites that can be evaluated by outstate labs in any one year is limited. An instate program to test and map developing neonicotinoid resistance in MN and ND would enhance our ability to respond to this developing problem.

Table 1. Neonicitinoid resistance levels found in Colorado Potato Beetle populations from 3 areas in MN in 2010. Resistance level refers to how much more insecticide was necessary to kill 50% of the sampled population than was necessary to kill the susceptible New Jersey population (kept as a colony in the U.Mich. lab).

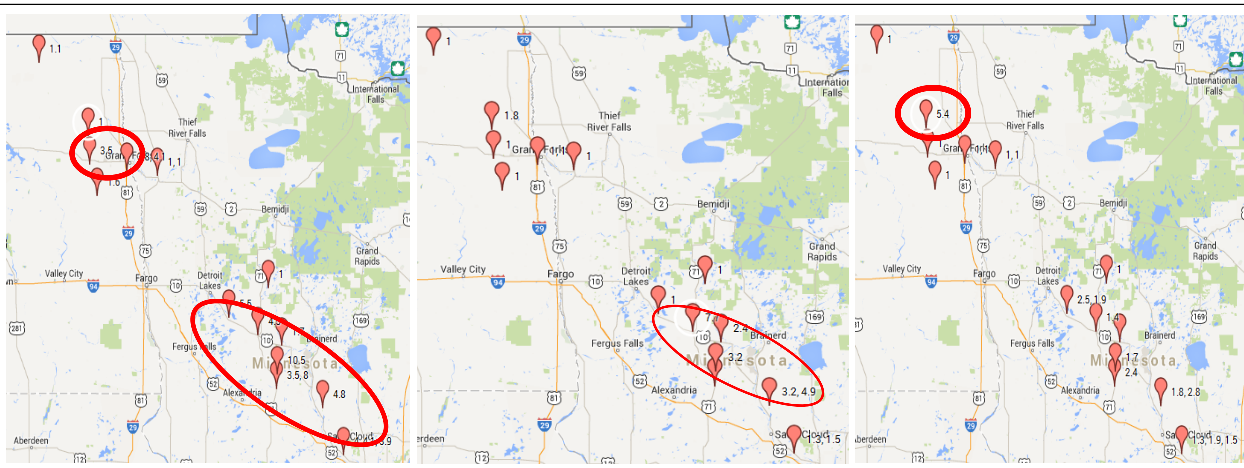
Location	Insecticide	LD_{50} (mg/ind.)	Resistance (X susc.)
Becker	Imidacloprid Thiomethoxam	0.473 0.102 (.087-.122)	**4 X** **1.3 X**
Perham	Imidacloprid Thiomethoxam	0.904 (.63-1.228) 0.198	**8 X** **2.5 X**
Long Prairie	Imidacloprid Thiomethoxam	0.399 (.189-.585) .193 (.164-.224)	**3.5 X** **2.4 X**
NJ Susceptible Population	Imidacloprid Thiomethoxam	0.115 (.068-.156) 0.082	**NA** **NA**
Becker (U.W.) 74 ind.	Imidacloprid Thiomethoxam	1.19	**10.4 X (timing??)**

Methods – Colorado potato beetle adults were be sampled from potato production areas within Minnesota and North Dakota. CPB populations that appear to becoming less susceptible to neonicotinoid insecticides received priority for collection and testing.

Populations of CPB were be collected and tested for neonicotinoid insensitivity. Beetles were collected by R.D. Offut and grower cooperators and UMN staff. Testing consisted of comparing LD_{50} values of collected beetles to those of the susceptible population. Adult beetles were tested using a contact exposure to varying concentration of three neonicotinoid insecticides: Imidacloprid (Admire Pro, Bayer CropScience), Thiamethoxam (Platinum, Syngenta Crop Protection), and Clothianidin (Belay, Valent Agricultural Products). Insecticides were applied in 1µl doses to the first abdominal segment of adult beetles using a micro-syringe applicator (Hamilton Co., Reno NV). Exposed beetles were then placed on potato leaves, the petioles of which were wrapped in damp cotton and placed into petrie plates. Beetles were stored for 7 days at 20C and potato leaves changed and/or re-wetted as necessary. Exposed beetles were examined daily for 7 days with final assessment on day 7, this is because CPB frequently show initial symptoms of intoxication but recover within 3-5 days. Any symptoms remaining after 7 days can be interpreted as susceptibility. Mortality rates between sample populations were compared with those from a known susceptible population using Probit Analyses; results were calculated using POLO Plus (LeOra Software, Petaluma, CA) software. Relative rates of resistance were calculated and compared. The comparative ratio of how much insecticide it takes to kill the same proportion of the sampled population compared to the lab populations which is known to be susceptible to the tested insecticide is called the Resistance ratio. It is a direct measure of how much more insecticide it takes to kill the sampled field population (i.e. a 4X Resistance ratio indicates it takes 4 times as much insecticide to control the sampled population, label rates will not be obviously not be effective in controlling an insect population that has a 4X Resistance Ratio!)

Results & Discussion – Results indicate a number of locations have either well-established or developing resistance to Imidacloprid and/or Clothianidin while resistance to Thiamethoxam does not seem be as well developed in Minnesota & North Dakota (Table 2). These results are from overwintered beetles in some locations and summer generation in others. Sites in Becker, Rice and Larimore all show minor to low levels of resistance to Imidacloprid. The Forest River population of beetles, while the analyses still indicate susceptibility, are at the high end of this range and this may indicate this population is losing susceptibility to Imidacloprid. We are seeing increasing tolerance to Imidacloprid in several North Dakota populations. There is still greater susceptibility to Thiomethoxam (Platinum) in both states as opposed to the other two Neonicotinoids tested. The results from both Larimore and Inskter ND are concerning as they indicate a greater distribution of CPB populations in North Dakota may be developing tolerance to these insecticides.

Geographically, it can be seen that: the efficacy of Imidacloprid is decreasing in CPB populations in central MN and in some of those in the cental Red River Valley (Fig 1), the efficacy of Clothianidin seems to be decreasing in some CPB populations in Central MN, there have not yet been tested populations shown to be tolerant of this insecticide in the Red River Valley (Fig 1) and the only reported CPB population demonstrated to tolerate Thiomethoxam is in the west central Red River Valley (Fig 1). The population tolerant to Thiomethoxam is



Imidacloprid **Clothianidin** **Thiomethoxam**

Figure 1. Geographical distribution of the tolerance of three neonitcotinoid insecticides in Colorado Potato Beetle populations sampled in MN and ND. Numbers on the maps represent the comparative Resistance Ratio of insects sampled at that location. Circles represent areas within which decreased efficacy of neonicotinoids have been demonstrated through laboratory testing.

associated with the research site located in Inkster and this tolerance may reflect aggressive CPB control necessary to suppress defoliation in experimental plots. Research plots frequently require suppression of pest (insect, weed and disease) well beyond that which may occur in commercial or seed fields; results from plots must be the result of the treatment and consequently pest eradication may be required, necessitating economically unsustainable management.

Table 2. Comparison of relative resistance rates of sampled sites and those of a known susceptible population, 2011-2013. Numbers indicate the comparative resistance factor (i.e. a value of 3.92 indicates the population at that sampled site is 3.92 times as resistance as a susceptible population – i.e. it would take 3.92 times as much insecticide to kill these less susceptible insects). Values of 0x-3x indicate susceptibility to that chemical, values 3x-5x indicate minor resistance, 5x-8x indicate low levels of resistance, values 8x-10x are moderate resistance, values over 10x indicate well-established, high resistance. Rations presented in red or italics are results of concern. NT = Not Tested.

2011	Imidacloprid (Admire)	Thiomethoxam (Cruiser)	Clothianidin (Belay)
Becker	**4**	**1.3**	NT
Long Prairie	**3.5**	2.4	NT
Perham	**8**	2.5	NT
Crookston	1	1	
2011			
Becker	**4.1**	1.9	1
Browerville2	**10.5**	1.7	**3.2**
Browerville1	1.4	1	1
Hubbard	1	1	1
Hatton	1.6	1	1
Rice	1.5	NT	**3.2**
Perham	**5.5**	1.9	1
Wadena	**4.5**	1.4	**7.7**
Grand Forks	**3.8**	1	1
Forest River	2.5	1.1	1.1
2013			
Becker	**3.9**	1.5	1.3
Rice2	**4.8**	2.8	**4.9**
Rice1	NT	1.8	1.9
Staples	1.7	NT	2.4
Crookston	1	1	1
Forest River	2	NT	NT
Langdon	1.1	1	1
Larimore	**3.5**	1	1
Inkster	1	**5.4**	1.8
Grand Forks	**4.1**	1	1

2) Foliar Trials - conducted in Becker, MN were planted 5/17/2013, with Russet Burbank seed potatoes in 36" rows, individual plots were 6 rows wide by 50' long and treaments assigned in an RCB design. No at-plant insecticide was used for foliar trials. Plants began to emerge June 01, most plants had emerged by June 06. All plots were treated weekly (from 3 wks post emergence) with alternating applications of Ridomil Bravo and mancozeb to protect from foliar fungal pathogens. No pathogenic symptoms were observed through the summer.

Fields were monitored every 7-10 days (as permitted) for Colorado Potato Beetle (CPB) by selecting 3-4 plants per plot and counting the total number of beetles per plant. Other insects were noted if present. Treatments were replicated 4 times in a Randomized Complete Block Design. Applications were made at 30 gal/ac equivalency, pH was tested to ensure solution range was within a range of 5-7. Treatments were mixed at the research farm, just prior to application. Treatments were applied 7/8, 7/16, and 7/24. Plots were irrigated 2-3 times weekly, depending on climatic conditions.

The trial was terminated on Aug 05 in response to increased movement of CPB from totally defoliated UTC and control failure plots to neighboring treated plots. It consequently became difficult to estimate control given the constant immigration of adult beetles. Plots were harvested 8/20 with a one row harvester and the middle 10 ft of one of the 2 center rows was collected in a potato basket and weighed with a digital, hanging scale. Harvested tubers, while small (because of late planting and early harvest) were well shaped and had no observable deformities.

While CPB were extremely numerous and the emergence of both spring and summer adults was extended over a longer than expected period, no other damaging insects were observed; there were no lepidopterous pests and aphids remained at very low levels in plots throughout the summer.

Results – Populations of CPB peaked in several plots late season, especially those treated with Blackhawk, varying rates of Cyazypyr, and Endigo ZC (not necessarily in

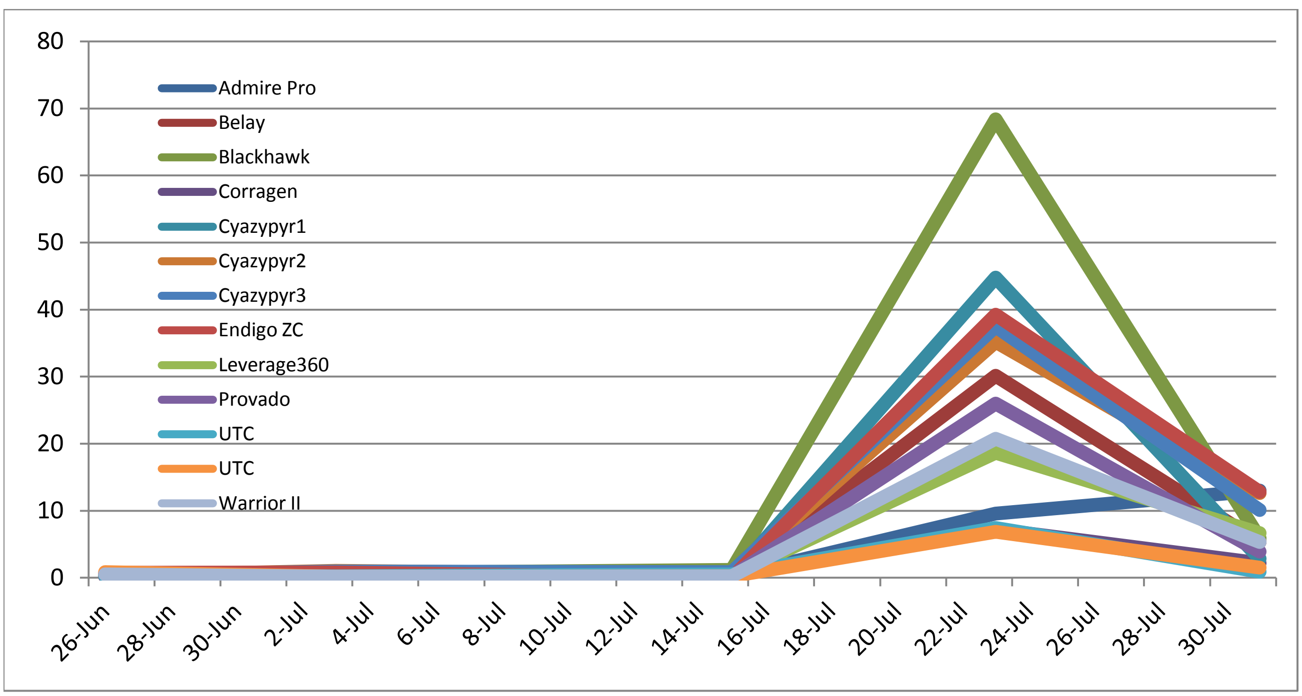


Figure 2-1. Seasonal population dynamics of Colorado Potato Beetle adults in foliar treatment plots at Becker, MN.

that order (Fig. 2-1). While it sounds counter-intuitive, when taken with defoliation data (Fig. 2-2) it can be seen that this peak is actually caused by adults in defoliated plots (untreated control or less effective treatment plots) into the Blackhawk, Cyazypyr and Endigo ZC plots. This is also borne out by these treatments yielding more than untreated controls and less effective treatments (Fig 2-3).

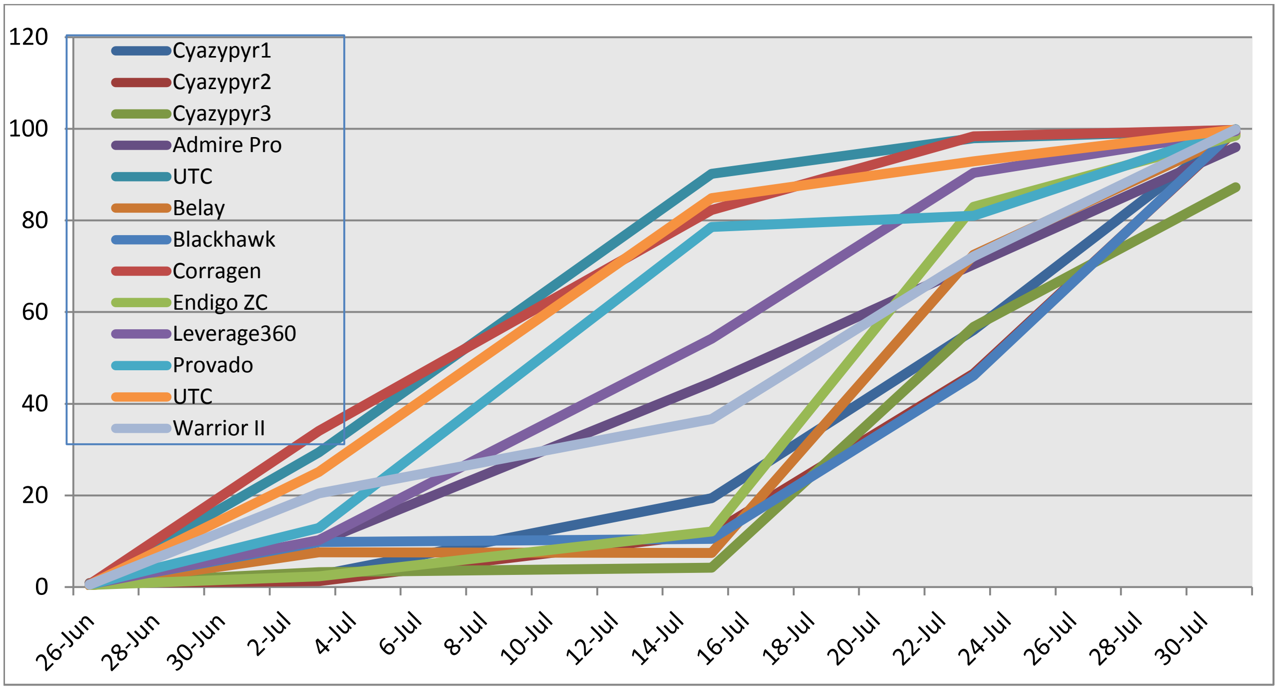


Figure 2-2. Percent defoliation in Colorado Potato Beetle foliar insecticide trials, Becker, MN.

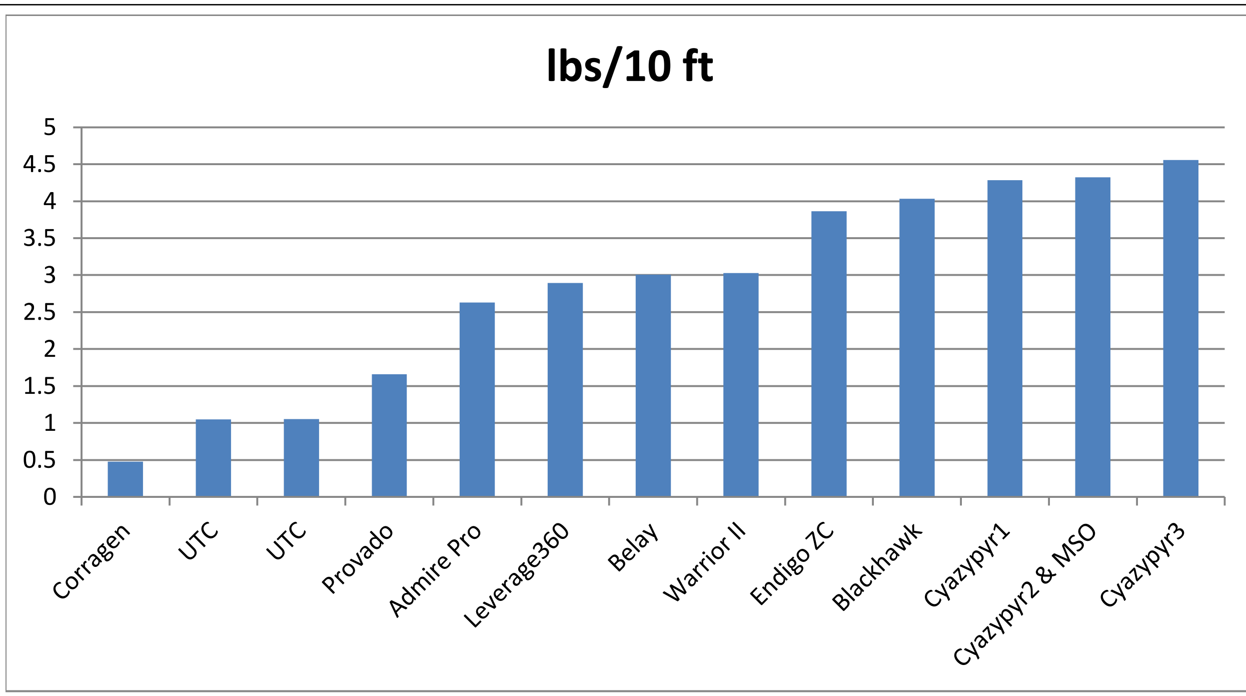


Figure 2-3. Yields from Colorado Potato Beetle foliar insecticide trials, Becker, MN.

3) In-Furrow Trials

Trials were conducted in Becker, MN, in sandy soils. Fields were planted 5/17/2013, with Russet Burbank seed potatoes in 36" rows, individual plots were 6 rows wide by 50' long and treatments assigned in an RCB design. No at-plant insecticide was used for foliar trials. Plants began to emerge June 01, most plants had emerged by June 06. All plots were treated weekly (from 3 wks post emergence) with alternating applications of Ridomil Bravo and mancozeb to protect from foliar fungal pathogens. No pathogenic symptoms were observed through the summer.

Fields were monitored every 7-10 days (as permitted) for Colorado Potato Beetle (CPB) by selecting 34 plants per plot and counting the total number of beetles per plant. Other insects were noted if present. Treatments were replicated 4 times in a Randomized Complete Block Design. Applications were made at 30 gal/ac equivalency, pH was tested to ensure solution range was within a range of 5-7. Treatments were mixed at the research farm, just prior to application. Treatments were applied 7/8 (canopy had not completely closed), 7/16 (canopy closed), and 7/24 (canopy closed). Plots were irrigated 2-3 times weekly, depending on climatic conditions.

The trial was terminated by applying Spinosad to all plots on Aug 05 and again on Aug 09. This decision was in response to increased movement of CPB from totally defoliated UTC and control failure plots to neighboring treated plots. It consequently became difficult to estimate control given the constant immigration of adult beetles. Plots were harvested 8/20 with a one row harvester and the middle 10 ft of one of the 2 center rows was collected in a potato basket and weighed with a digital, hanging scale. Harvested tubers, while small (because of late planting and early harvest) were well shaped and had no observable deformities.

While CPB were extremely numerous and the emergence of both spring and summer adults was extended over a longer than expected period, no other damaging insects were observed; there were no lepidopterous pests and aphids remained at very low levels in plots throughout the summer.

Treatments consisted of 3 rates of Cyazypyr (DuPont) (5oz/ac, 5oz/ac plus MSO, 6.75fl oz/ac), an application of Admire Pro (Imidacloprid, Bayer Crop Sci) and an Untreated Control Plot.

Populations Dynamics & Yields– Initial spring adult populations were low, with a small and extended emergence lasting from late June through ~July 10 (Fig. 3-1). Summer adults began emerging by mid-July, peaking by July 24. Numbers of adults during this late summer peak in the 3 Cyazypyr plots were higher than in either the UTC or Admire Pro plots, but from the point of insect control, this may be misleading. Note that defoliation (Fig 3-2) was significantly higher in both the UTC and Admire Pro plots by July15, leaving little or no food for emerging adult beetles. Consequently, the late summer adult beetle populations concentrated in those plots still containing foliage (the Cyazypyr treated plots). Defoliation did not become equal across all plots until late in the summer, after beetles had concentrated in the Cyazypyr plots. The trials were ended at this time because immigration rates of CPB into Cyazypyr plots were so high that constant repeated applications would have been necessary to control the populations. This immigration effect is corroborated by the seasonal larval population data (Fig 3-3). All plots treated with any of the 3 Cyazypyr applications had significantly fewer larvae through the early summer period. Larval numbers did not begin to be evenly distributed across all plots until mid-July (defoliation may again have played a major role in this dynamic).

It is obvious from the defoliation data (Fig 3-2) that the best suppression of CPB was by the Cyazypyr applications, the highest rate (6.75 fl oz/Ac) seemed to significantly suppress defoliation until at least mid-July (July 15).

Yield data indicates that plots containing any of the 3 Cyzapyr treatments had significantly higher tuber yields than did Untreated Control plots (P=0.005, Table 3-1). None of the Cyazypyr treatments had significantly greater yields than did the Admire Pro treatment, but the Admire Pro treatment also did not have a significantly higher tuber yield than did the Untreated Control.

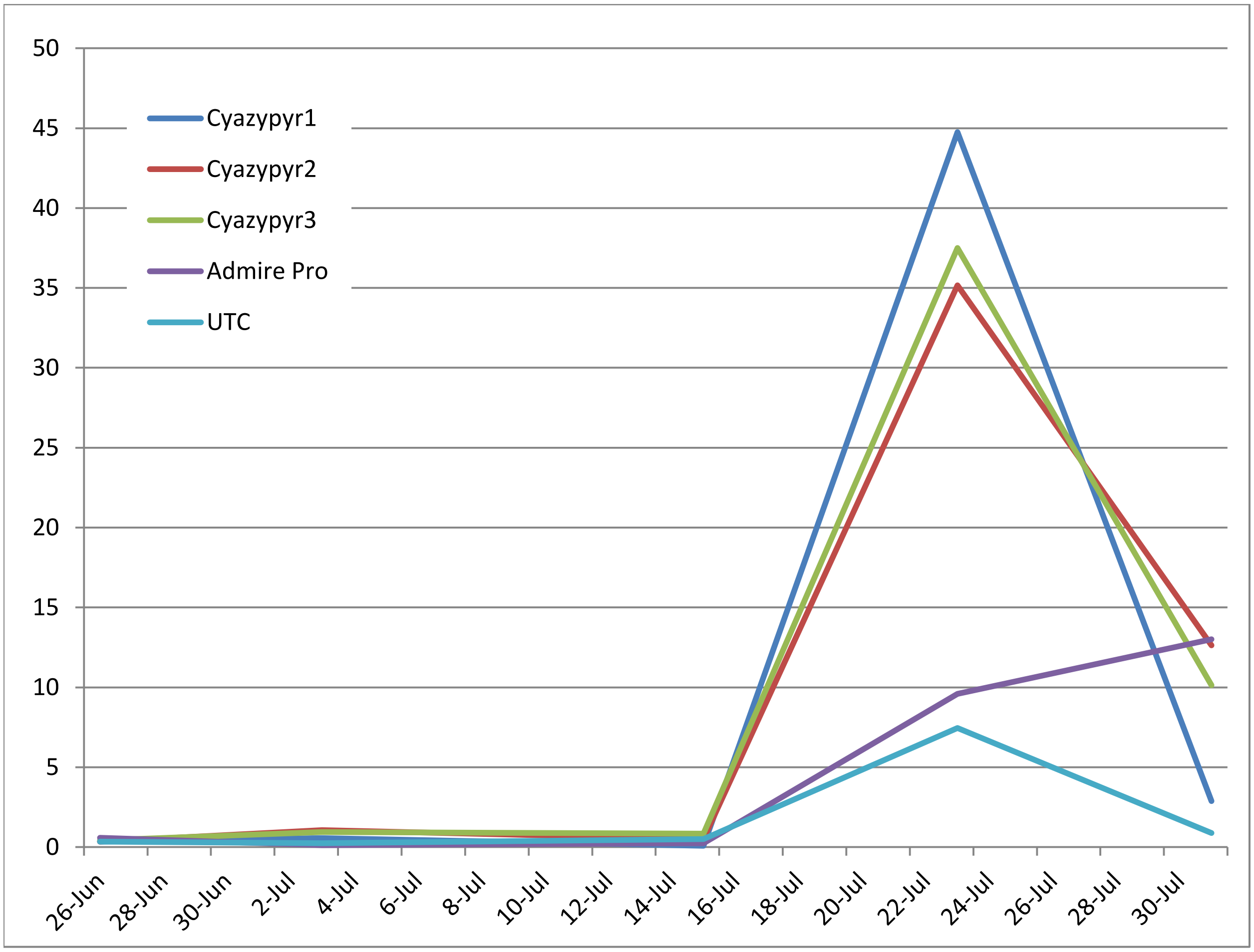


Figure 3-1. Seasonal dynamics of Colorado Potato Beetle adults. Note lower numbers of late summer adults in the Admire Pro and UTC plots than in the Cyazypyr plots. This was due to the near-com,plete defoliation of plants in those plots (resulting in a complete absence of food for beetles) and subsequent migration of adult beetles into Cyazypyr plots which still contained foliage.

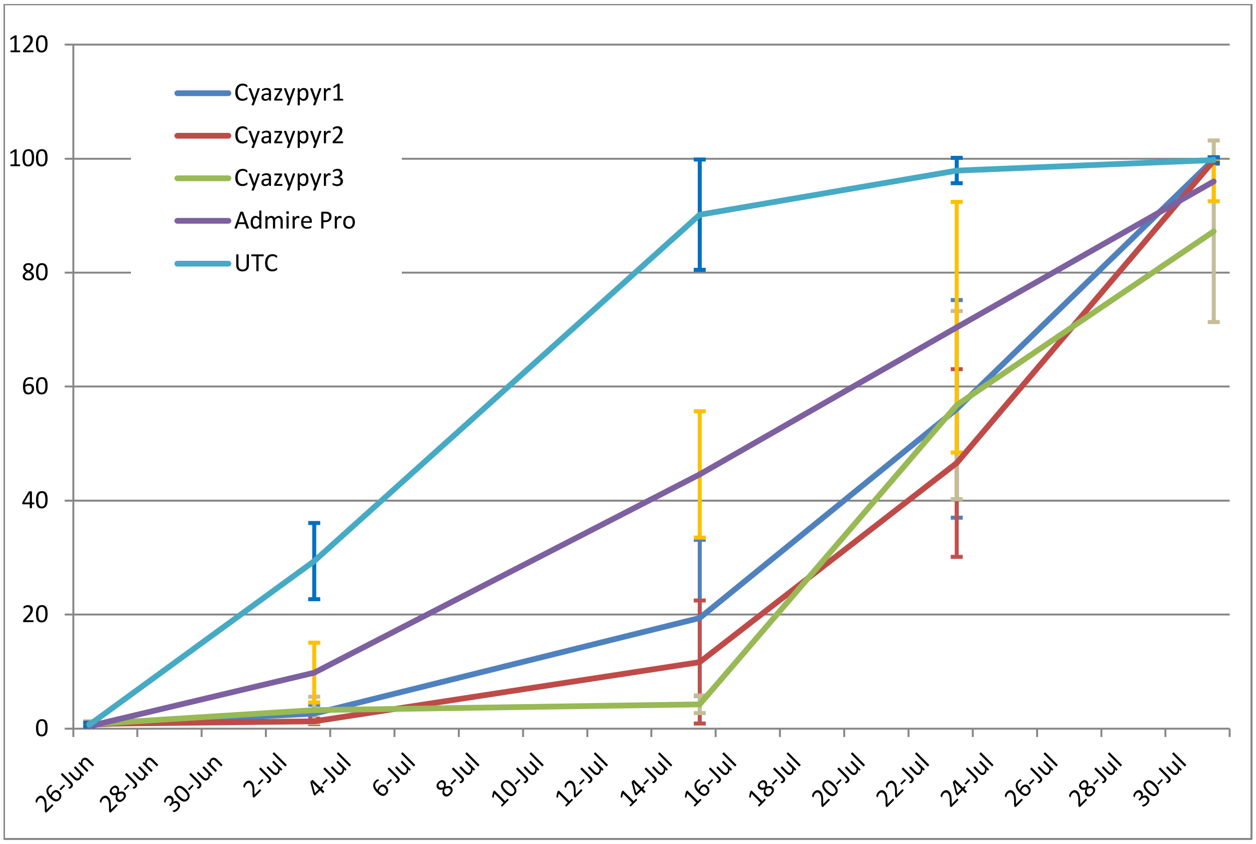


Figure 3-2. Seasonal defoliation of potato plants by Colorado Potato Beetles. Note near-complete defoliation of UTC and, to a lesser extent, Admire Pro plots by mid-July. This caused migration of adult beetles to Cyazypyr treated plots which still contained significantly more foliage at this

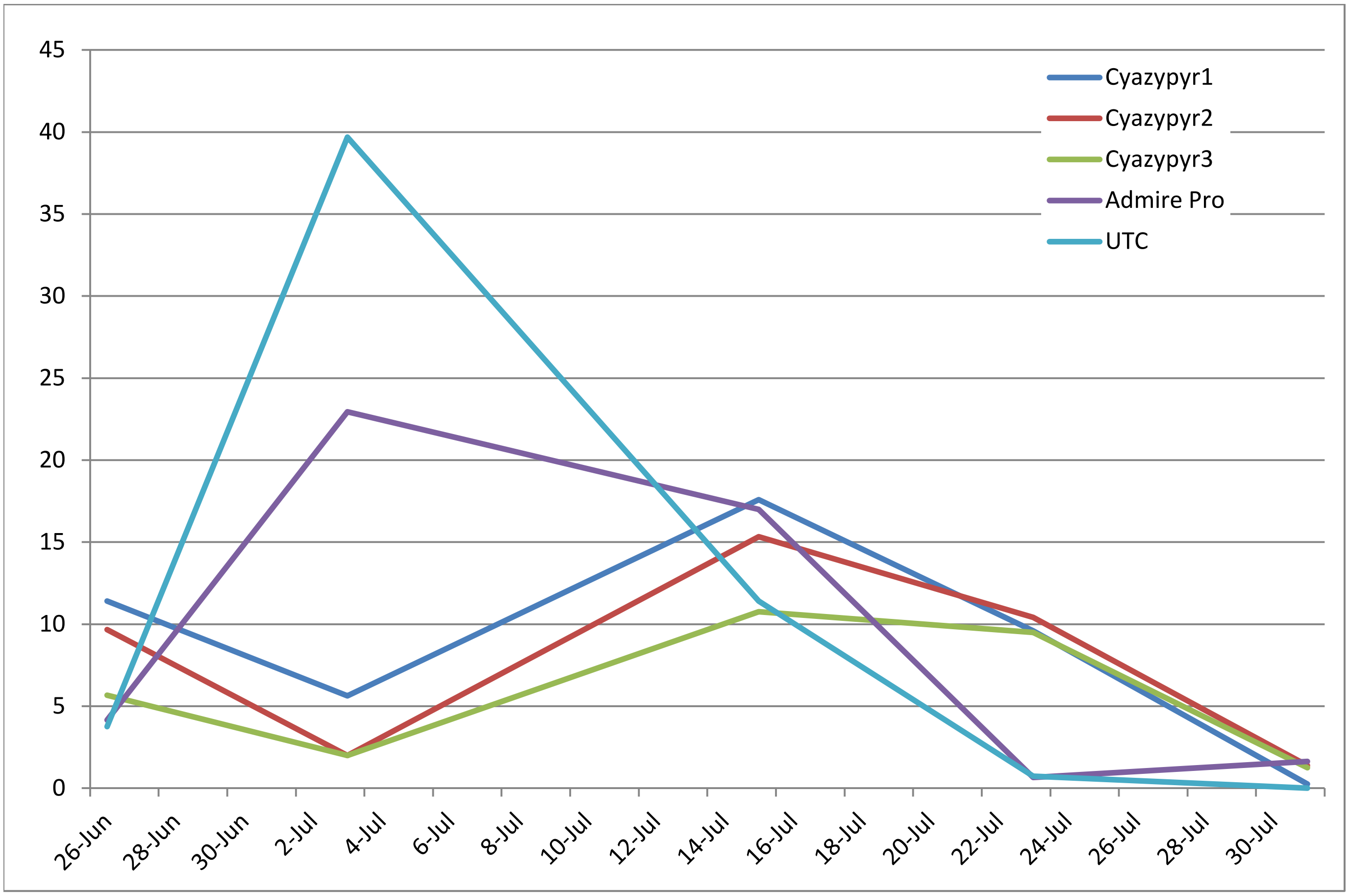


Figure 3-3. Seasonal dynamics of larval Colorado Potato Beetle. Note significantly lower populations of larvae in Cyazypyr treated plots from late June through to mid-July. The significantly higher populations of larvae in the UTC and, to a lesser extent, the Admire Pro plots contributed to the near-defoliation of those plots by mid-July.

Table 3-1. ANOVA and pairwise comparisons of tuber yields from Cyazypyr treated, Admire Pro treated , and Untreated Control plots.

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
TRTMNT$(1)	36.228	4	9.057	5.877	0.005
Error	23.117	15	1.541		

Tukey's Honestly Least Significant Difference test

Treatment (1)(i)	Treatment(1)(j)	Difference	p-Value	95% Confidence Interval Lower	Upper
Admire Pro	Cyazypyr1	-1.653	0.367	-4.363	1.058
Admire Pro	Cyazypyr2 & MSO	-1.692	0.345	-4.403	1.018
Admire Pro	Cyazypyr3	-1.927	0.234	-4.638	0.783
Admire Pro	UTC	1.575	0.412	-1.136	4.286
Cyazypyr1	Cyazypyr2 & MSO	-0.040	1.000	-2.751	2.671
Cyazypyr1	Cyazypyr3	-0.275	0.998	-2.986	2.436
Cyazypyr1	UTC	3.228	0.016	0.517	5.938
Cyazypyr2&MSO	Cyazypyr3	-0.235	0.999	-2.946	2.476
Cyazypyr2&MSO	UTC	3.267	0.015	0.557	5.978
Cyazypyr3	UTC	3.502	0.009	0.792	6.213

4) Organic Alternative Trial – Exicute (Teton Ag) is an organic product that may provide some alternative control of CPB. We designed and implemented a trial evaluating this product at the NWROC in Crookston.

Experimental Design/Agronomic Information**:** Trials were conducted in Crookston, MN, in Hegne-Fargo complex soils (silty-clay loams). Fields were planted 5/30/2013, with Norkota seed potatoes in 36" rows, individual plots were 4 rows wide by 50' long and treatments assigned in an RCB design. No at-plant insecticide was used for foliar trials. Plants began to emerge June 10, most plants had emerged by June 21. All plots were treated weekly (from 3 wks post emergence) with alternating applications of Ridomil Bravo and mancozeb to protect from foliar fungal pathogens. No pathogenic symptoms were observed through the summer.

Fields were monitored every 7-10 days (as permitted) for Colorado Potato Beetle (CPB) by selecting 3 plants per plot and counting the total number of beetles per plant (first sample date 4 plants were sampled). Other insects were noted if present. Treatments were replicated 4 times in a Randomized Complete Block Design. Applications were made at 30 gal/ac equivalency. Treatments were mixed at the NWROC just prior to application. Treatments were applied 7/10 (canopy had not completely closed). Plots were not irrigated and subjected to partial drought conditions later in the growing season (digital weather records attached).

The trial was terminated by applying Spinosad to all plots on Aug 09. This decision was in response to extreme defoliation across all plots. Harvested tubers, while small (because of late planting and early harvest) were well shaped and had no observable deformities.

While CPB were extremely numerous and the emergence of both spring and summer adults was extended over a longer than expected period, no other damaging insects were observed; there were no lepidopterous pests and aphids remained at very low levels in plots throughout the summer.

Treatments consisted of 3 rates of Exicute (Na Laural sulfate, clove oil, rosemary oil, Eugenol oil, mint oil, thyme oil, Teton Ag) (5 oz/ac, 6 oz/ac, and 8oz/ac), and an Untreated Control.

Results & Discussion – The 3 rates of Exicute did not successfully provide long-term suppression of Colorado Potato Beetles. The rates of defoliation in treated plots were similar to those seen in Untreated Control Plots (Fig 4-1). There was also no significant difference in yields (lb/10 linear row ft) (Figure 4-2). However, yields were close enough to indicate that multiple and more frequent applications of Exicute may well suppress populations of Colorado Potato Beetle. Further trials will be conducted in 2014.

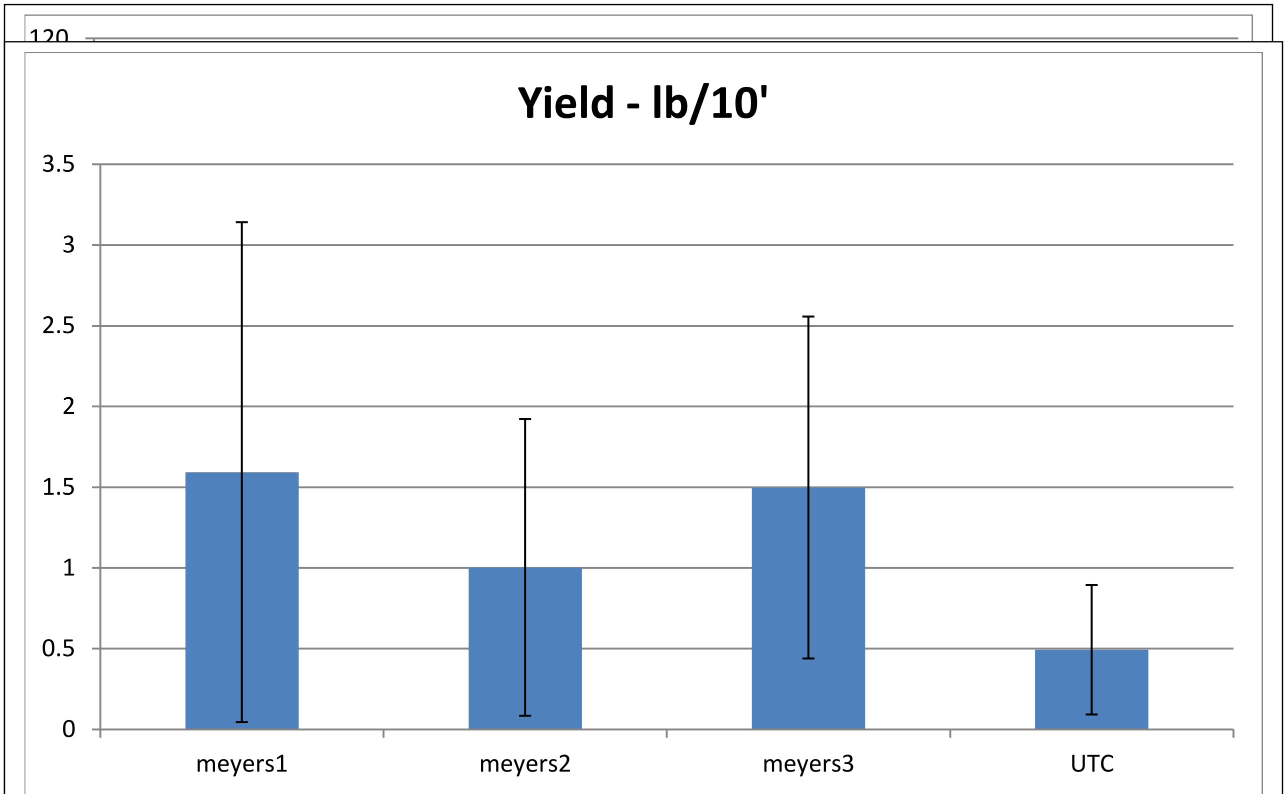


Figure 4-2. Yields from plots treated with one of 3 different rates of Exicute insecticide and Untreated Control Plots. Vertical lines are 95% Confidence Intervals.

Remote Sensing of Potato Virus Y – A Preliminary Assessment

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Executive Summary – This is a new project designed to provide preliminary data to assess the potential of remote sensing Potato Virus Y. The spectral reflectance and chlorophyll content of infected and uninfected plants in a number of varieties will be obtained and directly compared. If potential is demonstrated for this technique, a more complete proposal will follow.

Rationale – The Minnesota and North Dakota seed potato industry is at a critical juncture. Seed production acreage has suffered a significant decrease since 1995 in part because of aphid vectored viral diseases of seed potato, notably Potato Virus Y (PVY). Certification programs in Minnesota and North Dakota are operationally excellent, but it is difficult to turn the corner on potato virus epidemics because large amounts of virus-inoculum must be flushed from the seed production system. This is an increasingly difficult proposition with Potato Virus Y (PVY). New virus strains with variable levels of expression and a new vector species have resulted in what appears to be a change in the epidemiology of this viral disease. The ordinary (common) strain of PVY (PVY^o) causes mild to severe mosaic, leaf drop and leaf and stem necrosis. Of greater concern are PVY^N (tobacco veinal necrosis) and the relatively new strain PVY^{NTN}. While PVY^N produces mild to severe mild to severe mosaic symptoms, PVY^{NTN} potato tuber necrotic ringspot disease (PTNRD). Visible symptoms of infection of either strain vary according to potato cultivar with some cultivars being nearly or completely asymptomatic making within season diagnosis difficult. Consequently, rogueing infected plants based on visible recognition of symptoms is becoming more challenging. A new rapid, within field diagnostic tool for helping to identify infected plants would be extremely useful. The use of spectral reflectance (the data measured by techniques commonly referred to as remote sensing in vegetative studies) may be such a tool.

Plants do not use all of the wavelengths of light hitting them. Some light is reflected, the amount varies with the health of the plant. The wavelengths being reflected obviously include green in the visible light spectrum (i.e. the color of we see) but also include light in several wavelengths we cannot perceive. The light being reflected is called the spectral reflectance.

There is an inverse relationship between the energy of a photon (the individual pieces of energy in light) and the length of its wavelength. The photons found in the Near Infrared (NIR) and Infrared (IR) (both very long wavelengths of light) are very low, too low in energy to be used by plants in photosynthesis. Consequently, if plants absorb these wavelengths of light, what energy photons do have must be given off in some other form, such as heat, which the plant must then spend energy to dissipate. NIR and IR photons, therefore, would be a net energy cost to plants. Consequently, plants have evolved to reflect these wavelengths of light; chlorophyll a & b both contribute to this function.

Unhealthy and stressed plants have significantly lower levels of chlorophyll a and/or b (depending on the pathogen) and reflect less NIR and IR wavelengths of light than do healthy plants. By assessing the amount of NIR and IR that is reflected, one can judge the level of stress a plant is undergoing. This the basis of remote sensing using reflectance (radiometers measure the wavelengths being reflected or remote images are taken with lens filters that permit later image analysis of reflected light wavelengths).

Infection of potatoes by pathogens, such as Potato Virus Y (PVY) causes just such stress. Various diseases are known to affect the spectral reflectance of plants and recent advances in the acquisition and analysis of remotely sensed images now provide opportunities to develop scouting techniques based on these effects. Multispectral cameras, chlorophyll meters, and hand held radiometers can obtain the range of reflectance data associated with disease impact. Associating these reflectance data with presence of infection will facilitate the development of very rapid decision making tools. Spectral reflectance and chlorophyll content of potato plants may eventually be used to evaluate the infection rates in seed potato fields, evaluate winter grow-outs, and assess rates of inoculum in seeded fields. This technique has application to remotely sensed data from a variety of sources. While we tend to focus on aerial and satellite imagery, the use of hand held reflectometers like the GreenSeeker (NTech Industries, Ukiah CA) to assess fields for variable rate fertilizer, pest management and other uses has been growing steadily in the last several years. Generally these hand held units measure specific spectral bands and provide outputs in a given index; e.g. GreenSeeker provide data to construct the Normalized Difference Vegetation Index (NDVI). Vegetative indices are generally calculated as some ratio of NIR/IR to some wavelength of visible light. Consequently, they represent the relative amount of NIR/IR being reflected by plants of all the light available. The values of vegetative indices can, therefore, be used to express the level of stress being imposed on the plants sampled. The NDVI, for example, is calculated as NDVI = (NIR-RED)/(NIR + RED). Its values run from -1 to 1, although values under 0 mean no plants are present) so the higher the NDVI value, the more NIR is being refelceted and the healthier the plants being photographed.

Procedures – Direct comparison trials will be conducted assessing the photospectral response and chlorophyll content of infected and uninfected individual plants. Original trials will be conducted in greenhouses but field trials will be conducted when appropriate.

Plants – SUSIE – not sure what you have in culture -we should have not only susceptible and relative less susceptible varieties but also symptomatic and non-symptomatic. Plants will be infected with PVY. The photospectral reflection and chlorophyll content will be obtained and compared between infected and healthy plants. Infection of tested plants will be confirmed using Enzyme-linked Immunosorbent assay (*ELISA*).

Reflectance Data – The photospectral reflectance of plants will be obtained using both a MSR 16R® (CropScan Inc., Rochester, MN) and multispectral images of the plots obtained using a TetraCam ADC® (TetraCam Inc, Chatsworth, CA). The MSR 16R is a handheld, multi-spectral photospectrometer. Its sensors see and record the reflected wavelengths of light in 16 different bands of wavelengths. We currently have sensors sensitive to various bands in the NIR, IR, red, green, and blue wavelengths. The individual wavelength values of the reflected light from healthy and unhealthy plants will be recorded and reflectance curves (spectral signatures) constructed. These curves will then be compared (e.g. Fig 1). The TetraCam ADC is a digital multispectral camera sensitive to NIR and IR as well as visible light wavelengths. It will be used to obtain digital photographs of the trials plants. The photographs will be analyzed with the image analysis software PixelWrench2 (TetraCam Inc, Chatsworth CA). The software assess the wavelengths being reflected in the digital image and these data can be used to construct both NDVI and Soil Adjusted Vegetative Index (SAVI is similar to the NDVI but with an adjustment value incorporated to compensate for bare soil).

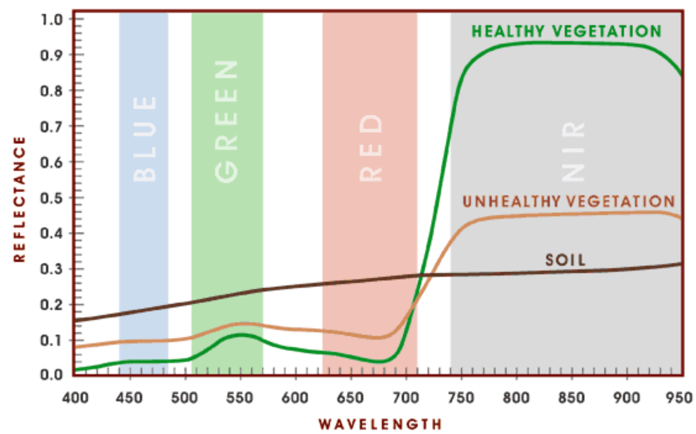

Figure 1. An example of the spectral signature (curves of the values of reflected light) comparison of unhealthy and healthy plants.

Changes in photospectral response are the result of changes in chlorophyll content brought on by stress. We will measure and compare the chlorophyll content of all trial plants using a Nikon SPAD S502 Chlorophyll meter. This is an in-field capable meter which can measure the chlorophyll content of a leaf in seconds.

Outcomes – If there is a difference in the spectral reflectance of healthy potato plants and those infected with PVY, it can facilitate the development of a fast and highly reliable, within-field method of scouting infected plants. Such a technique has the potential of making a significant impact on the management of virus in both seed and commercial potato fields.

Equipment – The North Dakota State University and the University of Minnesota's Northwest Research & Outreach Center have adequate equipment and facilities to complete the research.

Progress – Leaf chlorophyll levels have been obtained from 163 plants grown in a growth chamber using a SPAD chlorophyll meter. Leaf tissue samples from these plants have been collected and stored at -20C to be ELISA tested for PVY to determine which plants were infected. Chlorophyll content data and PVY infection will be correlated when ELISA results are available. ELISA testing has been delayed due to the plate reader being down for repairs/upgrade. We expect plate reader to be back online and testing to be completed by April 15, 2014.

Spectral reflectance trials were delayed until uninfected and plants confirmed as infected with PVY were available. Plants are being grown in the greenhouse over the next several months and spectral reflectance data will be collected and compared for infected and non-infected plants. In addition, leaf chlorophyll levels will be obtained using a SPAD chlorophyll meter. Spectral reflectance values obtained from greenhouse plants will provide comparative data between infected and non-infected potato plants. Within-field comparisons will be completed nest growing season.

Effects of Linex as a Preemergence Herbicide on Russet Burbank Potato

Andy Robinson, NDSU / U of M
Eric Brandvik, NDSU / U of M

Location: Perham, MN
Planting date: 24 May 2013
In-row spacing: 13 inches
Emergence: 17 June 2013
Treatment application: 13 June 2013
Harvest date: 26 September 2013

Objective: Evaluate the effects of Linex, Linex mixtures, and other preemergence herbicides in potato for weed control and yield.

All treatments: Applied with a nine-foot CO_2 backpack sprayer calibrated to deliver 15 gal/acre.

Results: After herbicide treatment there was no difference in plant stand, plant height, chlorosis, necrosis, or overall crop injury compared to the untreated check. Differences in weed control and graded yield were found across the treatments. Eastern black nighshade pressure was not consistent across treatments, thus only common lambsquarters and wild proso millet control is reported. Linex applied alone was not efficacious in controlling the weed species in this trial. However, when Linex was applied with metribuzin control was excellent. Control over 90% was also found with Chateau + metribuzin and Dual Magnum + Chateau + metribuzin.

As expected, no weed control reduced yield. The numerically highest total yield and marketable yield was found with the Linex at 12 oz/a + metribuzin at 1 lb/a. This treatment also had consistently high yields on the graded yield. This was likely because of good weed control and less herbicide for the potato plant to detoxify or sequester, allowing maximum yield potential. Linex at 12 oz/a + metribuzin at 1 lb/a was similar to Cheateau + metribuzin, which had consistently high yield. Fierce, not registered for potato, at 1.5 oz/a also had good graded yield. Although weed control was not above 90% at this rate, less stress on the plants likely resulted in higher yield. Chateau applied alone at lower rates likely had less yield then Chateau applied at higher rates because of reduced weed control. Overall, Linex (12 oz/a) applied with metribuzin (1 lb/a) was comparable with other herbicides at controlling weeds and produced a similar graded yield to other herbicide programs. Further research to confirm that tank mixing Linex with metribuzin is needed to confirm control of other weeds and that potato plants will not be injured in other environments.

Table 1. Efficacy of preemergence herbicides on Russet Burbank potato grown in Perham, MN 2013.

Treatment	Herbicide treatment	Application rate	Common lambsquarters control[a]				Wild proso millet control			
			3 WAT[b]		5 WAT		3 WAT		5 WAT	
1	Untreated		0	E[c]	0	C	0	C	0	C
2	Linex 4L	12 oz/a	30	DE	20	BC	67	AB	63	AB
3	Linex 4L	24 oz/a	55	CD	45	ABC	53	B	58	AB
4	Chateau	0.75 oz wt/a	78	ABC	66	AB	87	AB	75	AB
5	Chateau	1.5 oz wt/a	86	ABC	70	AB	98	A	78	AB
6	Chateau	3 oz wt/a	99	A	100	A	95	AB	80	AB
7	Chateau	0.75 oz wt/a	99	A	90	A	93	AB	90	AB
	Metribuzin	0.6 lb/a								
8	Chateau	0.75 oz wt/a	85	ABC	60	AB	70	AB	40	BC
	Linex 4L	12 oz/a								
9	Chateau	0.75 oz wt/a	88	AB	64	AB	78	AB	89	AB
	Linex 4L	24 oz/a								
10	Linex 4L	12 oz/a	96	A	95	A	100	A	91	AB
	Metribuzin	1 lb/a								
11	Linex 4L	24 oz/a	100	A	100	A	100	A	100	A
	Metribuzin	1 lb/a								
12	Dual Magnum	1 pt/a	90	AB	95	A	100	A	94	AB
	Chateau	0.5 oz wt/a								
	Metribuzin	1 lb/a								
13	Dual Magnum	1 pt/a	63	BCD	55	ABC	98	A	93	AB
	Linex 4L	12 oz/a								
14	Dual Magnum	1 pt/a	40	D	78	A	96	A	94	AB
	Linex 4L	24 oz/a								
15	Fierce	1.5 oz/a	85	ABC	73	AB	77	AB	78	AB
16	Fierce	2.25 oz/a	91	AB	83	A	95	A	83	AB

[a] Visual estimate of weed control using a scale of 0 to 100% (0 = no injury and 100 = plant death).
[b] Abbreviation: WAT, weeks after treatment
[c] Within columns means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.1$).

Table 2. Effect of preemergence herbicides on graded yield of Russet Burbank potato in Perham, MN in 2013.

Treatment	Herbicide	Rate	0-4 oz	4-6 oz	6-10 oz	10-14 oz	>14 oz	Total	#1s > 4 oz	#2s > 4 oz	Total marketable	> 6 oz	> 10 oz
			cwt / acre									%	
1	Untreated		103 ab[a]	112 ab	132 a	17 b	4 abc	369 ab	265 b	3 a	268 b	42 b	6 c
2	Linex 4L	12 oz/a	124 a	124 ab	137 a	27 ab	5 c	417 ab	292 ab	2 a	293 ab	41 b	8 c
3	Linex 4L	24 oz/a	97 ab	114 ab	159 a	54 ab	17 abc	440 ab	343 ab	6 a	349 ab	53 ab	16 abc
4	Chateau	0.75 oz wt/a	108 ab	101 ab	131 a	27 ab	9 abc	377 ab	267 ab	3 a	270 b	45 ab	10 bc
5	Chateau	1.5 oz wt/a	88 ab	100 ab	137 a	59 ab	13 abc	396 ab	307 ab	5 a	312 ab	53 ab	19 abc
6	Chateau	3 oz wt/a[b]	76 ab	91 ab	149 a	56 ab	30 ab	403 ab	325 ab	7 a	332 ab	58 ab	21 abc
7	Chateau	0.75 oz wt/a	97 ab	109 ab	176 a	81 a	26 ab	489 ab	390 ab	4 a	394 ab	58 ab	22 abc
	Metribuzin	0.6 lb/a											
8	Chateau	0.75 oz wt/a	65 ab	84 b	137 a	42 ab	18 ab	347 b	280 ab	10 a	290 ab	58 ab	18 abc
	Linex 4L	12 oz/a											
9	Chateau	0.75 oz wt/a	83 ab	113 ab	175 a	53 ab	12 abc	437 ab	351 ab	6 a	357 ab	55 ab	15 bc
	Linex 4L	24 oz/a											
10	Linex 4L	12 oz/a	108 ab	152 a	178 a	59 ab	10 abc	508 a	399 a	6 a	404 a	49 ab	14 bc
	Metribuzin	1 lb/a											
11	Linex 4L	24 oz/a	79 ab	121 ab	181 a	68 ab	4 abc	454 ab	373 ab	4 a	377 ab	56 ab	16 abc
	Metribuzin	1 lb/a											
12	Dual Magnum	1 pt/a	46 b	74 b	133 a	80 a	31 abc	364 ab	316 ab	11 a	327 ab	69 a	33 a
	Chateau	0.5 oz wt/a											
	Metribuzin	1 lb/a											
13	Dual Magnum	1 pt/a	103 ab	123 ab	170 a	55 ab	7 bc	458 ab	354 ab	4 a	358 ab	50 ab	13 bc
	Linex 4L	12 oz/a											
14	Dual Magnum	1 pt/a	89 ab	102 ab	175 a	36 ab	7 abc	409 ab	318 ab	5 a	323 ab	54 ab	11 bc
	Linex 4L	24 oz/a											
15	Fierce[c]	1.5 oz/a	72 ab	101 ab	170 a	73 ab	21 ab	437 ab	363 ab	8 a	371 ab	60 ab	21 abc
16	Fierce	2.25 oz/a	60 ab	89 ab	137 a	74 ab	30 a	390 ab	328 ab	5 a	333 ab	62 ab	26 ab

[a] Within columns means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.1$).
[b] Not labeled rate for potato. Read and follow labels for proper use of pesticides.
[c] Fierce is not labeled for use in potato.

Fresh Market Potato Variety Testing

Andrew P. Robinson, NDSU / U of M and Asunta Thompson, NDSU

Executive Summary

New variety adoption is important to the vitality of the potato industry in the Red River Valley. This purpose of this trial was to compare the graded yield of 23 red-skinned cultivars and 6 yellow-skinned cultivars. Additionally, a pressure bruising testing is being completed to determine which cultivars have the best potential for long-term storage. Of the cultivars tested, the most promising red-skinned varieties were MN0216, CO098102-5R, and ND8555-8R and the most promising yellow-skinned cultivar was MN 99380-1. There were many other cultivars that yielded well and were not statistically different than the aforementioned cultivars. Future trials will help validate the data from this trial.

Introduction

One of the main objectives of the extension potato agronomy program is to provide research-based evaluations of new potato varieties to assist growers in North Dakota and Minnesota to make the best production decisions. New potato varieties are continually being developed by potato breeders in North Dakota and Minnesota and throughout the world. Potato producers who specialize in growing red- and yellow-skinned varieties need to grow the best variety that will have a high yielding capacity, profitable size profile, and store well throughout the winter months. In order for the growers in our region to obtain necessary data on new varieties, testing of these varieties needs to be completed in North Dakota. Additionally, many wash plants will store potatoes for eight months or longer. These long storage periods can cause pressure bruising or flattening of potatoes that are stored near the bottom of the pile. In order for growers to select which varieties will store well, this project will assess the yield, quality, and the ability of varieties to maintain quality during long storage periods in order to maximize optimal returns for producers.

Many potato varieties are bred outside of North Dakota, and for this reason it is important to test new varieties in the Red River Valley to determine how they respond when grown in the Red River Valley when compared to local breeding program cultivars. The objectives of this experiment were to quantify graded yield and pressure bruise following long-term storage. Because potatoes are still in the pressure-bruising phase, only graded yield will be reported. Pressure bruising data will be presented in the Valley Potato Grower magazine.

Materials and Methods

This study was conducted in Crystal, ND on a commercial potato field. A randomized complete block design was utilized with four replications. There were 23 red-skinned and 6 yellow-skinned cultivars (Table 1 and 2). Seed was hand cut to 2.0 oz seed pieces. Following cutting, seed was allowed to suberize for approximately 10 days in 55 °F and 95% humidity. Agronomic practices followed typical practices for North Dakota dryland production. Planting was on June 24, 2013. After digging tubers, they were taken to East Grand Forks and sized on a Kerrian Speed Sizer. Size profile distribution was determined by sorting potatoes into C size (<1.5 inches), B size (1.5 to 2.25 inches), and A size (2.25 to 3.5 inches). There were very few Chef (>3.5 inches) sized potatoes, so they are added into the total yield. After sizing tubers, a 5 lb subsample was taken from each cultivar and replication and placed in ventilated container to simulate pressure flattening in a potato bin. The container setup was adapted from the design described by Castleberry and Jayanty (2012). After approximately 6 months in the pressure flattening container potatoes will be removed and each tuber will be rated for the amount of bruising.

Prior to analyzing graded yield, data were square-root transformed to meet the normality requirements needed to perform the analysis of variance. Graded yield was then subject to SAS Proc Mixed to test for significant effects of each graded yield parameter. Tukey pairwise comparison was used to determine if cultivar had a significant effect ($P \leq 0.05$) on graded yield. Data was back-transformed for ease of understanding.

Results and Discussion

Among the red-skinned cultivars there was not a surprise at the top yielding cultivar, Viking (Table 1). This was expected and Viking was used as a comparison to the new cultivars being tested. Other comparison cultivars were Pontiac, Red Norland, Sangre, Modoc, and Dark Red Norland. Somewhat unexpectedly, Dark Red Norland only yielded 126 cwt/a, with 50% of the yield being made up of B size tubers. While Viking, Pontiac, and Sangre had the highest amount of A sized tubers (> 109 cwt/a), which helps explain the high total yield.

MN0216, CO098102-5R, and ND8555-8R had significantly greater yields than ND7982-1R, MN10003PLWR-07R, and CO00291-5R. The number of C size and B size tubers for MN0216, CO098102-5R, and ND8555-8R were a large factor in total yield. This trial indicates that MN0216, CO098102-5R, and ND8555-8R could be viable, high yielding cultivars in the Red River Valley, but testing these cultivars in another year and environment is essential to proving their ability to withstand the environmental conditions of the Red River Valley.

Of the yellow-skinned cultivars tests, Milva was the highest yielding at 207 cwt/a (Table 2). It did not have a significantly different yield from MN 99380-1, Yukon Gold, or Yukon Nugget. Of the total yield of Milva, 58% was B sized tubers. A yellow-skinned cultivar of promise was MN 99380-1. This cultivar had a total yield of 168 cwt/a and 50% of the yield was made up of B sized tubers. This trial showed many differences in yield and as we continue to perform a variety tests, we expect that more data will help separate out differences and the best yielding cultivars will rise to the top of the list.

Literature Cited

Castleberry, H. C. and S. S. Jayanty. 2012. An experimental study of pressure flattening during long-term storage in four russet potato cultivars with differences in at-harvest tuber moisture loss. Am. J. Pot. Res. 89:269-276.

Table 1. Graded yield of red-skinned cultivars planted in 2013 in Crystal, ND.

Cultivar	C size[a]		B size		A size		Total yield	
	cwt/acre							
Viking	8	h[b]	46	abc	183	a	240	a
Pontiac	22	d-h	74	a	123	ab	220	ab
Red Norland	39	a-g	89	a	60	b-f	187	abc
MN0216	75	a	86	a	17	fgh	178	a-d
CO098102-5R	57	a-d	76	a	45	c-g	177	a-d
Sangre	9	gh	49	abc	110	abc	170	a-e
ND8555-8R	48	a-f	91	a	29	d-h	167	a-d
Red Maria	18	e-h	76	a	65	b-e	159	a-e
Villetta Rose	65	ab	73	ab	20	e-h	159	a-e
W8405-1R	59	abc	75	ab	21	e-h	154	a-e
Modoc	37	a-g	68	ab	47	c-g	151	a-e
MN10020PLWR-04R	52	a-e	70	ab	27	d-h	148	a-e
ND6002-1R	26	c-h	75	a	46	c-g	147	a-e
MN10003PLWR-06R	23	c-h	59	ab	65	b-e	146	a-e
Colorado Rose	14	gh	53	ab	79	bcd	145	a-e
ND7132-1R	37	a-g	69	ab	28	e-h	134	b-e
Dark Red Norland	32	b-h	63	ab	32	c-h	126	b-e
W6002-1R	57	a-d	49	abc	11	fgh	117	c-f
MN10003PLWR-02R	37	a-g	59	ab	19	e-h	115	c-f
CO04159-1R	41	a-g	41	abc	17	e-h	99	def
ND7982-1R	67	ab	15	c	1	h	82	ef
MN10003PLWR-07R	27	b-h	39	abc	15	fgh	81	ef
CO00291-5R	17	fgh	24	bc	9	gh	49	f

[a] Definitions: C size was <1.5 inches, B size was 1.5 to 2.25 inches, A size was 2.25 to 3.5 inches.
[b] Within columns, at each irrigation rate, means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.05$).

Table 2. Graded yield of yellow-skinned cultivars planted in 2013 in Crystal, ND.

Cultivar	C size[a]		B size		A size		Total yield	
	cwt/acre							
Milva	50	ab[b]	121	a	36	ab	207	a
MN 99380-1	68	a	85	a	16	bc	168	ab
Yukon Gold	22	c	60	ab	56	a	137	ab
Yukon Nugget	58	a	61	ab	15	bc	133	ab
Sierra Gold (Tx1523)	20	c	52	ab	40	ab	112	bc
MN04844-07	31	bc	21	b	2	c	54	c

[a] Definitions: C size was <1.5 inches, B size was 1.5 to 2.25 inches, A size was 2.25 to 3.5 inches.
[b] Within columns, at each irrigation rate, means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.05$).

Sustainable Production of Dakota Trailblazer

Andrew P. Robinson, Ryan Larsen, Asunta Thompson, Neil Gudmestad

Executive Summary

A trial was established in Becker, MN to determine the effect of different nitrogen rates and water on three potato cultivars (Russet Burbank, Dakota Trailblazer, and ND8068-5Russ). Three irrigation blocks were established to represent 50, 75, and 100% irrigation and within each block three cultivars and five nitrogen rates were implemented. The 75% irrigation regime totaled 16.66 inches, or 85% of the 100% irrigation regime. The 50% irrigation regime had total moisture of 14.23 inches, or 73% of the 100% irrigation regime. Across the irrigation rates Russet Burbank and Dakota Trailblazer tended to have the highest yield. Dakota Trailblazer had the highest percentage of tuber >6 oz when compared to the other cultivars. The addition of ESN increased yield when compared to no ESN. Total marketable yield was most profitable at the 75 and 100% irrigation regimes.

Introduction

The newly developed variety, Dakota Trailblazer has shown promise as a tablestock and frozen processing variety. Dakota Trailblazer is a long tuber type with medium russet skin with white flesh and a high yield potential. Additionally, Dakota Trailblazer has resistance to *Verticillium wilt*, sugar ends, and foliar late blight which may allow a reduction in the number of fungicide treatments and eliminate the need for fumigation. It also requires less nitrogen than Russet Burbank. Today's culture is concerned with how food is grown and minimizing inputs. Because of the traits Dakota Trailblazer possesses, further research needs to explore what is the relationship of Dakota Trailblazer when pesticides treatments are reduced, less nitrogen is applied, and smaller amounts of water are used for irrigation. The objectives of this study were to determine the effect of reduced nitrogen and irrigation rates and to quantify the cost of production for Dakota Trailblazer, Russet Burbank, and ND8068-5Russ.

Materials and Methods

Potatoes were planted May 10, 2013 at the Sand Plains Research Farm in Becker, MN. At the beginning of the experiment there was 20 lb/acre of available nitrogen in the soil. Three irrigation rate blocks were established with the intent to irrigate at 50, 75, and 100% normal field irrigation. Because rainfall also accounts for moisture, about two-thirds of the water needed for production was supplied through irrigation (Table 1). Within each irrigation regime a split-plot design was used. The main plot factor was cultivar (Russet Burbank, Dakota Trailblazer, and ND8068-5Russ) and the sub-plot was nitrogen rate (50, 90, 180, 270, and 360 lb N/acre).

Potassium was applied as 0-0-60 and 0-0-22 at 200 lb/a on April 29th. Following potassium application it was tilled in. Starter nitrogen was applied as urea at 50 lb N/acre on May 17th and lightly hilled in on the same day. Before re-hilling on May 24th, ESN was applied at 0, 40, 130, 220, and 310 lb N/acre. Seed from each cultivar was cut to an average size of 2 oz. All pesticides and other agronomic practices were completed according to recommended practices for potato production in Minnesota. Vines were chopped on September 5 and plots were harvested on September 12, 2013. Following harvest tubers were weighted and graded.

Data were analyzed in SAS Proc Mixed to test for significant effects of cultivar, nitrogen rate, and cultivar × nitrogen rate. Each irrigation regime was analyzed separately because they were not replicated. Additional years of research will provide replication of irrigation regime. Tukey pairwise comparison was used to determine if cultivar, nitrogen rate, and cultivar × nitrogen had a significant effect ($P \leq 0.05$) on graded yield and specific gravity.

Results and Discussion

Precipitation and irrigation

Total rainfall from May 10th to September 5th was 7.68 inches. When added to the total amount of irrigation the 100% irrigation regime had 19.48 inches of moisture for 2013 (Table 1). The 75% irrigation regime totaled 16.66 inches, or 85% of the 100% irrigation regime. And the 50% irrigation regime had total moisture of 14.23 inches, or 73% of the 100% irrigation regime.

Table 1. Total amount of moisture, through precipitation and irrigation on potatoes in 2013 in Becker, MN.

Irrigation regime	Precipitation	Irrigation	Total moisture	Percent of total moisture
	————	inches	————	%
100	7.68	11.8	19.48	100
75	7.68	8.98	16.66	85
50	7.68	6.55	14.23	73

Graded yield

Within each irrigation rate Russet Burbank and Dakota Trailblazer were top producing cultivars (Table 2). This was likely because ND8068-5Russ is an earlier maturing cultivar than Russet Burbank and Dakota Trailblazer. At 50 and 100% irrigation Russet Burbank and Dakota Trailblazer did not differ and total marketable yield, but at 75% irrigation Russet Burbank yielded 53 cwt/a more than Dakota Trailblazer. The higher yield was a result more tubers < 10 oz for Russet Burbank. However, at each irrigation rate, Dakota Trailblazer had the highest percentage of tubers > 6 oz when compared to Russet Burbank and ND8068-5Russ.

A general trend was observed as more nitrogen was applied, a higher percentage of tubers > 6 and > 10 oz was found at all irrigation regimes (Table 3). Total marketable yield at each irrigation regime had the lowest yield at 50 lb N/a as expected. In general, there was no response of nitrogen from 90 to 360 lb N/a for the yield components analyzed. This indicates that ESN did provide extra nutrition, but the ESN rate had minimal effect of yield. Specific gravity tended to decrease as nitrogen rate increased.

At 50% irrigation regime the cultivar × nitrogen rate interaction had no differences. The 75% irrigation rate had a small response for the cultivar × nitrogen interaction for tubers 4 to 14 oz, but there were no differences in the total marketable yield. In the 100% irrigation rate the cultivar × nitrogen rate did have an effect on the 4 to 10 oz tubers, tubers >1 4 oz, and on total marketable yield. The lowest yielding treatment was ND8068-5Russ × 50 lb N/a.

As expected, Russet Burbank was the highest yield cultivar in this trial. What is interesting is that although Dakota Trailblazer does not seem to have the yield capacity that Russet Burbank has, it produced fewer small tubers (< 6 oz) than Russet Burbank, and a higher percentage of Dakota Trailblazer tubers are above 6 and 10 oz.

Economic Analysis of Trailblazer

The trial results of each variety were used as an input into a crop budget simulation to analyze the impact on net returns to the farmer. Marketable yield was identified as the key variable as it is a key determinant is the farmer's bottom line. Table 5 provides a statistical summary of the marketable yields for each variety at the different nitrogen levels. Gross returns were defined as marketable yield multiplied by market price. Market price was taken from USDA average farmer price received for processing potatoes in Minnesota and North Dakota. Net returns were defined as net returns above operating expenses. Operating expenses were calculated using 2013 potato production budgets from University of Idaho. The budgets were adjusted to account for the differences between Minnesota and Idaho growing conditions.

In general ND8068-5Russ was the least profitable, followed up Dakota Trailblazer, and finally Russet Burbank. A 5.25 inch reduction in water was generally unprofitable. Most cultivars and nitrogen rates were profitable when a reduction of 2.82 inches of irrigation occurred. The 100% irrigation regime was profitable in most cases. Additional research will be performed in order to compare irrigation rates with nitrogen and cultivar.

Table 2. Response of graded yield of cultivars under different irrigation rates in 2013 in Becker, MN.

Cultivar	0-4 oz		4-6 oz		6-10 oz		10-14 oz		>14 oz		Total		Total marketable		>6 oz		>10 oz		Specific gravity	
	cwt/a														%					
50% of normal field irrigation																				
ND8068-5Russ	84	b[a]	88	b	60	b	10	b	1	b	246	b	161	b	29	b	4	b	1.0894	b
Russet Burbank	121	a	109	a	80	ab	34	a	14	a	358	a	237	a	34	b	12	ab	1.0820	c
Dakota Trailblazer	44	c	68	c	94	a	41	a	12	a	259	b	215	a	57	a	20	a	1.1035	a
75% of normal field irrigation																				
ND8068-5Russ	84	a	98	a	104	b	32	b	14	c	331	c	248	c	45	c	14	c	1.0818	b
Russet Burbank	91	a	114	a	140	a	88	a	55	b	487	a	397	a	57	b	28	b	1.0778	c
Dakota Trailblazer	28	b	63	b	114	b	88	a	79	a	372	b	344	b	75	a	45	a	1.0948	a
100% of normal field irrigation																				
ND8068-5Russ	70	b	106	a	117		49	c	19	b	361	b	291	b	50	b	18	c	1.0742	b
Russet Burbank	87	a	106	a	123		66	b	49	a	432	a	345	a	55	b	27	b	1.0726	b
Dakota Trailblazer	30	c	65	b	123		88	a	53	a	358	b	328	a	73	a	39	a	1.0899	a

[a] Within columns, at each irrigation rate, means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.05$). No letter following a value indicates no difference.

Table 3. Response of potato cultivars to nitrogen rate under three different irrigation rates in 2013 in Becker, MN.

Nitrogen	0-4 oz		4-6 oz		6-10 oz		10-14 oz		>14 oz		Total		Total marketable		>6 oz		>10 oz		Specific gravity	
lb N/acre	cwt/a														%					
50% of normal field irrigation																				
50	99	a[a]	94		56	b	16	b	4	b	269		170	b	28	c	7	c	1.0944	a
90	97	a	91		72	ab	18	b	5	b	282		186	ab	34	bc	8	bc	1.0932	a
180	80	ab	89		87	a	36	ab	13	ab	313		231	a	45	ab	16	ab	1.0909	ab
270	73	b	87		90	a	32	ab	5	b	287		214	ab	45	a	13	abc	1.0914	ab
360	65	b	81		86	a	42	a	19	a	292		227	a	49	a	20	a	1.0884	b
75% of normal field irrigation																				
50	85	a	99	ab	127		51	c	21	c	383		298	b	52	c	19	c	1.0881	a
90	77	ab	106	a	125		59	bc	31	bc	398		321	ab	54	bc	23	bc	1.0876	a
180	67	ab	92	ab	116		69	abc	57	ab	401		334	ab	60	ab	31	ab	1.0843	ab
270	61	bc	80	b	116		89	a	67	a	413		352	a	66	a	37	a	1.0834	b
360	45	c	79	b	113		79	ab	70	a	381		342	a	66	a	36	a	1.0814	b
100% of normal field irrigation																				
50	78	a	113	a	113	ab	37	b	9	d	350	c	272	b	45	b	13	d	1.0808	a
90	68	ab	104	ab	134	a	80	a	26	cd	414	a	345	a	58	a	25	c	1.0813	a
180	55	b	87	abc	127	ab	68	a	41	bc	378	bc	322	a	63	a	29	bc	1.0801	a
270	57	b	84	bc	122	ab	78	a	59	ab	400	ab	343	a	65	a	35	ab	1.0779	ab
360	54	b	73	c	110	b	78	a	68	a	379	abc	328	a	67	a	39	a	1.0745	b

[a] Within columns, at each irrigation rate, means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.05$). No letter following a value indicates no difference.

Table 4. Effect of cultivar × nitrogen rate three different irrigation rates in 2013 in Becker, MN.

Cultivar	Nitrogen	0-4 oz	4-6 oz		6-10 oz		10-14 oz		>14 oz	Total	Total marketable	>6 oz	>10 oz	Specific gravity
	lb N/acre	cwt/a										%		
50% of normal field irrigation														
ND[a]	50	104	89		43		3		0	238	135	19	1	1.0904
ND	90	92	85		50		1		0	228	136	23	0	1.0924
ND	180	84	94		62		13		4	278	185	30	5	1.0909
ND	270	64	76		80		19		0	239	174	41	8	1.0878
ND	360	74	96		67		17		1	255	180	33	7	1.0856
RB	50	138	112		45		12		7	314	176	19	6	1.0845
RB	90	149	115		69		21		7	362	213	26	7	1.0834
RB	180	110	114		100		39		13	375	266	40	14	1.0808
RB	270	121	109		81		33		4	347	226	33	10	1.0820
RB	360	87	95		107		65		37	391	304	53	25	1.0792
DT	50	56	81		81		32		4	255	198	46	14	1.1084
DT	90	49	73		96		33		7	257	208	52	15	1.1037
DT	180	47	59		99		50		22	277	230	62	26	1.1010
DT	270	35	76		109		45		12	276	241	60	21	1.1043
DT	360	34	52		83		44		18	231	196	63	27	1.1003
75% of normal field irrigation														
ND	50	102	99	abc[b]	89	b	24	e	4	318	216	37	9	1.0853
ND	90	94	103	abc	90	b	28	e	8	324	230	39	11	1.0842
ND	180	90	81	bcd	119	ab	35	de	15	339	249	50	15	1.0806
ND	270	73	101	abc	117	ab	47	cde	27	366	292	52	20	1.0794
ND	360	60	103	abc	106	ab	27	e	15	310	250	47	13	1.0795
RB	50	125	124	ab	147	ab	53	cde	16	466	340	47	15	1.0796
RB	90	103	144	a	156	a	59	b-e	23	485	382	49	17	1.0805
RB	180	78	122	ab	132	ab	101	abc	71	503	425	60	34	1.0795

RB	270	81	90	bcd	127	ab	127	a	74		501		419		65	40	1.0767
RB	360	58	88	bcd	139	ab	100	abc	90		481		418		68	38	1.0730
DT	50	28	73	cd	146	ab	76	a-e	42		365		338		72	32	1.0972
DT	90	33	72	cd	129	ab	91	a-d	62		386		353		73	40	1.0981
DT	180	33	73	cd	97	ab	72	a-e	85		360		327		70	43	1.0929
DT	270	28	49	d	105	ab	92	abc	99		373		345		79	51	1.0940
DT	360	20	45	d	95	b	111	ab	106		377		357		83	58	1.0917
100% of normal field irrigation																	
ND	50	82	104	b	90	b	20		5	e	300	f	218	c	37	8	1.0776
ND	90	73	122	b	106	b	44		14	e	358	c-f	286	bc	46	16	1.0743
ND	180	73	96	ab	134	ab	51		21	de	375	b-e	302	abc	55	19	1.0759
ND	270	65	107	ab	138	ab	79		21	de	410	a-d	346	ab	58	24	1.0743
ND	360	58	104	ab	118	ab	54		36	b-e	361	b-f	310	abc	54	24	1.0692
RB	50	113	137	b	112	b	38		12	e	412	a-d	300	abc	39	12	1.0746
RB	90	98	124	ab	134	ab	81		37	b-e	473	a	375	a	53	25	1.0770
RB	180	72	107	ab	130	ab	67		33	b-e	408	a-d	336	ab	56	25	1.0736
RB	270	79	88	ab	121	ab	63		74	abc	426	abc	346	ab	61	32	1.0694
RB	360	75	73	ab	119	ab	82		90	a	440	ab	365	ab	66	39	1.0684
DT	50	41	97	ab	139	ab	52		9	e	338	def	297	abc	58	18	1.0903
DT	90	35	68	a	162	a	116		28	cde	409	a-d	375	a	74	35	1.0927
DT	180	21	59	ab	117	ab	86		68	a-d	350	def	329	ab	77	44	1.0908
DT	270	26	58	b	106	b	92		80	ab	363	c-f	337	ab	77	48	1.0901
DT	360	27	42	b	93	b	92		78	ab	332	ef	304	abc	79	51	1.0859

[a] Abbreviation: Russet Burbank (RB), Dakota Trailblazer (DT), and ND8068-5Russ (ND).
[b] Within columns, at each irrigation rate, means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.05$). No letter following a value indicates no difference.

Table 5.

Cultivar	Nitrogen rate (lb N/acre)	Average Marketable Yield	Average Gross Returns	Average Net Returns above Operating Expenses
50 % of normal field irrigation				
ND[a]	50	134.89	$998.19	-$646.06
ND	90	135.91	$1,005.71	-$665.74
ND	180	185.28	$1,371.04	-$361.61
ND	270	174.39	$1,290.45	-$503.40
ND	360	180.19	$1,333.43	-$521.62
RB	50	176.13	$1,303.34	-$340.91
RB	90	212.57	$1,573.04	-$98.41
RB	180	265.86	$1,967.37	$234.72
RB	270	225.79	$1,670.82	-$123.03
RB	360	304.48	$2,253.18	$398.13
DT	50	198.49	$1,468.81	-$175.44
DT	90	208.36	$1,541.88	-$129.57
DT	180	229.71	$1,699.83	-$32.82
DT	270	240.74	$1,781.49	-$12.36
DT	360	196.46	$1,453.77	-$401.28
75 % of normal field irrigation				
ND	50	216.06	$1,598.83	-$45.42
ND	90	229.56	$1,698.75	$27.30
ND	180	249.16	$1,843.81	$111.16
ND	270	292.43	$2,164.00	$370.15
ND	360	250.32	$1,852.40	-$2.65
RB	50	340.38	$2,518.80	$874.55
RB	90	381.59	$2,823.73	$1,152.28
RB	180	424.86	$3,143.93	$1,411.28
RB	270	419.34	$3,103.10	$1,309.25

RB	360	417.74	$3,091.28	$1,236.23
DT	50	337.74	$2,499.24	$854.99
DT	90	352.69	$2,609.91	$938.46
DT	180	326.70	$2,417.58	$684.93
DT	270	345.00	$2,552.96	$759.11
DT	360	356.61	$2,638.92	$783.87
100 % of normal field irrigation				
ND	50	218.24	$1,614.94	-$29.31
ND	90	285.61	$2,113.50	$442.05
ND	180	302.16	$2,235.99	$503.34
ND	270	345.87	$2,559.41	$765.56
ND	360	309.95	$2,293.66	$438.61
RB	50	299.55	$2,216.65	$572.40
RB	90	375.20	$2,776.46	$1,105.01
RB	180	336.28	$2,488.50	$755.85
RB	270	346.46	$2,563.82	$769.97
RB	360	365.03	$2,701.24	$846.19
DT	50	296.79	$2,196.24	$551.99
DT	90	374.91	$2,774.31	$1,102.86
DT	180	328.59	$2,431.55	$698.90
DT	270	336.57	$2,490.64	$696.79
DT	360	304.48	$2,253.18	$398.13

[a] Abbreviation: Russet Burbank (RB), Dakota Trailblazer (DT), and ND8068-5Russ (ND).

Using Reduced Herbicide Rates to Control Buckwheat and Nightshade in Potatoes

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Executive summary:

Controlling broadleaf weeds postemergence in potato production is difficult because there are only two herbicides available, metribuzin and rimsulfuron. Nightshade is especially problematic because of its ability to act as an alternative host to many potato diseases, nematodes, and viruses. Reduced herbicide rates has been used in other crops to control multiple flushes of weeds and we wanted to test this method in potato production. A field was planted to Russet Burbank and herbicides treatments were applied preemergence and postemergence. Rates of metribuzin and rimsulfuron were switched and the thus too much rimsulfuron (2 to 8 oz/a) and too little metribuzin (0.02 to 0.09 lb/a) was applied. Because of this mistake we were able to analyze what would happen with an off label rate of rimsulfuron in potato. Weed control was better than 90% for all treated plots. Graded yield of treated plots was no different. This indicated that there was no difference of timing or rate of misapplication of rimsulfuron up to 8 oz/a.

Introduction

Nightshade and wild buckwheat populations are on the rise within a majority of potato acres in Minnesota and North Dakota. Nightshade is especially problematic because it acts as an alternative host to many potato diseases, nematodes, and viruses. It is also difficult to control because of its extended emergence pattern and density throughout the region. Previous research in other specialty crops has shown that multiple applications of reduced-rate herbicides can effectively control weeds. This project was designed to quantify the effect of multiple application timings and rates for weed control, while maintaining crop safety. The objectives were to determine the effect of treatment timings on season long nightshade control, quantify the effect of multiple applications of reduced-rates of rimsulfuron and metribuzin to control late emerging weeds, and to quantify the effect of treatments on crop tolerance and graded yield.

Materials and Methods

A field project was established in Perham, MN on a commercial field. Field preparation included fumigation with metam-sodium and spring chisel plow. Russet Burbank were planted on May 24, 2013 with 13 inch in-row spacing and 1 in below the soil level with a Logan cup planter. Soil temperature was 52 °F at planting. Emergence occurred on June 17. A randomized complete block arrangement of treatments was used with five replications.

All herbicide treatments were applied with a nine-foot CO_2 backpack sprayer calibrated to deliver 15 gal/acre. Treatments were metribuzin + rimsulfuron + the adjuvant Class Act NG and preemergence herbicides used were Chateau and metribuzin (Table 1). Herbicide application timings, dates, and rates are found in Table 1. Postemergence treatments occurred close to cotyledon formation of weed leaves. Plots were rated at 0, 14, and 28 days after treatment for estimated weed control ranging from 0 to 100. The middle 25 ft. row of each plot was harvested on September 26 with a single row plot harvester. Yield was graded at East Grand Forks, MN. Data were analyzed using SAS Proc Mixed to determine any significant effects of treatment. Tukey pairwise comparison was used to determine if herbicide treatment had a significant effect ($P \leq 0.05$) on weed control, crop tolerance, and graded yield.

Results

Rates of metribuzin and rimsulfuron were switched and the thus too much rimsulfuron and too little metribuzin was applied. Because of this mistake we were able to analyze what would happen with an off label rate of rimsulfuron in potato. The rates ranged from 2 to 8 oz/a of rimsulfuron, or 1.3 to 5.3x more than the labeled field use rate per treatment. All treated plots received a total of 8 oz/a rimsulfuron. The amount of metribuzin was much lower than labelled rates (Table 1).

Weed Control and Crop Tolerance

There was no crop injury observed from the treatments. This may be because of the tolerance of Russet Burbank to rimsulfuron and the ideal growing conditions at treatment timings. Because this trial was in a commercial field there was low weed pressure and densities varied throughout the plots making it difficult to gather meaningful weed control data. Weeds present were common lambsquarters, wild proso millet, and eastern black nightshade. Of the weeds observed, control averaged 90-100% for all treatments. This is likely a result of too much rimsulfuron, but it also indicated that Russet Burbank was able to tolerate high levels of rimsulfuron and the rimsulfuron + metribuzin rates were effective weed control in this commercial field.

Graded Yield

There was little differences found in graded yield. Total marketable yield and the percent of tubers > 6 oz indicated that the untreated check had reduced yield in some cases. Amongst herbicide treatments there was no difference in yield. It would have been ideal to have had a hand weeded check to compare. These data show that up to 8 oz/a rimsulfuron used at multiple timings and rates were no different than a single application on yield.

Table 1. Herbicide treatments used in the Perham, MN on Russet Burbank potatoes for weed control.

Treatment	Timing	Herbicide	Rate	Application date
1 (untreated)		-	-	-
2	B	Matrix	8 oz/a	June 25
		Metribuzin	0.09 lb/a	
		Class Act NG	2.5% v/v	
3	B	Matrix	4 oz/a	June 25
		Metribuzin	0.09 lb/a	
		Class Act NG	2.5% v/v	
	D	Matrix	4 oz/a	July 10
		Metribuzin	0.09 lb/a	
		Class Act NG	2.5% v/v	
4	B	Matrix	2.7 oz/a	June 25
		Metribuzin	0.03 lb/a	
		Class Act NG	2.5% v/v	
	C	Matrix	2.7 oz/a	July 2
		Metribuzin	0.03 lb/a	
		Class Act NG	2.5% v/v	
	D	Matrix	2.7 oz/a	July 10
		Metribuzin	0.03 lb/a	
		Class Act NG	2.5% v/v	
5	B	Matrix	2 oz/a	June 25
		Metribuzin	0.02 lb/a	
		Class Act NG	2.5% v/v	
	C	Matrix	2 oz/a	July 2
		Metribuzin	0.02 lb/a	
		Class Act NG	2.5% v/v	
	D	Matrix	2 oz/a	July 10
		Metribuzin	0.02 lb/a	
		Class Act NG	2.5% v/v	
	E	Matrix	2 oz/a	July 16
		Metribuzin	0.02 lb/a	
		Class Act NG	2.5% v/v	
6	A	Chateau	0.75 fl oz/a	June 13
		Metribuzin	0.6 lb/a	
	B	Matrix	4 oz/a	June 25
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
7	A	Chateau	0.75 fl oz/a	June 13
		Metribuzin	0.6 lb/a	
	B	Matrix	4 oz/a	June 25
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
	D	Matrix	4 oz/a	July 10
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
8	A	Chateau	0.75 fl oz/a	June 13
		Metribuzin	0.6 lb/a	
	B	Matrix	4 oz/a	June 25
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
	C	Matrix	4 oz/a	July 2
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
	D	Matrix	4 oz/a	July 10
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
9	A	Chateau	0.75 fl oz/a	June 13
		Metribuzin	0.6 lb/a	
	B	Matrix	4 oz/a	June 25
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
	C	Matrix	4 oz/a	July 2
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
	D	Matrix	4 oz/a	July 10
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	
	E	Matrix	4 oz/a	July 16
		Metribuzin	0.05 lb/a	
		Class Act NG	2.5% v/v	

Table 2. Graded yield affected by metribuzin + rimsulfuron on Russet Burbank potato in 2013 in Perham, MN.

Treatment	< 3 oz	3-6 oz	6-10 oz	10-14 oz	>14 oz	Total	#1s > 3 oz	#2s > 3 oz	Total marketable		> 6 oz		> 10 oz
	cwt / acre										%		
1	49	128	83	24	6	286	237	26	263	b	36	b	9
2	36	147	159	60	12	412	376	40	416	a	56	a	18
3	40	148	156	46	12	403	363	34	397	ab	53	ab	15
4	35	131	124	37	11	330	295	36	330	ab	49	ab	12
5	34	119	126	31	11	315	280	46	326	ab	51	ab	12
6	34	107	135	54	21	342	308	43	351	ab	59	a	19
7	32	109	104	48	11	302	270	43	313	ab	52	ab	19
8	34	109	143	49	17	348	314	31	345	ab	60	a	18
9	30	123	132	37	17	328	298	35	333	ab	52	ab	13

[a] Within columns means followed by the same letter are not significantly different according to Tukey pairwise comparison ($P \leq 0.1$).

Evaluation of Crystal Green as a Phosphate Source for Irrigated Potatoes

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Summary: A field experiment was conducted at the Sand Plain Research Farm in Becker, MN to evaluate potato response to the slow-release phosphorus (P) source Crystal Green (CG) and to measure the rate of P release from CG during the growing season. Twelve P treatments were used to compare CG with the commonly used P fertilizer monoammonium phosphate (MAP), evaluate combinations of the two P sources, and determine the effects of P source, rate, and application timing on Russet Burbank yield, tuber quality, and petiole P and Mg concentrations. The P in CG was released in two phases, which released P at different rates. In the first phase, about 35% of the total P was released in the first 7 days and a little over 40% by day 16. Very little P was released in the next 30 days, followed by a gradual release of additional P resulting in a 55% release of the total amount of P by the time of tuber harvest. There were no significant differences among treatments in either total tuber yield or marketable yield, but there were significant differences in tuber size due to P source, rate, and timing. The P source CG generally had lower yields of 0-3 oz tubers and higher percentages of >6 oz tubers than the P source MAP. These results were consistent with the slow release of P from CG, the more readily available P from MAP, and the increase in tuber set and greater numbers of small tubers that can result from higher levels of P nutrition. Similar effects on tuber size from differences in P rate and timing may also have been due to differences in P availability affecting tuber set, but the effects of P rate and application timing on tuber size were inconsistent. Petiole P was within the sufficiency range (>0.22% P) on every sampling for every treatment, which was consistent with the lack of a yield response from any P treatment. There were significant differences in petiole P that were consistent with reduced availability of P from CG, but these effects were not completely uniform. Except for a few marginally low concentrations on the 1st sampling date, petiole Mg was also within or above the sufficiency range for every treatment on every sampling date. Crystal Green is 10% Mg, so it is a slow release Mg source and this played a role in significant differences in petiole Mg. Results weren't entirely consistent, but the groups with the highest petiole Mg tended to be dominated by MAP treatments that were also fertilized with soluble Mg sources, and the groups with the lowest petiole Mg tended to be dominated by slow release CG treatments. Comparison of initial and post-harvest soil tests showed that there was a 5 ppm drawdown in soil test P in the zero P control plots from a potato crop with an average total yield of 382 cwt/A.

Background: Crystal Green (CG) is a slow-release P fertilizer recovered from the effluent of anaerobically digested sewage sludge at wastewater treatment plants. Struvite is a phosphate mineral ($MgNH_4PO_4 \cdot 6H_2O$) that can naturally precipitate from constituents in the wastewater stream. Ostara Nutrient Recovery Technologies, Inc. has developed technology to maximize the crystalization process and also permits recovery of struvite in a relatively pure, granular form. The P is citrate soluble and therefore plant available, although struvite (Crystal Green) is much less water soluble than conventional phosphate fertilizers resulting in its slow-release properties. Crystal Green provides the plant nutrients N and Mg in addition to P, and has a fertilizer grade of about 5-28-0-10Mg. It has shown potential as a P fertilizer, but additional research is needed to determine optimum management for its use on a wider variety of crops.

The objectives of this study were to: 1) evaluate potato response to CG as a P fertilizer and compare it with standard practices using monoammonium phosphate (MAP), 2) compare the effects of application rate and timing on the two P sources, 3) evaluate the effectiveness of combined applications of CG and MAP using different proportions of the two P fertilizers, and 4) determine the release rate of P from CG over the growing season.

Materials and Methods

This study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand soil. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6"): pH, 6.0; organic matter, 2.5%; Bray P1, 21 ppm; ammonium acetate extractable K, Ca, and Mg, 147, 705, and 122 ppm, respectively; Ca-phosphate extractable SO_4-S, 3 ppm; hot water extractable B, 0.3 ppm; and DTPA extractable Fe, Mn, Cu, and Zn, 48, 52, 0.7, and 1.6 ppm, respectively. Extractable nitrate-N in the top 2 ft of soil was 16.8 lb/A.

Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole "B" seed of Russet Burbank potatoes were hand planted in furrows on May 9, 2013. Row spacing was 12 inches within each row and 36 inches between rows. Each treatment was replicated four times in a randomized complete block design. Belay for beetle control and the systemic fungicide Quadris were banded at row closure. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Twelve P treatments varying in phosphate source, rate, and application timing were tested as described in Table 1 below: phosphate sources included CG, MAP, and combinations containing different proportions of the two sources; rates used were 0, 75, and 100 lb P_2O_5/A; and phosphate was applied preplant in three treatments and at planting in eight of the treatments. Preplant P was broadcast and incorporated to a depth of 3 to 4 inches with a field cultivator on May 6. Phosphate applied at planting was banded 3 inches to each side and 2 inches below the seed piece using a metered, drop fed applicator.

All treatments received a total of 240 lb N/A, which included 30 lb N/A applied preplant and/or at planting and 210 lb N/A applied at emergence/hilling. Preplant/planting N was supplied as a combination of the N included in the P source and urea. For example, Treatment #4 (Table 1) received 9 lb N/A from CG, 11 lb N/A from MAP, and 10 lb N/A from urea. All urea-N was banded at planting as described above for the treatments where P was applied at planting. Emergence N applications were supplied as ESN and mechanically incorporated during hilling on June 4.

In addition to N and P, additional nutrients were included in the banded fertilizer at planting to adjust for imbalances and ensure adequate fertility among all treatments. Because of the Mg in CG, potassium-magnesium sulfate (0-0-22-22S-11Mg) was added to the planting blend as necessary, so that all treatments received a minimum of 20 lb Mg/A. Treatments that did not receive potassium-magnesium sulfate (or low rates of it), were supplemented with potassium sulfate (0-0-50-17S) to ensure that all treatments received a minimum of 21 lb S/A. Potassium chloride (0-0-60) was used to balance the K applied in potassium-magnesium sulfate and K-sulfate, so that all treatments received 71 lb K_2O/A. All treatments also received 2.0 lb Zn/A applied as zinc sulfate and zinc hydroxide (EZ 20) and 1.0 lb B/A from sodium tetraborate (Granubor 2) in the banded fertilizer at planting.

In addition to the K applied at planting, all treatments received preplant applications of 164 lb K_2O/A for a total rate of 235 lb K_2O/A. This was supplied as a combination of potassium chloride and potassium-magnesium sulfate, which was broadcast on Apr 29 and incorporated with a chisel plow on Apr 30. The potassium-magnesium sulfate also supplied an additional 44 lb S/A and 22 lb Mg/A to each treatment.

Measured amounts of CG were placed in plastic mesh bags and buried at the same depth as P fertilizer placement on May 13. Bags were removed on May 20, May 29, Jun 3, Jun 10, Jun 25, Sep 3, and Oct 1. Remaining amounts of CG were measured for each date to track P release over time. Plant stands were measured on June 18 and stem number per plant on July 8. Petiole samples were collected from the 4^{th} leaf from the terminal on four dates: June 28, July 9, July 23, and Aug 7. Petioles were analyzed for P and Mg on a dry weight basis. Vines were killed by mechanical beating on Sept 24 and tubers were machine harvested on Oct 1. Two, 18-ft sections of row were harvested from each plot. Total tuber yield and graded yield were measured. Sub-samples of tubers were collected to determine tuber specific gravity, tuber dry matter, and the incidence of hollow heart, brown center, and scab. Post-harvest soil samples were collected on Oct 17 from the 0 to 6 inch depth of the four control (zero P) plots and analyzed for P to evaluate the effect of crop P removal on soil test P.

Table 1. Phosphate treatments tested on irrigated Russet Burbank potatoes.

Treatment #	Phosphate rate (lbs P_2O_5/ac)	Phosphate source[1]	Application timing
1	0	None	None
2	100	Crystal Green	Planting
3	100	MAP	Planting
4	100	50%CG / 50%MAP	Planting
5	75	Crystal Green	Planting
6	75	75%CG / 25%MAP	Planting
7	75	50%CG / 50%MAP	Planting
8	75	25%CG / 75%MAP	Planting
9	75	MAP	Planting
10	100	MAP	Preplant
11	75	MAP	Preplant
12	100	Crystal Green	Preplant

[1]Crystal Green (CG), Ostara Nutrient Recovery Technologies, Inc: 5-28-0-10Mg.
MAP (monoammonium phosphate): 10-50-0.

Results

Phosphorus Release from Crystal Green: Fig. 1 shows the rate of P release over the growing season from CG. The CG was in plastic mesh bags that were buried in the soil at the same depth as fertilizer incorporation, seven days after preplant treatments were incorporated and four days after P was banded at planting.

The P release curve shows that the P in CG can be described as consisting of two pools of P that are released at different rates. The first pool is released fairly quickly: about 35% of the total P in the first 7 days and a little over 40% by day 16. Following this initial phase, very little P is released until at least day 43. After day 43 the more stable pool of P begins to slowly release more P. This transition is probably at least partially controlled by increasing temperatures from early to mid-summer. The stable period of limited P release may be longer than shown on the graph, due to a lack of reliable samples for an extended period. From about day 43 until day 113 about 10% more of the total P is slowly released, followed by an additional 5% in the next 4 weeks until close to the time of harvest on day 141. This brings the P release for the growing season to just over 55% of the total P in CG. However, using the mesh bag technique may be underestimating release rates because for P to be released from CG a diffusion gradient needs to be established. The mesh bag will likely prevent this gradient from being established thereby reducing dissolution of the CG. Nonetheless, this release curve clearly suggests that there is a soluble pool from CG followed by a less soluble pool.

Tuber Yield and Size Distribution: Table 2 shows the effects of P source, rate, and application timing on tuber yield and size distribution. There were no significant differences among treatments in either total tuber yield or marketable yield. However, while not statistically significant, combinations of banded CG and MAP tended to result in numerically higher total and marketable yield than banded CG or MAP alone. Varying the percentage of CG vs. MAP when they were used in combination as a P source had no significant effect on tuber size, but there were a number of significant differences in tuber size due to other differences in P source, rate, and timing. Previous research has shown that P nutrition can affect tuber size through its effect on tuber set. Increased P increases set, which results in more tubers, but they are smaller in size. Differences among treatments in the amount of available P at the time of tuber initiation may have led to some of the observed differences in tuber size in this study.

The zero P control and the 100 lb P_2O_5/A preplant CG treatment had significantly lower yields of 0-3 oz tubers than all of the other treatments. They also had higher percentages of tubers in the >6 oz size class than all of the other treatments, and significantly higher percentages of >6 oz tubers than any of the treatments that had MAP as their sole P source. These results are consistent with limited P availability at the time of tuber set from the zero P control and the 100 lb P_2O_5/A preplant CG treatments, as well as being consistent with the most rapid P availability among the treatments studied from those with all their P supplied as MAP. Another way to evaluate these P availability effects on tuber size is to examine the 100 lb P_2O_5/A preplant MAP treatment, which should have had the largest amounts of immediately available P. This treatment had significantly greater yields of undersized 0-3 oz tubers than all of the other treatments. It also had a lower percentage of tubers in the >6 oz size class than all of the other treatments, and a significantly lower percentage of >6 oz tubers than all but one of the treatments that received any of their P as CG. These effects on tuber size and increased tuber set resulted in the 100 lb P_2O_5/A preplant MAP treatment having a numerically lower marketable yield than any of the other treatments, although none of these differences were statistically significant. In contrast, the 100 lb P_2O_5/A preplant CG resulted in numerically lowest total yield due to reduced tuber set.

Application rate and timing also had significant effects on tuber size, although the effects were inconsistent. For MAP, preplant application of 100 lb P_2O_5/A produced significantly greater yields of 0-3 oz tubers than preplant application of 75 lb P_2O_5/A. Preplant application of 100 lb P_2O_5/A from MAP also produced significantly greater yields of 0-3 oz tubers and a significantly lower percentage of tubers in the >6 oz size class than the same rate of P from MAP applied at planting. In both these comparisons, one possibility is that the higher P rate in one case and the earlier P application in the other led to higher amounts of available P at tuber initiation and caused the production of greater yields of small tubers. However, similar differences in tuber size did not occur between the 75 and 100 lb P_2O_5/A rates of MAP when they were applied at planting. And significant differences in tuber size also did not occur for preplant vs. planting comparisons of MAP when it was applied at 75 lb P_2O_5/A.

For CG, preplant application of 100 lb P_2O_5/A produced significantly lower yields of 0-3 oz tubers than the same rate of P from CG applied at planting. Given the slow release characteristics of CG (Fig. 1), earlier application to produce higher amounts of available P at tuber initiation and cause the production of greater yields of small tubers might be expected. A possible reason for the opposite outcome is that the banded application at planting resulted in a higher P concentration in the root zone at the time of tuber initiation than the earlier, but more diffuse placement of the P that was broadcast and then incorporated before planting.

Tuber Quality, Stand Count, and Stems per Plant: Table 3 shows the effects of P source, rate, and application timing on tuber quality, plant stand, and number of stems per plant. There were no significant differences among treatments in tuber specific gravity, incidence of hollow heart, brown center, or scab, tuber dry matter, and the number of stems per plant. Crystal Green applied at 100 lb P_2O_5/A preplant had significantly lower plant stand than every treatment except the 25% CG / 75% MAP application of 75 lb P_2O_5/A at planting, which was also significantly lower than six of the other treatments. However, these stand differences were relatively small, ranging from 97.9 to 100%, and possible effects on yield were not consistent. The treatment with the lowest stand did have the numerically lowest total yield, but the second lowest stand had the second highest total yield. It is not clear how the two treatments lowest would have had detrimental effects on emergence compared with other similar treatments.

Petiole P and Mg Concentrations: Table 4 shows the effects of P source, rate, and application timing on petiole P and Mg concentrations on four dates. The sufficiency range for petiole nutrient concentrations in potatoes has been established for petioles collected from the fourth leaf below the terminal, as sampled in this experiment, and using petioles sampled 40-50 days after emergence. The sampling dates in Table 4 were 24, 35, 49, and 64 days after emergence.

The sufficiency range for P is 0.22-0.40% and on every sampling date petiole P was within this range for every treatment. This is consistent with the lack of a yield response to P in this experiment (Table 2). Concentrations were in the lower half of the sufficiency range, tended to gradually decrease over the sampling period, and the zero P control was lowest or tied for the lowest on the first three dates and tied for second lowest on the final date.

On the 1st and 3rd sampling dates there were no significant differences among any of the treatments; although the control was the lowest or tied with the lowest petiole P concentration on both dates. Significant differences did occur on the 2nd and 4th dates, but they were relatively small and there was no consistent pattern among P sources, rates, or timing. On the 2nd date the highest treatment was the 100 lb P_2O_5/A preplant MAP treatment, consistent with its early application timing and early availability. The three lowest had CG as the sole or major P source, consistent with their slow release nature (Fig. 1). But the fourth lowest was the 100 lb P_2O_5/A MAP at planting treatment, which had a P concentration that was only 0.01% higher than the three CG treatments. On the 4th sampling date, the 100 lb P_2O_5/A preplant CG treatment and the 100 lb P_2O_5/A preplant treatment with 50% MAP/50% CG as the P source were tied for the highest petiole P concentration. The four treatments tied for the lowest P concentration were: zero P control, 75 lb P_2O_5/A preplant with 50% MAP/50% CG as the P source, 75 lb P_2O_5/A MAP at planting, and 100 lb P_2O_5/A preplant MAP.

The sufficiency range for Mg is 0.30-0.55% and except for five treatments on the 1st sampling date (which ranged from 0.27 to 0.29%), petiole Mg was within or above this range for every treatment on every sampling date. Magnesium concentrations were measured to evaluate availability of the Mg in CG, which is 10% Mg. Consistent with its Mg content and the slow-release pattern of the P in CG (Fig. 1), the treatments with CG as the major P source generally showed their greatest increases in petiole Mg in the last part of the sampling period. In contrast the treatments with MAP as the major P source, which were fertilized with more soluble forms of Mg, tended to reach relatively higher Mg concentrations earlier than CG. Over the sampling period, petiole Mg increased 2- to 3-fold for every treatment and the CG only treatments averaged a 3-fold increase.

On the 1st and 4th sampling dates there were no significant differences in petiole Mg among any of the treatments, but significant differences did occur on the 2nd and 3rd dates. On these dates the patterns weren't entirely consistent, but the groups with the highest petiole Mg tended to be dominated by MAP treatments that were accompanied by readily available Mg sources and the groups with the lowest petiole Mg tended to be dominated by slow release CG treatments. On the 2nd sampling date the four treatments with the highest petiole Mg were: 100% MAP, 50% MAP/50% CG, 75% MAP, and 100% MAP; and the four treatments with the lowest petiole Mg were: 75% CG, 100% CG, zero P control, and 50% MAP/50% CG. On the 3rd sampling date the four treatments with the highest petiole Mg were: 100% MAP, 75% MAP, 100% MAP, and 50% MAP/50% CG; and the four treatments with the lowest petiole Mg were: 75% CG, 50% MAP/50% CG, zero P control, and 100% CG.

Soil Test P: Initial soil tests found a field average of 21 ppm P (Bray P1) for the 0 to 6 inch soil depth. The recommended P rate for this soil test level and a yield goal of 500 cwt/A is 100 lb P_2O_5/A, which was the high rate used in this study. For the growing conditions in this field in

2013, there was no yield response to applied P. The highest total yield of any treatment was 436 cwt/A, so yield may have been limited by some factor other than P and thus limited any potential response to P fertilization.

Post-harvest soil samples were collected from the 0 to 6 inch depth of the four zero P control plots and analyzed for P to evaluate the effect of P removal by the harvested tubers on soil test P. The field average based on these four plots was 16 ppm. This change from the initial field average shows there was a 5 ppm drawdown in soil test P from a potato crop with a total yield of 382 cwt/A (Table 2).

Conclusions

The P in CG was released in two phases, reflecting pools of P that were released at different rates. In the first phase, about 35% of the total P was released in the first 7 days and a little over 40% by day 16. Very little P was released in the next 30 days, followed by a gradual release of additional P resulting in a 55% release of the total amount of P by the time of tuber harvest. Due to its slow release characteristics, combinations of CG and MAP might result in its most effective use compared with using CG as the sole P source. In addition, banded applications of CG and MAP appeared to be more effective than preplant broadcast applications.

There were no significant differences among treatments in either total tuber yield or marketable yield, but there were significant differences in tuber size due to P source, rate, and timing. The P source CG generally had lower yields of 0-3 oz tubers and higher percentages of >6 oz tubers than the P source MAP. These results were consistent with the slow release of P from CG, the more readily available P from MAP, and the increase in tuber set and greater numbers of small tubers that can result from higher levels of P nutrition.

Petiole P was within the sufficiency range on every sampling date for every treatment, which was consistent with the lack of a yield response from any P treatment. There were significant differences in petiole P that were consistent with reduced availability of P from CG, but these effects were not completely uniform. Except for a few marginally low concentrations on the 1st sampling date, petiole Mg was also within or above the sufficiency range for every treatment on every sampling date. Crystal Green is 10% Mg, but similar to P it appeared to be a slow release source of Mg as reflected by differences among treatments in petiole Mg.

Comparison of initial and post-harvest soil tests showed that there was a 5 ppm drawdown in soil test P in the zero P control plots from a potato crop with an average total yield of 382 cwt/A.

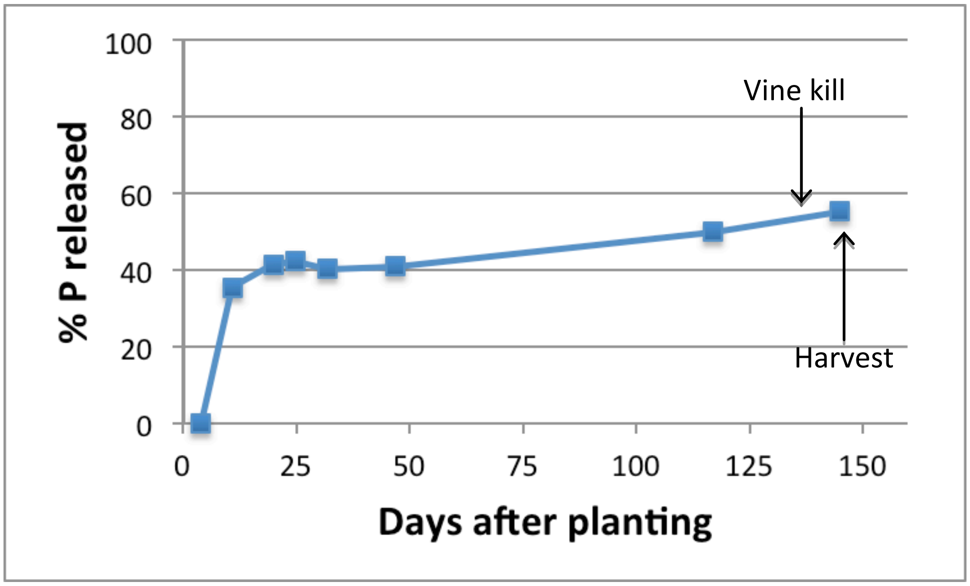

Fig. 1. Phosphorus release from Crystal Green granules placed at the same depth as fertilizer incorporation four days after planting.

Table 2. Effect of phosphate source, rate, and application timing on Russet Burbank tuber yield and size distribution.

Treatment				Tuber yield										
Treatment #	Phosphate rate (lbs P_2O_5/ac)	Phosphate source[1]	Application timing	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	#1s > 3 oz	#2s > 3 oz	Total marketable	> 6 oz	> 10 oz
				cwt / ac									%	
1	0	None	None	55.4	82.6	120.3	74.6	49.3	382.2	268.0	58.9	326.9	63.3	31.1
2	100	Crystal Green	Planting	70.2	95.0	136.5	61.5	41.8	405.1	266.4	68.5	334.9	58.7	25.0
3	100	MAP	Planting	85.2	104.1	103.7	66.0	36.4	395.3	242.1	68.1	310.2	51.7	25.8
4	100	50%CG / 50%MAP	Planting	76.2	106.5	108.6	61.8	40.6	393.7	263.7	53.8	317.5	53.6	25.9
5	75	Crystal Green	Planting	74.3	100.6	110.8	83.3	36.3	405.1	262.0	68.9	330.9	56.3	29.1
6	75	75%CG / 25%MAP	Planting	72.1	97.9	103.1	72.3	68.1	413.4	279.0	62.3	341.3	58.6	33.7
7	75	50%CG / 50%MAP	Planting	87.6	128.2	122.2	57.5	40.4	435.9	296.8	51.5	348.3	50.7	22.7
8	75	25%CG / 75%MAP	Planting	72.9	99.5	119.2	75.1	54.2	421.0	285.0	63.1	348.1	59.0	30.5
9	75	MAP	Planting	84.2	112.5	103.3	62.5	42.8	405.3	254.5	66.6	321.1	51.1	25.9
10	100	MAP	Preplant	103.8	107.6	96.9	43.3	26.2	377.8	220.3	53.6	274.0	43.5	18.0
11	75	MAP	Preplant	87.8	119.4	118.6	46.6	35.1	407.6	258.6	61.2	319.8	48.1	19.1
12	100	Crystal Green	Preplant	54.2	88.8	118.6	58.9	46.1	366.6	255.3	57.2	312.4	60.8	28.5
			Significance[2]	**	++	NS	NS	NS	NS	NS	NS	NS	**	NS
			LSD (0.1)	14.9	28.3	--	--	--	--	--	--	--	8.2	--

[1]Crystal Green (CG), Ostara Nutrient Recovery Technologies Inc: 5-28-0-10Mg. MAP (monoammonium phosphate): 10-50-0.

[2]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 3. Effect of phosphate source, rate, and application timing on Russet Burbank tuber quality, plant stand, and number of stems per plant.

Phosphate treatments				Tuber quality					Plant stand	Stems per plant
Treatment #	Phosphate rate (lbs P_2O_5/ac)	Phosphate source[1]	Application timing	Specific gravity	Hollow heart	Brown center	Scab	Dry matter		
					%					
1	0	None	None	1.0769	8	12	0	21.9	99.3	4.1
2	100	Crystal Green	Planting	1.0783	13	13	0	21.3	100.0	3.9
3	100	MAP	Planting	1.0793	13	12	0	21.5	100.0	4.1
4	100	50%CG / 50%MAP	Planting	1.0766	19	21	0	20.6	99.3	3.4
5	75	Crystal Green	Planting	1.0740	7	7	1	21.7	100.0	3.6
6	75	75%CG / 25%MAP	Planting	1.0842	11	15	2	20.8	99.3	3.9
7	75	50%CG / 50%MAP	Planting	1.0780	11	11	1	21.0	100.0	4.3
8	75	25%CG / 75%MAP	Planting	1.0784	14	15	0	21.6	98.6	3.6
9	75	MAP	Planting	1.0768	13	12	1	21.3	100.0	4.1
10	100	MAP	Preplant	1.0815	17	18	2	22.8	100.0	4.2
11	75	MAP	Preplant	1.0811	13	14	0	21.8	100.0	4.0
12	100	Crystal Green	Preplant	1.0758	14	16	2	20.8	97.9	3.3
			Significance[2]	NS	NS	NS	NS	NS	*	NS
			LSD (0.1)	--	--	--	--	--	1.4	--

[1]Crystal Green (CG), Ostara Nutrient Recovery Technologies Inc: 5-28-0-10Mg. MAP (monoammonium phosphate): 10-50-0.

[2]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 4. Effect of phosphate source, rate, and application timing on petiole phosphorus and magnesium concentrations on four sampling dates.

Phosphate treatments				Petiole P				Petiole Mg			
Treatment #	Phosphate rate (lbs P_2O_5/ac)	Phosphate source[1]	Application timing	28-Jun	9-Jul	23-Jul	7-Aug	28-Jun	9-Jul	23-Jul	7-Aug
				%							
1	0	None	None	0.22	0.23	0.26	0.24	0.27	0.43	0.72	0.88
2	100	Crystal Green	Planting	0.28	0.25	0.26	0.26	0.34	0.53	0.85	0.94
3	100	MAP	Planting	0.31	0.24	0.27	0.25	0.32	0.58	0.92	0.90
4	100	50%CG / 50%MAP	Planting	0.29	0.25	0.27	0.27	0.36	0.65	0.88	0.79
5	75	Crystal Green	Planting	0.27	0.25	0.28	0.24	0.28	0.50	0.75	0.86
6	75	75%CG / 25%MAP	Planting	0.31	0.23	0.26	0.25	0.27	0.37	0.69	0.79
7	75	50%CG / 50%MAP	Planting	0.30	0.26	0.26	0.24	0.29	0.47	0.72	0.82
8	75	25%CG / 75%MAP	Planting	0.31	0.27	0.28	0.25	0.32	0.60	0.90	0.93
9	75	MAP	Planting	0.32	0.25	0.28	0.24	0.34	0.52	0.77	0.72
10	100	MAP	Preplant	0.28	0.30	0.26	0.25	0.36	0.66	0.89	0.90
11	75	MAP	Preplant	0.31	0.26	0.26	0.23	0.36	0.57	0.87	0.95
12	100	Crystal Green	Preplant	0.27	0.23	0.28	0.27	0.29	0.43	0.81	0.91
			Significance[2]	NS	**	NS	++	NS	*	*	NS
			LSD (0.1)	--	0.03	--	0.03	--	0.17	0.17	--

[1]Crystal Green (CG), Ostara Nutrient Recovery Technologies Inc: 5-28-0-10Mg. MAP (monoammonium phosphate): 10-50-0.

[2]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Evaluation of StollerUSA Products on Potato Yield and Quality

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Summary: A field experiment at the Sand Plain Research Farm in Becker, MN was conducted in 2013 to evaluate the effects of products (Stimulate® 2-0-3, Seed Power®, X-Cyte®, BioForge®, Nitrate Balancer®, Nitro Plus 9®, STO-33® and Sugar Mover®) manufactured by Stoller USA on Russet Burbank potato tuber yield and quality. A comparison was made between a standard practices control and treatments that included the standard control plus the Stoller products in various combinations. Under the conditions of this study, the use of the Stoller products in various combinations did not significantly affect tuber yield or size distribution compared with the control. Many of the Stoller products are formulated to help the plant withstand stress; however, under irrigated conditions on a sandy soil, there was little water stress during the growing season.

Background: StollerUSA products are a proprietary blend of compounds intended to increase crop yields. Bio-Forge (2-0-3) contains compounds that are supposed to up-regulate genes that enhance tolerance to drought and other stresses. Nitro Plus 9 (9-0-0, 9% Ca, 0.1% B) is a liquid form of nitrogen containing amine nitrogen, calcium, and boron. Sugar Mover is intended to redirect the flow of sugars in plants from the vegetative parts (leaves) to the fruiting parts of plants to increase yields. Stimulate is intended to enhance plant growth and yield; reduce damage from nematodes; promote increased root growth and downward rooting, seedling vigor, and reproductive growth to facilitate higher yields. X-Cyte is intended to increase fertility in high temperatures during the stressful pollination or flowering period and up-regulate key genes associated with sugar transport. Nitrate Balancer is a product containing boron and molybdenum. STO-33 is an experimental compound for use in crop production. In this study, we compared a conventional fertilizer control and various combinations of the eight Stoller products on potato yield and quality.

The objective of this study was, under field conditions, to evaluate the effect of Stoller products on yield and quality of Russet Burbank potato.

Materials and Methods

The study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand using the potato cultivar Russet Burbank. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6"): water pH, 6.5; organic matter, 1.9%; Bray P1, 39 ppm; ammonium acetate extractable K, Ca, and Mg, 150, 743, and 125 ppm, respectively; Ca-phosphate extractable SO_4-S, 2 ppm; DTPA extractable Zn, 1.2 ppm; and hot water extractable B, 0.2. Extractable nitrate-N in the top 2 ft of soil was 7.3 lb/A.

Whole "B" seed was hand planted in furrows on May 6, 2013. Four, 20 ft rows were planted for each plot with 18 ft of each of the middle two rows used for sampling and harvest. Spacing was 36 inches between rows and 12 inches within each row. Six treatments were replicated four times in a randomized complete block design. Weeds, diseases, and insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling. The six treatments tested are listed below (Table 1).

A starter fertilizer containing 30 lb N/A, 130 lb P_2O_5/A, 181 lb K_2O/A, 20 lb Mg/A, and 46 lb S/A as a blend of ammonium phosphate (MAP), potassium chloride, potassium magnesium sulfate, and ammonium sulfate were applied to all plots at planting. In addition, the Stimulate component was applied at planting at a rate of 1 oz per cwt of potatoes to treatments 2, 4, and 6. Seed power was applied in furrow to treatments 3 and 5 at the rate of 2 oz/A at planting. Nitrogen was sidedressed at the rate of 170 lb N/A as polymer-coated urea (ESN, Agrium Inc.) and mechanically incorporated at emergence on June 3 to all treatments. On June 28, Bio-Forge was applied at 16 oz/A to treatment 6 as a foliar application. STO 33 was applied as a foliar application at 16 oz /A on June 28 and July 11 to treatment 5. Nitrate Balancer was applied at 32 oz/A and X-Cyte applied at 16 oz/A on August 30 to treatment 4. Nitro Plus 9 was applied to treatment 6 at the rate of 20 gal/A on July 2 and July 17. An equivalent rate of N was applied to all treatments that did not receive Nitro Plus 9 as urea-ammonium nitrate (UAN) on the same dates. Following the N applications, irrigation was applied to simulate fertigation. On August 30, Sugar Mover was applied to treatment 6 at the rate of 64 oz/A.

Table 1. StollerUSA treatments tested in the Russet Burbank yield and quality study.

Treatment #	Stimulate or Seed Power[1]	Nitrate Balancer + X-Cyte[2]	STO-33[3]	BioForge, Nitro Plus 9, Sugar Mover[4]
1	Neither	No	No	No
2	Stim	No	No	No
3	SP	No	No	No
4	Stim	Yes	No	No
5	SP	No	Yes	No
6	Stim	No	No	Yes

[1]Stim: Stimulate, applied as seed treatment (1 oz/cwt). SP: Seed Power, applied in furrow (2 oz/ac).

[2]Nitrate Balancer: 32 oz/ac. X-Cyte: 16 oz/ac. (August 30)

[3]STO-33: 16 oz/ac at bud break (June 28), 16 oz/ac 14 days later (July 11).

[4]Bio-Forge (16 oz/ac June 28). N+9: Nitro Plus 9 (20 gal/ac - July 2, 20 gal/ac - July 17).
Sugar Mover (64 oz/ac) (August 30).

Plant stands stems per plant were measured on July 3. Petiole samples were collected from the 4th leaf from the terminal on June 24, July 8, July 24, and August 7. Petioles were analyzed for nitrate-N on a dry weight basis. On September 25, vines were killed via mechanical beating. Plots were machine-harvested on October 1 and total tuber yield, graded yield, tuber specific gravity, and the incidence of scab, hollow heart, and brown center were measured. Subsamples were sent to the USDA East Grand Forks Potato Work Station for frying. The fried samples were sent back to the U of M Mass Spectroscopy lab for acrylamide analysis.

All trials of the experiment were statistically analyzed using GLM procedures on SAS and means were separated using a Waller-Duncan LSD test at $P = 0.10$.

Results

Rainfall and irrigation amounts are presented in Figure 1. The 2013 growing season was wet early in the season but dry after June.

Tuber Yield and Size Distribution: Total yields, marketable yields and tuber size distribution were not significantly affected by treatment (Table 1).

Petiole Nitrate-N Concentrations, Plant Stand and Stems per Plant: Petiole nitrate concentrations were not affected by treatment on any of the sampling dates (Table 2). Plant stand and stems per plant were also not affected by treatment.

Tuber Quality: Specific gravity was significantly highest in the conventionally fertilized treatment (Table 3). Stoller products tended to result in lower specific gravity readings, although Tuber dry matter was not affected by treatment. Hollow heart and brown center were not affected by treatment. Scab incidence was highest in the control with no incidence of scab in the treatments with Stoller products.

Tuber Acrylamide Content: Tuber acrylamide content was not available at the time of this report.

Conclusions

The use of the StollerUSA products tested in various combinations did not affect tuber yield or size distribution compared with the control under the conditions of this study. The Stoller products tended to reduce specific gravity. Many of the Stoller products are formulated to help the plant withstand stress; however, under irrigated conditions on a sandy soil, there was little water stress during the growing season.

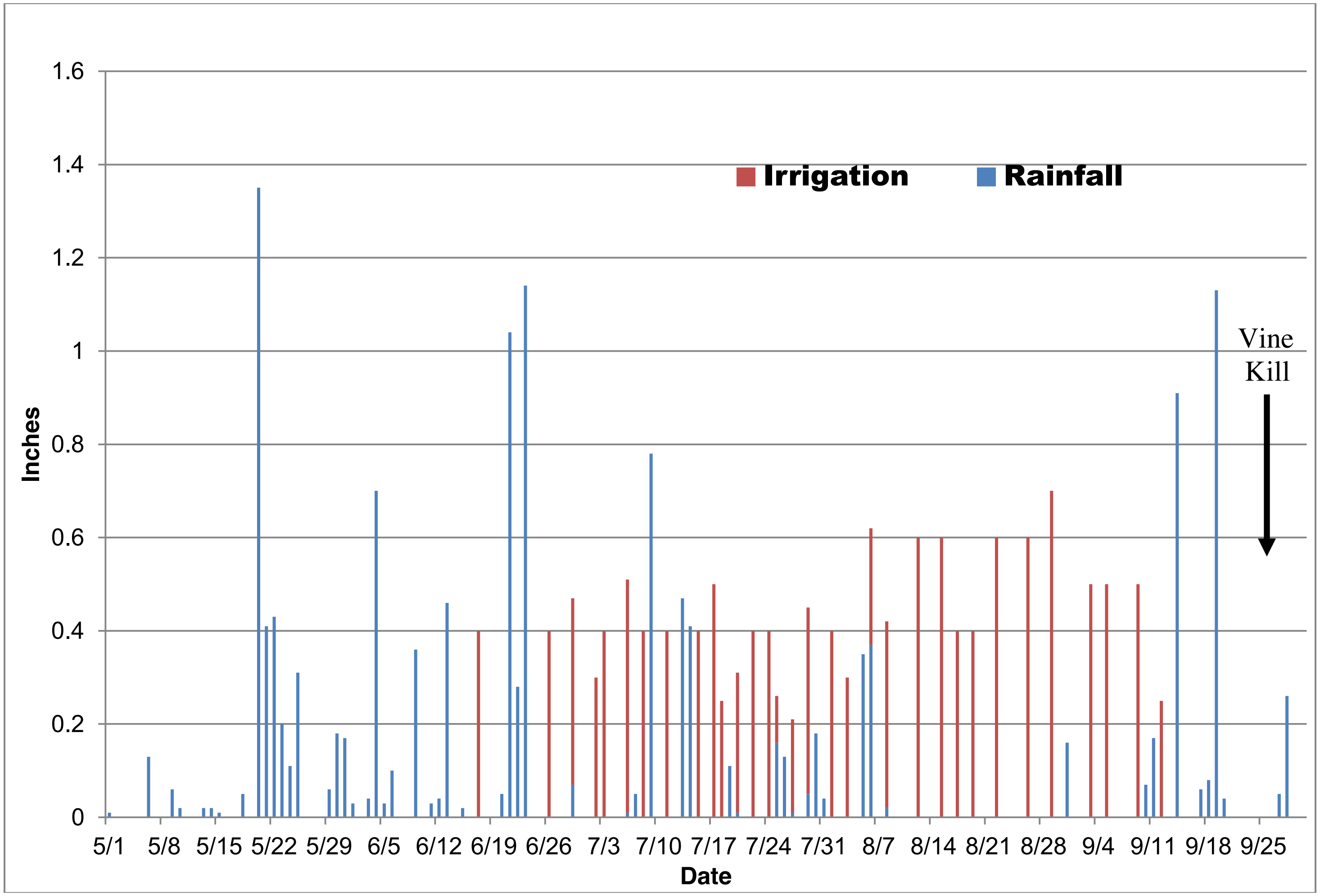

Figure 1. Rainfall and irrigation amounts during the 2013 growing season.

Table 1. Effects of StollerUSA products on Russet Burbank tuber yield and size distribution.

Treatment #	Stim or SP[1]	Nitrate balancer + X-Cyte[2]	STO-33[3]	BF, N+9, SM[4]	Tuber Yield										
					0-3 oz	3-6 oz	6-10 oz	10-14 oz	>14 oz	Total	#1s > 3 oz.	#2s > 3 oz	Total Marketable	> 6 oz	> 10 oz
					cwt / ac									%	%
1	-	-	-	-	84	118	143	106	118	569	383	103	486	64	39
2	Stim	-	-	-	72	149	160	103	96	580	386	122	508	62	34
3	SP	-	-	-	77	149	141	91	91	549	383	89	472	59	33
4	Stim	Yes	-	-	79	134	157	104	118	591	392	120	513	64	37
5	SP	-	Yes	-	73	138	132	107	112	561	380	108	488	62	39
6	Stim	-	-	Yes	75	164	166	86	85	576	374	128	502	58	30
Significance[5]					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.1)					--	--	--	--	--	--	--	--	--	--	--

[1]Stim: Stimulate, applied as seed treatment (1 oz/cwt). SP: Seed Power, applied in furrow (2 oz/ac).

[2]Nitrate Balancer: 32 oz/ac. X-Cyte: 16 oz/ac. (August 30)

[3]STO-33: 16 oz/ac at bud break (June 28), 16 oz/ac 14 days later (July 11).

[4]BF: Bio-Forge (16 oz/ac June 28). N+9: Nitro Plus 9 (20 gal/ac - July 2, 20 gal/ac - July 17). SM: Sugar Mover (64 oz/ac August 30).

[5]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 2. Effects of StollerUSA products on petiole nitrate concentrations, stems plant per plant, and plant stand.

Treatment #	Stim or SP[1]	Nitrate balancer + X-Cyte[2]	STO-33[3]	BF, N+9, SM[4]	Percent plant stand	# of Stems per Plant	Petiole Nitrate - N			
							24-Jun	8-Jul	24-Jul	5-Aug
							---------------- ppm ---------------			
1	Neither	No	No	No	**100.0**	**2.90**	**18103**	**19333**	**9843**	**5972**
2	Stim	No	No	No	**99.3**	**3.05**	**18151**	**18410**	**12846**	**5060**
3	SP	No	No	No	**98.6**	**3.53**	**19320**	**19946**	**10892**	**6932**
4	Stim	Yes	No	No	**100.0**	**3.03**	**18541**	**18877**	**9662**	**5701**
5	SP	No	Yes	No	**100.0**	**2.85**	**18422**	**19602**	**10147**	**5714**
6	Stim	No	No	Yes	**99.3**	**3.08**	**18138**	**18743**	**8352**	**5390**
				Significance[5]	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
				LSD (0.1)	--	--	--	--	--	--

[1]Stim: Stimulate, applied as seed treatment (1 oz/cwt). SP: Seed Power, applied in furrow (2 oz/ac).

[2]Nitrate Balancer: 32 oz/ac. X-Cyte: 16 oz/ac. (August 30)

[3]STO-33: 16 oz/ac at bud break (June 28), 16 oz/ac 14 days later (July 11).

[4]BF: Bio-Forge (16 oz/ac June 28). N+9: Nitro Plus 9 (20 gal/ac - July 2, 20 gal/ac - July 17).
SM: Sugar Mover (64 oz/ac August 30).

[5]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 3. Effect of Stoller products on tuber quality.

Treatment #	Stim or SP[1]	Nitrate balancer + X-Cyte[2]	STO-33[3]	BF, N+9, SM[4]	Tuber Quality			Specific Gravity	Dry Matter %
					HH	BC	Scab		
					%				
1	Neither	No	No	No	20	24	5	1.0877	22.8
2	Stim	No	No	No	18	21	0	1.0864	22.3
3	SP	No	No	No	13	17	0	1.0862	22.4
4	Stim	Yes	No	No	18	21	0	1.0859	21.6
5	SP	No	Yes	No	14	19	0	1.0841	21.8
6	Stim	No	No	Yes	23	23	0	1.0838	22.0
				Significance[5]	NS	NS	++	++	NS
				LSD (0.1)	--	--	4	0.0026	--

[1]Stim: Stimulate, applied as seed treatment (1 oz/cwt). SP: Seed Power, applied in furrow (2 oz/ac).

[2]Nitrate Balancer: 32 oz/ac. X-Cyte: 16 oz/ac. (August 30)

[3]STO-33: 16 oz/ac at bud break (June 28), 16 oz/ac 14 days later (July 11).

[4]BF: Bio-Forge (16 oz/ac June 28). N+9: Nitro Plus 9 (20 gal/ac (July 2), 20 gal/ac (July 17).
SM: Sugar Mover (64 oz/ac August 30).

[5]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Irrigated Potato Response to Rate and Application Timing of Two Controlled Release Nitrogen Fertilizers

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Summary: A field experiment was conducted at the Sand Plain Research Farm in Becker, MN, to evaluate alternative methods of improving nitrogen use efficiency in irrigated potato production. Specifically, the goals of the study were (1) to evaluate two polymer-coated urea products, ESN and Duration, relative to uncoated urea, as nitrogen sources for potatoes and (2) to evaluate the use of a chlorophyll meter and petiole nitrate analysis as diagnostic tools for determining the nitrogen status of the crop. Eighteen treatments were used to determine the effects of nitrogen source, application timing, and application rate on tuber yield, size, and quality, plant stand and stems per plant, and petiole nitrate concentration and leaflet chlorophyll content. To determine nitrogen release dynamics in the field, mesh bags of ESN and Duration were buried at the same times these products were applied to the treatment plots and determined the percentage of urea dry weight lost at multiple times throughout the season. In contrast to earlier seasons, when Duration released urea much more slowly than ESN, the two products showed very similar nitrogen release dynamics in this season. Accordingly, the two products produced similar tuber yields when applied at emergence. However, Duration performed significantly better than ESN when applied before planting. The treatments receiving Duration at planting with no other nitrogen source had the highest marketable yields among all treatments at their respective nitrogen application rates. Petiole nitrate concentration and leaflet chlorophyll content were strongly correlated with each other, especially in July and August, and they thus usually showed very similar relationships to other variables. They were positively correlated with the percentage of total yield represented by tubers over six or ten ounces and the percentage of marketable yield represented by U.S. No. 1 tubers, and negatively correlated with the prevalences of hollow heart and brown center. It is not clear why ESN and Duration performed differently from each other when applied before planting in this season, but it is unlikely to be an artifact of our method for assessing nitrogen release dynamics. Petiole nitrate concentration and leaflet chlorophyll content may prove valuable in predicting, and possibly controlling, tuber size distribution, grade, and quality. The two methods appear to largely explain the same variation in these variables, and it is possible that either method alone can provide as much information as both can together.

Background

Studies with controlled release nitrogen fertilizer have been conducted for the past ten years at the Sand Plain Research Farm in Becker, Minnesota, using ESN, a polymer coated urea product manufactured by Agrium. ESN has been found to be most effective on potatoes when applied at the time of shoot emergence. While results have been promising and adoption by growers has occurred, a product that could be applied prior to planting would be preferable. A product called "Duration", also manufactured by Agrium, may be a suitable substitute for ESN for this purpose. The thicker coating provides slower urea release than that of ESN. This slower release rate may make a preplant application more effective for Duration than an application at shoot emergence.

The overall goal of this research was to evaluate alternative methods of improving nitrogen use efficiency in irrigated potato production. The specific objectives were (1) to compare the effects of ESN with Duration on potato yield, grade, and quality, relative to an unfertilized control and applications of uncoated urea and ammonium nitrate, and (2) to evaluate the use of a chlorophyll meter and petiole nitrate analysis as diagnostic tools for determining the nitrogen status of the crop. An additional objective was to test the effectiveness of NZone, a urea source coated with compounds intended to maintain nitrogen in the ammonium form and thus reduce nitrate leaching.

Materials and Methods

This study was conducted in 2013 at the Sand Plain Research Farm in Becker, Minnesota, on a Hubbard loamy sand soil. The previous crop was rye. Selected characteristics for the top six inches of soil in the study field are shown in Table 1.

Prior to planting, 200 lb/ac 0-0-60 and 200 lb/ac 0-0-22 were broadcast and incorporated with a chisel plow. Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole "B" seed of Russet Burbank potatoes was hand planted in furrows on April 12, 2012. A red potato was planted at each end of each of the two harvest rows in each plot, and Russet Burbank thus occupied the central 18 feet out of the 20 feet in each harvest row. Row spacing was 12 inches within each row and 36 inches between rows. Belay was applied in-furrow for beetle control, along with the systemic fungicide Quadris. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Each treatment was replicated four times in a randomized complete block design. Each block was surrounded by a buffer strip of Russet Burbank, one row wide along either side and five feet wide at either end. In the harvest rows, the buffer strip had red potatoes.

There were 18 nitrogen fertilizer treatments (Table 2). Sixteen treatments were used to evaluate the effects of application rate and timing for urea/UAN, ESN, and Duration. The other two treatments involved an application of NZone at emergence at a rate of 70 or 105 lbs N/ac, which were supposed to be followed by five applications throughout the season at 14 or 21 lbs N/ac, respectively. However, the post emergence applications were not applied and therefore a valid comparison with other N sources at equivalent N rates is not possible. These treatments are still included because they do provide additional information about potato response to N rate.

Preplant urea, ESN, and Duration fertilizer were hand-broadcast the day before planting, on May 6, and incorporated with a field cultivator. At planting (May 7), all treatments received 30 lbs N/ac, 130 lbs P_2O_5/ac, 181 lbs K_2O/ac, 20 lbs Mg/ac, 46 lbs S/ac, 3.3 lbs B/ac, and 5.6 lbs Zn/ac. This was applied at row closure as a blend of monoammonium phosphate, ammonium sulfate, potassium chloride, potassium magnesium sulfate, boric acid, and zinc oxide, banded three inches to each side and two inches below the seed piece using a metered, drop-fed applicator incorporated into the planter. Nitrogen applications at emergence (June 3) were applied using a Gandy metered, drop-fed applicator and mechanically incorporated during hilling. Post-hilling UAN was applied over the row with a tractor-mounted sprayer as a 28% UAN solution in 25 gal of water/ac. The tractor traveled in the irrigation alleys to prevent damage to the crop. Irrigation was applied immediately following application of UAN to simulate fertigation with an overhead irrigation system. Post-hilling UAN was applied on June 26, July 3, July 11, July 22, and July 31.

A WatchDog weather station from Spectrum Technologies was used to monitor rainfall, air temperature, soil moisture, and soil temperature. Three pairs of soil moisture and temperature sensors were installed at different times in two locations.

One pair was installed in a plot receiving a preplant application of 210 lb N/ac as ESN (treatment 8), and another was placed in a plot receiving Duration at the same rate and time (treatment 10). These probes were placed in the planting hill two inches below the soil surface soon after planting. The second pair was installed in a plot receiving 210 lb N/ac from ESN at emergence (treatment 6). These probes were installed at emergence and initially placed at the same depth as the first pair of probes, two inches below the soil surface. Both sets of probes were then buried deeper by the tillage involved in hilling, and they were all four inches below the surface of the hill for the remainder of the growing season.

Measured amounts of ESN and Duration fertilizer were placed in plastic mesh bags ("teabags") and buried at the depth of fertilizer placement when both the preplant and emergence applications were made (May 6 and June 3, respectively). Because Duration produced for the 2013 season appeared much lighter in color than the same product produced for 2012, bags containing 2012 Duration were placed along with bags of 2013 Duration and ESN at the time of the preplant application. Bags of (2013) Duration, ESN, and a 50:50 blend were placed at emergence. Bags from the preplant group were removed on May 10, May 20, May 29, June 3, June 10, June 24, July 8, July 29, September 3, and September 16. Bags from the emergence group were removed on June 10, June 17, July 8, July 17, July 22, July 29, August 7, September 3, and September 16. The dry weight of the remaining fertilizer (minus the mean prill coat weight) was determined for each collection date to track urea release over time.

Plant stands were measured and stems counted for each plot on June 18. Chlorophyll readings were taken from the terminal leaflet of the 4^{th} leaf from the terminal, and the petiole of that leaflet was collected on four dates: June 28, July 10, July 23, and August 6. Chlorophyll readings were measured with a SPAD meter. Petioles were analyzed for nitrate nitrogen on a dry weight basis.

Vines were harvested on September 16 from two, 10-ft sections of row, and mechanically beaten over the entire plot area. Plots were machine harvested on September 23, and tubers were sorted and graded on September 27 and 30. Sub-samples of vines and tubers were collected to determine moisture percentage and nitrogen concentration, which will be used to calculate nitrogen uptake and distribution within the plant (Note: the data for nitrogen uptake were unavailable at the time of this report and therefore will be presented at a later time). Tuber sub-samples were also used to determine tuber specific gravity and dry matter content, as well as the prevalences of hollow heart, brown center, and scab.

ANOVA tests were performed using replicate, nitrogen treatment, cultivar, and the treatment-by-cultivar interaction as independent variables. A Waller-Duncan k-ratio t-test was performed on all significant results for nitrogen treatment to determine the minimum significant difference between treatments ($P < 0.10$).

Results

Weather

Rainfall and irrigation for the 2013 growing season are provided in Figure 1, soil moisture is in Figure 2, and air and soil temperatures are in Figure 3. Between May 7 and September 20, 12.25 inches of rainfall were supplemented with 15.0 inches of irrigation for a total of 25.4 inches of water. There were three rain events with at least one inch of rainfall, on May 20, June 21, and June 23, delivering 1.35, 1.04, and 1.14 inches of water, respectively. Soil water potential dropped around the time of each of these events, at three times between June 6 and June 13, and from July 10 to July 16. Water potential rose for a period in early July. The moisture probes installed before planting also indicated a long period of relatively high water potential (over 30 kPa) from early August to early September. While this is not reflected in the data from the probes installed at emergence (Figure 2), the high temperatures (Figure 3) and low precipitation (Figure 1) during this period indicate that increased water potential probably occurred.

Nitrogen release from ESN and Duration

The urea release curves for mesh bags of controlled release fertilizers installed during the preplant and emergence fertilizer applications (May 6 and June 3) are shown in Figure 4. The difference in prill color between 2012 Duration and 2013 Duration proved to be meaningful. The release curve for 2013 Duration installed before planting resembles the curve for ESN rather than the curve for 2012 Duration. Consistent with this result, the release curves for 2013 Duration, ESN, and the 1:1 blend installed at emergence were quite similar to each other.

The release curve for 2013 Duration installed before planting diverged from the curve for ESN from about 22 to 48 days after planting (May 7). As a result, for bags installed during preplant fertilization, 2013 Duration reached 50% release about 7 days later (around 41 days after planting) than ESN (34 days after planting, 35 days after installation).

The divergence between the ESN curve and the Duration curve was smaller for the emergence installation, and the 1:1 blend had a urea release curve was similar to both. ESN installed at emergence had released 50% of its urea by about 55 days after planting, or 28 days after installation. Duration and the 1:1 blend installed at emergence released 50% of its urea by about 62 days after planting, or 35 days after installation.

Maximum nitrogen uptake rates by Russet Burbank generally occur between 40 and 80 days after planting. Duration installed before planting had released approximately 50% of its urea by 40 days after planting and 80% by 80 days, for a release of about 30% of its urea content during this period. ESN installed before planting had released about 60% of its urea by 40 days after planting and 88% by 80 days, and therefore released about 28% of its urea content during this period.

Duration installed at emergence had released 23% of its nitrogen by 40 days after planting and 69% by 80 days after planting, for a total release of just 46% of its urea during the period of maximum uptake. ESN installed at emergence had released 29% of its nitrogen by 40 days after planting and 75% by 80 days after planting, for a release of 46% of its urea during this period. The 1:1 blend of the two fertilizers had released 25% of its nitrogen by 40 days after planting and 72% by 80 days after planting, thus releasing about 47% of its urea content during this period.

By the end of the season, ESN installed at either time had released 93 – 94% of its nitrogen content, and Duration had released 87 – 89% The blend of the two fertilizers installed at emergence had released 91% of its nitrogen content. 2012 Duration had released 79% of its content.

Plant stand and stems per plant

The treatment receiving 210 lbs N/ac as uncoated urea before planting (treatment 4) had significantly lower plant stand (91.7%) two weeks after shoot emergence (i.e., June 18) than any other treatment (Table 3). There was no significant effect of treatment on the number of stems per plant (which ranged from 3.90 to 4.75 stems per plant; Table 2).

Leaflet chlorophyll content (SPAD readings) and petiole NO_3 concentration

Leaflet chlorophyll content as indicated by relative SPAD readings and petiole nitrate concentration were strongly positively correlated with each other, especially after the first sampling date (June 25). Across the four collection periods, both chlorophyll content and petiole nitrate concentration declined over time (Table 3). By and large, these variables decreased in parallel for all treatments; a high-chlorophyll, high-nitrate treatment in June was generally a high-chlorophyll, high-nitrate treatment in August. However, there was a tendency for treatments receiving ESN or urea at emergence to rank higher in both variables as the season progressed. Also, while application timing was more important than application rate early in the season (treatments receiving preplant nitrogen having higher chlorophyll contents and petiole nitrate concentrations than those receiving no nitrogen before emergence), application rate became increasingly important later in the season (chlorophyll content and petiole nitrate concentration both increasing with application rate).

The effect of not adding post-hilling applications to the NZone treatments (treatments 17 and 18) became increasingly apparent across the season, as these treatments went from having typical chlorophyll and nitrate levels early in the season to having the lowest levels in the study aside from the control (treatment 1) by the final sampling date (August 6).

Throughout all four periods, treatments receiving 210 lbs N/ac before planting as urea (treatment 4), ESN (treatment 8), or Duration (treatment 10) had among the highest chlorophyll contents and petiole nitrate concentrations.

Tuber yield

Tuber yield results are presented in Table 3. The control treatment (treatment 1) had significantly lower total yield and marketable yield than any of the other treatments.

Generally, treatments receiving 170 lbs total N/ac had lower total and marketable yields than their counterparts receiving 240 lbs total N/ac. The differences were significant for the treatments receiving ESN at emergence (treatment 5 vs. 6). The treatments receiving a blend of ESN and Duration before planting are the exception: the treatment receiving 170 lbs total N/ac (treatment 13) had insignificantly higher total and marketable yield than its high-nitrogen counterpart (treatment 14).

The treatments receiving Duration before planting (treatments 9 and 10) had the highest total and marketable yields among treatments with their respective application rates. The treatment receiving 210 lbs N/ac as Duration before planting (treatment 10) had significantly higher total and marketable yield than the ones receiving the same amount of nitrogen as ESN or uncoated urea at the same time (treatments 8 and 4, respectively). It also had significantly higher total and marketable yield than the treatments receiving 210 lbs N/ac as a blend of ESN and Duration before planting (treatment 14) and as Duration before planting and urea at emergence (treatment 11). This treatment had significantly higher total yield, but not marketable yield, than the treatment receiving 210 lbs N/ac as a blend of ESN and urea at emergence (treatment 7). The treatment receiving 170 lbs N/ac at Duration before planting (treatment 9) did not have significantly higher total or marketable yield than any other treatment at that application rate.

While Duration applied before planting did not produce significantly higher yield than Duration applied at emergence (treatment 10 versus 12), ESN applied at emergence produced significantly higher yield than ESN applied before planting (treatment 6 versus 8).

There was a definite tendency for marketable yield to increase with fertilization rate. This tendency was more evident for total application rates between 30 and 170 lbs N/ac (including the NZone treatments, 17 and 18, which received 100 and 135 total lbs N/ac, respectively) than for those between 170 and 240 lbs N/ac, where nitrogen source and application timing were also relevant. Three treatments receiving 240 lbs total N/ac had conspicuously lower marketable yields than expected for this application rate: the one receiving ESN at planting (treatment 8), the one receiving Duration at planting and urea at emergence (treatment 11), and the one receiving a blend of ESN and Duration at planting (treatment 14). Two other treatments receiving 240 lbs total N/ac also had yields more typical of those receiving 170 lbs total N/ac: the treatment receiving urea at planting (treatment 4) and the one receiving a blend of urea and ESN at emergence (treatment 7).

Tuber size

As marketable yield increased, the size distribution shifted toward larger sizes (Table 4). There were two clear exceptions to the trend toward more large-biased size distributions with larger total yields. The treatment receiving 210 lbs N/ac as urea before planting (treatments 4) and the one receiving 210 lbs N/ac as a blend of urea and ESN at emergence (treatment 7) had large percentages of their yields in tubers over 6 or 10 ounces for their marketable yields.

As expected from the positive relationship between total yield and the percentage of yield in large size classes, treatments receiving less nitrogen tended to have greater portions of their yields in tubers under 3 ounces, and greater portions in tubers over 14 ounces. One exception was the treatment receiving 210 lbs N/ac as ESN and Duration before planting (treatment 14), which had less of its yield in tubers over 14 ounces than most treatments receiving 170 lbs total N/ac. Another exception was the treatment receiving 140 lbs N/ac as Duration before planting (treatment 9), which had more of its yield in tubers over 14 ounces than four of the treatments receiving 240 lbs total N/ac.

The percentage of yield represented by tubers over 6 or 10 ounces increased with both petiole nitrate concentration and leaflet chlorophyll content, with the relationships getting stronger after the first (June 25) leaf sampling date. This was true even if the lowest-N treatments (treatments 1, 17, and 18) were excluded. In addition, treatments with more stems per plant two weeks after emergence (i.e., on June 18) tended to have less of their yield represented by large tubers, even if the lowest-N treatments were excluded.

Tuber quality

Yields for U.S. No. 1 and U.S. No. 2 tubers are presented in Table 4.

There was no apparent relationship between nitrogen source, timing of application, or fertilization rate and percentage of marketable yield represented by U.S. No. 1 tubers.

There was no relationship between the absolute yield of U.S. No 1 tubers, or the percentage of marketable yield represented by U.S. No. 1 tubers, and the absolute yield or percentage of total yield represented by any given size class.

As petiole nitrate concentration and leaflet chlorophyll content increased, the percentage of marketable yield represented by U.S. No. 1 tubers decreased (and the percentage represented by U.S. No. 2 tubers increased), suggesting that higher rates of nitrogen resulted in misshapen tubers.

Tuber quality results are presented in Table 5.

There was a significant treatment effect on the prevalence of brown center, as well as marginal effects on the prevalence of hollow heart and on percent dry matter. Treatment had no significant effect on the prevalence of scab or on tuber specific gravity.

Hollow heart and brown center tended to co-occur. There is no clear relationship between the prevalence of these tuber flaws and nitrogen application rate, application timing, or nitrogen source. The control treatment (treatment 1) had the lowest prevalence of both flaws of any treatment (and was similar to the treatment receiving 210 lbs N/ac as ESN before planting, treatment 8, for brown center). Overall, however, there was no clear relationship between prevalence and yield or tuber size distribution.

Treatments receiving 240 lbs total N/ac tended to have lower percent dry matter than treatments receiving 170 lbs total N/ac. The control treatment (treatment 1) had intermediate dry matter content. There was no clear effect of application timing or nitrogen source on tuber percent dry matter.

Prevalences of hollow heart and brown center strongly tended to decrease with increasing petiole nitrate concentration and leaflet chlorophyll content, if treatments receiving < 170 lbs total N/ac were excluded. The control treatment (treatment 1) tended to weaken these relationships, while the NZone treatments (treatments 17 and 18) tended to strengthen them. For petiole nitrate concentration, the negative correlation with the prevalences hollow heart and brown center became stronger later in the season (r increased from 0.251 to 0.728 between June 25 and August 6). For leaflet chlorophyll content, the correlation strengthened early in the season (r increased from 0.557 on June 25 to 0.731 on July 10), then weakened at the end of the season (r decreased from 0.0.736 on July 23 to 0.549 on August 6).

Prevalences of hollow heart and brown center, specific gravity, and dry matter were all positively correlated to the percentage of marketable tubers that were graded U.S. No. 1.

Conclusions

Duration and ESN produced in 2013 had very similar release dynamics. It is surprising, then, that there were substantial differences in the performances of the two fertilizers. While the two fertilizers and a 1:1 blend of the two all performed almost identically when applied at shoot emergence (compare treatments 6, 12, and 15), Duration produced far higher yields than ESN or the blend when installed before planting (compare treatments 8, 10, and 14). It is also surprising that each product showed similar results to previous years regarding the relative yields for application before planting versus at emergence at the same rate. Duration produced insignificantly higher yields when applied before planting than when applied at emergence, while ESN produced significantly higher yields when applied at emergence than before planting.

It is conceivable that the results of the field treatments are inconsistent with the observed release dynamics of each product because the release dynamics observed in our buried-bag tests were not representative of the release dynamics in the treatment plots. However, this possibility is unlikely. Because the two fertilizers showed very similar release dynamics to each other whether installed before planting or at emergence, the similarity in their release dynamics is almost certainly attributable to similarities in the physical properties of the prills. Also the 2012 Duration had release rates similar to Duration release rate found in previous years. Even if the conditions of the prills inside the mesh bags were sufficiently different from those of the prills in the treatment plots to affect release dynamics, there is no clear reason why the release dynamics of ESN would be influenced differently from those of Duration.

The treatments receiving Duration before planting (treatments 9 and 10) had the highest marketable yields at their respective application rates, and they had relatively large percentages of yield in tubers over six and ten ounces. While the treatment receiving 170 lbs total N/ac (treatment 9) had a high percentage of marketable yield in U.S. No. 2 tubers and high percentages of tubers with hollow heart and brown center, this was not the case for the higher-N treatment (treatment 10). However, this again raises the question of why the results for Duration were any different from those of ESN, given that the two products are designed to differ only in their release dynamics.

Assessments of plant health during the growing season (percent stand, stems per plant, petiole nitrate concentration, and leaflet chlorophyll content) were poor predictors of tuber yield, but were often good predictors of tuber size and quality. Petiole nitrate concentration and leaflet chlorophyll content, in particular, were positively correlated with the percentage of total yield represented by tubers over six or ten ounces and the percentage of marketable yield represented by U.S. No. 1 tubers, and negatively correlated with the prevalences of hollow heart and brown center. Petiole nitrate concentration and leaflet chlorophyll content were also found to be poor predictors of yield but good predictors of tuber size and grade in 2012, suggesting that these assessments may be consistently more useful for predicting (and potentially controlling) grade and quality than yield. The strong correlation between the two measurements, and the fact that they both were correlated with the same tuber grade and quality variables, suggests that either method alone may provide as much information as both methods together.

Figure 1. Rainfall and irrigation amounts during the 2013 growing season.

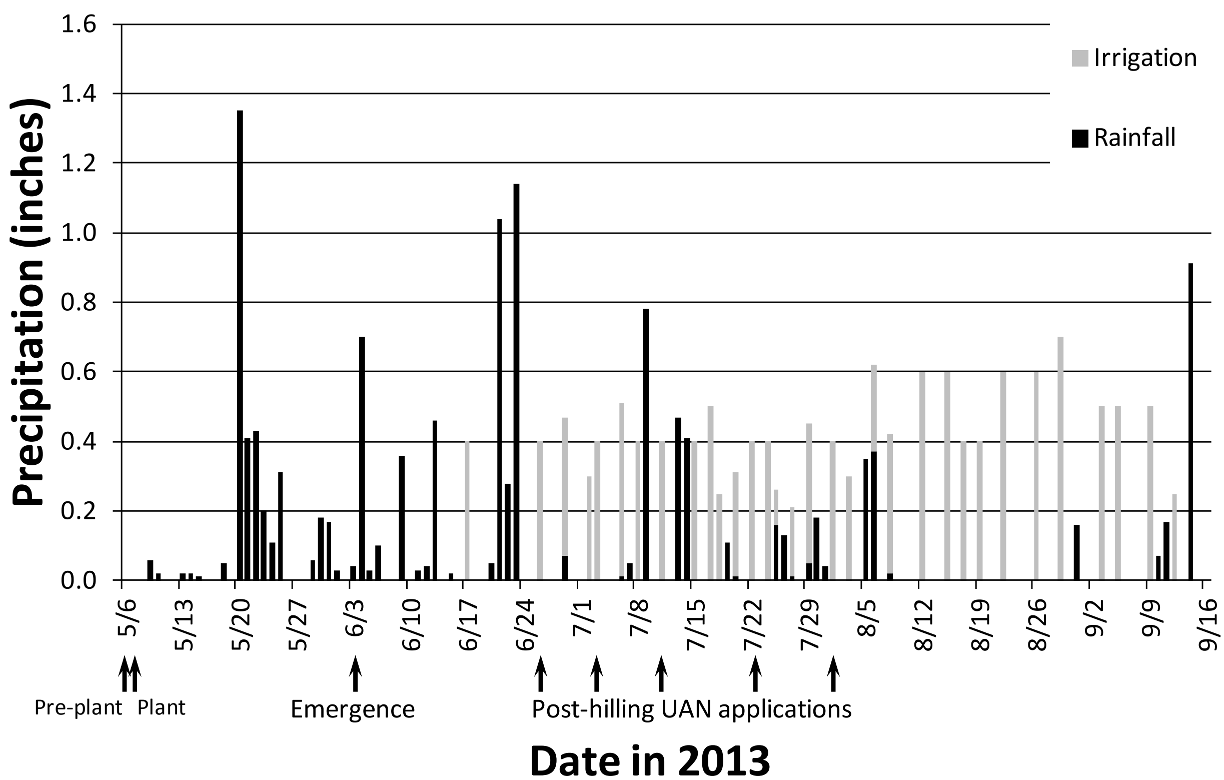

Figure 2. Soil moisture during the 2013 growing season, recorded by two probes placed before planting and one placed at shoot emergence and hilling.

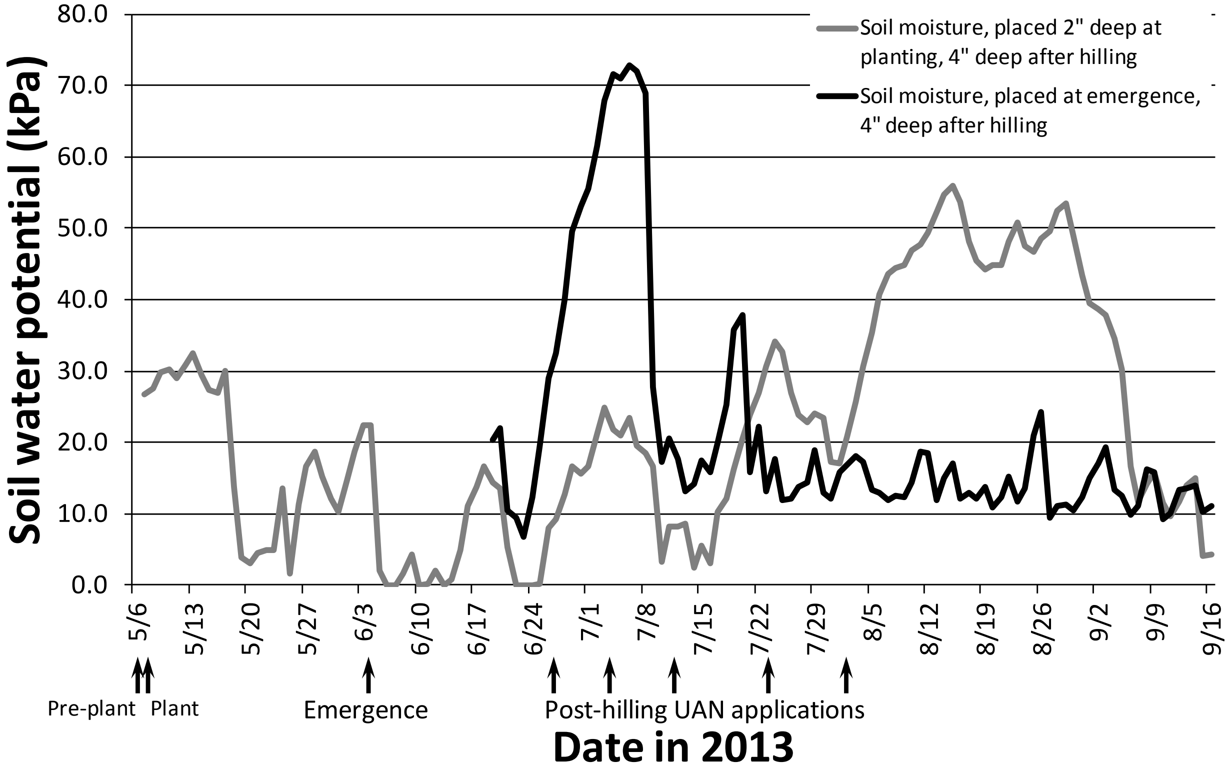

Figure 3. Air temperature and soil temperature during the 2013 field season.

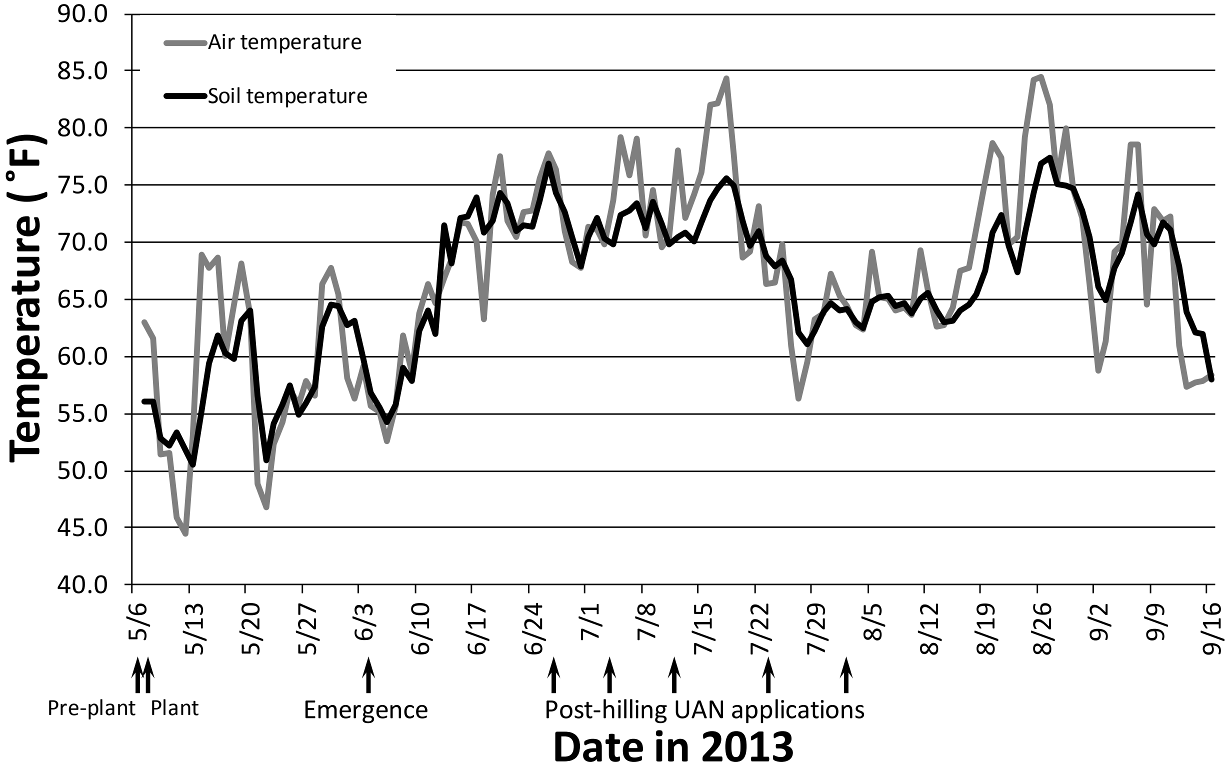

Figure 4. Nitrogen release over time from mesh bags of ESN, Duration, and a 1:1 blend of the two, buried at tuber depth before planting (2" deep) or at potato shoot emergence (4" deep; the bags buried at planting were also approximately 4" deep after hilling at emergence). Because Duration released in 2013 appeared different in color from earlier releases, Duration from 2012 was also buried before planting to determine whether the difference in color indicated a difference in release rate. Preplant mesh bags were installed on May 6, one day before planting. The final date of bag removal was September 16, 132 days after planting.

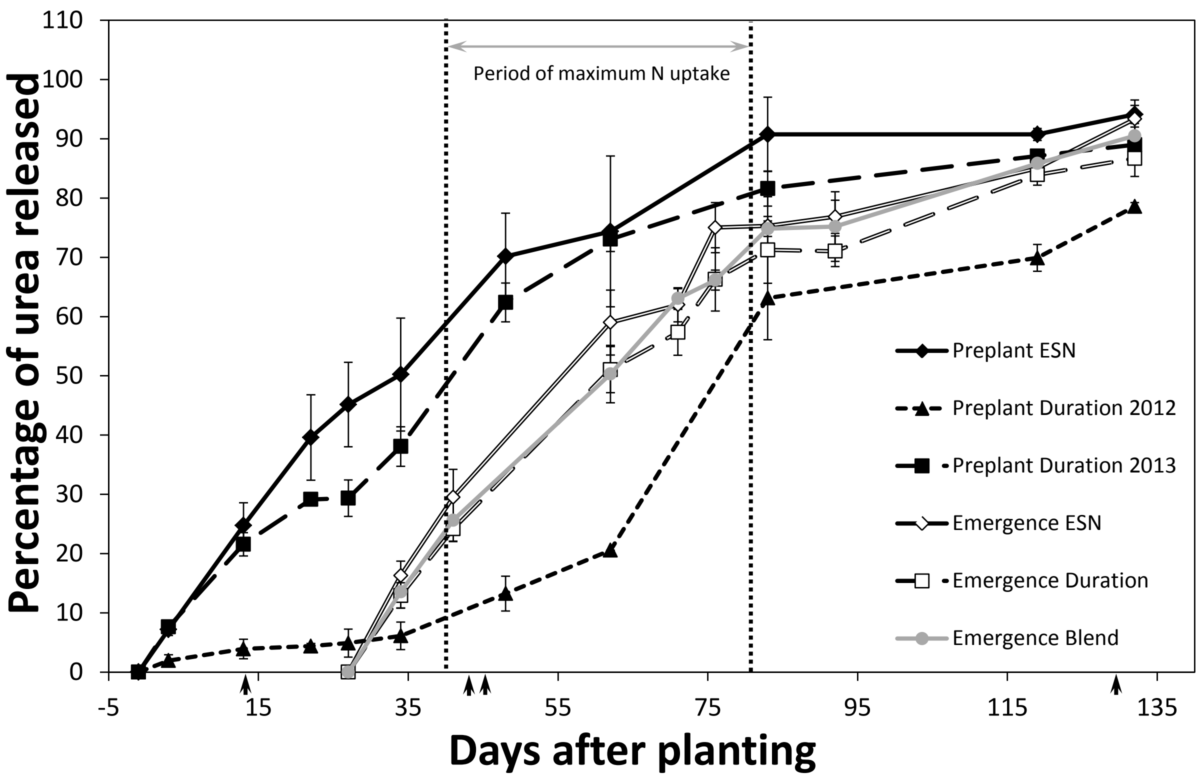

Table 1. Soil characteristics of the study site at the beginning of the season.

NO_3 (ppm)	Bray-P (ppm)	NH_4OAc-K (ppm)	NH_4OAc-Ca (ppm)	NH_4OAc-Mg (ppm)	DTPA-Zn (ppm)	DTPA-Cu (ppm)	DTPA-Fe (ppm)	DTPA-Mn (ppm)	SO4-S (ppm)	Hot Water B (ppm)	Water pH	O.M. LOI (%)
1.074	28	143	672	125	2.0	0.794	39.6	31.3	4	0.295	6.1	2.2

Table 2. Nitrogen treatments applied to irrigated Russet Burbank potatoes.

Treatment	Timing of nitrogen applications				Total nitrogen (lbs N/Ac)
	Preplant	Planting	Emergence	Post-hilling[1]	
	Nitrogen sources[2] and rates (lbs N/ac)				
1	0	30 MAP + AS	0	0	30
2	0	30 MAP + AS	70 Urea	70 UAN	170
3	0	30 MAP + AS	105 Urea	105 UAN	240
4	210 Urea	30 MAP + AS	0	0	240
5	0	30 MAP + AS	140 ESN	0	170
6	0	30 MAP + AS	210 ESN	0	240
7	0	30 MAP + AS	105 Urea + 105 ESN	0	240
8	210 ESN	30 MAP + AS	0	0	240
9	140 Duration	30 MAP + AS	0	0	170
10	210 Duration	30 MAP + AS	0	0	240
11	105 Duration	30 MAP + AS	105 Urea	0	240
12	0	30 MAP + AS	210 Duration	0	240
13	70 ESN + 70 Duration	30 MAP + AS	0	0	170
14	105 ESN + 105 Duration	30 MAP + AS	0	0	240
15	0	30 MAP + AS	105 ESN + 105 Duration	0	240
16	0	30 MAP + AS	105 Urea + 105 Duration	0	240
17	0	30 MAP + AS	70 NZone	0	100
18	0	30 MAP + AS	105 NZone	0	135

[1]Post-hilling: 5 applications (June 26, July 3, 11, 22, and 31).

[2]AS (ammonium sulfate): 21-0-0-24S. Duration (Agrium, Inc.): 43-0-0. ESN (Environmentally Smart Nitrogen, Agrium, Inc.): 44-0-0. MAP (monoammonium phosphate): 11-50-0. NZone (AgXplore International): nitrogen stabilizer. UAN (urea + ammonium nitrate): 28-0-0. Urea: 46-0-0.

Table 3. Effect of nitrogen source and application timing and rate on Russet Burbank plant stand, stems per plant, petiole nitrate concentration, and leaflet chlorophyll content.

Nitrogen Treatments				Whole plants		Petiole nitrate - N				Leaflet chlorophyll content			
Treatment #	Nitrogen source[1]	Nitrogen timing[2] (PP, P, E, PH)	Nitrogen rate (lbs N/ac)	Plant stand (%)	Stems per plant	28-Jun	10-Jul	23-Jul	6-Aug	28-Jun	10-Jul	23-Jul	6-Aug
						------------------ ppm ----------------				SPAD readings			
1	MAP + AS	0, 30, 0, 0	30	99.3	4.70	4713	1081	318	98	39.2	34.3	26.7	21.8
2	MAP + AS, Urea, UAN	0, 30, 70, 70	170	100.0	4.28	18385	10078	3363	1064	42.2	40.0	35.8	36.0
3	MAP + AS, Urea, UAN	0, 30, 105, 105	240	97.9	4.05	20554	16348	8780	4375	42.6	42.5	39.1	39.0
4	Urea, MAP + AS	210, 30, 0, 0	240	91.7	3.98	20778	16745	13157	6318	44.8	43.6	41.7	40.0
5	MAP + AS, ESN	0, 30, 140, 0	170	100.0	4.18	20621	14000	4771	360	43.0	40.7	37.4	35.0
6	MAP + AS, ESN	0, 30, 210, 0	240	99.3	4.40	18951	16625	9505	3824	43.3	42.4	39.9	39.7
7	MAP + AS, Urea + ESN	0, 30, 105+105, 0	240	97.2	3.90	22133	16931	9414	3112	44.3	43.0	39.2	38.1
8	ESN, MAP + AS	210, 30, 0, 0	240	98.6	4.75	21862	18133	14251	7495	44.7	44.3	42.0	40.3
9	Duration, MAP + AS	140, 30, 0, 0	170	96.5	4.55	22907	16216	7174	2281	43.9	43.1	38.9	37.1
10	Duration, MAP + AS	210, 30, 0, 0	240	99.3	4.33	23705	17819	14270	7165	44.4	44.2	41.5	40.1
11	Duration, MAP + AS, Urea	105, 30, 105, 0	240	97.2	4.60	23310	18426	10553	5969	44.6	43.5	40.7	38.9
12	MAP + AS, Duration	0, 30, 210, 0	240	100.0	4.18	18427	16206	8695	2636	43.5	42.9	39.8	35.9
13	ESN+Duration, MAP + AS	70+70, 30, 0, 0	170	99.3	4.15	20452	15692	5961	2374	43.6	41.7	37.3	38.0
14	ESN+Duration, MAP + AS	105+105,30,0,0	240	100.0	4.75	24224	18464	13416	5109	44.3	44.0	41.3	39.3
15	MAP + AS, ESN+Duration	0,30,105+105,0	240	98.6	4.75	19328	16257	9344	2116	43.5	42.0	39.2	38.8
16	MAP + AS, Urea+Duration	0,30,105+105,0	240	98.6	4.33	21099	16685	10667	4102	43.3	42.9	41.5	39.4
17	MAP + AS, NZone, NZone	0, 30, 70, 0	100	98.6	4.50	17382	7676	546	148	43.2	39.2	32.0	29.4
18	MAP + AS, NZone, NZone	0, 30, 105, 0	135	98.6	4.28	19952	9404	2350	531	43.5	40.0	35.0	34.0
			Treatment significance[1]	*	NS	**	**	**	**	**	**	**	**
			Treatment LSD (0.1)	4.1	--	2323	1698	2191	1737	0.9	1.3	1.7	2.2

[1]ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Duration (Agrium, Inc.) = 43-0-0; UAN (urea + ammonium nitrate) = 28-0-0; MAP (monoammonium phosphate) = 11-50-0; Urea = 46-0-0; NZone (AgXplore International): nitrogen stabilizer.

[2]PP=preplant, P=planting, E=emergence/hilling, PH=post-hilling (5 applications).

[3]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 4. Effect of nitrogen source and application timing and rate on Russet Burbank tuber yield, size, and grade.

Nitrogen Treatments				Tuber yield										
Treatment #	Nitrogen source[1]	Nitrogen timing[2] (PP, P, E, PH)	Nitrogen rate (lbs N/ac)	0-3 oz	3-6 oz	6-10 oz	10-14 oz	>14 oz	Total	U.S. No. 1 > 3 oz	U.S. No. 2 > 3 oz	Total marketable	> 6 oz	> 10 oz
				cwt / ac									%	
1	MAP + AS	0, 30, 0, 0	30	146.1	150.5	54.0	15.4	0.8	366.8	172.5	48.2	220.7	19.1	4.5
2	MAP + AS, Urea, UAN	0, 30, 70, 70	170	112.6	173.3	114.7	52.2	36.8	489.7	282.2	94.8	377.1	41.2	17.8
3	MAP + AS, Urea, UAN	0, 30, 105, 105	240	102.4	142.4	129.5	93.2	52.5	520.0	302.6	115.1	417.6	53.0	28.0
4	Urea, MAP + AS	210, 30, 0, 0	240	71.2	121.5	120.5	77.4	64.1	454.7	285.6	98.0	383.5	58.0	31.3
5	MAP + AS, ESN	0, 30, 140, 0	170	96.0	155.8	111.0	61.4	34.0	458.1	290.6	71.5	362.1	44.5	20.3
6	MAP + AS, ESN	0, 30, 210, 0	240	105.4	161.5	125.2	68.0	58.4	518.5	309.6	103.6	413.1	48.5	24.3
7	MAP + AS, Urea + ESN	0, 30, 105+105, 0	240	79.8	133.3	117.7	86.0	57.4	474.2	266.2	128.2	394.4	54.8	30.2
8	ESN, MAP + AS	210, 30, 0, 0	240	99.4	133.7	119.1	54.6	33.4	440.1	233.8	107.0	340.8	47.2	20.0
9	Duration, MAP + AS	140, 30, 0, 0	170	107.1	156.7	127.7	65.7	45.3	502.5	303.4	92.1	395.4	46.9	21.8
10	Duration, MAP + AS	210, 30, 0, 0	240	91.5	147.3	140.2	87.8	61.6	528.3	311.2	125.6	436.8	54.5	28.0
11	Duration, MAP + AS, Urea	105, 30, 105, 0	240	99.3	147.2	109.0	63.6	39.3	458.4	258.5	100.6	359.1	46.1	22.2
12	MAP + AS, Duration	0, 30, 210, 0	240	98.5	172.0	126.6	72.0	48.5	517.6	312.3	106.8	419.1	47.7	23.2
13	ESN+Duration, MAP + AS	70+70, 30, 0, 0	170	117.6	164.1	120.2	50.6	34.8	487.2	276.7	92.9	369.7	42.4	17.7
14	ESN+Duration, MAP + AS	105+105,30,0,0	240	100.9	153.0	116.0	60.1	34.1	464.1	257.7	105.6	363.3	45.5	20.6
15	MAP + AS, ESN+Duration	0,30,105+105,0	240	91.1	169.9	126.7	69.3	63.4	520.5	321.2	108.2	429.4	49.7	25.4
16	MAP + AS, Urea+Duration	0,30,105+105,0	240	91.9	152.8	128.8	74.5	62.1	510.1	321.8	96.5	418.3	51.3	26.2
17	MAP + AS, NZone, NZone	0, 30, 70, 0	100	108.6	160.1	110.6	43.2	12.8	435.2	261.2	65.4	326.6	37.6	12.4
18	MAP + AS, NZone, NZone	0, 30, 105, 0	135	100.0	161.8	129.9	61.0	31.1	483.7	310.0	73.7	383.7	45.7	18.6
Treatment significance[1]				**	NS	**	**	**	**	**	NS	**	**	**
Treatment LSD (0.1)				19.8	--	20.9	21.3	28.7	47.9	54.2	--	45.4	7.6	6.9

[1]ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Duration (Agrium, Inc.) = 43-0-0; UAN (urea + ammonium nitrate) = 28-0-0; MAP (monoammonium phosphate) = 11-50-0; Urea = 46-0-0; NZone (AgXplore International): nitrogen stabilizer.

[2]PP=preplant, P=planting, E=emergence/hilling, PH=post-hilling (5 applications).

[3]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 5. Effect of nitrogen source and application timing and rate on Russet Burbank tuber flaws, specific gravity, and dry matter percentage.

Nitrogen Treatments				Tuber Flaws			Specific Gravity	Dry Matter %
Treatment #	Nitrogen source[1]	Nitrogen timing[2] (PP, P, E, PH)	Nitrogen rate (lbs N/ac)	HH	BC	Scab		
				%				
1	MAP + AS	0, 30, 0, 0	30	4	5	16	1.0808	21.23
2	MAP + AS, Urea, UAN	0, 30, 70, 70	170	28	30	11	1.0797	21.23
3	MAP + AS, Urea, UAN	0, 30, 105, 105	240	20	20	7	1.0802	21.01
4	Urea, MAP + AS	210, 30, 0, 0	240	18	21	7	1.0817	20.85
5	MAP + AS, ESN	0, 30, 140, 0	170	25	25	10	1.0832	21.55
6	MAP + AS, ESN	0, 30, 210, 0	240	14	15	1	1.0816	21.06
7	MAP + AS, Urea + ESN	0, 30, 105+105, 0	240	17	17	9	1.0810	21.79
8	ESN, MAP + AS	210, 30, 0, 0	240	6	5	16	1.0781	20.43
9	Duration, MAP + AS	140, 30, 0, 0	170	27	30	6	1.0831	21.67
10	Duration, MAP + AS	210, 30, 0, 0	240	15	15	3	1.0824	20.90
11	Duration, MAP + AS, Urea	105, 30, 105, 0	240	18	23	5	1.0805	19.72
12	MAP + AS, Duration	0, 30, 210, 0	240	12	13	13	1.0813	21.63
13	ESN+Duration, MAP + AS	70+70, 30, 0, 0	170	24	24	14	1.0825	21.48
14	ESN+Duration, MAP + AS	105+105,30,0,0	240	14	19	11	1.0783	20.96
15	MAP + AS, ESN+Duration	0,30,105+105,0	240	26	27	10	1.0803	20.97
16	MAP + AS, Urea+Duration	0,30,105+105,0	240	20	23	6	1.0789	21.66
17	MAP + AS, NZone, NZone	0, 30, 70, 0	100	21	22	16	1.0816	21.92
18	MAP + AS, NZone, NZone	0, 30, 105, 0	135	28	28	5	1.0821	20.70
Treatment significance[1]				++	*	NS	NS	++
Treatment LSD (0.1)				17	17	--	--	1.44

[1]ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Duration (Agrium, Inc.) = 43-0-0; UAN (urea + ammonium nitrate) = 28-0-0; MAP (monoammonium phosphate) = 11-50-0; Urea = 46-0-0; NZone (AgXplore International): nitrogen stabilizer.

[2]PP=preplant, P=planting, E=emergence/hilling, PH=post-hilling (5 applications).

[3]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

On-Farm Evaluation of Potato Response to Nitrogen Source and Rate

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Summary: A field experiment was conducted with Russet Burbank potatoes in a center pivot field near Park Rapids, MN, to evaluate alternative methods of improving nitrogen use efficiency in irrigated potato production. Specifically, the objectives of the study were (1) to evaluate the polymer-coated urea product ESN, relative to other nitrogen sources for potatoes, (2) to assess the value of a chlorophyll meter and petiole nitrate analysis as diagnostic tools for determining the nitrogen status of the crop, and (3) to determine the effect of field planting history on nitrogen response. Nine nitrogen treatments were applied at just prior to shoot emergence, comparing six different application rates of ESN (0, 80, 120, 160, 200, and 240 lbs N/ac) and comparing four nitrogen sources (ESN, uncoated urea, ammonium sulfate, and a blend of ESN and the slower-releasing polymer-coated urea product Duration) at a single application rate (120 lbs N/ac). In addition to the nitrogen applied at emergence, each treatment received 105 lbs N/ac from other sources at other times, resulting in total application rates from 105 to 345 lbs N/ac. The study was conducted in two locations within the same center pivot, each with four replicates. One block was placed in a part of the field with a long history of potato cultivation (the fumigated "old field"), while the other was placed in the field that had been covered with trees until the previous year (the non-fumigated "new field"). Nitrogen application rate was positively related to petiole nitrate concentration and leaflet chlorophyll content in July and August, and to vegetative cover at harvest, while nitrogen source was not significantly related to any of these variables. Marketable yield and the percentage of yield represented by tubers over six or ten ounces both increased while tuber specific gravity decreased with application rate, but none of these variables were affected by nitrogen source. Total and marketable yield were similar between the two fields, but significantly more of the yield in the new field was represented by tubers over six or ten ounces, and tuber specific gravity was significantly higher in the old field. The negative relationship between nitrogen application rate and specific gravity was generally consistent across the tested application rates in the old field, but was only evident in the lowest and highest rates in the new field. Higher-nitrogen treatments generally had higher soil nitrate concentrations one month after harvest, particularly in the top 18 inches of soil. There was also a weak tendency for the ESN:Duration blend to have higher residual soil nitrogen than the other nitrogen sources. This finding is consistent with the slower release rate observed for this blend, compared to pure ESN, for fertilizer prills buried at planting depth in mesh bags. When averaged over the growing season, nitrogen source affected soil water nitrate concentrations, but the effect was not consistent between fields. The new field had significantly fewer *Verticillium dahliae* propagules per gram of soil (VPPG) than the old field. The new field also generally had higher petiole nitrate concentration, leaflet chlorophyll content, and vegetative cover at harvest, larger tubers, and lower tuber specific gravity. Within the old field, VPPG was negatively related to cover at harvest and residual soil nitrate one month later, but it was not significantly related to tuber yield.

Background

ESN (Environmentally Smart Nitrogen; Agrium, Inc.) is a polymer coated urea (PCU) product that releases nitrogen more gradually than uncoated urea. This reduces the risk of damaging seedlings with excessive urea and losing nitrogen to nitrate leaching before plants are able to take it up. Over the course of ten years of study at the

Sand Plain Research Farm in Becker, Minnesota, ESN has been found to be most effective on potatoes when applied at the time of shoot emergence. It is desirable, however, to test the effectiveness of this product and determine its ideal application rate in other locations.

In this study, we evaluated ESN in a field near Park Rapids, MN, approximately 120 miles NNE of Becker. Using nine treatments, ESN was compared with three other nitrogen sources (urea, ammonium sulfate, and a blend of ESN and Duration – a thicker-coated PCU) at a constant application rate (120 lbs N/ac, plus 105 lbs N/ac from other sources). ESN was also evaluated at a range of application rates (0, 80, 120, 160, 200, and 240 lbs N/ac, plus 105 lbs N/ac from other sources).

A field's agricultural history may also have substantial effects on crop performance, optimum rates and sources of nitrogen, and the prevalence of crop-specific pathogens in the field. To examine these effects, this study was conducted on two locations within the same center pivot. The "old field" was planted in an area with a long history of potato cultivation, while the "new field" was planted in an area that was covered in trees until the previous year. The density of propagules of *Verticillium dahliae* (the pathogen that causes verticillium wilt) was determined in each field.

The overall objectives of this study were (1) to evaluate the polymer-coated urea product ESN as a nitrogen source for potatoes, relative to other sources, (2) to assess the value of a chlorophyll meter and petiole nitrate analysis as diagnostic tools for determining the nitrogen status of the crop, and (3) to determine the effect of field planting history on nitrogen response.

Materials and Methods

The study was conducted in 2013 on a center pivot field (the Lepp Field) near Park Rapids, MN, on soil in a Verndale-Nymore soil complex, using the potato cultivar Russet Burbank. The study was established on two locations within the same field in close proximity. The "new field" was planted on land with a loamy sand texture that was covered in trees until the previous year. The "old field" was planted in land with a sand texture and a long history of potato cultivation. Characteristics of the top 10 inches of soil at planting are presented for each field in Table 1.

Within each field, nine treatments, as shown in Table 2, were planted in a randomized complete block design with four replicates (36 plots per field). Each plot was 18 feet wide and 40 feet long. Tubers were planted on May 11, 2013, with 3-foot spacing between rows (six rows per plot) and 1-foot spacing within rows. Tubers harvested for analysis were collected from the central 30 feet of the middle two rows.

Both fields received 525 lbs/ac potash on October 8, 2012, and 8 lbs 14.3% borate/ac and 150 lbs Pel-Lime/ac on May 8, 2013. Each treatment received 105 lbs N/ac over multiple applications, including 49 lbs N/ac as ammonium sulfate and urea before planting (May 8, 2013), 22 lbs N/ac as 10-34-0 at planting (May 11), and 34 lbs N/ac through fertigation with 32-0-0 and 12-0-0-26 (July 1 and 7).

Treatments differed in the amount and form of nitrogen applied just prior to shoot emergence (May 28). Five treatments received 80, 120, 160, 200, or 240 lbs N/ac as ESN (185 to 345 lbs N/ac in total), and three treatments received 120 lbs N/ac (225 lbs N/ac total) as urea, ammonium sulfate, or a blend of ESN and Duration. A control treatment received no fertilizer at emergence (105 lbs N/ac in total). This treatment was not included in the field layouts initially, but was added after the other treatment plots were established. Control plots were therefore arrayed around the outside of the blocks containing the other eight treatments. As a result, the control treatment was excluded from some analyses, as indicated below.

From June 18 through August 31, rainfall was monitored on-site, and overhead irrigation was applied, a half-inch at a time, as needed. Rainfall data from a nearby weather station was also recorded.

Suction tube lysimeters were installed on May 23 and flushed when the emergence fertilizer treatments were applied on May 28. In each of the two fields, the lysimeters were placed in each of the four replicates for the treatment receiving 240 lbs N/ac as ESN (treatment 6) and the ones receiving 120 lbs N/ac as ESN, urea, ammonium sulfate, and a 1:1 mixture of ESN and Duration (treatments 3, 7, 8, and 9, respectively). Samples were collected on June 4, 11, 18, and 25, July 3, 10, 17, 24, and 31, August 7, 13, 21, and 27, and September 4, 11, and 16. The samples were stored frozen and then tested for nitrate content.

Mesh bags containing 3 grams of polymer coated fertilizer were placed 4 inches below the soil surface in each field at shoot emergence, on May 28. They were collected 7, 14, 21, 28, 36, 43, 57, and 111 days after emergence (i.e., on June 4, 7, 11, 18, and 25, July 3, 10, and 24, and September 16). Each bag contained either ESN or a 1:1 blend of ESN and Duration. Three bags were planted for each fertilizer for each collection day except for September 16, when six bags were collected for each fertilizer. Collected bags were dried and their contents weighed to measure the percentage of their fertilizer content that had been released (accounting for the weight of the prill coats, which were assumed not to have changed).

Soil was sampled on June 13 in each plot except control plots in each field to test it for *Verticillium dahliae* propagules per gram of soil. The samples were sent to Pest Pros Inc. (Plainfield, WI) for testing using a dilution planting method on Sorenson's NPX, a selective growth medium. Intensity of infestation was measured as *Verticillium* propagules per gram (VPPG) of soil. Treatment thresholds for potato are placed at 8 VPPG.

Terminal petioles and leaflets were collected and chlorophyll readings taken on June 25, July 12, July 25, and August 16. Chlorophyll content was measured for the terminal leaflet of the 4th leaf from the end of a shoot using a SPAD meter. The petiole of this leaflet was then sampled to be analyzed for nitrate nitrogen concentration on a dry-weight basis. The control plots were sampled only on August 16.

On September 17, aerial photos were taken of the study site and used to determine percent ground cover for each plot. Ground cover was determined for the control plots in the new field, but not in the old field.

Tubers were harvested on September 17 and 18, and cleaned, sorted, and graded as soon as possible afterward. About 2% of harvested tubers were too damaged to grade. These were classified as “unusable” and were included in total yield, but not in other summary variables. Specific gravity was determined for a subset of marketable tubers from each plot.

To assess residual soil nitrate and ammonium concentrations after harvest, soil cores were collected from each plot on October 18 for two depth ranges: 0-18” and 18-36”. These were sent to Midwest Laboratories Inc. (Omaha, NE) for analysis.

For most variables, ANOVA tests were performed (GLM procedure in SAS 9.3) using field, nitrogen treatment, replicate, and the field*treatment interaction as independent variables. A Waller-Duncan k-ratio t-test was performed on all significant results for nitrogen treatment to determine the minimum significant difference between treatments. The effects of VPPG on vine, tuber, and soil variables were tested using ANOVA tests with VPPG as the independent variable. The tests were performed both including and excluding a plot with an exceptionally high VPPG (24, versus 12 for the next highest density observed).

Results:

Precipitation

Rainfall and irrigation amounts for the 2013 growing season are shown in Figure 1. There were four large rainfall events (close to or above an inch) between tuber planting, on May 11, and June 21. After this, the next large rainfall event was on September 14. The largest amount of rainfall received in one day between June 21 and September 14 was 0.51 inches (received on June 28). A total of 12.8 inches of water were applied on the fields as irrigation between June 18 and August 30. Rainfall total during this same period was 8.5 inches. Rainfall plus irrigation totaled 28.8 inches between planting (May 11) and harvest (September 17 and 18).

Soil water Nitrate-N Concentrations

Soil water nitrate-N (NO_3-N) concentration did not appear to change over time for the first 21 days after shoot emergence (through June 18; Figure 2). From then until 50 days after emergence (July 17), NO_3-N concentration increased from 23-39 ppm (days 7 to 21 after emergence) to 86-109 ppm (day 50). The beginning of this period of increase is concurrent with two large rainfall events (> 1 inch in 24 hours) and the onset of irrigation. Beyond 50 days after emergence, soil water NO_3-N concentration did not appear to vary consistently for all treatments over time.

At no single sampling time did soil water NO_3-N concentration differ significantly among the treatments. On the first water sampling date (June 4), the new field had a marginally significantly higher average soil water NO_3-N concentration than the old field, but the two fields were not significantly different on any subsequent sampling date.

For whole-season-average soil water NO_3-N, there was a highly significant field-by-treatment interaction.

Within the new field, there was a highly significant effect of treatment on whole-season-average soil water NO_3-N. The treatment receiving 120 lbs N/ac as ESN (treatment 3) had significantly lower soil water NO_3-N than any other treatment, and the treatment receiving uncoated urea (treatment 7) had significantly higher soil water NO_3-N than the treatment receiving the blend of ESN and Duration (treatment 9).

There was also a significant effect of fertilization treatment on whole-season average soil water NO_3-N in the old field. The treatment receiving 240 lbs N/ac as ESN (treatment 6) had significantly higher soil water NO_3-N than the treatment receiving 120 lbs N/ac as ESN (treatment 3) or the treatments receiving uncoated urea or ammonium sulfate (treatments 7 and 8). The treatment receiving the blend of ESN and Duration (treatment 9) also had significantly higher soil water NO_3-N than the treatments receiving uncoated urea or ammonium sulfate.

Fertilizer N Release from Coated Urea

Fertilizer release over time for ESN and a 1:1 blend of ESN and Duration placed in mesh bags and buried is illustrated in Figure 3. Bags were installed at shoot emergence, on May 28.

The release curve for ESN is typical for polymer-coated fertilizers, with the release rate rapid and accelerating soon after application and reaching a plateau when most of the fertilizer is depleted. Half of the fertilizer in the prills had been released by about 12 days after installation (June 9). The release rate slowed distinctly after the bag collection at three weeks (June 18), by which time 81% of the fertilizer had been released. By the final collection date, 111 days after installation (September 16, the day before harvest began), the prills had released 98.9% of their contents.

The release curve for the blend did not apparently plateau. The release rate was slightly slower than that of pure ESN in the first week and remained fairly steady until the second week, by the end of which 34.6% of the fertilizer had been released. After the second week, the release rate slowed. The prills had released 50% of their contents by about 45 days after installation (July 12). By 111 days after installation (September 16), they had released 86.1% of their contents. Assuming the ESN in the blend (like that in the bags of pure ESN) had released 98.9% of its contents by that time, the Duration in the blend had released approximately 37% of its fertilizer by harvest time.

Release rate did not apparently respond to large rainfall events (≥ 1 inch) or the onset or termination of irrigation (Figure 3).

Verticillium dahliae

The soil from the new field had a significantly lower density of *Verticillium* propagules (0.1 VPPG) than the soil from the old field (6.2 VPPG; Table 4). There was no significant difference among treatments in either field or for both fields together, and there was no significant treatment-by-field interaction. Only two of the 36 plots in the new field had detectable propagules. Most plots in the old field had them (seven did not), and eight plots had VPPG ≥ 8.

Leaflet chlorophyll content and petiole nitrate concentration

Leaflet chlorophyll content and petiole nitrate concentration did not respond to the nitrogen application rate (comparing treatments 2 – 6) at the first leaf sampling date (June 25; Table 4). However, for the old field, and for the average of the two fields, chlorophyll content and nitrate concentration increased significantly with application rate for all subsequent sampling dates. For the new field, the effect of application rate was only significant on the final sampling date, August 16, but this effect was significant whether or not the control treatment (treatment 1) was included in the analysis.

Among the treatments receiving 120 lbs N/ac at emergence from different sources (ESN, treatment 3; urea, treatment 7; ammonium sulfate, treatment 8; and a blend of ESN and Duration, treatment 9), leaflet chlorophyll content and petiole nitrate concentration generally did not vary significantly. For the old field, there was a marginally significant effect of nitrogen source on chlorophyll content in the second sampling, on July 12, and a significant effect in the third sampling, on July 25. There was also a marginally significant effect of source on petiole nitrate for this field on this date. In each case, the treatment receiving a blend of ESN and Duration (treatment 9) had a significantly lower mean chlorophyll content or nitrate concentration than one or more of the other treatments, which did not differ significantly from each other.

There was a significant effect of field at each sampling date. On the second sampling date, July 12, the old field samples had higher leaflet chlorophyll content than the new field samples. On each of the other three sampling dates, the new field had the higher chlorophyll content. In contrast, for petiole nitrate concentration, it was on the first sampling date that the samples from the old field had higher values, with the old field having lower nitrate concentrations thereafter.

Vegetative cover at harvest

Vegetative cover at harvest time generally increased with fertilizer application rate (treatments 1 – 6; Table 4). In the new field, this trend was apparent only in that the control treatment (treatment 1) had significantly lower cover than some of the other treatments. In the old field, where cover was not determined for the control treatment, the two treatments receiving the highest total nitrogen application rates (treatments 5 and 6) had significantly higher cover than the other treatments.

There was no significant effect of nitrogen source on vegetative cover among the treatments receiving 120 lbs N/ac at emergence as ESN (treatment 3), urea (treatment 7), ammonium sulfate (treatment 8), or a blend of ESN and Duration (treatment 9).

The new field had significantly greater vegetative cover than the old field.

Tuber yield

Tuber yield data are presented in Table 5. Both linear and quadratic contrasts were significant for total yield as a function of ESN application rate. Yield increased approximately linearly with application rate between 105 and 305 lbs total N/ac, but total yield at the rate of 345 lbs total N/ac (treatment 6) was lower than for any other treatment receiving pure ESN (treatments 2 – 5). The decrease in total yield at the highest application rate was partially due to low yields of tubers under three ounces and unusable tubers. As a result, the decline in yield between the 305 and 345 total N/ac application rates was less dramatic for marketable yield, and the quadratic contrast was only marginally significant. The yield of U.S. No. 1 tubers showed a similar pattern to that of total marketable yield, while the yield of U.S. No. 2 tubers generally increased with application rate, but with the highest yields at rates of 265 to 305 lbs total N/ac. The peak in yield at the second-highest application rate was evident in the new field, but not in the old field, in which yield increased with application rate throughout the tested range. In none of these categories did yield respond significantly to nitrogen source (comparing treatments 3, 7, 8, and 9).

The effect of fertilization treatment on yield was more evident in the old field than in the new field, based on ANOVA P-values. However, overall, the two fields did not differ significantly in marketable yield or yield of U.S. No. 1 tubers, and there were no significant field-by-treatment interaction effects for these variables. The old field had marginally significantly higher total yield and significantly higher yield of U.S. No. 2 tubers than the new field. There was also a significant field-by-treatment interaction effect for yield of U.S. No. 2 tubers, with the old field showing a clear increase in yield with application rate that was not evident in the new field.

While nitrogen source had no effect on the percentages of yield represented by tubers over 6 ounces and tubers over 10 ounces, the percentage of large tubers clearly increased with nitrogen application rate. This trend was seen in both fields taken separately, and there was no field-by-treatment interaction. However, the new field did have significantly greater percentages of tubers over 6 and 10 ounces than the old field.

Specific gravity decreased highly significantly with increasing nitrogen application rate. This trend was very clear in the old field, but was supported only by the control treatment (treatment 1) and the highest-nitrogen treatment (treatment 6) in the new field. Accordingly, the field-by-treatment effect was highly significant when only the ESN treatments (treatments 1-6) were considered. Nitrogen source (comparing treatments 3, 7, 8, and 9) had no significant effect on specific gravity. The old field produced tubers with significantly higher specific gravity than the new field.

Residual soil nitrogen

Soil NH_4-N concentration after harvest was not significantly affected by fertilization treatment (Table 6).

In general, residual soil NO_3-N concentration increased with increasing nitrogen application rate. Comparing the treatments in which ESN was applied at different rates (treatments 1 – 6), this relationship was significant in the shallower soil samples for the old field and for both fields combined. It was marginally significant in the shallower samples for the new field and in the deeper samples for the new field and for both fields combined.

For the new field and for the two fields combined, there was a marginally significant effect of nitrogen source (comparing treatments 3, 7, 8, and 9) on residual NO_3-N in the deeper samples, with the treatment receiving a blend of ESN and Duration (treatment 9) having a significantly higher mean concentration than the other three. While this trend was reflected numerically in the shallower samples, it was not significant.

There were also effects of nitrogen source on the concentration of NH_4-N. The treatment receiving the ESN/Duration blend (treatment 9) and the one receiving ammonium sulfate (treatment 8) sometimes had significantly higher concentrations than one or both of those receiving the other nitrogen sources (ESN, treatment 3; and urea, treatment 7).

Effects of Verticillium *density on potato plants and tubers*

The *Verticillium* density in a plot was unrelated to all potato vine and tuber variables. However, the plot with the highest density had twice the VPPG of the next-highest plot (24 propagules per gram versus 12). When this outlier was removed, there were significant negative relationships between VPPG and vegetative cover at harvest (R^2 = 0.1266; P = 0.495; Figure 4a). VPPG also had a significant negative relationship to the residual nitrate concentration of the top 18 inches of soil (R^2 = 0.1340; P = 0.0428). While tuber yield tended to decrease with VPPG, the relationship was not significant for any yield variable (e.g., marketable yield: $R^2 = 0.0433$; $P = 0.2633$; Figure 4b).

Conclusions

Based on the results for fertilizer prills placed in mesh bags and buried at the 4" depth, the blend of Duration and ESN was much slower to release its urea content than pure ESN was. Both coated fertilizers presumably released their fertilizer more slowly than uncoated urea or uncoated ammonium sulfate. This difference in release rate would be expected to have implications for petiole nitrate concentration, chlorophyll content, vine cover at harvest, tuber size and yield, and residual soil nitrogen after harvest. However, the only effects of nitrogen source on any variable were marginally significant (0.05 < ≤P 0.10) effects on residual soil ammonia and nitrate concentrations. As expected, the ESN-Duration blend had higher residual nitrogen than other nitrogen sources, but the ammonium sulfate treatment showed the same effect with equal strength for residual ammonium (though not for residual nitrate). It should be noted that approximately 50% of the total nitrogen applied in the source comparisons was as soluble nitrogen. Therefore, true differences due to source may have been masked to some degree.

The effects of ESN application rate were much more pronounced. While there was no difference among application rates as of June 25, leaflet chlorophyll content and petiole nitrate concentration increased with application rate on subsequent sample dates (July 12 and 25 and August 16), as did vegetative cover at harvest. These effects were more apparent in the old field, and were not significant in the new field until August 16. Yield also generally increased with application rate, peaking at the second-highest rate (200 lbs N/ac as ESN, 305 lbs N/ac total). The effect was stronger for marketable yield than for total yield, and stronger in the old field than in the new field. Yield in the larger size classes was more strongly affected, so that the percentage of yield represented by tubers over six or ten ounces increased with application rate in each field and for both fields combined. While yield increased, the specific gravity of tubers decreased with increasing application rate, probably due to increased allocation of energy to vine growth and a resultant delay in tuber maturation at high nitrogen rates. The observed increase in vegetative cover with nitrogen application rate is consistent with this. Finally, residual soil nitrate concentration at both sampled depthsincreased with ESN application rate.

The new field and old field differed significantly in almost every variable measured. Most of the differences were similar to what would be expected if the field had been fertilized with a higher nitrogen application rate. Leaflet chlorophyll content, petiole nitrate concentration, and vegetative cover at harvest were all generally higher in the new field. While total yield was higher in the old field, the new field had a higher yield in the larger size categories. Tubers in the new field had lower mean specific gravity than those in the old field. Finally, the new field had a higher residual nitrate concentration, with the difference being significant in the 0 – 18" soil samples.

The two fields may have differed in their concentrations of organic nitrogen. This is consistent with the much higher initial organic matter content of the new field. It may also explain why yield peaked at the second-highest application rate in this field, but continued to increase throughout the tested range of application rates in the old field. However, if the new field did have larger organic nitrogen reserves than the new field, this is not clearly reflected in the soil water nitrate concentrations measured by lysimeters, even averaged over the whole season.

The timing of precipitation and irrigation did not appear to be connected with changes in nitrogen release from bagged prills over time. Soil water nitrate concentration did begin to increase at the same time that two major rainfall events (over 1 inch in 24 hours) and the onset of irrigation occurred. However, there were no other dramatic changes in precipitation between this time and harvest, and it is therefore unclear whether these events are causally connected.

The density of *Verticillium dahliae* propagules detected in plots in the old field showed weak negative relationships to vine cover at harvest and residual soil nitrate in the top 18 inches of soil one month after harvest. The relationship to cover is consistent with verticillium wilt. However, the relationship to residual nitrate is not intuitive, as plots with less vegetative cover would be expected to have more free soil nitrate in the soil, as less nitrogen is incorporated into the vines.

Table 1. Initial soil characteristics in each of the two study fields.

Field	OM (%)	pH	CEC	P (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	S (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	B (ppm)	Sand (%)	Silt (%)	Clay (%)	Soil Type
New	1.7	6.1	9	120	162	186	1147	10	2.9	5	35	0.5	0.4	80	16	4	Loamy sand
Old	0.7	5.9	5.2	115	125	111	612	9	4.2	5	41	0.5	0.3	90	8	2	Sand

Table 2. Nitrogen treatments tested on irrigated Russet Burbank potatoes.

Treatment	Nitrogen source[1] at emergence	Nitrogen application rate at emergence (lbs N/ac)	Total nitrogen application rate (lbs N/ac)
1	None	0	105
2	ESN	80	185
3	ESN	120	225
4	ESN	160	265
5	ESN	200	305
6	ESN	240	345
7	Urea	120	225
8	Ammonium sulfate	120	225
9	1:1 ESN: Duration	120	225

[1]Ammonium sulfate: 21-0-0. Urea: 46-0-0. ESN (Environmentally Smart Nitrogen, Agrium, Inc.): 44-0-0. Duration (Agrium, Inc.): 43-0-0.

Figure 1. Precipitation received as rainfall and irrigation in the 2013 growing season. The arrow indicates shoot emergence, when emergence fertilizer treatments were applied, lysimeters were purged (see Figure 2), and mesh bags of fertilizer were planted (see Figure 3).

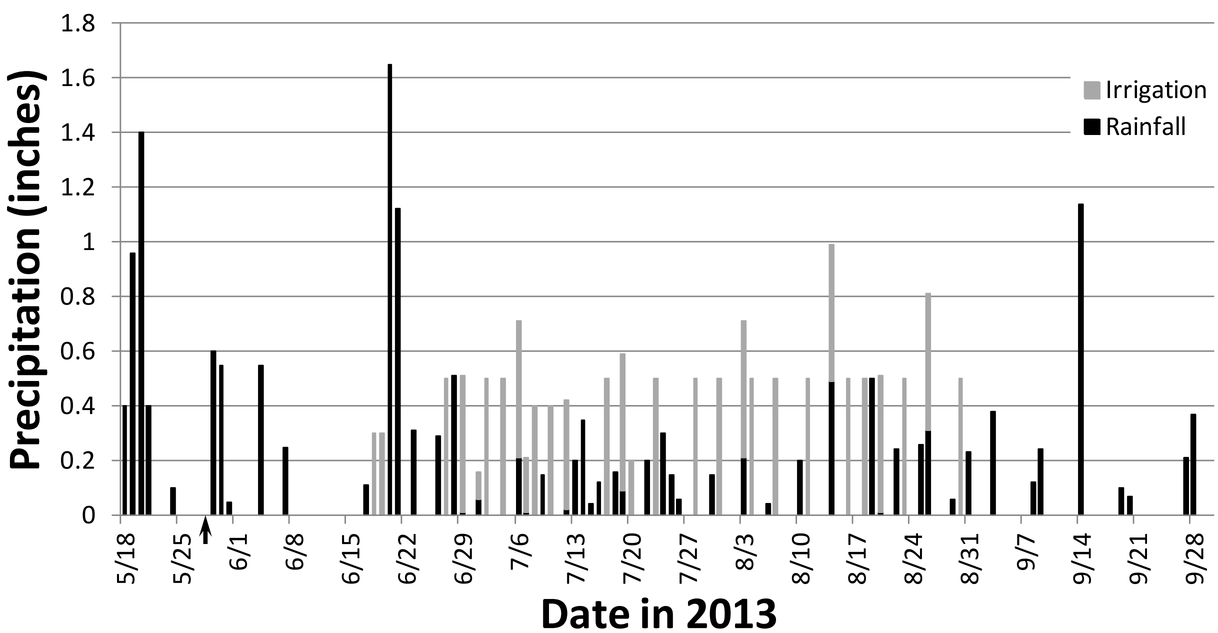


Figure 2. Nitrate concentration (ppm) of soil water sampled from lysimeters throughout the growing season staring at shoot emergence for the new field (a) and the old field (b). Arrows indicate major precipitation events (> 1 inch).

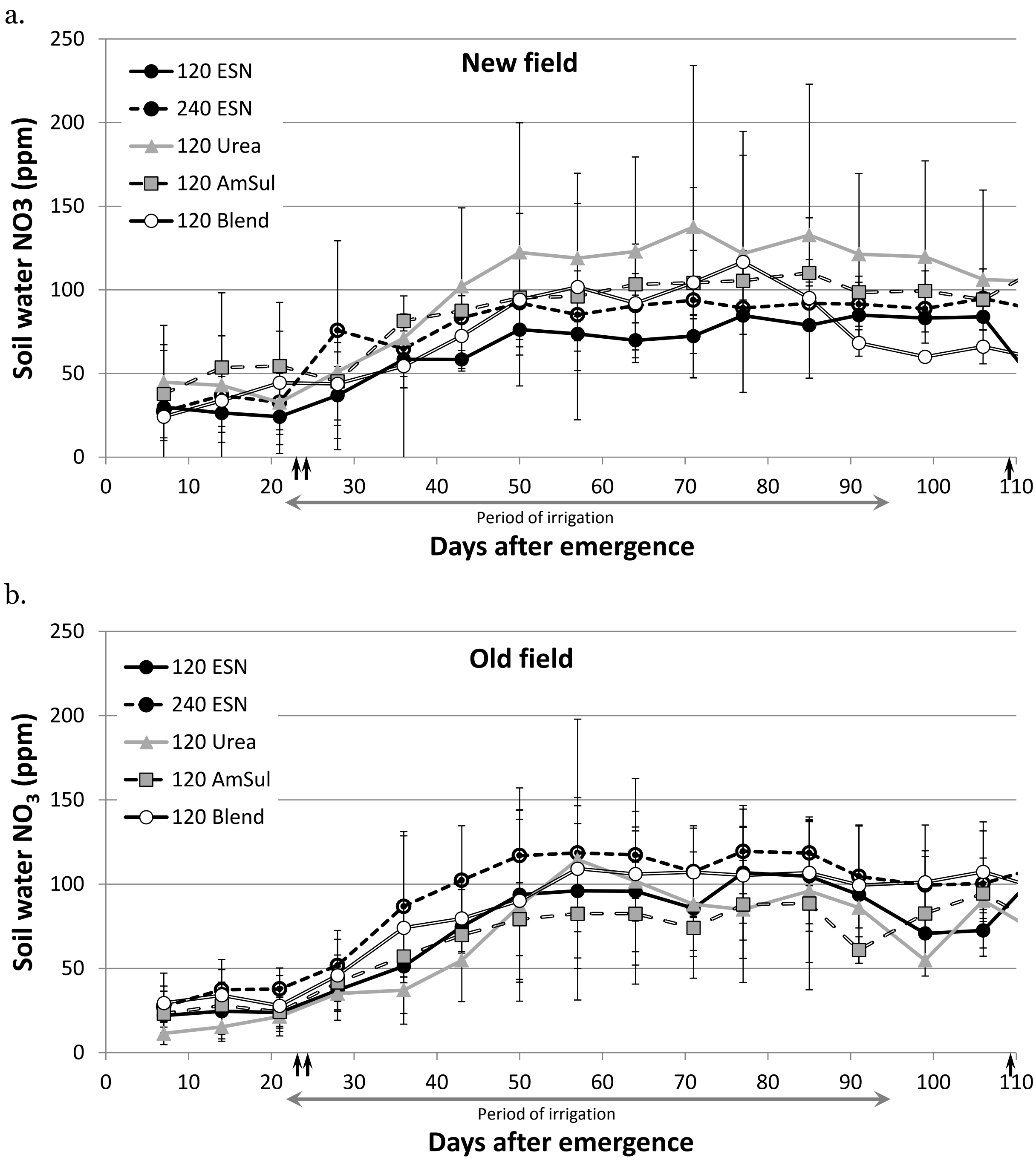


Table 3. Effects of nitrogen application rate and source on whole-season-average soil water nitrate concentration.

Field	Treatment	Nitrogen source[1]	Application rate at emergence (lbs N/ac)	Total nitrogen (lbs N/ac)	Soil water NO_3 (ppm)
New	3	ESN	120	225	56.7
	6	ESN	240	345	77.0
	7	Urea	120	225	93.8
	8	AS	120	225	83.2
	9	ESN + Duration	120	225	69.4
				Treatment significance[2]	**
				Treatment LSD (P < 0.1)	12.6
Old	3	ESN	120	225	70.7
	6	ESN	240	345	89.6
	7	Urea	120	225	65.9
	8	AS	120	225	64.3
	9	ESN + Duration	120	225	80.5
				Treatment significance[2]	**
				Treatment LSD (P < 0.1)	12.2

Both	Treatment significance[2]	**
	Field significance[2]	NS
	Field * Treatment significance[2]	**

[1]ESN (Environmentally Smart Nitrogen, Agrium, Inc.) = 44-0-0; Urea = 46-0-0; AS (ammonium sulfate) = 21-0-0-24S; Duration (Agrium, Inc.) = 43-0-0.

[3]NS = Not significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Figure 3. Percentage of fertilizer released from prills of ESN and a 1:1 blend of ESN and Duration buried in mesh bags 4 inches beneath the soil surface in study plots. The bags were installed when the emergence fertilizer applications were made, on May 28. Arrows indicate major precipitation events (> 1 inch).

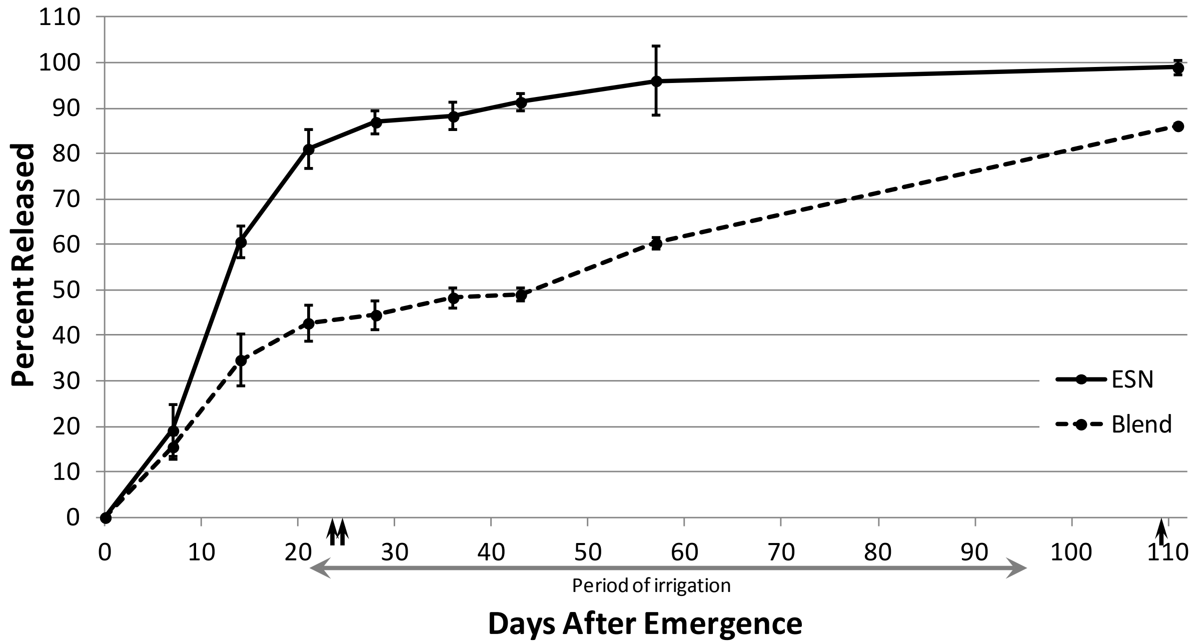


Table 4. Effects of nitrogen source on *Verticillium* propagule density and Russet Burbank leaflet chlorophyll content, petiole nitrate concentration, and percent cover.

Field	Treatment	Nitrogen source[1]	Application rate at emergence (lbs N/ac)	Total nitrogen (lbs N/ac)	*Verticillium* propagules / gram (VPPG)	Chlorophyll content 25-Jun	12-Jul	25-Jul	16-Aug	Petiole nitrate concentration 25-Jun	12-Jul	25-Jul	16-Aug	Cover (%)
						(SPAD readings)				(ppm)				
Both	1	Control	0	105	--				27.6				160	60
	2	ESN	80	185	2.0	44.5	41.2	37.0	33.9	18826	12485	6386	1977	70
	3	ESN	120	225	2.3	45.6	42.1	38.9	37.1	19167	15216	9992	2116	71
	4	ESN	160	265	4.0	45.3	42.2	39.0	38.1	20619	16199	9745	3235	70
	5	ESN	200	305	4.8	44.7	42.4	39.5	38.6	19515	17867	10810	4585	74
	6	ESN	240	345	1.8	45.6	42.3	40.8	40.7	19605	18080	14001	6732	82
	7	Urea	120	225	2.8	45.6	41.6	38.1	35.0	19916	13628	8314	740	62
	8	AS	120	225	4.0	46.1	42.3	38.3	36.0	19670	13875	9731	1368	67
	9	ESN + Duration	120	225	3.8	45.4	41.4	37.5	36.5	18921	12502	7016	1889	64
Treatment significance[2]					NS	NS	*	**	**	NS	**	**	**	**
Treatment LSD (P < 0.1)					--	--	0.9	1.6	1.8	--	1754	2239	1641	12
New	All				0.1	45.9	41.2	39.1	37.2	18261	15991	10837	3771	80
Old	All				6.2	44.8	42.7	38.1	34.7	20799	13971	8162	1296	57
Field significance[2]					**	**	**	*	**	**	**	**	**	**
Field * Treatment significance[2]					NS	NS	++	NS	NS	NS	NS	*	NS	*
Effect of ESN application rate (comparing treatments 1-6).			Treatment significance[2]		NS	NS	*	**	**	NS	**	**	**	**
			Treatment LSD (P < 0.1)		--	--	0.8	1.7	1.9	--	1659	2319	1885	11
			Contrasts[2]	Linear	NS	NS	*	**	**	NS	**	**	**	*
				Quadratic	NS	NS	++	NS	**	NS	NS	NS	NS	NS
Effect of nitrogen source (comparing treatments 3, 7, 8, and 9).			Treatment significance[2]		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			Treatment LSD (P < 0.1)		--	--	--	--	--	--	--	--	--	--

[1]AS (ammonium sulfate): 21-0-0. Urea: 46-0-0. ESN (Environmentally Smart Nitrogen, Agrium, Inc.): 44-0-0. Dur: Duration (Agrium, Inc.): 43-0-0.

[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 5. Effects of nitrogen source on Russet Burbank tuber yield, size distribution, and specific gravity.

Nitrogen Treatments					Tuber yield											Quality
Field	Treatment	Nitrogen source[1]	Application rate at emergence (lbs N/ac)	Total nitrogen (lbs N/ac)	Unusable	0-3 oz	3-6 oz	6-10 oz	> 10 oz	Total	#1s > 3 oz.	#2s > 3 oz	Total marketable	> 6 oz	> 10 oz	Specific Gravity
					cwt / ac									%		
Both	1	Control	0	105	12	68	212	154	22	467	371	16	387	37	5	1.0889
	2	ESN	80	185	10	62	209	194	36	510	419	19	438	45	7	1.0834
	3	ESN	120	225	16	48	185	219	54	522	428	30	458	52	11	1.0845
	4	ESN	160	265	11	54	182	228	59	534	438	31	469	54	11	1.0835
	5	ESN	200	305	15	53	187	230	67	552	460	24	484	54	12	1.0825
	6	ESN	240	345	5	45	150	229	79	507	431	27	458	61	16	1.0813
	7	Urea	120	225	13	53	203	210	49	529	436	27	463	49	9	1.0840
	8	AS	120	225	9	52	198	208	52	520	425	33	459	50	10	1.0843
	9	ESN + Duration	120	225	12	46	189	234	49	530	449	23	472	54	9	1.0846
Treatment significance[2]					NS	*	*	**	**	NS	++	**	*	**	**	**
Treatment LSD (P < 0.1)					--	13	33	29	16	--	52	8	48	6	3	0.0018
New	All				6	48	166	223	63	507	429	23	453	56	12	1.0830
Old	All				16	59	214	200	41	530	427	28	455	45	8	1.0851
Field significance[2]					**	**	**	**	**	++	NS	*	NS	**	**	**
Field * Treatment significance[2]					NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	*
Effect of ESN application rate (comparing treatments 1-6).			Treatment significance[2]		NS	*	**	**	**	++	*	*	*	**	**	**
			Treatment LSD (P < 0.1)		--	12	23	31	15	54	51	10	48	5	2	0.0018
			Contrasts[2]	Linear	NS	**	**	**	**	*	**	*	**	**	**	**
				Quadratic	NS	NS	NS	++	NS	*	NS	++	++	NS	NS	NS
Effect of nitrogen source (comparing treatments 3, 7, 8, and 9).			Treatment significance[2]		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			Treatment LSD (P < 0.1)		--	--	--	--	--	--	--	--	--	--	--	--

[1]AS (ammonium sulfate): 21-0-0. Urea: 46-0-0. ESN (Environmentally Smart Nitrogen, Agrium, Inc.): 44-0-0. Dur: Duration (Agrium, Inc.): 43-0-0.

[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Table 6. Residual soil nitrogen in the study field on October 18, one month after harvest.

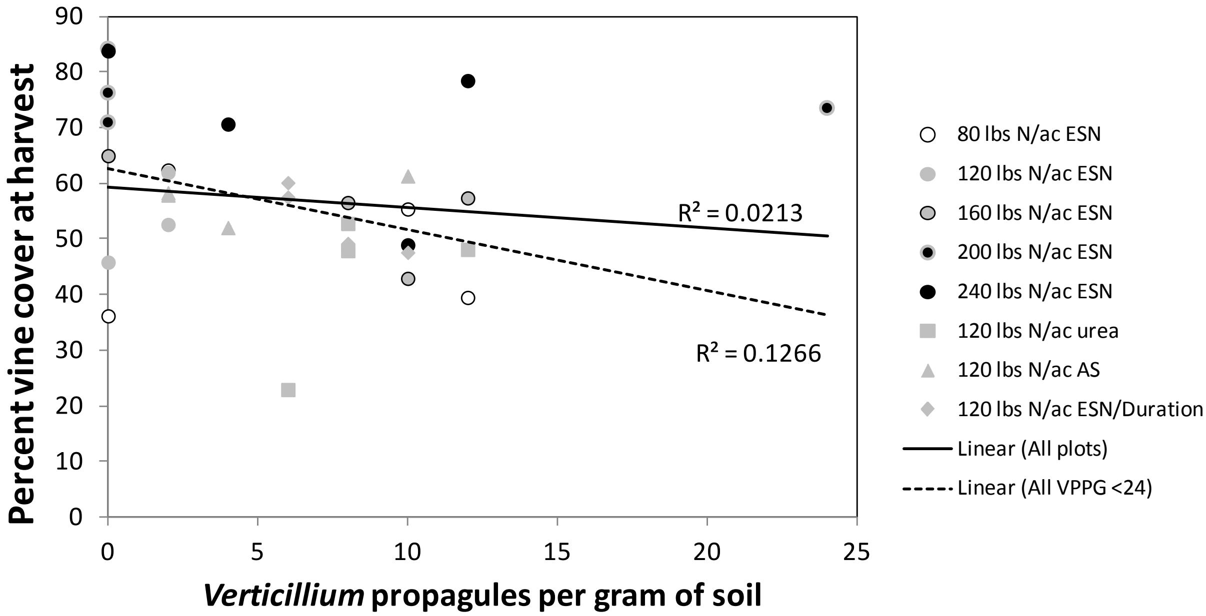
Field	Treatment	Nitrogen source[1]	Application rate at emergence (lbs N/ac)	Total nitrogen (lbs N/ac)	Residual soil nitrogen (ppm), 0-18"		Residual soil nitrogen (ppm), 18-36"	
					NO_3-N	NH_4-N	NO_3-N	NH_4-N
Both	1	Control	0	105	4.4	5.4	3.0	5.6
	2	ESN	80	185	5.8	5.9	2.8	5.0
	3	ESN	120	225	5.3	5.4	3.1	4.4
	4	ESN	160	265	7.3	5.5	3.8	5.0
	5	ESN	200	305	7.8	5.5	5.0	4.9
	6	ESN	240	345	7.0	5.5	6.1	4.8
	7	Urea	120	225	5.0	5.3	2.3	4.3
	8	AS	120	225	6.0	5.8	3.4	4.9
	9	ESN + Duration	120	225	7.4	5.9	4.9	5.1
Treatment significance[2]					++	NS	*	NS
Treatment LSD (P < 0.1)					2.4	--	2.3	--
New	All				7.8	5.7	4.4	5.0
Old	All				4.6	5.4	3.3	4.8
Field significance[2]					**	NS	*	NS
Field * Treatment significance[2]					NS	NS	NS	NS
Effect of ESN application rate (comparing treatments 1-6).			Treatment significance[2]		*	NS	++	NS
			Treatment LSD (P < 0.1)		1.9	--	2.5	--
			Contrasts[2]	Linear	**	NS	*	NS
				Quadratic	NS	NS	++	NS
Effect of nitrogen source (comparing treatments 3, 7, 8, and 9).			Treatment significance[2]		**	NS	**	NS
			Treatment LSD (P < 0.1)		NS	NS	*	NS

[1]AS (ammonium sulfate): 21-0-0. Urea: 46-0-0. ESN (Environmentally Smart Nitrogen, Agrium, Inc.): 44-0-0. Dur: Duration (Agrium, Inc.): 43-0-0.

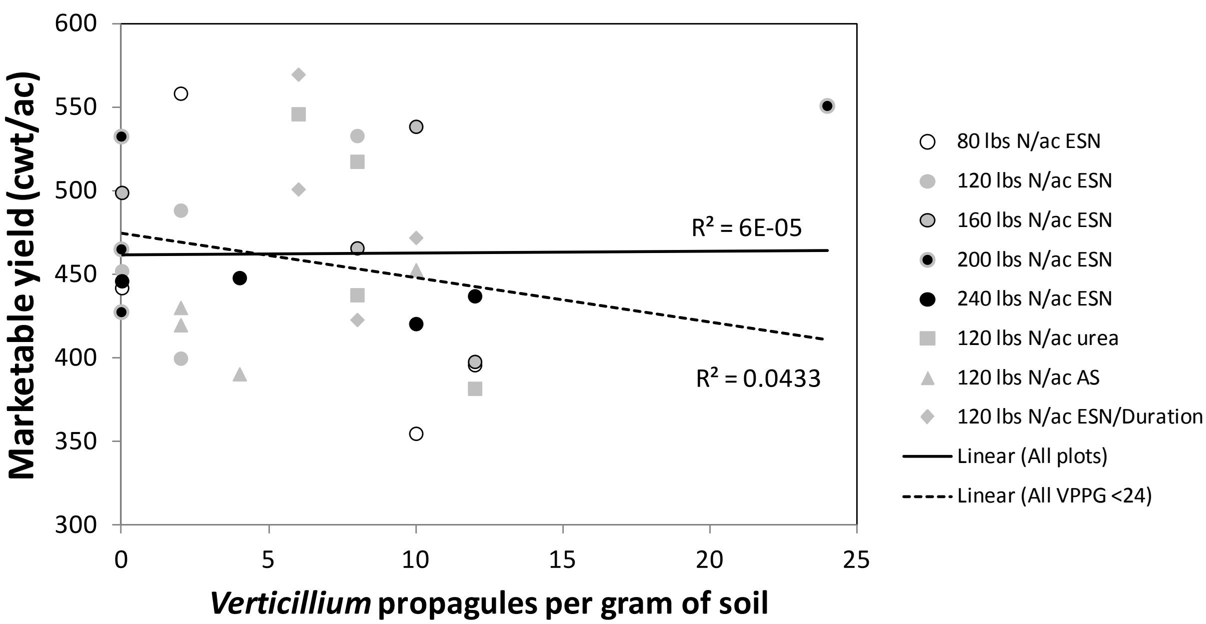
[2]NS = Non significant; ++, *, ** = Significant at 10%, 5%, and 1%, respectively.

Figure 4. Marketable yield (a) and percent vine cover (b) for plots in the old field as a function of *Verticillium* prevalence in the soil. Regression lines were produced both including (solid line) and excluding (dashed line) an outlying plot with 24 propagules per gram.

a.



b.



Optimizing Potassium Management for Irrigated Potato Production
Red Norland

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Summary: A field experiment was conducted at the Sand Plain Research Farm in Becker, MN to evaluate the effect of potassium (K) application rate and timing on Red Norland yield and quality, petiole K concentrations, and differences in soil test K at three soil depths after harvest. Six K treatments were tested: a zero K control; 160 and 320 lb K_2O/A applied preplant; 160 lb K_2O/A applied at planting; a split application of 160 lb K_2O/A preplant + 160 lb K_2O/A at planting; and a split application of 160 lb K_2O/A at planting + 160 lb K_2O/A at emergence. None of the K fertilizer treatments increased yield above the zero K control, but there were significant differences in tuber yield and size among the K treatments. Total yields were significantly greater when 160 lb K_2O/A was applied preplant rather than at planting, due to significant increases in tuber size. The zero K control and 160 lb K_2O/A preplant treatments had the highest total yields, primarily due to larger tuber size. Increasing K rate was associated with decreases in yield and tuber size, but this was inconsistent due to interactions with application timing. The Hue and Value components of red skin color were highest at 160 lb K_2O/A, whereas Chroma was lowest at this K rate. The zero K treatment had the highest specific gravity and there was a significant linear decrease in tuber specific gravity as K application rate increased. There were significant linear increases in petiole K on all three sampling dates as K application rate increased. Petiole K was consistently within or above the sufficiency range for all treatments, except for some marginal values in the zero K control, so lack of a yield response to K fertilization was not due to inadequate uptake of the extra K supplied. There was a significant linear increase in residual soil K in the 0-6 in. depth as the rate of K fertilizer application increased. Soil test K in this depth decreased by 10 ppm from initial spring levels in the zero K control, but increased by 40 ppm for the 160 lb K_2O/A treatments and 47 ppm for the 320 lb K_2O/A treatments. These changes show a 10 ppm drawdown in soil test K from a potato crop with a total yield of 432 cwt/A and suggest that a K rate much lower than 160 lb K_2O/A is required to maintain soil test K at this yield level. There were no significant differences among treatments in soil K at either the 6-12 or 12-24 in. soil depths in the fall, indicating limited movement of K below the zone of K fertilizer incorporation during the growing season.

Background: In response to numerous questions over several growing seasons about soil test potassium (K) levels, potential leaching losses of K, and lower petiole K levels than normal, a K study was initiated on Russet Burbank potatoes in 2012. This study was designed to determine when soil test K provides a reasonable measure of K availability, how much K might be leaching below the crop root zone, and how much soil K drops after growing a crop of potatoes fertilized at various K rates. Following the first year of this research, similar questions were asked about K management for Red Norland, so the study was expanded to include this earlier maturing potato cultivar in 2013.

The objectives of the Red Norland part of the study were to: 1) evaluate Red Norland response to K fertilizer rate and timing, 2) determine changes in soil test K resulting from K fertilization, and 3) determine the extent of K movement in the soil during the growing season.

Materials and Methods

This study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand soil. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6“): pH, 6.6; organic matter, 1.8%; Bray P1, 42 ppm; ammonium acetate extractable K, Ca, and Mg, 94, 716, and 129 ppm, respectively; Ca-phosphate extractable SO_4-S, 2 ppm; hot water extractable B, 0.2 ppm; and DTPA extractable Fe, Mn, Cu, and Zn, 24, 18, 0.7, and 0.9 ppm, respectively. Extractable nitrate-N in the top 2 ft of soil was 9.7 lb/A.

Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole "B" seed of Red Norland potatoes were hand planted in furrows on May 3, 2013. Row spacing was 10 inches within each row and 36 inches between rows. Each treatment was replicated four times in a randomized complete block design. Belay for beetle control and the systemic fungicide Quadris were banded at row closure. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Six K treatments were tested as described in Table 1 below: a zero K control; 160 and 320 lb K_2O/A applied preplant; 160 lb K_2O/A applied at planting; a split application of 160 lb K_2O/A preplant + 160 lb K_2O/A at planting; and a split application of 160 lb K_2O/A at planting + 160 lb K_2O/A at emergence. Preplant K was broadcast and incorporated to a depth of 3 to 4 inches with a field cultivator on May 2. Potassium applied at planting was banded 3 inches to each side and 2 inches below the seed piece using a metered, drop fed applicator. Emergence K was sidedressed on May 29 and mechanically incorporated during hilling. Potassium chloride (0-0-60) was the K source for all treatments.

All treatments received a total of 180 lb N/A applied at planting (40 lb N/A) and emergence/hilling (140 lb N/A). Nitrogen at planting was supplied as diammonium phosphate (DAP) and was banded as described above for the treatments with K applied at planting. Emergence N applications were supplied as a combination of urea (115 lb N/A) + ammonium sulfate (25 lb N/A) and mechanically incorporated during hilling on May 29 (along with the emergence K treatment). The ammonium sulfate also supplied 29 lb S/A. In addition to N, banded fertilizer at planting (for all treatments) included 102 lb P_2O_5/A, 1.5 lb S/A, 2.0 lb Zn/A, and 1.0 lb B/A applied as a blend of DAP, zinc sulfate and zinc oxide (EZ 20), and sodium tetraborate (Granubor 2).

Plant stands were measured on June 11 and stem number per plant on July 3. Petiole samples were collected from the 4th leaf from the terminal on three dates: June 19, July 3, and July 11. Petioles were analyzed for K on a dry weight basis. Vines were chemically killed using two applications of the dessicant Reglone on Jul 25 and Aug 1. Tubers were machine harvested on Aug 15 from two, 18-ft sections of row in each plot. Total tuber yield and graded yield were measured. Sub-samples of tubers were collected to determine tuber specific gravity, tuber dry matter, and the incidence of hollow heart, brown center, and scab. Soil samples were collected after harvest on Sep 3 from three soil depths (0-6 in., 6-12 in., and 12-24 in.) in each plot and analyzed for ammonium acetate extractable K.

Table 1. Potassium treatments[1] tested on irrigated Red Norland potatoes.

Treatment #	Timing and rate of potassium application			Total potassium
	Preplant	Planting	Emergence	
	lbs K_2O/ac			
1	0	0	0	0
2	160	0	0	160
3	320	0	0	320
4	0	160	0	160
5	160	160	0	320
6	0	160	160	320

[1]All K fertilizer was applied as potassium chloride (0-0-60).

Results

Tuber Yield and Size Distribution: Table 2 shows the effects of K rate and application timing on tuber yield and size distribution. The zero K control had the highest total yield numerically and there was actually a significant linear decrease in yield when application timing was ignored and yields were averaged for the different total K rates: 432 cwt/A for zero K, 410 cwt/A for 160 lb K_2O/A, and 397 cwt/A for 320 lb K_2O/A. However, this negative response to K is misleading when the effects of application timing are considered. Total yields were significantly greater when 160 lb K_2O/A was applied preplant than when the same total rate was applied at planting (trt 2 vs. 4). Among the treatments where K fertilizer was applied, the two that received no preplant K (4 and 6) had the lowest yields. These results were consistent with an early demand for K in this early-maturing variety, even though K applied at planting is generally considered equally available for early plant growth and potentially more effective since it is concentrated closer to the zone of initial root growth. A conclusion that there was a yield response to preplant K is also inconsistent with the fact that the zero K treatment had the highest total yield and no preplant K application. Both the zero K and preplant 160 lb K_2O/A treatments had significantly greater yields than the two treatments receiving no preplant K.

Higher total yields for the zero K and preplant 160 lb K_2O/A treatments were primarily due to larger tuber size. About 90% of the difference between those treatments and the two lowest yielding treatments was from greater yields in the 2.25-2.50 in. and 2.50-3.00 in. tuber size classes. As with total yield, differences in tuber size were also associated with differences in K rate and application timing. There was a significant linear increase in small tubers < 1.75 in. as K application rate increased and a significant decrease in yield of 2.25-2.50 in. tubers as the K rate increased. There was also a significantly greater yield of 2.50-3.00 in. tubers when the total K rate was 160 lb K_2O/A compared with 320 lb K_2O/A. For the 160 lb K_2O/A rate the yield of 2.50-3.00 in. tubers was significantly greater when it was applied preplant rather than at planting. Yield of tubers > 3.00 in. was also numerically much greater for preplant application. The combined yield difference for these two largest tuber size classes accounted for 80% of the significantly greater total yield when 160 lb K_2O/A was applied preplant rather than at planting. Although the difference was not statistically significant, the two treatments with the lowest total yields and no preplant K had much lower yields of large tubers > 3.00 in.

Tuber Quality: Table 3 shows the effects of K rate and timing on tuber quality. For the Munsell color components Hue and Value there were quadratic increases as the total K rate increased, whereas a quadratic decrease in Chroma occurred as K rate increased. Hue and Value were highest at 160 lb K_2O/A. Value was highest for the zero K control and lowest for 160 lb K_2O/A. However, there was no effect on color when evaluated visually. Application timing had no effects on color and neither rate nor timing affected the degree of tuber skinning.

The zero K treatment had the highest specific gravity and there was a significant linear decrease in tuber specific gravity as K application rate increased. This response to K was similar to last year's results in the Russet Burbank component of this study, although this year specific gravity did not decrease as K rate increased for Russet Burbank. Application timing did not affect specific gravity.

Tuber dry matter followed the same pattern as specific gravity and decreased as K rate increased. None of the K treatments affected the incidence of hollow heart, brown center, or scab. They also had no effect on plant stand or the number of stems per plant.

Petiole K Concentrations: Petiole K concentrations on three dates as affected by K fertilizer rate and application timing are presented in Table 4. There were significant linear increases in petiole K on all three dates as K application rate increased. Therefore, the absence of a positive yield response to K fertilization in this study (Table 2) was not due to inadequate uptake of the extra K supplied. The lack of a yield response can be explained by comparing the K concentrations in Table 4 with the sufficiency range for petiole K in potatoes of 8.0-10.0%. This range is for petioles from the fourth leaf from the terminal, as sampled in this experiment, and it was established for petioles sampled 40-50 days after emergence. On the 1st sampling date (21 days after emergence), petiole K for all treatments was above the sufficiency range. On the 2nd sampling date (35 days after emergence), petiole K was within or above the sufficiency range for all treatments except the zero K control. However, the K concentration of 7.92 % for this treatment was barely below the sufficiency level of 8.0%. Results were similar on the 3rd sampling date (43 days after emergence), when the zero K control was again the only treatment below the sufficiency. It was lower this time at 7.48%, but any effect on yield was minimal since this treatment was the highest yielding. Petiole K concentrations gradually decreased between the 1^{st} and 3^{rd} sampling dates for all treatments.

On the 1^{st} sampling date, petiole K concentrations for the treatments receiving 320 lb K_2O/A were significantly greater when it was applied in split applications than when it was all applied preplant. This could have been due to leaching of some K below the root zone as a result of earlier application. However, the only other significant effect of application timing was that on the 3^{rd} sampling date petiole K was higher when 160 lb K_2O/A was applied preplant than when the same amount of K was applied at planting. This result was the opposite of what would occur with leaching of early-applied K.

Soil Test K: Table 5 shows K concentrations in the fall after harvest at the 0-6 in., 6-12 in., and 12-24 in. soil depths. There was a significant linear increase in residual soil K in the 0-6 in. depth as the rate of K fertilizer application increased. There were no significant differences among treatments in soil K at either the 6-12 or 12-24 in. soil depths in the fall. This could indicate that even in this loamy sand soil there was limited movement of K below the zone of K fertilizer incorporation during the growing season, although there are no data on pre-fertilization levels for comparison. The 320 lb K_2O/A treatment with split application at planting and emergence did have much higher K concentrations in the 6-12 in. and 12-24 in. soil depths than any other treatments. And its K concentration in the 0-6 in. soil depth was lower than any treatment but the zero K control, suggesting that some K movement may have occurred. However, similar trends did not occur in the other 320 lb K_2O/A treatment.

The initial soil tests before fertilizer application found 94 ppm K in the 0-6 in. soil layer. This decreased to 84 ppm in the zero K control, whereas soil test K increased by 40 ppm for the 160 lb K_2O/A treatments and 47 ppm for the 320 lb K_2O/A treatments. These changes show a 10 ppm drawdown in soil test K from a potato crop with a total yield of 432 cwt/A (Table 2). They also suggest that a K rate much lower than 160 lb K_2O/A is required to maintain soil test K at this yield level. It is not possible to calculate an approximate maintenance rate using the data from this experiment, since there wasn't a uniform rate of change in soil test K with each lb of K_2O/A applied for the different K treatments.

At the initial soil test K level in this field and for the highest total yields achieved, the recommended K rate would have been 200 lb K_2O/A. For the growing conditions in this field in 2013, no additional K was required for maximum yield (Table 2). Petiole K data (Table 4) suggest that only a small amount of K would have been adequate to increase the zero K control into the sufficiency range for all sampling dates, although the recommended rate of 200 lb K_2O/A was less than required to maximize K uptake and petiole K concentrations.

Conclusions

This study found that in a field with an initial soil test K level of 94 ppm, increasing the K fertilizer rate was associated with decreases in yield and tuber size. These effects were inconsistent due to interactions with application timing, such as significantly greater total yields and tuber size when 160 lb K_2O/A was applied preplant rather than at planting.

The zero K treatment had the highest specific gravity and there was a significant linear decrease in tuber specific gravity as K application rate increased. This was similar to the Russet Burbank component of this K study in 2012, although this year K application had no effect on Russet Burbank specific gravity.

Petiole K was consistently within or above the sufficiency range for all treatments, except for some marginal values in the zero K control, so lack of a yield response to K fertilization was not due to inadequate uptake of the extra K supplied.

There was a significant linear increase in residual soil K in the 0-6 in. depth as the rate of K fertilizer application increased. Soil test K in this depth decreased by 10 ppm from initial spring levels in the zero K control, but increased by 40 ppm for the 160 lb K_2O/A treatments and 47 ppm for the 320 lb K_2O/A treatments. These changes show a 10 ppm drawdown in soil test K from a potato crop with a total yield of 432 cwt/A and suggest that a K rate much lower than 160 lb K_2O/A is sufficient to maintain soil test K in this field at this yield level.

Table 2. Effect of potassium application rate and timing on Red Norland tuber yield and size distribution.

Potassium treatments			Tuber yield					
Treatment #	Potassium timing[1] (PP, P, E)	Total potassium	< 1.75"	1.75" - 2.25"	2.25" - 2.50"	2.50" - 3.00"	> 3.00"	Total
	lbs K_2O/ac		cwt/ac					
1	0, 0, 0	0	11	90	168	138	25	432
2	160, 0, 0	160	15	85	155	148	26	430
3	320, 0, 0	320	17	92	127	136	26	398
4	0, 160, 0	160	13	91	144	130	11	389
5	160, 160, 0	320	13	106	144	121	25	408
6	0, 160, 160	320	18	93	133	124	17	385
		Significance[2]	NS	NS	NS	NS	NS	++
		LSD (0.1)	--	--	--	--	--	35
Contrasts[2]	K rate: 160 vs. 320 (trt 2,4 vs. 3,5,6)		NS	NS	NS	++	NS	NS
	Preplant vs. Split (trt 3 vs. 5,6)		NS	NS	NS	NS	NS	NS
	Preplant vs. Planting (trt 2 vs. 4)		NS	NS	NS	++	NS	*
	Linear K rate (trt 1, 2/4, 3/5/6)		++	NS	*	NS	NS	*
	Quadratic K rate (trt 1, 2/4, 3/5/6)		NS	NS	NS	NS	NS	NS

[1]PP: preplant. P: planting. E: emergence / hilling.

[2]NS: Non significant. ++, *, **: Significant at 10%, 5%, and 1%, respectively.

Table 3. Effect of potassium application rate and timing on Red Norland tuber quality, plant stand, and number of stems per plant.

Potassium treatments			Tuber quality											Plant stand	Stems per plant
Treatment #	Potassium timing[1] (PP, P, E)	Total potassium	Munsell color (Red)			Visual red[2]	Visual skinning[3]	Specific gravity	Hollow heart	Brown center	Scab	Dry matter			
	lbs K_2O/ac		Hue	Value	Chroma				%						
1	0, 0, 0	0	5.99	4.29	4.61	3	1.75	1.0627	0	2.5	100	17.5		99.4	3.1
2	160, 0, 0	160	6.69	4.35	4.24	3	1.25	1.0585	0	0.8	100	16.5		100.0	3.9
3	320, 0, 0	320	5.88	4.28	4.47	3	1.75	1.0569	0	1.7	100	15.2		97.2	3.1
4	0, 160, 0	160	6.38	4.39	4.37	3	1.50	1.0603	0	0.0	100	16.9		98.9	3.4
5	160, 160, 0	320	6.00	4.32	4.46	3	1.75	1.0586	0	0.0	100	16.0		93.8	3.2
6	0, 160, 160	320	6.29	4.37	4.36	3	1.75	1.0545	0	1.7	100	15.9		99.4	2.6
Significance[4]			NS	NS	NS	NA	NS	*	NA	NS	NA	*		NS	NS
LSD (0.1)			--	--	--	--	--	0.0044	--	--	--	1.2		--	--
Contrasts[4]	K rate: 160 vs. 320 (trt 2,4 vs. 3,5,6)		++	NS	NS	NA	NS	++	NA	NS	NA	*		NS	NS
	Preplant vs. Split (trt 3 vs. 5,6)		NS	NS	NS	NA	NS	NS	NA	NS	NA	NS		NS	NS
	Preplant vs. Planting (trt 2 vs. 4)		NS	NS	NS	NA	NS	NS	NA	NS	NA	NS		NS	NS
	Linear K rate (trt 1, 2/4, 3/5/6)		NS	NS	NS	NA	NS	**	NA	NS	NA	**		NS	NS
	Quadratic K rate (trt 1, 2/4, 3/5/6)		++	*	*	NA	NS	NS	NA	NS	NA	NS		NS	NS

[1]PP: preplant. P: planting. E: emergence / hilling.

[2]On a scale of 1: pale red to 5: dark red.

[3]On a scale of 1: < 10% to 5: > 80%.

[4]NS: Non significant. NA: no variability. ++, *, **: Significant at 10%, 5%, and 1%, respectively.

Table 4. Effect of potassium application rate and timing on petiole potassium concentrations on three dates.

Potassium treatments			Petiole K		
Treatment #	Potassium timing[1] (PP, P, E)	Total potassium	19-Jun	3-Jul	11-Jul
	lbs K_2O/ac		%		
1	0, 0, 0	0	10.67	7.92	7.48
2	160, 0, 0	160	10.95	9.61	9.53
3	320, 0, 0	320	11.20	10.60	10.01
4	0, 160, 0	160	11.40	9.56	8.82
5	160, 160, 0	320	12.00	11.45	10.21
6	0, 160, 160	320	12.28	10.38	9.28
		Significance[2]	**	**	**
		LSD (0.1)	0.55	0.75	0.67
Contrasts[2]	K rate: 160 vs. 320 (trt 2,4 vs. 3,5,6)		**	**	*
	Preplant vs. Split (trt 3 vs. 5,6)		**	NS	NS
	Preplant vs. Planting (trt 2 vs. 4)		NS	NS	++
	Linear K rate (trt 1, 2/4, 3/5/6)		**	**	**
	Quadratic K rate (trt 1, 2/4, 3/5/6)		NS	NS	++

[1]PP: preplant. P: planting. E: emergence / hilling.

[2]NS: Non significant. ++, *, **: Significant at 10%, 5%, and 1%, respectively.

Table 5. Effect of potassium application rate and timing on potassium concentrations at three soil depths in the fall after harvest.

Potassium treatments			Soil potassium[2] (ppm)		
Treatment #	Potassium timing[1] (PP, P, E)	Total potassium	Soil depth (inches)		
	lbs K_2O/ac		0-6	6-12	12-24
1	0, 0, 0	0	84	102	78
2	160, 0, 0	160	123	106	94
3	320, 0, 0	320	124	105	90
4	0, 160, 0	160	144	100	74
5	160, 160, 0	320	185	101	74
6	0, 160, 160	320	117	127	111
		Significance[3]	**	NS	NS
		LSD (0.1)	38	--	--
Contrasts[3]	K rate: 160 vs. 320 (trt 2,4 vs. 3,5,6)		NS	NS	NS
	Preplant vs. Split (trt 3 vs. 5,6)		NS	NS	NS
	Preplant vs. Planting (trt 2 vs. 4)		NS	NS	NS
	Linear K rate (trt 1, 2/4, 3/5/6)		**	NS	NS
	Quadratic K rate (trt 1, 2/4, 3/5/6)		NS	NS	NS

[1]PP: preplant. E: emergence / hilling.

[2]Ammonium acetate extractable K.

[3]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Optimizing Potassium Management for Irrigated Potato Production
Russet Burbank

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Summary: A field experiment was conducted at the Sand Plain Research Farm in Becker, MN to evaluate the effect of potassium (K) application rate and timing on Russet Burbank yield and quality, petiole K concentrations, and changes in soil test K at different depths in the soil. Soil test K was also measured in another field on samples collected in Aug and Oct to see if K fertilizer recommendations for the following year were affected by time of sampling. Six K treatments were tested: rates of 0, 90, 180, 270, and 360 lb K_2O/A applied preplant, and a split application of 180 lb K_2O/A preplant + 180 lb K_2O/A at emergence. Both total and marketable yields increased significantly as K rate increased to 180 lb K_2O/A, before leveling off at the higher K rates. Yield increases were due to significantly greater yields of #1 tubers >3 oz in size and higher percentages of >6 oz, and >10 oz tubers. Except for unexplained increases in hollow heart and brown center for one treatment, there were no significant differences in tuber quality due to K application rate and timing. On the first three of four sampling dates, there were significant linear increases in petiole K as the K application rate increased. On the 4th sampling date, K application rate had no effect on petiole K concentration. Differences in petiole K and comparisons with K sufficiency ranges were generally consistent with the yield responses to K application rate. There were significant linear increases in residual soil K in the fall postharvest in both the 0-6 in. and 6-12 in. soil depths as the rate of K fertilizer application increased. Changes in soil test K as the K application rate increased were correlated with the similar increases in petiole K with greater rates of K application. Except for decreases in the 0-6 in. depth for the zero and 90 lb K_2O/A rates, soil test K increased between spring and fall at all sampling depths for every treatment. Soil test changes indicate that under the growing conditions in 2013 and the combined effects of crop removal and leaching, K application greater than 90 lb K_2O/A, but less than 180 lb K_2O/A, was required to maintain soil test K levels in the in the 0-6 in. depth. For soil samples collected from the 0-6 in. soil depth of a field planted to soybeans in 2013 that will be the site of the third year of this K study in 2014, soil test K was lower for samples collected during the growing season on Aug 3 than for samples collected on Oct 10 after harvest. These differences resulted in average K fertilizer recommendations for an ensuing potato crop that were about 29 lb K_2O/A greater when they were based on midseason sampling than when they were based on samples collected in the fall.

Background: Numerous questions about soil test potassium (K) levels and potential leaching losses of K were asked over the last few growing seasons. Agronomists noted lower petiole K levels than normal, which prompted questioning of when the soil should be tested for K. The currently recommended times are in the fall or early spring prior to planting. However, in some cases samples are taken in June of the previous season while soybeans are being grown. Research is needed to determine when soil test K provides a reasonable measure of K availability, how much K might be leaching below the crop root zone, and how much soil K drops after growing a crop of potatoes fertilized at various K rates.

The objectives of this study were to: 1) evaluate potato response to K fertilizer rate and timing, 2) determine the effect of timing of sampling on soil test K, 3) determine K drawdown following a crop of potatoes, and 3) determine the extent of K movement through the growing season. This is the second year of the study.

Materials and Methods

This study was conducted at the Sand Plain Research Farm in Becker, Minnesota on a Hubbard loamy sand soil. The previous crop was rye. Selected soil chemical properties before planting were as follows (0-6"): pH, 6.2; organic matter, 1.4%; Bray P1, 39 ppm; ammonium acetate extractable K, Ca, and Mg, 78, 690, and 129 ppm, respectively; Ca-phosphate extractable SO_4-S, 5 ppm; hot water extractable B, 0.2 ppm); and DTPA extractable Fe, Mn, Cu, and Zn, 30, 9.3, 0.6, and 1.3 ppm, respectively. Extractable nitrate-N in the top 2 ft of soil was 3.3 lb/A.

Four, 20-ft rows were planted for each plot with the middle two rows used for sampling and harvest. Whole "B" seed of Russet Burbank potatoes were hand planted in furrows on May 10, 2013. Row spacing was 12 inches within each row and 36 inches between rows. Each treatment was replicated four times in a randomized complete block design. Belay for beetle control and the systemic fungicide Quadris were banded at row closure. Weeds, diseases, and other insects were controlled using standard practices. Rainfall was supplemented with sprinkler irrigation using the checkbook method of irrigation scheduling.

Six K treatments were tested as described in Table 1 below: 0, 90, 180, 270, and 360 lb K_2O/A applied preplant and a split application of 180 lb K_2O/A preplant + 180 lb K_2O/A at emergence. Preplant K was broadcast and incorporated to a depth of 3 to 4 inches with a field cultivator on May 10. Emergence K was sidedressed on June 7 and mechanically incorporated during hilling. Potassium chloride (0-0-60) was the K source for all treatments.

All treatments received a total of 240 lb N/A applied at planting (30 lb N/A), emergence/hilling (170 lb N/A), and post-hilling (two applications of 20 lb N/A). Nitrogen at planting was supplied as monoammonium phosphate (MAP) and was banded 3 inches to each side and 2 inches below the seed piece using a metered, drop fed applicator. Emergence N applications were supplied as a combination of ESN (145 lb N/A) + ammonium sulfate (25 lb N/A) and mechanically incorporated during hilling on June 7 (along with the emergence K treatment). The ammonium sulfate also supplied 29 lb S/A. Post-hilling N was applied over the row with a tractor-mounted sprayer as a 28% UAN solution in 25 gal of water/A. The tractor traveled in the irrigation alleys to prevent damage to the crop. Irrigation was applied immediately following application of UAN to simulate fertigation with an overhead irrigation system. Post-hilling N was applied on July 2 and July 17. In addition to N, banded fertilizer at planting (for all treatments) included 136 lb P_2O_5/A, 1.5 lb S/A, 2.0 lb Zn/A, and 1.0 lb B/A applied as a blend of MAP, zinc sulfate and zinc oxide (EZ 20), and sodium tetraborate (Granubor 2).

Plant stands were measured on June 11 and stem number per plant on July 3. Petiole samples were collected from the 4th leaf from the terminal on four dates: June 28, July 9, July 23, and Aug 7. Petioles were analyzed for K on a dry weight basis. Vines were killed by mechanical beating on Sept 24 and tubers were machine harvested on Oct 1. Two, 18-ft sections of row were harvested from each plot. Total tuber yield and graded yield were measured. Sub-samples of tubers were collected to determine tuber specific gravity, tuber dry matter, and the incidence of hollow heart, brown center, and scab.

Soil samples were collected in the spring and fall from three soil depths (0-6 in., 6-12 in., and 12-24 in.) in each plot and analyzed for ammonium acetate extractable K. Spring samples were collected on May 10 before fertilizer application and planting. Fall samples were collected after harvest on Oct 9.

Soil samples were also collected in 2013 from a soybean field that will be rotated to potatoes in 2014 for the third year of this K study. Two groups of samples from the 0-6 in. depth of the field were obtained on Aug 13 and Oct 10 to see if there were differences in soil test K between samples obtained during the growing season and in the fall after harvest. These samples were analyzed for ammonium acetate extractable K and results for the two dates were compared to see if K fertilizer recommendations varied with the time of sample collection.

In addition to the preplant and emergence K treatments studied in 2013, the 2014 K study will include fall applied K treatments of 90, 180, 270, and 360 lb K_2O/A. These treatments were applied to replicate plots in the soybean field described above on Nov 13, 2013 by the same methods used for preplant K applications in the spring of 2013: potassium chloride (0-0-60) was broadcast and incorporated to a depth of 3 to 4 inches with a field cultivator.

Table 1. Potassium treatments[1] tested on irrigated Russet Burbank potatoes.

Treatment #	Timing and rate of potassium application		Total potassium
	Preplant	Emergence	
	lbs K_2O/ac		
1	0	0	0
2	90	0	90
3	180	0	180
4	270	0	270
5	360	0	360
6	180	180	360

[1]All K fertilizer was applied as potassium chloride (0-0-60).

Results

Tuber Yield and Size Distribution: Table 2 shows the effects of K rate and timing on tuber yield and size distribution. Both total and marketable yields increased significantly as K rate increased to 180 lb K_2O/A, before leveling off at the higher K rates. Yield increases were due to increases in tuber size. All treatments receiving 180 lb K_2O/A or more had significantly greater yields of #1 tubers >3 oz than the 0 and 90 lb K_2O/A treatments. The higher-yielding treatments also had consistently greater yields of 6-10 oz, 10-14 oz, and >14 oz tubers, as well as higher percentages of >6 oz, and >10 oz tubers.

In 2012 K rate had no significant effect on yield, even though total yields across treatments averaged 22% more and marketable yields 39% more than in 2013, and a yield response to K might be more likely to occur in a year with greater yield potential. The lower yields in 2013 were probably due to the fact that planting was four weeks later. Effects of K rate on tuber size were similar in both years, although in 2012 the increases in larger tubers were offset by comparable decreases in smaller-sized tubers, so that overall yield was not affected. Another difference was that in 2012 the percentages of tubers >6 oz and >10 oz increased as K rate increased to 360 lb K_2O/A, while in 2013 these effects on tuber size plateaued at the 180 lb K_2O/A rate.

Although the differences were not statistically significant, both total and marketable yields were numerically greater with split application of 360 lb K_2O/A than when the same total amount of K was applied preplant. This trend in 2013 was similar to results in 2012, when the yield increases with split application were statistically significant. In both years, a large part of the yield difference between split and preplant application of 360 lb K_2O/A was accounted for by greater yield of #2 tubers with split application.

Tuber Quality, Plant Stand, and Stems per Plant: The only significant effect of K application rate or timing on tuber quality was that the incidence of hollow heart and brown center was greater at 90 lb K_2O/A than at any of the other rates (Table 3). The reason for this effect is unclear. These internal disorders are most common in large tubers, but the 90 lb K_2O/A treatment had the lowest percentage of tubers >10 oz in size and a lower yield of tubers >14 oz than any treatment except the control. In 2012, there were no differences in hollow heart or brown center for the 90 lb K_2O/A treatment.

Neither K rate nor application timing affected tuber specific gravity, which differed from 2012 when tuber specific gravity decreased significantly as K application rate increased. Plant stand and number of stems per plant were also not affected by K rate or application timing.

Petiole K Concentrations: Petiole K concentrations on four dates as affected by K fertilizer rate and application timing are presented in Table 4. On the first three dates, there were significant linear increases in petiole K as the K application rate increased. These increases in petiole K as the K rate increased were generally consistent, except for the 3rd date when the 360 lb K_2O/A treatments had significantly lower petiole K concentrations than the 270 lb K_2O/A treatment. On the 4th sampling date, K application rate had no effect on petiole K concentration. For all treatments, petiole K consistently decreased between the 1st and 3rd sampling dates, followed by large increases in petiole K between the 3rd and 4th sampling dates. The four treatments receiving less than 270 lb K_2O/A had their highest petiole K concentrations of the season on the 4th date.

There were no significant differences in petiole K on any sampling date between the treatments receiving preplant vs. split application of 360 lb K_2O/A. This differed from 2012, when petiole K was significantly greater on all sampling dates for the treatment with split application. Petiole K concentrations for the first three sampling dates in 2013 were actually numerically lower for the split application treatment.

The sufficiency range for petiole K concentrations in potatoes is 8.0-10.0%. This range is for petioles from the fourth leaf from the terminal, as sampled in this experiment, and it was established for petioles sampled 40-50 days after emergence. On June 28 (21 days after emergence), and July 9 (32 days after emergence), the 180 lb K_2O/A rate was required to maintain petiole K in the 8.0-10.0% range. Petiole K on these dates was less than 7% for treatments receiving lower K rates. These differences in petiole K are consistent with the significant increases in total and marketable yield as K rate increased to 180 lb K_2O/A, before leveling off at the higher K rates (Table 2). Petiole K decreased for all treatments on July 23 (46 days after emergence), but was maintained in the 6 to 7% range for K rates of 270 K_2O/A or more. At lower K rates, petiole K was less than 5% on this date. On the final sampling date (Aug 7, 61 days after emergence), all treatments produced petiole K concentrations in the 8.0-10.0% range. For the growing conditions in 2013, petiole K at this stage of growth was not a useful indicator of eventual differences in yield. The large increase in petiole K this late in the growing season was also unusual.

Using the initial preplant soil test for the entire field of 110 ppm K would have resulted in a K fertilizer recommendation for potatoes (for a yield goal of 500 cwt/A or more) of 300 lb K_2O/A. This is generally consistent with the amount of fertilizer K required to maximize petiole K on the first three sampling dates of this experiment, although it is less than the 180 K_2O/A rate that was sufficient to maximize yield (Table 2).

Soil Test K: Table 5 shows K concentrations in the spring before fertilizer application, in the fall after harvest, and the change in soil K between spring and fall at the 0-6 in., 6-12 in., and 12-24 in. soil depths. As expected, there were no significant differences among treatments in soil K in the upper one-foot of soil before K fertilizer application in the spring. There was some variability in soil K in the 12-24 in. depth, primarily due to relatively higher concentrations in the control plots.

Treatment effects were seen in the fall postharvest, when there were significant linear increases in residual soil K in both the 0-6 in. and 6-12 in. soil depths as the rate of K fertilizer application increased. This suggests that leaching of soil K below the zone of K fertilizer incorporation occurred during the growing season and differs from results in 2012 when there were no differences in soil K among treatments in the 6-12 in. soil depth. There were no significant differences among treatments in soil K at the 12-24 in. soil depth in the fall, indicating that the differences found in this layer in the spring were due to sampling variability.

Residual soil K in the 0-6 in. soil depth was significantly lower for the treatment receiving 360 lb K_2O/A in split applications than when the same total amount of K was applied preplant. Although the difference was not significant, residual soil K was also lower in the 6-12 in. soil depth for the treatment with split application of K.

For Treatment #1 with no K fertilizer applied, soil K decreased 14 ppm in the 0-6 in. layer, but increased 4 ppm in the 6-12 in. layer and 7 ppm in the 12-24 in. soil layer. These changes suggest that removal of soil K in a potato crop with a total yield of 446 cwt/A (Table 2) had no effect on soil test K levels under the conditions of this experiment. Movement of K into deeper soil layers can account for the decrease in soil K in the upper 0-6 in. layer. Similar downward movement of K from the surface soil can also account for the changes in soil test K between spring and fall for the 90 lb K_2O/A treatment. The slight decrease in soil K for the 0-6 in. depth could also be interpreted as showing that a slightly higher K application rate would be required to maintain soil test K in this depth, which is the sampling depth used to determine K fertilizer recommendations, due to the combined effects of crop removal and leaching under the growing conditions in 2013. For the next higher rate of 180 lb K_2O/A, which was sufficient to produce maximum yields, soil test K increased in all three soil depths between spring and fall.

The effects of K fertilization on changes in soil test K in 2013 were very different from the results in 2012. Except for the decreases in the 0-6 in. depth for the zero and 90 lb K_2O/A rates, soil test K increased at all sampling depths for every treatment in 2013. In contrast, soil test K decreased at all sampling depths between spring and fall for every treatment in 2012. Results in 2012 indicated that application of 360 lb K_2O/A, or at least something greater than the next highest rate of 270 lb K_2O/A, was necessary to maintain soil K in the 0-6 in. soil layer. Because total yields across treatments averaged 22% more in 2012 than in 2013, there was greater drawdown of soil K due to greater crop removal. Another difference in 2013 was the effect of split vs. preplant application of the 360 lb K_2O/A rate. The significantly greater level in residual soil K noted above for the preplant treatment in the 0-6 in. soil depth also resulted in a significantly greater change between spring and fall for this treatment than for split application. In the 12-24 in. depth, there was a greater increase in soil test K with split application. Application timing had no effect on changes in soil K in 2012.

On the first three of four sampling dates, there were significant linear increases in petiole K as the K application rate increased. On the 4th sampling date petiole K was relatively high for this growth stage and K application rate had no effect on K concentrations. Differences in petiole K and comparisons with K sufficiency ranges were generally consistent with the yield and tuber size responses to K application.

Table 6 shows differences in soil test K, and resulting differences in K fertilizer recommendations for a potato crop, when soil samples are collected at different times. These samples were from the 0-6 in. soil depth of a field planted to soybeans in 2013 that will be the site of the third year of this K study in 2014. The field was divided into four replicate blocks and for this part of the experiment each replicate was split in half to generate eight sampling areas for comparison. Sampling times were once during the growing season on Aug 13 and again on Oct 10 after soybean harvest.

For six of the eight sampling areas, soil test K was lower for samples collected during the growing season than for samples collected after harvest. The average difference in soil test K was 5.5 ppm and these differences resulted in different K fertilizer recommendations for an ensuing potato crop. For the Aug 13 sampling date, the average recommendation (for a yield goal of 500 cwt/A or more) was 350 lb K_2O/A, but for the Oct 10 sampling the average recommendation was 313 lb K_2O/A. If you remove the Rep 2, Area 7 sample, since the soil tests are very close but just above and below the 80 ppm separation point for a recommendation of 300 or 400 lb K_2O/A, the difference in fertilizer recommendations is 29 lb K_2O/A. Because average soil test K was greater in Oct than in Aug, these differences were not due to K uptake by soybeans between the two sampling times and subsequent K removal with the harvested crop. In a similar comparison in 2012, soil test K was also lower for samples collected during the growing season than in the fall after harvest. The difference of 16 ppm in 2012 was greater, which may have been due to the longer time interval between sampling dates (Jun 26 and Nov 2).

Conclusions

This study found that in a field with an initial soil test K level of 78 ppm, both total and marketable yields increased significantly as K rate increased to 180 lb K_2O/A before leveling off at higher K rates. Yield increases were due to increases in tuber size. There were no meaningful differences in tuber quality from K application rate or timing. This contrasts with 2012 when tuber specific gravity decreased significantly as K application rate increased from 0 to 360 lb K_2O/A, but there was no yield response to K in a field with an initial soil test level of 101 ppm K.

On the first three of four sampling dates, there were significant linear increases in petiole K as the K application rate increased. On the 4th sampling date, K application rate had no effect on petiole K concentration. Differences in petiole K and comparisons with K sufficiency ranges were generally consistent with the yield and tuber size responses to K application.

Comparison of preplant and postharvest soil tests showed a 14 ppm drawdown in soil test K in the 0-6 in. depth from a potato crop with a total yield of 446 cwt/A, but that this decrease in K could be accounted for by K increases in the 6-12 in. and 12-24 in. soil layers. This contrasts with a 44 ppm drawdown in soil K from a potato crop with a total yield of 614 cwt/A in 2012 and data indicating that application of approximately 300 lb K_2O/A, was necessary to maintain soil K at its previous level.

For the second year in a row, K fertilizer recommendations for an ensuing potato crop were greater when they were based on midseason sampling than when they were based on samples collected in the fall. The 29 lb K_2O/A difference was similar to the 37 lb K_2O/A difference found last year. It may be necessary to modify K fertilizer rates depending on when soil samples are collected.

Table 2. Effect of potassium application rate and timing on Russet Burbank tuber yield and size distribution.

Potassium treatments			Tuber yield										
Treatment #	Potassium timing[1] (PP, E)	Total potassium	0-3 oz	3-6 oz	6-10 oz	10-14 oz	> 14 oz	Total	#1s > 3 oz.	#2s > 3 oz	Total marketable	> 6 oz	> 10 oz
	lbs K_2O/ac		cwt/ac									%	
1	0, 0	0	110	147	102	60	28	446	231	105	336	42.1	19.3
2	90, 0	90	126	160	124	63	30	502	295	81	376	43.1	18.5
3	180, 0	180	114	143	161	78	44	540	344	82	426	52.4	22.6
4	270, 0	270	120	140	148	77	50	535	349	65	415	51.0	23.0
5	360, 0	360	116	145	142	75	42	520	344	60	404	49.7	22.4
6	180, 180	360	115	160	139	83	57	554	361	78	439	50.6	25.1
		Significance[2]	NS	NS	*	NS	NS	**	**	*	**	*	NS
		LSD (0.1)	--	--	29	--	--	41	43	25	46	7.3	--
Contrasts[2]	Linear K rate (trt 1,2,3,4,5)		NS	NS	*	*	++	**	**	**	**	**	++
	Quadratic K rate (trt 1,2,3,4,5)		NS	NS	**	NS	NS	*	*	NS	++	NS	NS
	Preplant vs. Split (trt 5 vs. 6)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]PP: preplant. E: emergence / hilling.

[2]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 3. Effect of potassium application rate and timing on Russet Burbank tuber quality.

Potassium treatments			Tuber quality					Plant stand	Stems per plant
Treatment #	Potassium timing[1] (PP, E)	Total potassium	Specific gravity	Hollow heart	Brown center	Scab	Dry matter		
	lbs K_2O/ac			%					
1	0, 0	0	1.0865	16	18	0	23.4	100.0	3.5
2	90, 0	90	1.0862	31	31	0	23.3	100.0	3.4
3	180, 0	180	1.0825	12	18	0	22.8	100.0	3.5
4	270, 0	270	1.0846	9	11	0	21.7	99.3	3.7
5	360, 0	360	1.0842	12	14	0	21.7	100.0	3.5
6	180, 180	360	1.0866	15	16	0	24.7	99.3	3.0
		Significance[2]	NS	*	++	NA	NS	NS	NS
		LSD (0.1)	–	13	13	–	--	--	--
Contrasts[2]	Linear K rate (trt 1,2,3,4,5)		NS	++	++	NA	NS	NS	NS
	Quadratic K rate (trt 1,2,3,4,5)		NS	NS	NS	NA	NS	NS	NS
	Preplant vs. Split (trt 5 vs. 6)		NS	NS	NS	NA	NS	NS	NS

[1]PP: preplant. E: emergence / hilling.

[2]NS: not significant. NA: no variability. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 4. Effect of potassium application rate and timing on petiole K concentrations on four dates.

Potassium treatments			Petiole K			
Treatment #	Potassium timing[1] (PP, E)	Total potassium	28-Jun	9-Jul	23-Jul	7-Aug
	lbs K_2O/ac		%			
1	0, 0	0	6.44	5.63	3.23	9.48
2	90, 0	90	6.71	6.41	4.58	8.71
3	180, 0	180	8.49	8.21	4.48	9.07
4	270, 0	270	9.04	8.88	7.21	9.39
5	360, 0	360	9.69	9.42	6.54	9.10
6	180, 180	360	9.48	9.26	6.10	9.20
		Significance[2]	**	**	**	NS
		LSD (0.1)	0.69	0.53	0.67	–
Contrasts[2]		Linear K rate (trt 1,2,3,4,5)	**	**	**	NS
		Quadratic K rate (trt 1,2,3,4,5)	NS	*	++	NS
		Preplant vs. Split (trt 5 vs. 6)	NS	NS	NS	NS

[1]PP: preplant. E: emergence / hilling.

[2]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 5. Potassium concentrations at three soil depths: 1) in the spring before K fertilizer application and planting, 2) in the fall after harvest, and 3) the change in soil K between spring and fall (fall minus spring).

Potassium treatments			Soil potassium[2] (ppm)								
Treatment #	Potassium timing[1] (PP, E)	Total potassium	Spring			Fall			Change from Spring to Fall		
			Soil depth (inches)								
	lbs K_2O/ac		0-6	6-12	12-24	0-6	6-12	12-24	0-6	6-12	12-24
1	0, 0	0	75	47	49	61	51	56	-14	4	7
2	90, 0	90	77	45	42	73	55	57	-4	10	15
3	180, 0	180	76	40	44	92	57	57	16	17	13
4	270, 0	270	83	47	41	106	62	59	23	15	18
5	360, 0	360	73	38	45	146	73	55	73	35	10
6	180, 180	360	83	42	38	98	63	60	15	21	22
Significance[3]			NS	NS	NS	**	NS	NS	**	NS	++
LSD (0.1)			--	--	--	30	--	--	26	--	10
Contrasts[3]	Linear K rate (trt 1,2,3,4,5)		NS	NS	++	**	*	NS	**	NS	**
	Quadratic K rate (trt 1,2,3,4,5)		NS	NS	NS	NS	NS	NS	*	NS	NS
	Preplant vs. Split (trt 5 vs. 6)		NS	NS	NS	*	NS	NS	++	NS	*

[1]PP: preplant. E: emergence / hilling.

[2]Ammonium acetate extractable K.

[3]NS: not significant. ++, *, **: significant at 10%, 5%, and 1%, respectively.

Table 6. Effect of sample timing on soil test K and potash recommendations for potatoes.

Sampling location in soybean field		Soil test K[1] (ppm)		Potash recommendation[2] (lb K_2O/A)	
		Time of sampling			
		13-Aug	10-Oct	13-Aug	10-Oct
Rep 1	Area 5	99	92	300	300
	Area 6	68	79	400	400
Rep 2	Area 7	79	83	400	300
	Area 8	91	81	300	300
Rep 3	Area 9	81	104	300	300
	Area 10	75	85	400	300
Rep 4	Area 11	85	86	300	300
	Area 12	75	87	400	300

[1]Ammonium acetate extractable K in the 0 to 6 inch soil depth.

[2]For a yield goal of 500 cwt or more.

Blemish Disease Research 2013

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Introduction. ND and MN are noted nationally for the production and marketing of high quality tablestock potatoes that are produced by many growers and distributed by numerous packing plants in the region. Red-skinned, white fleshed varieties comprise most of the production, but yellow-flesh varieties and specialty varieties are increasing in popularity. Because table potatoes are sold for direct consumption, consumers choose potatoes by their appearance; they "buy with their eyes". Consumers naturally buy potatoes free of blemishes, and avoid selecting blemished potatoes. Silver scurf disease is the most important cause of potato tuber blemish. Silver scurf is most often caused by the fungal pathogen *Helminthosporium solani*, but in recent years black dot, caused by the fungal pathogen *Colletotrichum coccodes*, has also become an important cause of blemish. Silver scurf is a seed borne disease, whereas black dot both a seed- and soil-borne disease. Management of silver scurf blemish requires an integrated approach, and continues to be a serious problem for tablestock grower despite implementation of integrated control measures. In 2013, with funding from the Area II Potato Growers, two field trials were conducted to determine the cause of blemish disease of tablestock potatoes in central MN, determine whether *H. solani* can persist in the soil, and evaluate the effect of fungicide seed and in-furrow treatments on blemish disease of tubers.

Evaluate the soil persistence of H. solani, the cause of silver scurf. The objective was to determine the soil persistence of *H. solani*, the cause of silver scurf, using silver scurf of *H. solani*-free minitubers as bait crops for *H. solani* persisting in the soil.

Greenhouse produced minitubers of a silver scurf susceptible variety Dakota Pearl and a yellow-flesh variety, Agata, were used in this trial. The seed tubers used in the trial were courtesy of Valley Tissue Culture were free of H. solani, the cause of silver scurf. Each variety was planted May 6 as four replications of 10 minitubers in each of five fields on the Paul Gray farm near Becker, MN. The fields used in the trial had not been planted with potatoes for different number of years. The five fields and the number of years since the last potato crop were: Dick's, potatoes in 2013, Imholtz, one year, Beck's, two years, Big Pivot, five years, and Lockwood, seven years. Potatoes were harvested from each field on September 4, incubated in plastic boxes for three weeks to induce sporulation and examined visually using a dissecting microscope for the presence of H. solani. Fifty tubers/rep from each field were examined for *H. solani* (a total of 200 tubers/field).

Results. No *H. solani* was observed on any of the tubers examined. From this data we conclude that *H. solani* did not survive persist in soil in these fields, and supports the previous conclusion that silver scurf is a seed-borne disease, not soil-borne. During tuber assay, many tubers with blemish caused by black dot were observed, indicating that soil inoculum of C. coccodes, can be the source of tuber blemish disease.

Evaluate newly registered and experimental seed treatment and in-furrow fungicides for control of silver scurf blemish disease. The objective was to determine if fungicides applied at planting would reduce the incidence of silver scurf blemish of harvested potatoes.

A trial was planted on May 7 in a commercial field on the Scott Hayes farm near Becker MN. Yukon Gold seed with 25-30% silver scurf, was inoculated with *H. solani* prior to planting by dipping tubers in a suspension of *H. solani* spores at a concentration of 10,000 spores/ml. The trial was irrigated and maintained the same as the commercial potatoes in the field. The trial was harvested on September 5, and 50 tubers/rep/treatment were evaluated for silver scurf. The treatment list can be seen in the accompanying table. Harvested tubers were scored for silver scurf, and yield and grade calculated. No silver scurf was observed on any of the harvested tubers, but most, if not all tubers, were affected with black dot blemish. There were no significant differences among treatments or compared to the untreated control for stand at four dates, yield or grade. There was a significant difference in blemish, but none of the treatments resulted in a reduction of tuber black dot blemish, and in fact, the non-treated control had the lowest amount of black dot blemish, although not significantly so. Based on this one year of data, it appears that the main cause of blemish disease in this trial was black dot. No silver scurf was observed despite planting infected seed and inoculating withprior to planting. . Additional work will be necessary to confirm black dot as the major blemish disease in the Becker area, and to further evaluate fungicide treatments that reduce black dot of harvested tubers.

2013 Area II Silver Scurf Seed Treatment

Treatment		Rate	Application	STAND 2-Jun	STAND 6-Jun	STAND 9-Jun	STAND 7-Jul	Yield	Blemish
801	Non-treated	-	-	56.5	70.0	76.0	76.5	324.6	30.4
802	Priaxor	8 fl oz / a	Seed	40.0	63.0	77.0	72.5	284.2	36.4
803	Emesto Silver	0.31 fl oz / cwt	Seed	56.5	70.5	74.5	78.0	231.7	40.9
804	Vertisan	1.6 fl oz / 1000 row ft	In-furrow	51.0	83.0	79.0	74.5	252.0	35.9
805	Penthiopyrad	0.5 g ai / cwt	Seed	50.0	73.0	83.5	79.0	272.7	37.5
806	Vibrance	0.077 fl oz / cwt	Seed	46.0	71.5	79.5	81.0	280.2	39.1
807	Blocker	10.4 fl oz / 1000 row ft	In-furrow	53.5	78.0	79.0	74.0	288.5	59.5
808	Regalia	8.8 fl oz / 1000 row ft	In-furrow	41.5	73.5	80.0	79.5	286.9	36.2
809	Serenade Soil	6.0 qt / a	In-furrow	60.0	74.0	80.5	81.5	250.9	55.5
810	ActinoGrow	12.0 oz / a	In-furrow	45.5	67.0	72.0	82.0	328.1	45.8
811	Maxim 4FS Quadris	0.08 fl oz / cwt 0.8 fl oz / 1000 row ft	Seed In-furrow	55.5	73.0	76.0	78.5	309.4	37.5
LSD $_{p>0.05}$				NS	NS	NS	NS	NS	8.19

Treatment		Rate	Yield	Total Weight (lbs)	0-4 oz (lbs)	% 0-4 oz	4-6 oz (lbs)	% 4-6 oz (lbs)	6-10 oz (lbs)	% 6-10 oz (lbs)	10+ oz (lbs)	% 10+ oz (lbs)
801	Non-treated	-	324.6	47.5	9.0	19.1	6.2	13.5	20.3	43.1	12.0	24.3
802	Priaxor	8 fl oz / a	284.2	49.0	8.6	18.0	6.7	13.7	20.4	41.4	13.3	26.9
803	Emesto Silver	0.31 fl oz / cwt	231.7	37.0	8.8	23.1	5.7	15.2	16.8	46.2	5.7	15.4
804	Vertisan	1.6 fl oz / 1000 row ft	252.0	42.2	8.1	19.3	5.3	11.7	19.0	46.1	9.9	22.9
805	Penthiopyrad	0.5 g ai / cwt	272.7	46.8	9.0	19.7	8.0	16.4	21.3	45.4	8.6	18.5
806	Vibrance	0.077 fl oz / cwt	280.2	44.1	8.9	21.5	6.5	15.6	18.9	43.1	9.9	19.8
807	Blocker	10.4 fl oz / 1000 row ft	288.5	44.9	8.6	21.8	6.4	12.5	22.7	50.3	7.3	15.4
808	Regalia	8.8 fl oz / 1000 row ft	286.9	47.2	7.6	18.8	7.8	13.6	22.7	50.3	9.1	17.3
809	Serenade Soil	6.0 qt / a	250.9	41.6	8.4	20.3	5.9	13.5	19.6	47.4	7.8	18.8
810	ActinoGrow	12.0 oz / a	328.1	45.5	7.3	16.0	5.6	12.2	20.5	45.8	12.1	26.0
811	Maxim 4FS Quadris	0.08 fl oz / cwt 0.8 fl oz / 1000 row ft	309.4	39.5	9.6	24.9	7.1	17.5	18.7	47.6	4.2	10.1
LSD $_{p>0.05}$			NS	NS	NS	NS	NS	NS	NS	NS	NS	10.07

Project Title: **Potato Breeding and Genetics University of Minnesota**

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GOALS OF THIS RESEARCH

The objective of this research is to develop and release potato varieties adapted to Minnesota and North Dakota. Selection will emphasize lines having superior yield, quality, and host plant resistance to biotic and abiotic stress.

2013 RESEARCH OBJECTIVES (See Data Tables 1 to 21 for results)

OBJECTIVE 1	BREEDING, EVALUATION, AND SELECTION FOCUSED ON FRY AND CHIP PROCESSING AND FRESH MARKET RUSSET, RED AND YELLOW VARIETIES
OBJECTIVE 2	GROWER FIELD TRIALS (Fry & Chip processing, Fresh russet, Fresh Red, and Fresh Yellow)
OBJECTIVE 3	NATIONAL TRIALS (NFPT & NCPT)
OBJECTIVE 4	TISSUE CULTURE BANK MANAGEMENT, VIRUS CLEAN-UP RESEARCH, AND PRE-NUCLEAR / G1 SEED PRODUCTION
OBJECTIVE 5	SEED DEVELOPMENT
OBJECTIVE 6	OUTREACH

SUMMARY

Research emphasized the development, evaluation and release of potato varieties with improved yield, quality, and resistance to biotic and abiotic stress.

SELECTION AND CLONAL ADVANCEMENT:

Breeding lines advance through the UM program in generations. Early generations are Single-hills, and Generation 1 (G1); Mid-generations are G2, G3, and G4; Late-generations are G5 and G6. By the time a selected clone moves to G2 and beyond, sufficient breeder's seed is available for multi-location evaluations.

Single-hills: Represent selected clones from new hybrid crosses. After a cross and sowing of new hybrid seed, seedlings are first grown in the greenhouse to produce mini-tubers. These minitubers are planted to the field as *single-hills*. In 2013 we had 57,000 SH from 168 families. Single hills were grown at Pine Lake Wild Rice (35,000), Williston (15,000), and Missouri (Black Gold Farms) (7,000). We selected 1525 at PLWR, 25 at Williston, and 66 at Missouri.

Generation1: Single-hills selected from the previous year are planted for the first time in the field using normal plant spacing and production practices as *G1*. Typically, only 4 to 8-hills of each clone are available for planting. In 2013 we selected 53 from 260 planted at PLWR, and 20 from 88 planted at Williston.

Early Generational Selections

Market	PLWR SH	PLWR G1	Williston SH	Williston G1	Missouri SH
Reds	131	10	10	3	-
Yellows	53	3	1	0	-
Russets	178	15	14	13	-
Chip	1163	25	0	4	66
Total	1525	53	25	20	66

Generation 2: Selected *G1* clones are moved to the next year as *G2* selections. Typically, sufficient seed is available to evaluate the clones from multiple locations using replicated plots, and more comprehensive data is collected including yield, size and grade, internal and external physiological defects, specific gravity and processing quality. Additionally, the clones are segregated into market-type and planted as *Fresh, Processing, or Chipping Trials.*

Generation 3 to G6:

Selected *G2 clones and beyond* are evaluated at multiple locations using replicated plots, and more comprehensive data is collected including yield, size and grade, internal and external physiological defects, specific gravity and processing quality. Additionally, the clones are segregated into market-type and planted as *Fresh, Processing, or Chipping Trials.* In 2013 the *G3's and beyond* were planted at Becker Early harvest, Becker Late harvest, Williston, Crystal, and Grand Forks.

Locations	Total	G2	G3	G4	G5	G6	G9	G10	G11	G15
		Number of Clones Tested by Generation								
Fresh Market										
Becker Early	32	0	24	1	2	2	1	0	3	2
Becker Late	45	8	25	1	3	2	1	0	3	2
Williston	45	8	25	1	3	2	1	0	3	2
Crystal	29	0	22	1	3	1	1	0	1	0
Grand Forks	36	1	24	1	3	2	0	0	3	2
	187									
Processing										
Becker Late	71	30	22	9	1	5	0	0	2	2
Williston	70	31	22	9	1	5	0	0	2	2
Grand Forks	50	9	21	9	1	4	0	0	4	2
	191									
Chippers										
Becker Late	29	8	1	3	3	10	1	1	2	0
Williston	30	9	1	3	3	10	1	1	2	0
Grand Forks	20	2	1	3	3	10	0	0	1	0

Trial Data: Yield, size and grade, internal and external physiological defects, specific gravity and processing quality. (See Tables 1 to 14).

Generation 3 to G6: Grower Trials

Clones were also evaluated in *Grower Field Trials at Peterson Farms, Dechene Farms, Hayes Farms, Five Star Produce, Edling Farms, and at 6 MN Organic Farms.*

Grower Trials	Peterson Farms	Dechene Farms	Hays Farms	Five Star Produce	Edling Farms	MN Organic Farms
Number of Clones	24	24	1	3	1	6

Trial Data: Yield, size and grade, internal and external physiological defects, specific gravity and processing quality. (See Tables 15 to 17).

Generation 7 and beyond - Advanced, Seed Spacing, and Advanced Processing Trials:

After *G6,* several of our clones are evaluated in *seed spacing*, and *Processing Trials.*

At Williston, ND the variety MonDak Gold was evaluated in a plant spacing trial at 4.5", 6", 9", and 12". The purpose of these evaluations was to determine tuber size profiles for the restaurant market (Table 18).

At Williston, ND six advanced clones were evaluated in strip trials. Tubers were harvested and evaluated by Ag World, Grand Forks, ND for processing quality.

Trial Data: MonDak Gold Spacing (Table 18), Advanced Strip & Processing (Ag World) (Tables 19 to 21)

TISSUE CULTURE AND VIRUS ELIMINATION IN UM BREEDING LINES

In 2013 progress was made entering ALL clones *G3 and beyond* into tissue culture for the purpose of clonal preservation and virus clean-up. Clones were entered into the germplasm bank by taking tuber sprouts and treating them with anti-fungal agents prior to introduction. After introduction, each clone underwent sub-culture 3x to produce healthy growing plants from which virus testing can be done. We are scheduled to virus test the germplasm bank from February to March this year.

Clones having virus will be treated using a new method "*CRYOTHERAPY*" and compared to the old method "*HEAT AND DRUGTHERPY*" to determine the most efficient method that a breeding program should use for virus elimination in breeding lines.

SEED

In 2013, and as have occurred in the past 4 years, UM clones have been inspected for *SEED POTATO CERTIFICATION* by the Minnesota Department of Agriculture. This includes Greenhouse minituber populations, Single-hill field populations, and advancing clones grown at PLWR. In 2013, 25 lines were sent to Hawaii for winter testing. The 25 clones will be available for grower trials in 2014.

DISEASE RESISTANCE BREEDING
Disease screening for foliar and tuber late blight, common scab, PVY resistance and PVY symptom expression, are performed on all selections from the *G2 and beyond*. Data in not included in this report, but is used for selection by UM and other US Breeding Programs.

Late blight resistance: The primary focus of this research is to develop new potato varieties and parental germplasm resistant to late blight. Breeding lines are evaluated 3x for % late blight infection after inoculation. This work is done at UMORE Park, Rosemount, MN.

Common scab resistance: The primary focus of this research is to develop new potato varieties and parental germplasm resistant to common scab. Breeding lines are evaluated for disease incidence (% coverage) and disease severity (surface, raised, and pitted scab; individual or coalesced lesions). This work is done at the Sand Plains Research Farm in Becker, MN.

PVY resistance and PVY symptom expression: The primary focus of this research is to develop new potato varieties and parental germplasm resistant to PVY. Additionally this research explores the symptom expression of PVY and its relationship to variety.

Disease Screening Trials

	PVY	**Late Blight**	**Common Scab**
UM Breeding clones	670	670	137
UM Germplasm clones	171	8	
Other US Breeding Programs	207	207	234

NCPT and NFPT Trial
As has occurred in the past 4 years, UM participates in the NCPT and NFPT program. UM Breeding lines have been entered into both programs. Clonal performance data can be found at the NCPT and NFPT database websites. An additional role for UM is the evaluation of ALL entered lines for disease characterization.

In NCPT for 2014, 4 UM lines advanced from Tier 1 to Tier 2 in NCPT; 10 new lines were entered into Tier 1. Additionally, UM is studying the inheritance of biochemical markers UGPase, acid invertase, and invertase inhibitor in relation to the cold sweetening process. (See Gupta Progress Report).

In NFPT, UM is evaluating the processing potential of NFPT clones. In this research, Dr. Gupta is exploring biochemical markers UGPase, acid invertase, and invertase inhibitor in relation to the cold sweetening process and tuber quality related to sugar ends. (See Gupta Progress Report).

EXTENSION / OUTREACH / COMMUNICATION:
1. MN Area II: Reporting Conference & Field-day @ Becker
2. NPPGA: Reporting Conference / Expo & Twilight Field Tour
3. MONDAK: MonDak Ag Tour @ Nesson Valley
4. NPC EXPO: San Antonio, Texas

FUNDING: NPPGA, MN Area II Research and Promotion Council, Williston Ag Diversification, USPB, NIFA, Minnesota Ag Experiment Station. **THANK YOU.**

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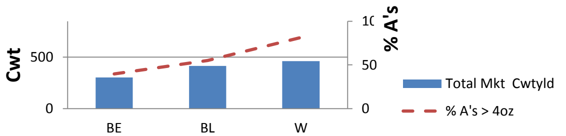
2013 University of Minnesota Potato Breeding and Genetics

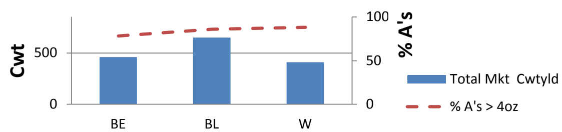
Most Advanced Clones Overview

Table 1

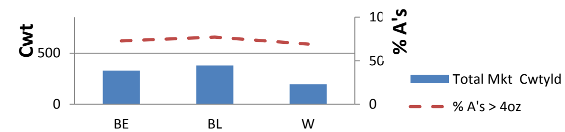
Clone	Loc	2013 Trial	Mkt	Skin Color	Culls Cwtyld	Culls %	B size (< 4 oz) Cwtyld	B size (< 4 oz) %	4 - 8 oz. Cwtyld	8 - 12 oz. Cwtyld	12 - 14 oz. Cwtyld	Over 14 oz Cwtyld	A size (> 4 oz) Cwtyld	A size (> 4 oz) %	Total Mkt Cwtyld
MonDak	BE	G15	FF/FM	Red	6.95	2.23	181.16	58.21	111.25	11.86	0.00	0.00	123.11	39.56	304.28
	BL				61.87	12.97	151.78	31.82	184.74	53.06	11.59	13.99	263.38	55.21	415.15
	W				37.04	7.43	55.00	11.03	123.73	133.38	66.24	83.25	406.59	81.54	461.60
MN18747	BE	G15	FF/FM	LW	2.06	0.45	98.27	21.33	217.03	91.17	19.80	32.31	360.32	78.22	458.59
	BL				38.64	5.61	58.54	8.50	205.27	226.59	61.86	97.72	591.44	85.89	649.97
	W				16.85	3.96	34.02	7.99	119.00	137.38	52.95	65.57	374.90	88.05	408.92
MN02467Rus/Y	BE	G11	FF/FM	Rus	1.94	0.59	88.91	26.77	137.18	63.48	40.57	0.00	241.24	72.64	330.15
	BL				34.96	8.42	60.35	14.53	151.87	109.40	17.68	40.95	319.90	77.04	380.25
	W				34.48	15.09	36.39	15.92	80.10	47.41	10.84	19.33	157.67	68.99	194.07
MN02574	BE	G11	FM	W	0.90	0.24	314.80	83.13	59.14	3.83	0.00	0.00	62.96	16.63	377.76
	BL				8.17	1.04	416.70	53.22	310.46	40.76	0.00	6.93	358.15	45.74	774.85
	W				28.96	5.95	175.87	36.12	212.48	51.57	11.06	6.98	282.09	57.93	457.96
MN02419	BL	G11	FF	LW	180.49	31.24	107.68	18.64	185.33	62.72	26.90	14.68	289.62	50.13	397.31
	W				37.35	9.37	86.95	21.81	146.10	74.04	22.35	31.88	274.36	68.82	361.31
MN02586	BE	G11	FM/C	W	0.47	0.14	240.63	73.04	79.71	8.63	0.00	0.00	88.34	26.82	328.97
	BL				0.00	0.00	263.83	32.78	392.39	125.95	22.71	0.00	541.04	67.22	804.87
	W				5.95	1.28	167.74	35.94	213.21	71.59	8.23	0.00	293.03	62.78	460.77
MN02588	BL	G11	C	W	3.69	0.71	211.71	40.71	227.24	58.92	11.48	7.03	304.67	58.58	516.38
	W				15.71	3.71	143.61	33.91	217.80	40.59	5.74	0.00	264.13	62.38	407.74
MN03339-4	BL	G10	C	W	0.00	0.00	144.34	44.14	135.24	41.91	5.54	0.00	182.69	55.86	327.04
	W				1.42	0.59	79.86	33.50	94.76	38.60	16.83	6.94	157.13	65.91	236.98
MN04844-07	BE	G9	FM/C	W	0.00	0.00	163.41	54.66	91.73	36.80	0.00	7.03	135.56	45.34	298.97
	BL				0.00	0.00	172.34	36.56	193.73	80.09	17.38	7.83	299.03	63.44	471.37
	W				1.56	0.53	149.04	50.22	110.20	30.47	5.50	0.00	146.17	49.25	295.21



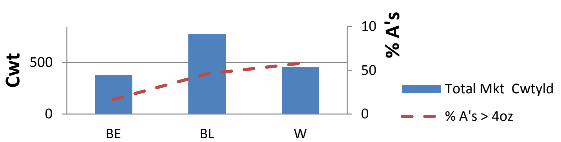
Mondak Gold



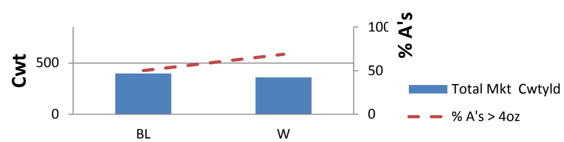
MN18747



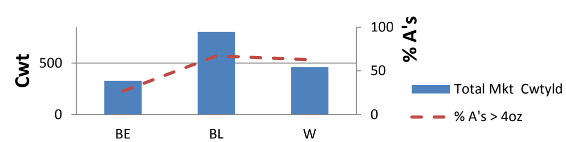
MN02467Rus/Y



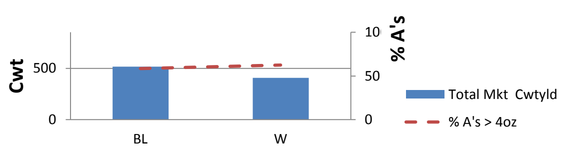
MN02574



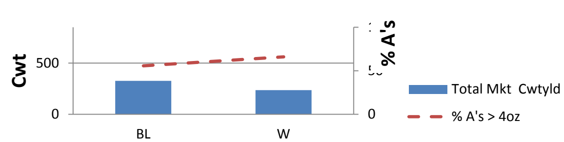
MN02419



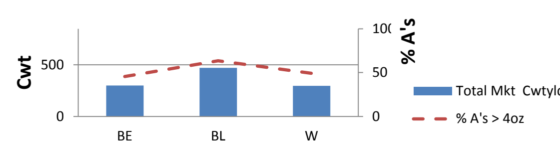
MN02586



MN02588

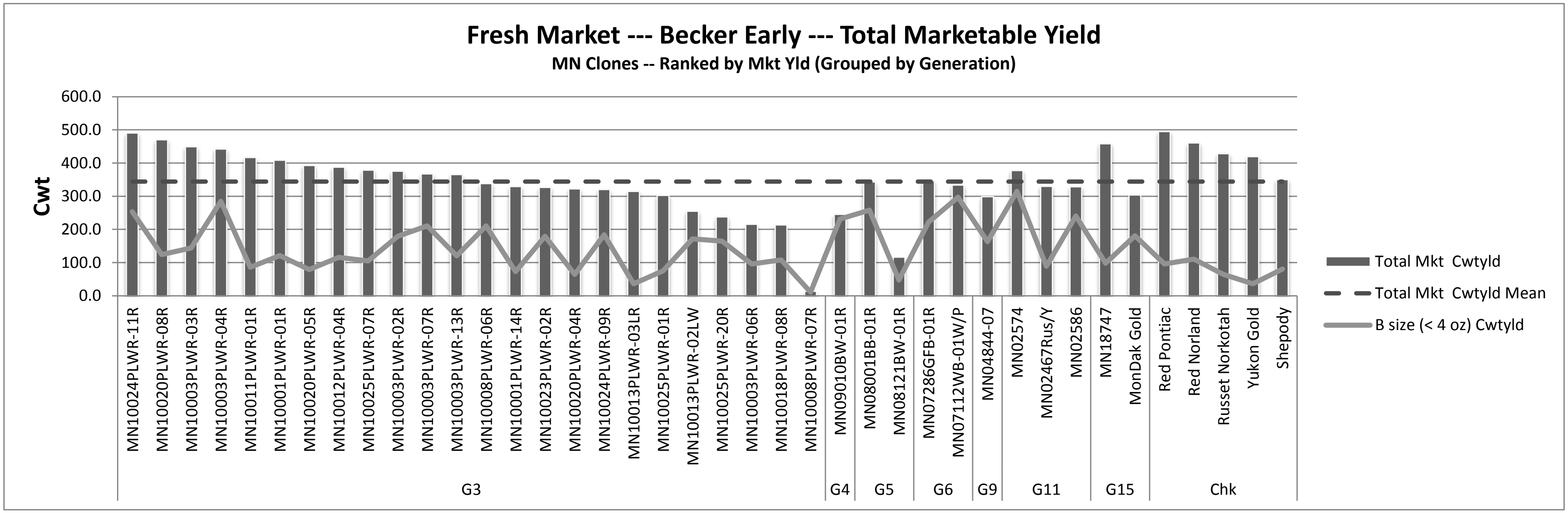


MN03339-4



MN04844-07

Table 2


Fresh Market --- Becker Early --- Total Marketable Yield
MN Clones -- Ranked by Mkt Yld (Grouped by Generation)
Cwt
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN10024PLWR-11R
MN10020PLWR-08R
MN10003PLWR-03R
MN10003PLWR-04R
MN10011PLWR-01R
MN10001PLWR-01R
MN10020PLWR-05R
MN10012PLWR-04R
MN10025PLWR-07R
MN10003PLWR-02R
MN10003PLWR-07R
MN10003PLWR-13R
MN10008PLWR-06R
MN10001PLWR-14R
MN10023PLWR-02R
MN10020PLWR-04R
MN10024PLWR-09R
MN10013PLWR-03LR
MN10025PLWR-01R
MN10013PLWR-02LW
MN10025PLWR-20R
MN10003PLWR-06R
MN10018PLWR-08R
MN10008PLWR-07R
MN09010BW-01R
MN08001BB-01R
MN08121BW-01R
MN07286GFB-01R
MN07112WB-01W/P
MN04844-07
MN02574
MN02467Rus/Y
MN02586
MN18747
MonDak Gold
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
Shepody
G3
G4
G5
G6
G9
G11
G15
Chk
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
B size (< 4 oz) Cwtyld

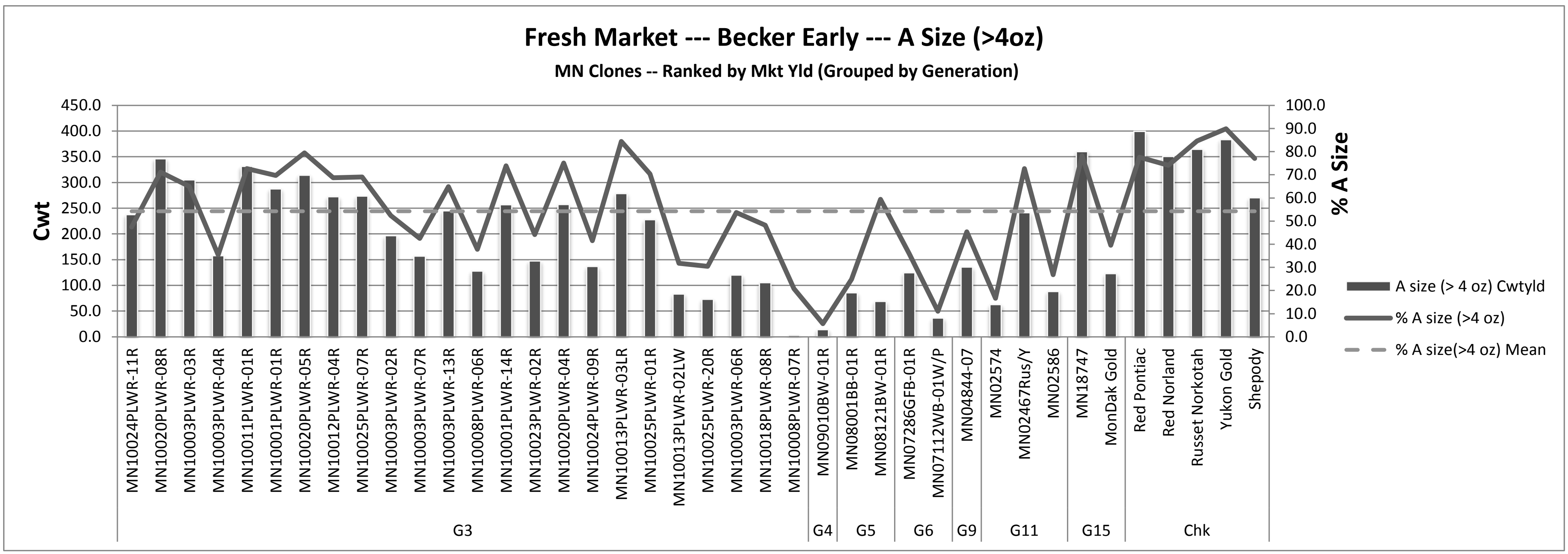
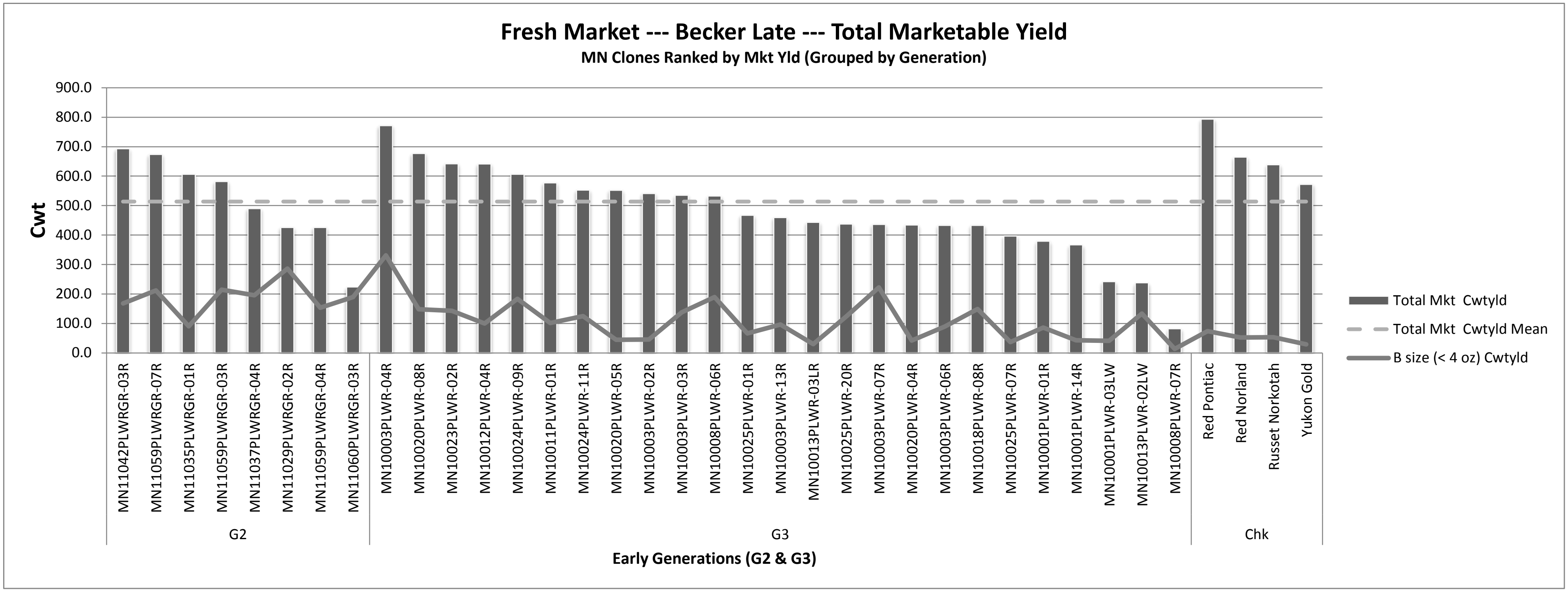

Fresh Market --- Becker Early --- A Size (>4oz)
MN Clones -- Ranked by Mkt Yld (Grouped by Generation)
Cwt
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
% A Size
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
MN10024PLWR-11R
MN10020PLWR-08R
MN10003PLWR-03R
MN10003PLWR-04R
MN10011PLWR-01R
MN10001PLWR-01R
MN10020PLWR-05R
MN10012PLWR-04R
MN10025PLWR-07R
MN10003PLWR-02R
MN10003PLWR-07R
MN10003PLWR-13R
MN10008PLWR-06R
MN10001PLWR-14R
MN10023PLWR-02R
MN10020PLWR-04R
MN10024PLWR-09R
MN10013PLWR-03LR
MN10025PLWR-01R
MN10013PLWR-02LW
MN10025PLWR-20R
MN10003PLWR-06R
MN10018PLWR-08R
MN10008PLWR-07R
MN09010BW-01R
MN08001BB-01R
MN08121BW-01R
MN07286GFB-01R
MN07112WB-01W/P
MN04844-07
MN02574
MN02467Rus/Y
MN02586
MN18747
MonDak Gold
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
Shepody
G3
G4
G5
G6
G9
G11
G15
Chk
A size (> 4 oz) Cwtyld
% A size (>4 oz)
% A size(>4 oz) Mean

Table 3


Fresh Market --- Becker Late --- Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Cwt
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN11042PLWRGR-03R
MN11059PLWRGR-07R
MN11035PLWRGR-01R
MN11059PLWRGR-03R
MN11037PLWRGR-04R
MN11029PLWRGR-02R
MN11059PLWRGR-04R
MN11060PLWRGR-03R
MN10003PLWR-04R
MN10020PLWR-08R
MN10023PLWR-02R
MN10012PLWR-04R
MN10024PLWR-09R
MN10011PLWR-01R
MN10024PLWR-11R
MN10020PLWR-05R
MN10003PLWR-02R
MN10003PLWR-03R
MN10008PLWR-06R
MN10025PLWR-01R
MN10003PLWR-13R
MN10013PLWR-03LR
MN10025PLWR-20R
MN10003PLWR-07R
MN10020PLWR-04R
MN10003PLWR-06R
MN10018PLWR-08R
MN10025PLWR-07R
MN10001PLWR-01R
MN10001PLWR-14R
MN10001PLWR-03LW
MN10013PLWR-02LW
MN10008PLWR-07R
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G2
G3
Chk
Early Generations (G2 & G3)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
B size (< 4 oz) Cwtyld

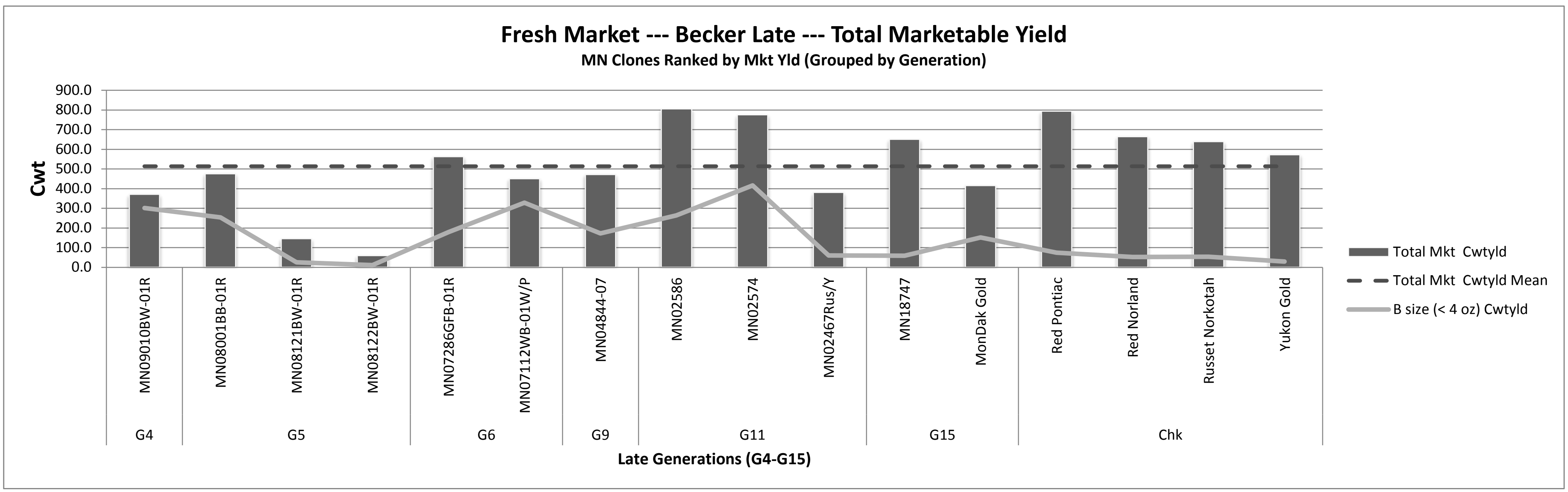
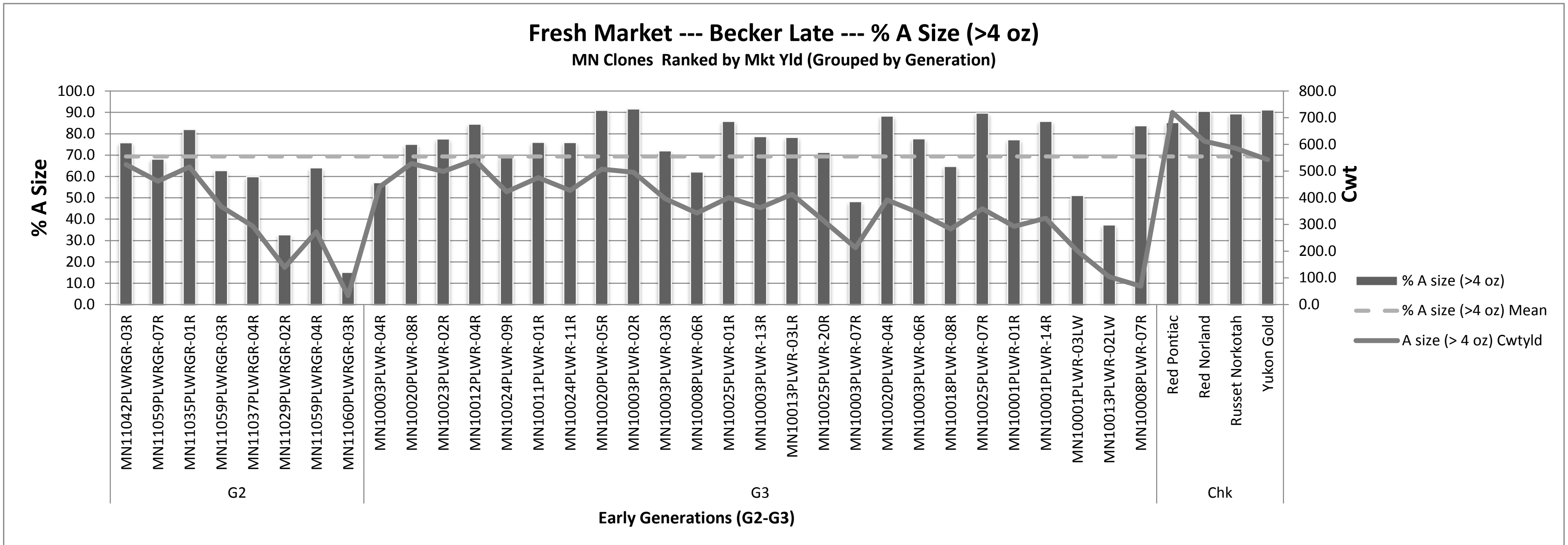
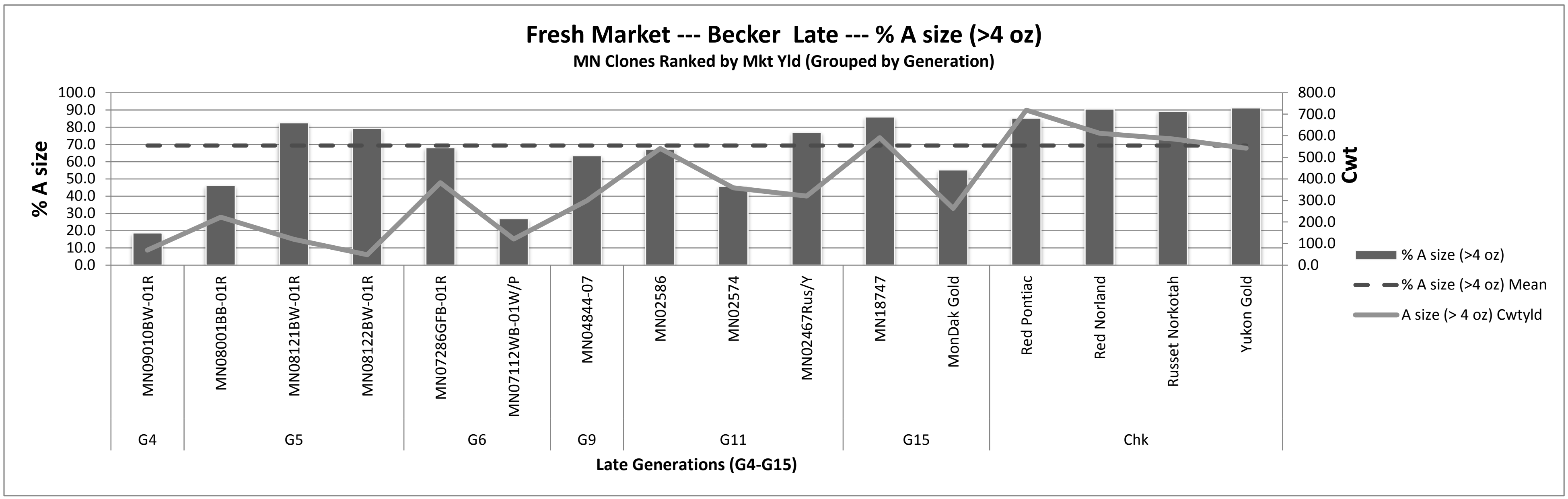

Fresh Market --- Becker Late --- Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Cwt
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN09010BW-01R
MN08001BB-01R
MN08121BW-01R
MN08122BW-01R
MN07286GFB-01R
MN07112WB-01W/P
MN04844-07
MN02586
MN02574
MN02467Rus/Y
MN18747
MonDak Gold
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G4
G5
G6
G9
G11
G15
Chk
Late Generations (G4-G15)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
B size (< 4 oz) Cwtyld

Table 3 (cont.)

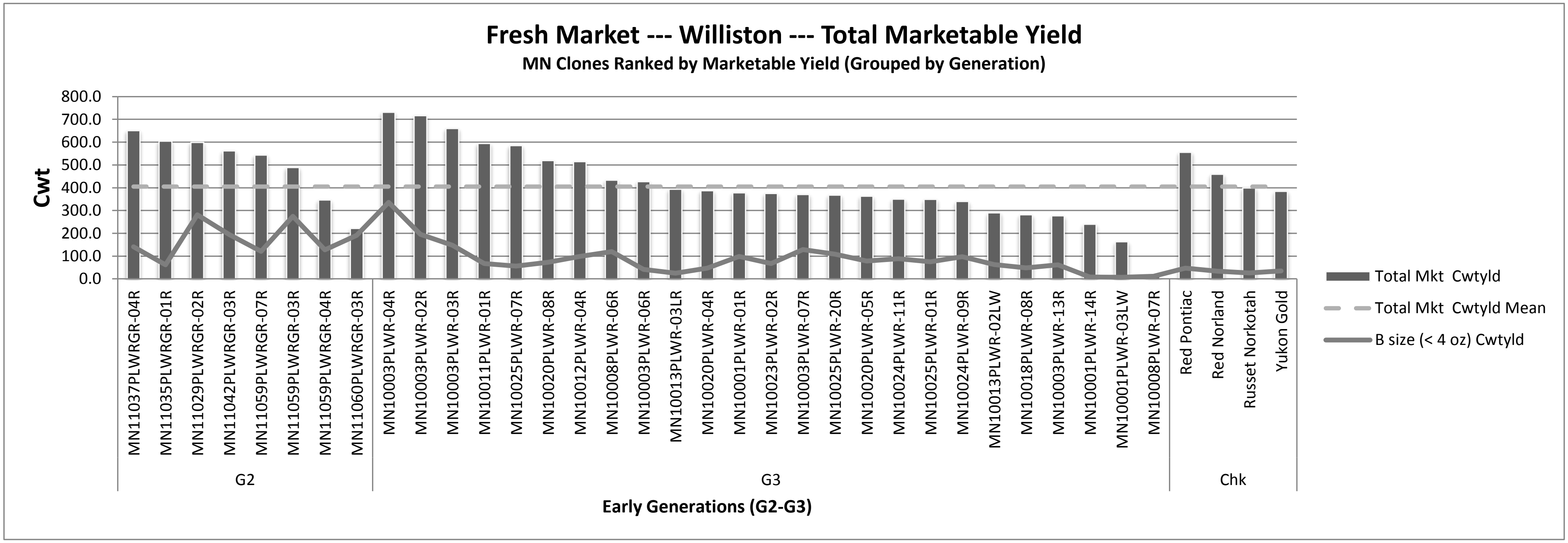


Fresh Market --- Becker Late --- % A Size (>4 oz)
MN Clones Ranked by Mkt Yld (Grouped by Generation)
% A Size
Cwt
MN11042PLWRGR-03R
MN11059PLWRGR-07R
MN11035PLWRGR-01R
MN11059PLWRGR-03R
MN11037PLWRGR-04R
MN11029PLWRGR-02R
MN11059PLWRGR-04R
MN11060PLWRGR-03R
MN10003PLWR-04R
MN10020PLWR-08R
MN10023PLWR-02R
MN10012PLWR-04R
MN10024PLWR-09R
MN10011PLWR-01R
MN10024PLWR-11R
MN10020PLWR-05R
MN10003PLWR-02R
MN10003PLWR-03R
MN10008PLWR-06R
MN10025PLWR-01R
MN10003PLWR-13R
MN10013PLWR-03LR
MN10025PLWR-20R
MN10003PLWR-07R
MN10020PLWR-04R
MN10003PLWR-06R
MN10018PLWR-08R
MN10025PLWR-07R
MN10001PLWR-01R
MN10001PLWR-14R
MN10001PLWR-03LW
MN10013PLWR-02LW
MN10008PLWR-07R
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G2
G3
Chk
Early Generations (G2-G3)
% A size (>4 oz)
% A size (>4 oz) Mean
A size (> 4 oz) Cwtyld



Fresh Market --- Becker Late --- % A size (>4 oz)
MN Clones Ranked by Mkt Yld (Grouped by Generation)
% A size
Cwt
MN09010BW-01R
MN08001BB-01R
MN08121BW-01R
MN08122BW-01R
MN07286GFB-01R
MN07112WB-01W/P
MN04844-07
MN02586
MN02574
MN02467Rus/Y
MN18747
MonDak Gold
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G4
G5
G6
G9
G11
G15
Chk
Late Generations (G4-G15)
% A size (>4 oz)
% A size (>4 oz) Mean
A size (> 4 oz) Cwtyld

Table 4


Fresh Market --- Williston --- Total Marketable Yield
MN Clones Ranked by Marketable Yield (Grouped by Generation)
Cwt
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN11037PLWRGR-04R
MN11035PLWRGR-01R
MN11029PLWRGR-02R
MN11042PLWRGR-03R
MN11059PLWRGR-07R
MN11059PLWRGR-03R
MN11059PLWRGR-04R
MN11060PLWRGR-03R
MN10003PLWR-04R
MN10003PLWR-02R
MN10003PLWR-03R
MN10011PLWR-01R
MN10025PLWR-07R
MN10020PLWR-08R
MN10012PLWR-04R
MN10008PLWR-06R
MN10003PLWR-06R
MN10013PLWR-03LR
MN10020PLWR-04R
MN10001PLWR-01R
MN10023PLWR-02R
MN10003PLWR-07R
MN10025PLWR-20R
MN10020PLWR-05R
MN10024PLWR-11R
MN10025PLWR-01R
MN10024PLWR-09R
MN10013PLWR-02LW
MN10018PLWR-08R
MN10003PLWR-13R
MN10001PLWR-14R
MN10001PLWR-03LW
MN10008PLWR-07R
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G2
G3
Chk
Early Generations (G2-G3)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
B size (< 4 oz) Cwtyld

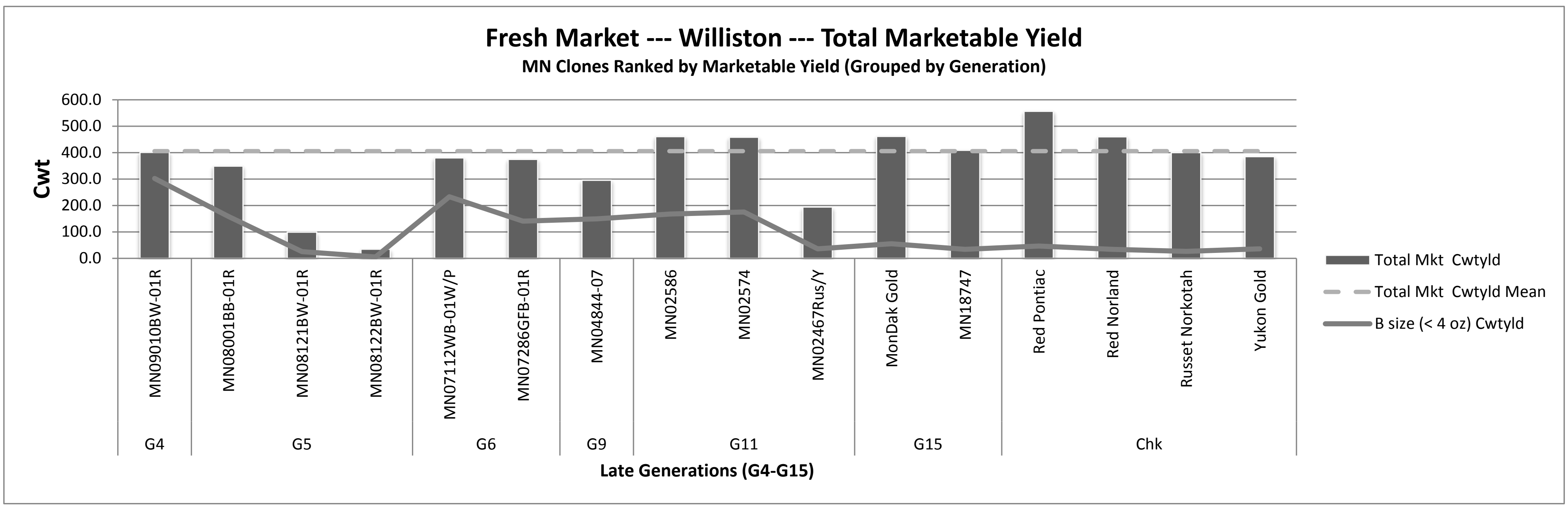
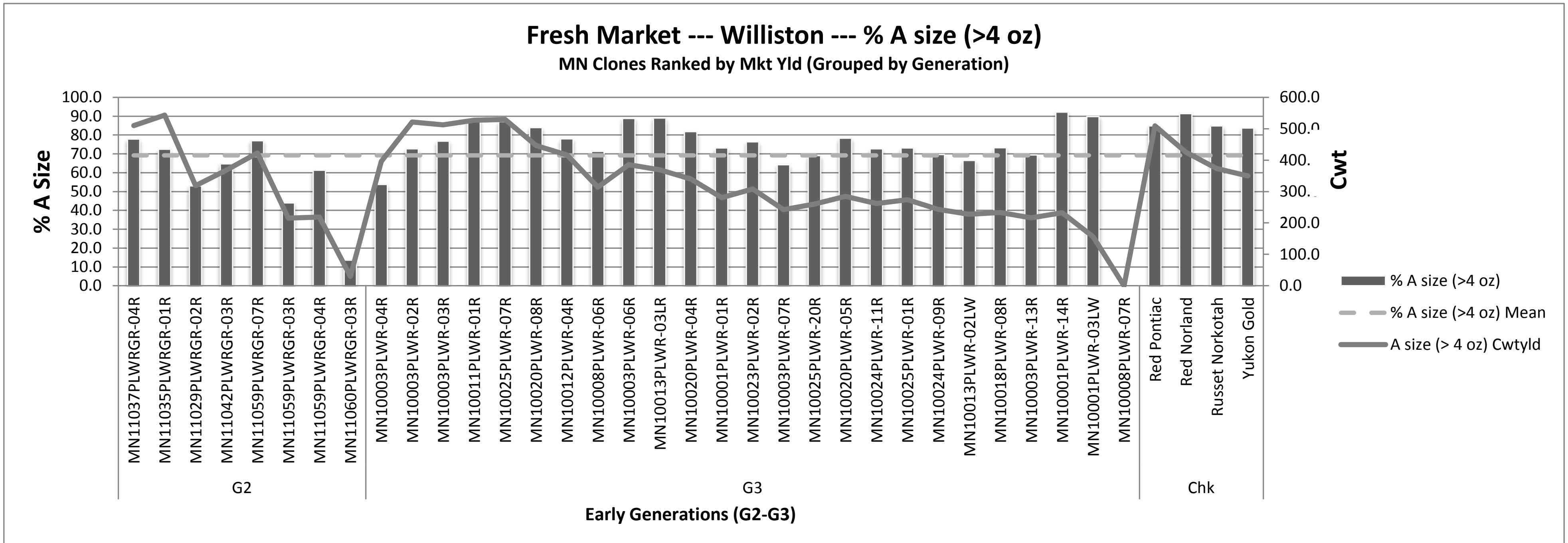
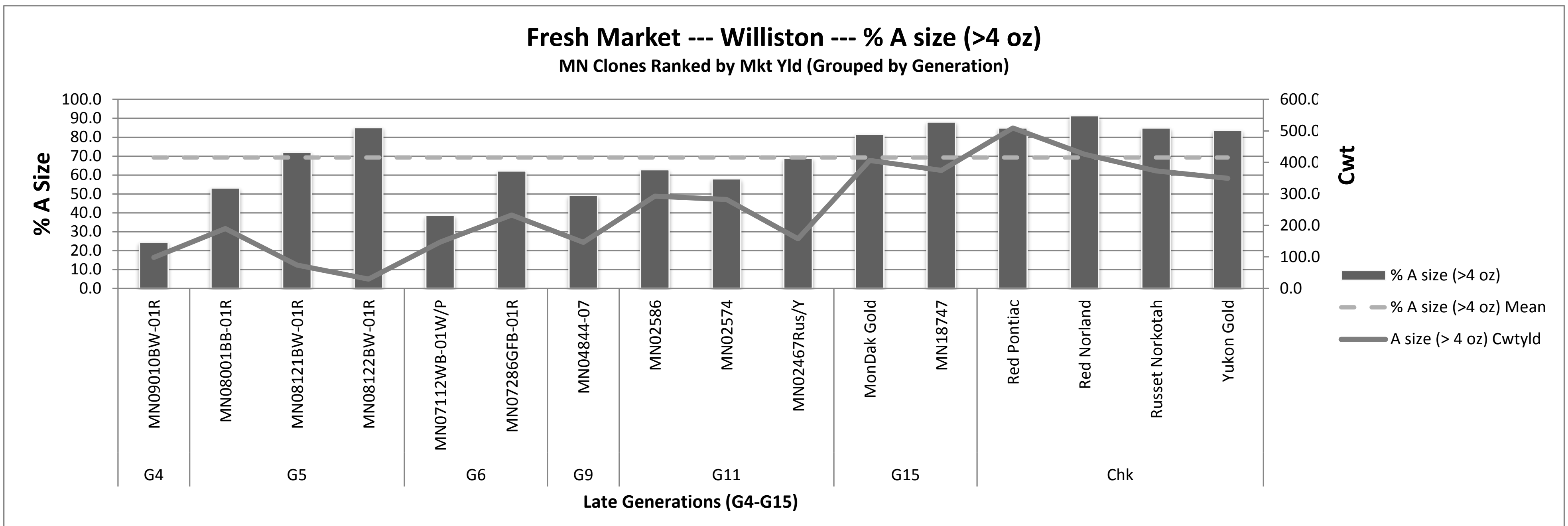

Fresh Market --- Williston --- Total Marketable Yield
MN Clones Ranked by Marketable Yield (Grouped by Generation)
Cwt
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN09010BW-01R
MN08001BB-01R
MN08121BW-01R
MN08122BW-01R
MN07112WB-01W/P
MN07286GFB-01R
MN04844-07
MN02586
MN02574
MN02467Rus/Y
MonDak Gold
MN18747
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G4
G5
G6
G9
G11
G15
Chk
Late Generations (G4-G15)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
B size (< 4 oz) Cwtyld

Table 4 (cont.)



Fresh Market --- Williston --- % A size (>4 oz)
MN Clones Ranked by Mkt Yld (Grouped by Generation)
% A Size
Cwt
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
% A size (>4 oz)
% A size (>4 oz) Mean
A size (> 4 oz) Cwtyld
MN11037PLWRGR-04R
MN11035PLWRGR-01R
MN11029PLWRGR-02R
MN11042PLWRGR-03R
MN11059PLWRGR-07R
MN11059PLWRGR-03R
MN11059PLWRGR-04R
MN11060PLWRGR-03R
MN10003PLWR-04R
MN10003PLWR-02R
MN10003PLWR-03R
MN10011PLWR-01R
MN10025PLWR-07R
MN10020PLWR-08R
MN10012PLWR-04R
MN10008PLWR-06R
MN10003PLWR-06R
MN10013PLWR-03LR
MN10020PLWR-04R
MN10001PLWR-01R
MN10023PLWR-02R
MN10003PLWR-07R
MN10025PLWR-20R
MN10020PLWR-05R
MN10024PLWR-11R
MN10025PLWR-01R
MN10024PLWR-09R
MN10013PLWR-02LW
MN10018PLWR-08R
MN10003PLWR-13R
MN10001PLWR-14R
MN10001PLWR-03LW
MN10008PLWR-07R
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G2
G3
Chk
Early Generations (G2-G3)



Fresh Market --- Williston --- % A size (>4 oz)
MN Clones Ranked by Mkt Yld (Grouped by Generation)
% A Size
Cwt
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
% A size (>4 oz)
% A size (>4 oz) Mean
A size (> 4 oz) Cwtyld
MN09010BW-01R
MN08001BB-01R
MN08121BW-01R
MN08122BW-01R
MN07112WB-01W/P
MN07286GFB-01R
MN04844-07
MN02586
MN02574
MN02467Rus/Y
MonDak Gold
MN18747
Red Pontiac
Red Norland
Russet Norkotah
Yukon Gold
G4
G5
G6
G9
G11
G15
Chk
Late Generations (G4-G15)

Sort 4	Clone	Loc	2013 Trial	Mkt	Color Skin	Flesh	Int	External Defects Knobs	GC	Grn	Bruise	Internal Defects HH	IN	VD	BC	Bruise	Chip/FF Score[3]	SPGR
								%				%						
1	**Red Norland**	BE	**Chk**	FM	Red	W	P1	0	0	0	0	0	0	0	0	0		1.060
2		BL						0	0	0	0	12	0	0	0	4		1.063
3		W						0	0	0	0	5	0	5	0	5		1.073
4																		
5	**Red Pontiac**	BE	**Chk**	FM	Red	W	R2	0	0	0	0	7	0	0	6	0		1.052
6		BL						0	4	0	8	29	4	8	0	13		1.059
7		W						10	0	0	0	0	0	20	0	0		1.074
8																		
9	**Russet Norkotah**	BE	**Chk**	FM	Rus	W		0	0	0	0	31	0	0	0	0		1.067
10		BL						0	8	0	8	8	4	8	13	4		1.070
11		W						0	0	0	10	10	0	0	0	10		1.076
12																		
13	**Yukon Gold**	BE	**Chk**	FM	W	Y		0	0	6	0	63	0	0	0	0		1.069
14		BL						0	7	0	0	20	0	10	0	7		1.087
15		W						0	0	0	0	52	0	11	0	0		1.081
16																		
17	CV00088-3	BL	NCR	FM	Red	W	R1	0	0	0	38	4	0	0	8	33		1.068
18																		
19	MN02467Rus/Y	BE	G11	FF/FM	Rus	Y		0	0	0	0	50	0	0	0	0		1.070
20		BL						0	0	0	0	0	0	0	0	0	1	1.070
21		W						0	0	0	0	18	0	0	0	0	1	1.083
22																		
23	MN02574	BE	G11	FM	W	Y		0	6	0	0	31	0	0	13	0		1.069
24		BL						0	8	0	14	0	0	56	17	0		1.075
25		W						0	0	0	5	5	0	20	5	10		1.091
26																		
27	MN02586	BE	G11	FM/C	W	Y		0	0	0	0	6	0	0	0	0		1.072
28		BL						0	0	0	8	0	0	0	0	0	2.5	1.084
29		W						0	0	0	0	0	0	15	0	0	2.5	1.092
30																		
31	MN0484407	BE	G9	FM/C	W	Y		0	0	0	0	44	0	0	0	0		1.071
32		BL						0	0	0	0	32	0	38	0	0	2	1.081
33		W						0	0	0	0	10	0	10	0	0	1.5	1.095
34																		
35	MN07112WB01W/P	BE	G6	FM	W/Purple	P/W		0	0	0	0	5	0	0	0	0		1.065
36		BL						0	8	0	0	0	0	0	0	0		1.079
37		W						0	0	0	5	0	0	0	0	5		1.086
38																		

			2013		Color			External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Int	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip/FF Score[3]	SPGR
								%				%						
39	MN07286GFB01R	BE	G6	FM	Red	Y	DR1	0	0	6	6	0	0	0	0	0		1.062
40		BL						0	0	0	0	0	0	0	0	0		1.068
41		W						0	0	0	0	0	0	0	0	0		1.078
42																		
43	MN08001BB01R	BE	G5	FM	Red	W	DR1	0	0	0	0	0	0	0	0	0		1.054
44		BL						0	0	0	0	8	0	0	0	17		1.062
45		W						0	0	0	10	0	0	5	0	10		0.528
46																		
47	MN08121BW01R	BE	G5	FM	Red	W	DR1	0	0	0	0	0	0	0	0	0		1.060
48		BL						0	6	6	0	0	0	0	0	21		1.067
49		W						0	0	13	5	0	0	0	0	18		1.082
50																		
51	MN08122BW-01R	BL	G5	FM	Red	W		0	0	0	33	0	0	0	0	50		1.063
52		W						0	0	0	5	0	0	0	0	5		1.083
53																		
54	MN09010BW01R	BE	G4	FM	Red	C	DR1	5	0	0	0	5	0	0	0	0		1.062
55		BL						0	0	0	8	0	0	0	0	17		1.085
56		W						0	0	0	5	0	0	0	0	5		1.096
57																		
58	MN10001PLWR01R	BE	NCR/G3	FM	Red	W	P2	0	0	6	0	0	0	0	0	0		1.063
59		BL						0	11	11	5	11	10	0	0	15		1.066
60		W						0	5	5	0	5	0	5	0	15		1.07
61																		
62	MN10001PLWR-03LW	BL	G3	FF/FM	LW	W		0	0	8	17	0	0	0	0	25		1.061
63		W						0	0	0	20	25	0	8	0	38		1.074
64																		
65	MN10001PLWR14R	BE	G3	FM	Red	W	DR1	6	6	0	0	25	0	0	0	0		1.061
66		BL						0	8	0	0	0	0	17	17	8		1.062
67		W						0	5	5	0	0	0	0	0	0		1.068
68																		
69	MN10003PLWR02R	BE	G3	FM	Red	W	DR1	0	0	0	0	0	0	0	0	0		1.061
70		BL						0	0	0	67	0	0	8	0	67		1.070
71		W						0	0	0	25	5	0	0	0	0		1.067
72																		
73	MN10003PLWR03R	BE	NCR/G3	FM	Red	W	DR1	0	14	0	0	28	0	6	0	0		1.061
74		BL						0	12	0	15	13	0	4	0	43		1.057
75		W						0	0	0	5	0	0	10	0	5		1.069
76																		

Sort 4	Clone	Loc	2013 Trial	Mkt	Color Skin	Flesh	Int	External Defects Knobs	GC	Grn	Bruise	Internal Defects HH	IN	VD	BC	Bruise	Chip/FF Score[3]	SPGR
								%				%						
77	MN10003PLWR04R	BE	G3	FM	Red	W	DR1	0	0	0	0	6	0	0	0	0		1.057
78		BL						0	0	0	17	0	8	0	0	15		1.064
79		W						0	0	0	10	0	0	0	0	5		1.074
80																		
81	MN10003PLWR06R	BE	G3	FM	Red	C	DR1	0	0	6	0	6	0	0	0	0		1.054
82		BL						0	0	0	0	8	0	8	8	25		1.063
83		W						0	0	0	15	5	0	5	10	20		1.071
84																		
85	MN10003PLWR07R	BE	NCR/G3	FM	Red	W	DR1	0	0	0	0	0	0	0	0	0		1.051
86		BL						0	4	0	7	4	7	4	4	15		1.055
87		W						0	0	0	10	0	0	15	0	10		1.068
88																		
89	MN10003PLWR13R	BE	G3	FM	Red	W	DR1	0	0	0	0	6	0	0	0	6		1.052
90		BL						0	7	0	49	0	0	0	0	45		1.059
91		W						0	0	0	5	0	0	0	0	15		1.062
92																		
93	MN10008PLWR06R	BE	G3	FM	Red	W	DR1	0	0	0	0	0	0	0	0	0		1.059
94		BL						0	7	0	24	0	0	0	0	17		1.066
95		W						0	0	0	0	0	0	0	0	0		1.071
96																		
97	MN10008PLWR07R	BE	G3	FM	Red	W	P1	0	0	0	0	0	0	0	0	7		1.029
98		BL						0	17	0	8	0	8	0	0	17		1.043
99		W						0	0	0	0	0	0	0	0	0		NA
100																		
101	MN10011PLWR01R	BE	G3	FM	Red	C	DR1	0	0	0	0	19	0	0	0	0		1.072
102		BL						0	0	8	42	17	0	0	0	58		1.068
103		W						0	0	0	40	5	0	0	0	10		1.07
104																		
105	MN10012PLWR04R	BE	G3	FM	Red	W	DR1	0	0	0	0	13	0	13	6	0		1.062
106		BL						0	0	0	8	25	0	0	0	17		1.063
107		W						0	10	0	0	0	0	0	5	0		1.073
108																		
109	MN10013PLWR02LW	BE	G3	FF/FM	LW	Y		0	0	6	0	7	0	0	0	0		1.061
110		BL						0	0	0	0	17	0	8	0	0	1	1.069
111		W						0	0	0	10	20	0	0	0	10	0	1.08
112																		
113	MN10013PLWR03LR	BE	G3	FF/FM	LR	C		0	6	0	0	6	0	0	0	0		1.058
114		BL						0	8	0	0	0	0	0	0	0	0	1.068
115		W						0	0	0	5	5	0	10	0	15	0	1.075
116																		

			2013		Color			External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Int	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip/FF Score[3]	SPGR
								%				%						
117	MN10018PLWR08R	BE	G3	FM	Red	W	DR1	0	0	13	0	19	0	0	0	0		1.059
118		BL						0	0	0	0	0	0	14	0	25		1.066
119		W						0	0	5	60	10	0	0	10	45		1.074
120																		
121	MN10020PLWR04R	BE	G3	FM	Red		DR1	0	0	0	0	25	0	0	25	0		1.057
122		BL						0	17	0	17	0	0	17	0	8		1.066
123		W						0	0	0	30	0	0	0	0	45		1.068
124																		
125	MN10020PLWR05R	BE	G3	FM	Red	C	R1	0	6	0	0	19	0	0	0	0		1.061
126		BL						0	0	0	0	0	8	14	0	15		1.067
127		W						0	0	0	0	5	0	10	0	10		1.071
128																		
129	MN10020PLWR08R	BE	NCR/G3	FM	Red		DR1	0	0	0	13	0	0	6	0	6		1.059
130		BL						0	8	0	13	0	0	0	4	13		1.058
131		W						0	0	5	5	0	0	10	0	10		1.069
132																		
133	MN10023PLWR02R	BE	G3	FM	Red	W	R2	0	0	0	0	25	6	0	6	0		1.057
134		BL						0	0	0	0	8	0	15	0	31		1.063
135		W						0	0	0	5	5	0	15	10	15		1.064
136																		
137	MN10024PLWR09R	BE	G3	FM	Red	W	DR1	0	0	0	0	0	0	0	0	0		1.057
138		BL						0	0	0	0	0	0	0	0	8		1.066
139		W						0	0	0	45	0	0	5	5	30		1.068
140																		
141	MN10024PLWR11R	BE	G3	FM	Red	W	R2	0	0	6	13	0	0	0	0	6		1.049
142		BL						0	0	0	58	0	0	0	0	58		1.297
143		W						0	0	5	0	0	0	0	0	10		1.065
144																		
145	MN10025PLWR01R	BE	G3	FM	Red	W	DR1	0	13	0	0	0	25	0	50	6		1.061
146		BL						0	7	0	0	0	14	23	0	0		1.065
147		W						0	10	0	0	0	0	15	0	5		1.072
148																		
149	MN10025PLWR07R	BE	G3	FM	Red	W	DR1	0	6	6	0	19	0	0	0	0		1.057
150		BL						0	8	8	0	0	0	17	0	8		1.064
151		W						0	6	18	5	0	0	5	6	6		1.069
152																		
153	MN10025PLWR20R	BE	G3	FM	Red	W	DR1	0	0	6	0	6	0	0	0	0		1.051
154		BL						0	0	0	0	0	0	0	0	44		1.058
155		W						0	6	0	23	0	0	0	5	23		1.068
156																		

			2013		Color			External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Int	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip/FF Score[3]	SPGR
								%				%						
157	MN11029PLWRGR-02R	BL	G2	FM	Red	W	R1	0	0	0	14	0	0	0	0	14		1.075
158		W						0	0	0	0	0	0	0	0	10		1.085
159																		
160	MN11035PLWRGR-01R	BL	G2	FM	Red	W	R3	0	0	0	0	0	0	33	0	17		1.058
161		W						0	0	0	0	0	0	0	0	0		1.063
162																		
163	MN11037PLWRGR-04R	BL	G2	FM	Red	C	R2	0	0	0	0	0	0	14	0	14		1.062
164		W						0	0	10	0	0	0	0	0	0		1.071
165																		
166	MN11042PLWRGR-03R	BL	G2	FM	Red	W	R2	0	0	0	17	0	0	0	0	17		1.071
167		W						0	0	0	0	0	0	0	0	0		1.076
168																		
169	MN11059PLWRGR-03R	BL	G2	FM	Red	Y	R1	0	0	0	20	0	0	0	0	40		1.066
170		W						0	0	0	0	0	0	0	0	0		1.087
171																		
172	MN11059PLWRGR-04R	BL	G2	FM	Red	Y	R2	0	0	0	57	0	0	0	0	57		1.071
173		W						0	0	0	20	0	0	0	0	20		1.082
174																		
175	MN11059PLWRGR-07R	BL	G2	FM	Red	W	R1	0	0	0	17	0	0	0	0	17		1.068
176		W						0	0	0	10	0	0	0	0	10		1.074
177																		
178	MN11060PLWRGR-03R	BL	G2	FM	Red	W	R1	0	0	0	33	0	0	0	0	33		1.072
179		W						0	0	0	0	0	0	0	0	20		1.087
180																		
181	MN18747	BE	G15	FF/FM	LW	W		0	6	0	0	6	0	6	0	0		1.060
182		BL						0	0	0	0	0	0	8	0	0	0	1.069
183		W						0	0	0	0	0	0	10	5	0	0	1.081
184																		
185	MonDak Gold	BE	G15	FF/FM	Red	Y	P1	0	0	0	0	0	0	0	0	0		1.055
186		BL						0	0	0	0	0	0	8	0	0	1	1.077
187		W						0	0	5	0	0	0	25	0	0	0	1.087
188																		
189	ND6002-1R	BL	NCR	FM	Red	W	R2	0	0	7	8	0	0	0	4	24		1.067
190																		
191	ND7132-1R	BL	NCR	FM	Red	W		0	4	0	0	4	0	8	4	11		1.063
192																		
193	ND7982-1R	BL	NCR	FM	Red	W		0	0	0	0	0	0	0	0	54		1.073
194																		
195	W6002-1R	BL	NCR	FM	Red	W	R1	0	0	0	7	0	0	13	0	11		1.063
196																		
197	W8405-1R	BL	NCR	FM	Red	W		0	8	0	0	0	13	38	0	13		1.064

Sort 4	Clone	Loc	2013 Trial	Mkt	Color Skin	Tubers #/plant	Mkt Yld Cwtyld	Culls Cwtyld	Culls %	Total Yld Cwtyld	Size Distribution B's Cwtyld	Size Distribution % B's < 4 oz	Size Distribution A's Cwtyld	Size Distribution % A's > 4 oz	US #1 %
1	**Red Norland**	BE	**Chk**	FM	Red	11.0	460.9	12.7	2.7	473.6	110.1	23.2	350.9	74.1	74.1
2		BL				10.5	664.4	11.7	1.7	676.1	52.5	7.8	611.9	90.5	90.5
3		W				7.4	459.4	6.4	1.4	465.8	33.8	7.3	425.6	91.4	91.4
4															
5	**Red Pontiac**	BE	**Chk**	FM	Red	10.5	495.0	19.2	3.7	514.2	95.7	18.6	399.3	77.7	77.7
6		BL				12.1	793.4	51.5	6.1	844.9	73.7	8.7	719.6	85.2	85.2
7		W				8.2	556.0	44.0	7.3	600.1	46.9	7.8	509.1	84.8	84.8
8															
9	**Russet Norkotah**	BE	**Chk**	FM	Rus	8.3	428.9	1.8	0.4	430.8	64.4	15.0	364.5	84.6	84.6
10		BL				9.3	638.4	17.3	2.6	655.7	53.1	8.1	585.2	89.3	89.3
11		W				5.9	399.6	40.2	9.1	439.8	26.5	6.0	373.1	84.8	84.8
12															
13	**Yukon Gold**	BE	**Chk**	FM	W	6.7	419.9	6.7	1.6	426.5	36.4	8.5	383.4	89.9	89.9
14		BL				7.0	572.2	23.3	3.9	595.5	29.4	4.9	542.8	91.1	91.1
15		W				6.7	384.9	32.5	7.8	417.4	35.6	8.5	349.3	83.7	83.7
16															
17	CV00088-3	BL	NCR	FM	Red	12.1	611.6	13.2	2.1	624.8	87.0	13.9	524.6	84.0	84.0
18															
19	MN02467Rus/Y	BE	G11	FF/FM	Rus	7.8	330.1	1.9	0.6	332.1	88.9	26.8	241.2	72.6	72.6
20		BL				8.2	380.2	35.0	8.4	415.2	60.3	14.5	319.9	77.0	77.0
21		W				4.6	194.1	34.5	15.1	228.5	36.4	15.9	157.7	69.0	69.0
22															
23	MN02574	BE	G11	FM	W	19.0	377.8	0.9	0.2	378.7	314.8	83.1	63.0	16.6	16.6
24		BL				28.0	774.8	8.2	1.0	783.0	416.7	53.2	358.2	45.7	45.7
25		W				14.1	458.0	29.0	5.9	486.9	175.9	36.1	282.1	57.9	57.9
26															
27	MN04844-07	BE	G9	FM/C	W	10.4	299.0	0.0	0.0	299.0	163.4	54.7	135.6	45.3	45.3
28		BL	G9	FM/C	W	13.2	471.4	0.0	0.0	471.4	172.3	36.6	299.0	63.4	63.4
29		W	G9	FM/C	W	10.2	295.2	1.6	0.5	296.8	149.0	50.2	146.2	49.3	49.3
30															
31	MN07112WB-01W/P	BE	G6	FM	W/Purple	19.6	334.0	0.0	0.0	334.0	297.2	89.0	36.8	11.0	11.0
32		BL				21.4	450.4	0.0	0.0	450.4	328.7	73.0	121.7	27.0	27.0
33		W				15.8	379.9	1.0	0.3	380.9	232.7	61.1	147.3	38.7	38.7
34															
35	MN07286GFB-01R	BE	G6	FM	Red	13.0	346.9	0.0	0.0	346.9	222.4	64.1	124.6	35.9	35.9
36		BL				14.3	561.9	0.0	0.0	561.9	179.1	31.9	382.8	68.1	68.1
37		W				11.5	373.9	1.4	0.4	375.3	140.8	37.5	233.1	62.1	62.1
38															
39															
40															

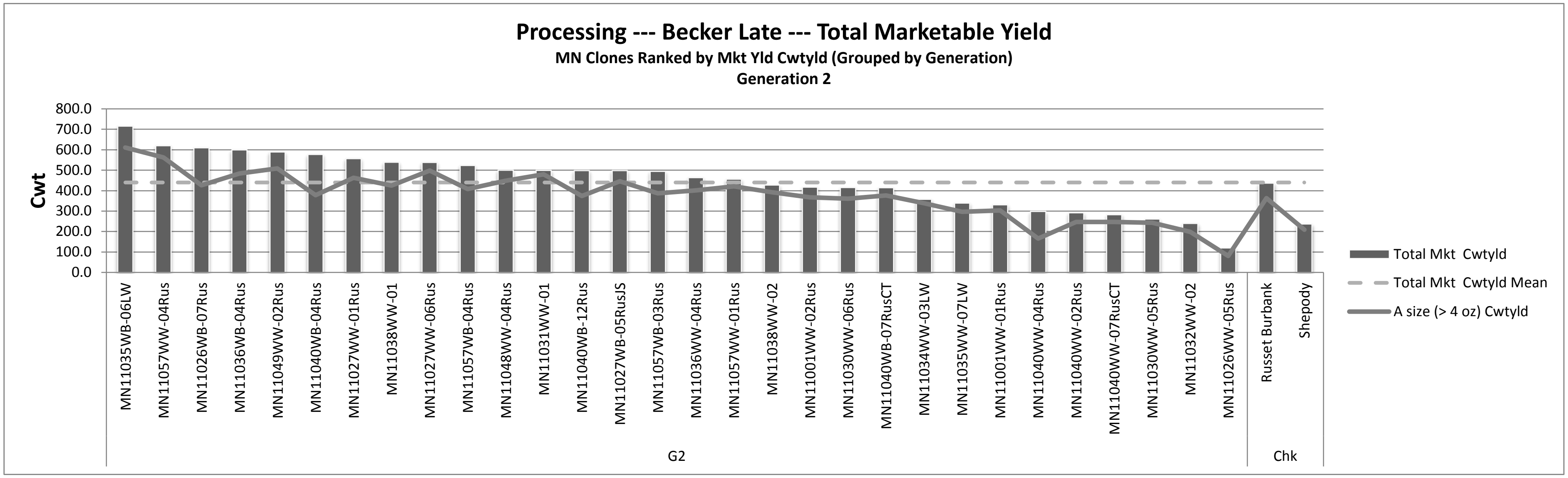
			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	Size Distribution B's	% B's	A's	% A's	US #1
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	Cwtyld	%	Cwtyld	Cwtyld	< 4 oz	Cwtyld	> 4 oz	%
41	MN08001BB-01R	BE	G5	FM	Red	15.1	343.5	2.0	0.6	345.6	257.8	74.6	85.7	24.8	24.8
42		BL				16.4	475.7	6.3	1.3	482.1	253.3	52.5	222.4	46.1	46.1
43		W				12.0	348.7	8.2	2.3	356.8	158.9	44.5	189.8	53.2	53.2
44															
45	MN08121BW-01R	BE	G5	FM	Red	3.7	116.5	0.0	0.0	116.5	47.4	40.6	69.1	59.4	59.4
46		BL				3.1	145.1	0.0	0.0	145.1	25.2	17.4	119.9	82.6	82.6
47		W				2.4	99.0	3.4	3.3	102.4	25.2	24.6	73.8	72.1	72.1
48															
49	MN08122BW-01R	BL	G6	FM	Red	1.3	59.4	1.8	3.0	61.3	10.9	17.8	48.5	79.2	79.2
50		W				0.6	34.1	0.0	0.0	34.1	5.1	14.9	29.0	85.1	85.1
51															
52	MN09010BW-01R	BE	G4	FM	Red	16.5	245.5	0.0	0.0	245.5	231.5	94.3	14.0	5.7	5.7
53		BL				18.7	371.1	0.0	0.0	371.1	301.6	81.3	69.6	18.7	18.7
54		W				17.8	400.8	0.0	0.0	400.8	302.6	75.5	98.1	24.5	24.5
55															
56	MN10001PLWR-01R	BE	NCR/G3	FM	Red	10.6	408.7	4.0	1.0	412.8	120.9	29.3	287.8	69.7	69.7
57		BL				9.2	379.1	0.3	0.1	379.4	86.2	22.7	292.9	77.2	77.2
58		W				9.9	378.2	4.7	1.2	382.9	98.1	25.6	280.1	73.2	73.2
59															
60	MN10001PLWR-03LW	BL	G3	FF/FM	LW	6.0	241.9	151.0	38.4	392.9	41.3	10.5	200.6	51.0	51.0
61		W				2.4	163.3	10.5	6.0	173.8	7.2	4.2	156.1	89.8	89.8
62															
63	MN10001PLWR-14R	BE	G3	FM	Red	7.8	329.4	18.4	5.3	347.9	72.6	20.9	256.8	73.8	73.8
64		BL				6.7	366.7	10.5	2.8	377.2	43.2	11.4	323.6	85.8	85.8
65		W				3.3	240.8	11.1	4.4	251.9	8.6	3.4	232.3	92.2	92.2
66															
67	MN10003PLWR-02R	BE	G3	FM	Red	12.3	375.7	0.0	0.0	375.7	179.1	47.7	196.6	52.3	52.3
68		BL				9.0	541.1	0.0	0.0	541.1	45.4	8.4	495.7	91.6	91.6
69		W				18.3	717.3	0.0	0.0	717.3	196.0	27.3	521.3	72.7	72.7
70															
71	MN10003PLWR-03R	BE	NCR/G3	FM	Red	12.4	449.4	20.2	4.3	469.6	144.0	30.7	305.3	65.0	65.0
72		BL				12.7	534.9	16.6	3.0	551.5	138.2	25.1	396.7	71.9	71.9
73		W				16.1	660.3	6.9	1.0	667.2	148.1	22.2	512.2	76.8	76.8
74															
75	MN10003PLWR-04R	BE	G3	FM	Red	18.5	442.9	2.5	0.6	445.4	285.0	64.0	157.8	35.4	35.4
76		BL				23.4	771.6	0.0	0.0	771.6	331.0	42.9	440.6	57.1	57.1
77		W				24.5	731.3	4.6	0.6	735.9	335.6	45.6	395.6	53.8	53.8
78															
79	MN10003PLWR-06R	BE	G3	FM	Red	6.5	216.0	7.6	3.4	223.6	96.0	42.9	120.1	53.7	53.7
80		BL				9.7	433.0	9.4	2.1	442.4	89.6	20.3	343.4	77.6	77.6
81		W				6.9	427.2	7.0	1.6	434.2	41.6	9.6	385.5	88.8	88.8

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	Size Distribution B's	% B's	A's	% A's	US #1
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	Cwtyld	%	Cwtyld	Cwtyld	< 4 oz	Cwtyld	> 4 oz	%
82															
83	MN10003PLWR-07R	BE	NCR/G3	FM	Red	12.4	368.0	1.7	0.5	369.7	210.8	57.0	157.2	42.5	42.5
84		BL				14.5	436.2	6.9	1.6	443.2	222.6	50.2	213.6	48.2	48.2
85		W				10.5	370.8	6.4	1.7	377.2	128.6	34.1	242.2	64.2	64.2
86															
87	MN10003PLWR-13R	BE	G3	FM	Red	10.0	365.6	11.6	3.1	377.2	120.7	32.0	244.9	64.9	64.9
88		BL				9.6	459.3	2.2	0.5	461.5	96.2	20.8	363.1	78.7	78.7
89		W				7.3	277.3	33.7	10.8	311.0	61.3	19.7	216.0	69.4	69.4
90															
91	MN10008PLWR-06R	BE	G3	FM	Red	12.7	338.4	0.0	0.0	338.4	210.6	62.2	127.8	37.8	37.8
92		BL				14.9	532.2	19.8	3.6	552.0	189.7	34.4	342.5	62.0	62.0
93		W				11.4	433.6	6.7	1.5	440.3	119.7	27.2	313.9	71.3	71.3
94															
95	MN10008PLWR-07R	BE	G3	FM	Red	1.1	13.9	0.0	0.0	13.9	11.0	79.2	2.9	20.8	20.8
96		BL				1.6	82.2	0.0	0.0	82.2	13.4	16.3	68.8	83.7	83.7
97		W				0.9	11.5	0.0	0.0	11.5	11.5	100.0	0.0	0.0	0.0
98															
99	MN10011PLWR-01R	BE	G3	FM	Red	9.5	417.2	39.0	8.6	456.2	85.8	18.8	331.4	72.6	72.6
100		BL				12.5	577.4	49.0	7.8	626.4	101.5	16.2	475.9	76.0	76.0
101		W				11.2	594.5	3.5	0.6	598.0	67.2	11.2	527.3	88.2	88.2
102															
103	MN10012PLWR-04R	BE	G3	FM	Red	10.0	387.9	8.7	2.2	396.6	115.4	29.1	272.5	68.7	68.7
104		BL				12.5	641.5	0.0	0.0	641.5	99.6	15.5	541.8	84.5	84.5
105		W				12.0	514.8	19.9	3.7	534.7	98.1	18.3	416.7	77.9	77.9
106															
107	MN10013PLWR-02LW	BE	G3	FF/FM	LW	9.9	254.9	7.8	3.0	262.8	171.5	65.3	83.4	31.7	31.7
108		BL				9.5	237.8	42.1	15.0	279.9	133.4	47.6	104.4	37.3	37.3
109		W				7.7	290.2	52.5	15.3	342.7	62.5	18.2	227.8	66.5	66.5
110															
111	MN10013PLWR-03LR	BE	G3	FF/FM	LR	5.6	315.0	15.3	4.6	330.3	36.2	11.0	278.9	84.4	84.4
112		BL				7.0	443.1	85.0	16.1	528.1	29.7	5.6	413.3	78.3	78.3
113		W				5.5	393.9	20.5	5.0	414.4	25.0	6.0	368.9	89.0	89.0
114															
115	MN10018PLWR-08R	BE	G3	FM	Red	7.3	213.8	5.3	2.4	219.2	108.3	49.4	105.6	48.2	48.2
116		BL				11.6	433.0	6.1	1.4	439.1	149.3	34.0	283.8	64.6	64.6
117		W				6.3	281.9	37.1	11.6	319.0	48.2	15.1	233.7	73.3	73.3
118															
119	MN10020PLWR-04R	BE	G3	FM	Red	7.5	322.4	20.5	6.0	342.9	64.9	18.9	257.5	75.1	75.1
120		BL				6.4	433.8	10.1	2.3	443.9	42.1	9.5	391.7	88.2	88.2
121		W				7.7	387.4	28.3	6.8	415.7	47.3	11.4	340.1	81.8	81.8
122															

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	Size Distribution B's	% B's	A's	% A's	US #1
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	Cwtyld	%	Cwtyld	Cwtyld	< 4 oz	Cwtyld	> 4 oz	%
123															
124	MN10020PLWR-05R	BE	G3	FM	Red	8.8	393.0	2.5	0.6	395.5	78.7	19.9	314.3	79.5	79.5
125		BL				8.8	551.9	6.0	1.1	557.9	44.5	8.0	507.4	91.0	91.0
126		W				8.3	363.1	0.0	0.0	363.1	78.7	21.7	284.4	78.3	78.3
127															
128	MN10020PLWR-08R	BE	NCR/G3	FM	Red	11.2	470.4	16.7	3.4	487.1	123.9	25.4	346.4	71.1	71.1
129		BL				15.1	676.7	27.4	3.9	704.0	148.5	21.1	528.2	75.0	75.0
130		W				10.4	519.4	12.5	2.4	531.9	73.0	13.7	446.4	83.9	83.9
131															
132	MN10023PLWR-02R	BE	G3	FM	Red	11.2	327.0	7.3	2.2	334.3	179.4	53.7	147.6	44.2	44.2
133		BL				14.1	641.9	1.9	0.3	643.8	143.0	22.2	498.9	77.5	77.5
134		W				8.2	375.6	27.8	6.9	403.4	67.5	16.7	308.1	76.4	76.4
135															
136	MN10024PLWR-09R	BE	G3	FM	Red	11.9	320.5	8.9	2.7	329.4	183.6	55.7	136.9	41.6	41.6
137		BL				15.8	606.3	1.4	0.2	607.8	183.9	30.3	422.4	69.5	69.5
138		W				9.3	340.3	8.5	2.5	348.8	97.5	28.0	242.8	69.6	69.6
139															
140	MN10024PLWR-11R	BE	G3	FM	Red	16.2	490.9	9.9	2.0	500.8	253.3	50.6	237.6	47.4	47.4
141		BL				12.8	552.4	11.8	2.1	564.2	124.6	22.1	427.8	75.8	75.8
142		W				8.8	350.7	10.3	2.8	360.9	88.5	24.5	262.1	72.6	72.6
143															
144	MN10025PLWR-01R	BE	G3	FM	Red	7.6	303.1	21.2	6.5	324.3	75.0	23.1	228.0	70.3	70.3
145		BL				8.7	467.0	0.0	0.0	467.0	66.4	14.2	400.6	85.8	85.8
146		W				8.2	349.3	25.8	6.9	375.2	75.1	20.0	274.3	73.1	73.1
147															
148	MN10025PLWR-07R	BE	G3	FM	Red	9.3	379.0	17.4	4.4	396.4	105.1	26.5	273.9	69.1	69.1
149		BL				5.8	396.3	4.1	1.0	400.4	37.3	9.3	359.1	89.7	89.7
150		W				10.3	585.5	21.9	3.6	607.4	56.2	9.3	529.3	87.1	87.1
151															
152	MN10025PLWR-20R	BE	G3	FM	Red	10.2	238.0	3.0	1.2	241.0	164.7	68.3	73.3	30.4	30.4
153		BL				10.6	437.6	3.8	0.9	441.4	123.1	27.9	314.5	71.3	71.3
154		W				9.3	368.2	8.1	2.1	376.3	108.4	28.8	259.8	69.0	69.0
155															
156	MN11029PLWRGR-02R	BL	G2	FM	Red	16.6	425.8	0.0	0.0	425.8	286.7	67.3	139.1	32.7	32.7
157		W				20.1	599.8	1.2	0.2	601.0	281.5	46.8	318.4	53.0	53.0
158															
159	MN11035PLWRGR-01R	BL	G2	FM	Red	11.8	606.3	22.7	3.6	629.0	90.4	14.4	515.8	82.0	82.0
160		W				10.6	605.3	145.3	19.4	750.6	61.7	8.2	543.6	72.4	72.4
161															
162	MN11037PLWRGR-04R	BL	G2	FM	Red	14.2	489.5	1.6	0.3	491.1	195.4	39.8	294.0	59.9	59.9
163		W				15.0	651.2	4.0	0.6	655.2	141.1	21.5	510.1	77.9	77.9

Sort 4	Clone	Loc	2013 Trial	Mkt	Color Skin	Tubers #/plant	Mkt Yld Cwtyld	Culls Cwtyld	Culls %	Total Yld Cwtyld	Size Distribution B's Cwtyld	% B's < 4 oz	A's Cwtyld	% A's > 4 oz	US #1 %
164															
165	MN11042PLWRGR-03R	BL	G2	FM	Red	16.6	693.0	0.0	0.0	693.0	167.9	24.2	525.1	75.8	75.8
166		W				15.9	562.7	7.1	1.2	569.8	194.0	34.0	368.7	64.7	64.7
167															
168	MN11059PLWRGR-03R	BL	G2	FM	Red	17.6	581.5	2.8	0.5	584.3	215.0	36.8	366.5	62.7	62.7
169		W				17.8	489.4	0.0	0.0	489.4	274.2	56.0	215.1	44.0	44.0
170															
171	MN11059PLWRGR-04R	BL	G2	FM	Red	12.2	425.6	0.0	0.0	425.6	153.3	36.0	272.3	64.0	64.0
172		W				10.2	346.6	10.6	3.0	357.2	127.7	35.7	218.9	61.3	61.3
173															
174	MN11059PLWRGR-07R	BL	G2	FM	Red	17.2	673.6	4.2	0.6	677.8	211.9	31.3	461.7	68.1	68.1
175		W				12.8	543.7	5.2	0.9	548.9	121.2	22.1	422.6	77.0	77.0
176															
177	MN11060PLWRGR-03R	BL	G2	FM	Red	11.5	223.6	0.0	0.0	223.6	190.0	85.0	33.6	15.0	15.0
178		W				11.8	221.6	0.0	0.0	221.6	191.5	86.4	30.1	13.6	13.6
179															
180	MN18747	BE	G15	FF/FM	LW	9.7	458.6	2.1	0.4	460.7	98.3	21.3	360.3	78.2	78.2
181		BL				10.8	650.0	38.6	5.6	688.6	58.5	8.5	591.4	85.9	85.9
182		W				6.7	408.9	16.8	4.0	425.8	34.0	8.0	374.9	88.1	88.1
183															
184	MonDak Gold	BE	G15	FF/FM	Red	11.0	304.3	6.9	2.2	311.2	181.2	58.2	123.1	39.6	39.6
185		BL				12.5	415.2	61.9	13.0	477.0	151.8	31.8	263.4	55.2	55.2
186		W				8.1	461.6	37.0	7.4	498.6	55.0	11.0	406.6	81.5	81.5
187															
188	ND6002-1R	BL	NCR	FM	Red	15.4	701.5	3.8	0.5	705.2	134.7	19.1	566.7	80.4	80.4
189															
190	ND7132-1R	BL	NCR	FM	Red	11.6	603.4	6.9	1.1	610.2	75.1	12.3	528.3	86.6	86.6
191															
192	ND7982-1R	BL	NCR	FM	Red	16.7	561.2	1.9	0.3	563.1	255.5	45.4	305.6	54.3	54.3
193															

Table 7


Processing --- Becker Late --- Total Marketable Yield
MN Clones Ranked by Mkt Yld Cwtyld (Grouped by Generation)
Generation 2
Cwt
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN11035WB-06LW
MN11057WW-04Rus
MN11026WB-07Rus
MN11036WB-04Rus
MN11049WW-02Rus
MN11040WB-04Rus
MN11027WW-01Rus
MN11038WW-01
MN11027WW-06Rus
MN11057WB-04Rus
MN11048WW-04Rus
MN11031WW-01
MN11040WB-12Rus
MN11027WB-05RusJS
MN11057WB-03Rus
MN11036WW-04Rus
MN11057WW-01Rus
MN11038WW-02
MN11001WW-02Rus
MN11030WW-06Rus
MN11040WB-07RusCT
MN11034WW-03LW
MN11035WW-07LW
MN11001WW-01Rus
MN11040WW-04Rus
MN11040WW-02Rus
MN11040WW-07RusCT
MN11030WW-05Rus
MN11032WW-02
MN11026WW-05Rus
Russet Burbank
Shepody
G2
Chk
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
A size (> 4 oz) Cwtyld

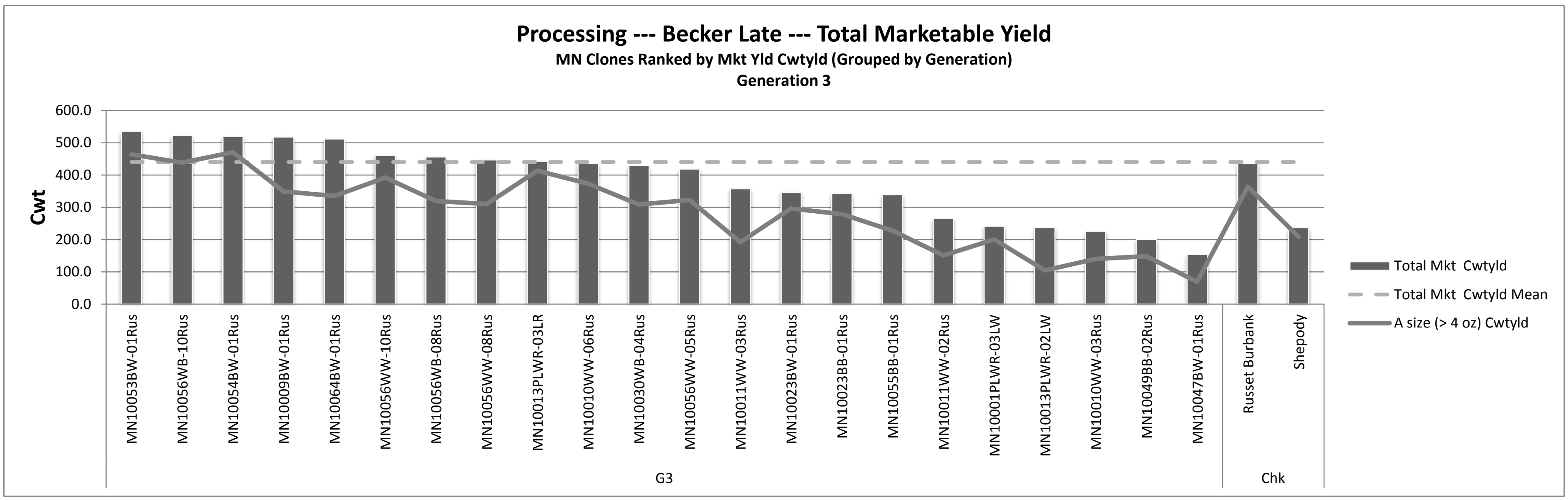

Processing --- Becker Late --- Total Marketable Yield
MN Clones Ranked by Mkt Yld Cwtyld (Grouped by Generation)
Generation 3
Cwt
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN10053BW-01Rus
MN10056WB-10Rus
MN10054BW-01Rus
MN10009BW-01Rus
MN10064BW-01Rus
MN10056WW-10Rus
MN10056WB-08Rus
MN10056WW-08Rus
MN10013PLWR-03LR
MN10010WW-06Rus
MN10030WB-04Rus
MN10056WW-05Rus
MN10011WW-03Rus
MN10023BW-01Rus
MN10023BB-01Rus
MN10055BB-01Rus
MN10011WW-02Rus
MN10001PLWR-03LW
MN10013PLWR-02LW
MN10010WW-03Rus
MN10049BB-02Rus
MN10047BW-01Rus
Russet Burbank
Shepody
G3
Chk
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
A size (> 4 oz) Cwtyld

Table 7 (cont'd.)

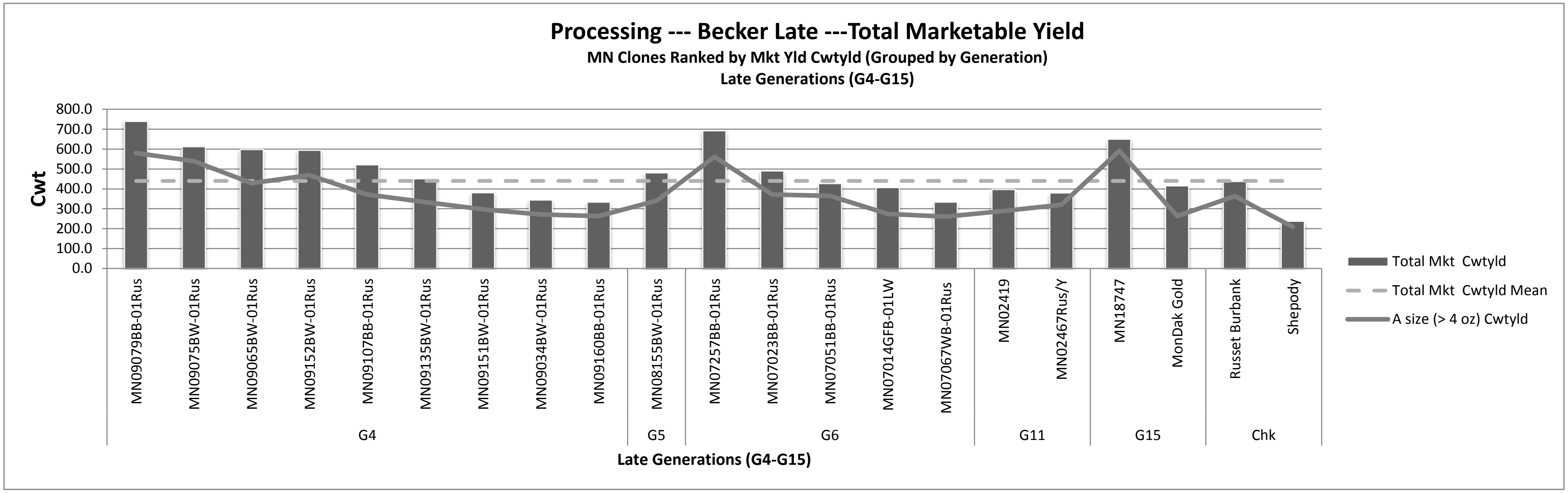
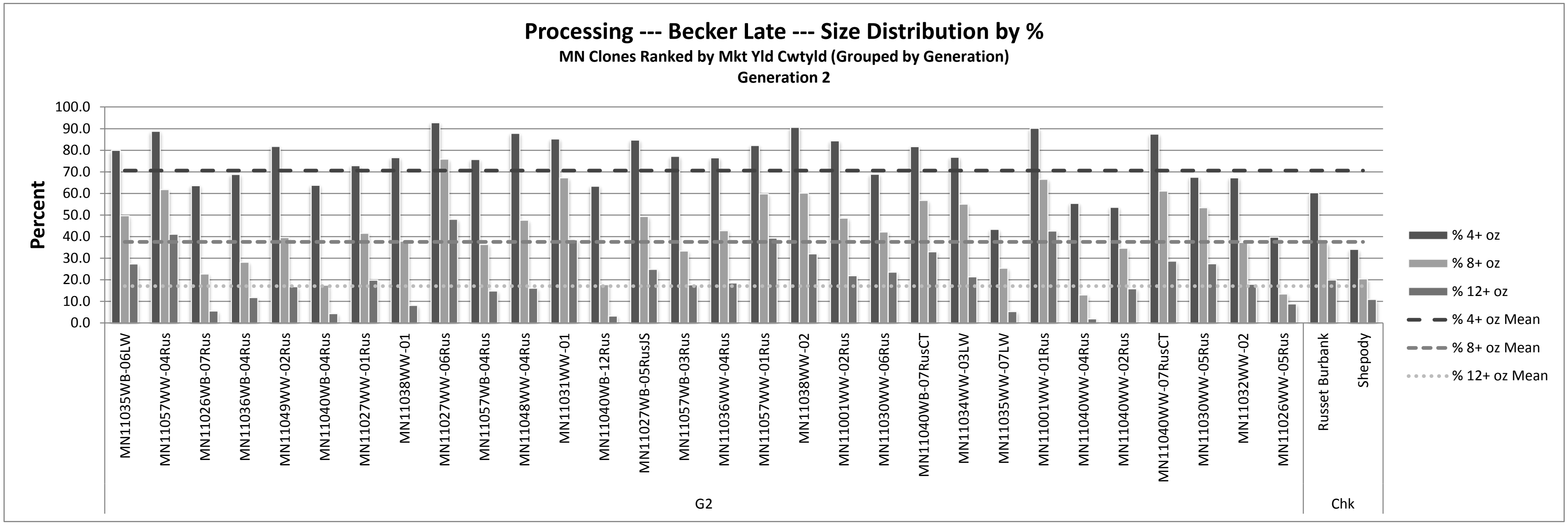


Table 7 (cont'd.)



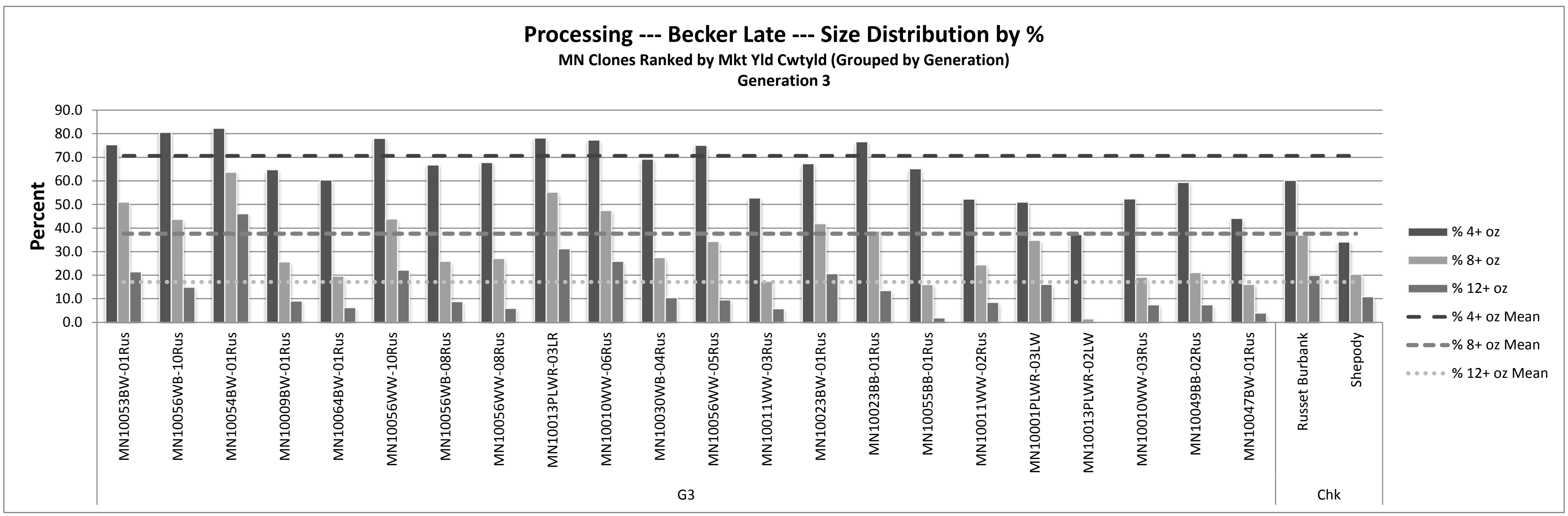


Table 7 (cont'd.)

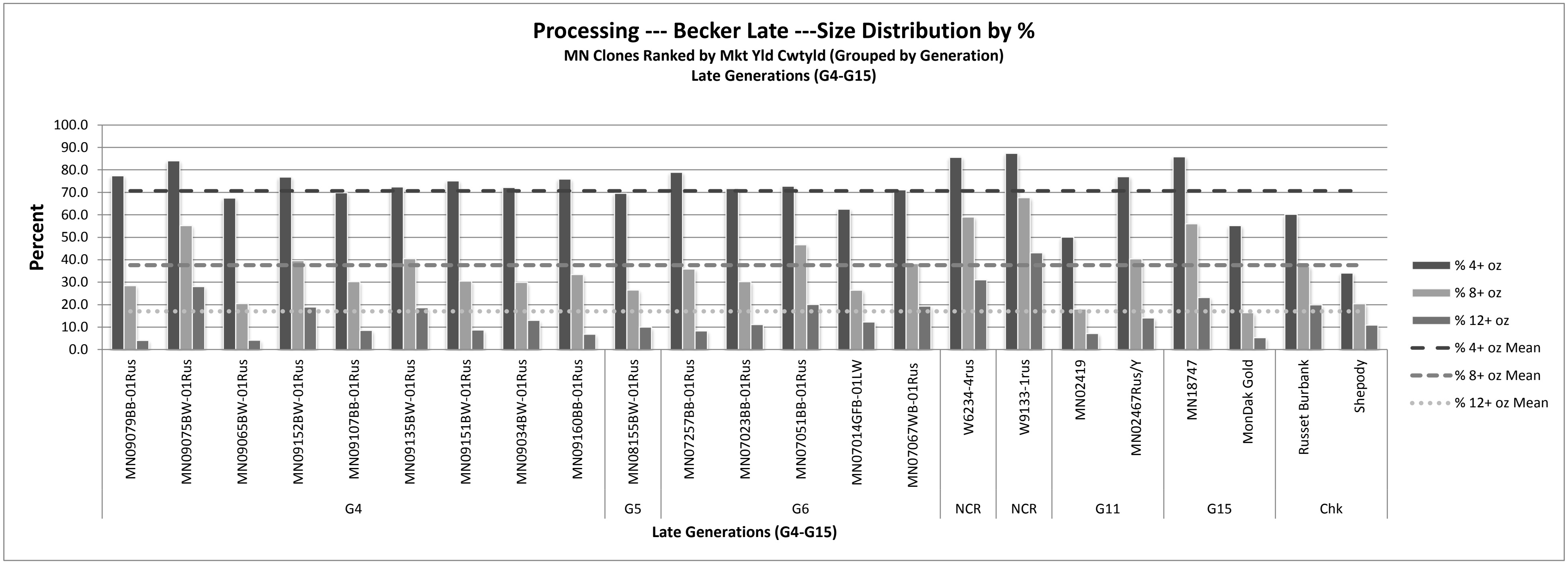
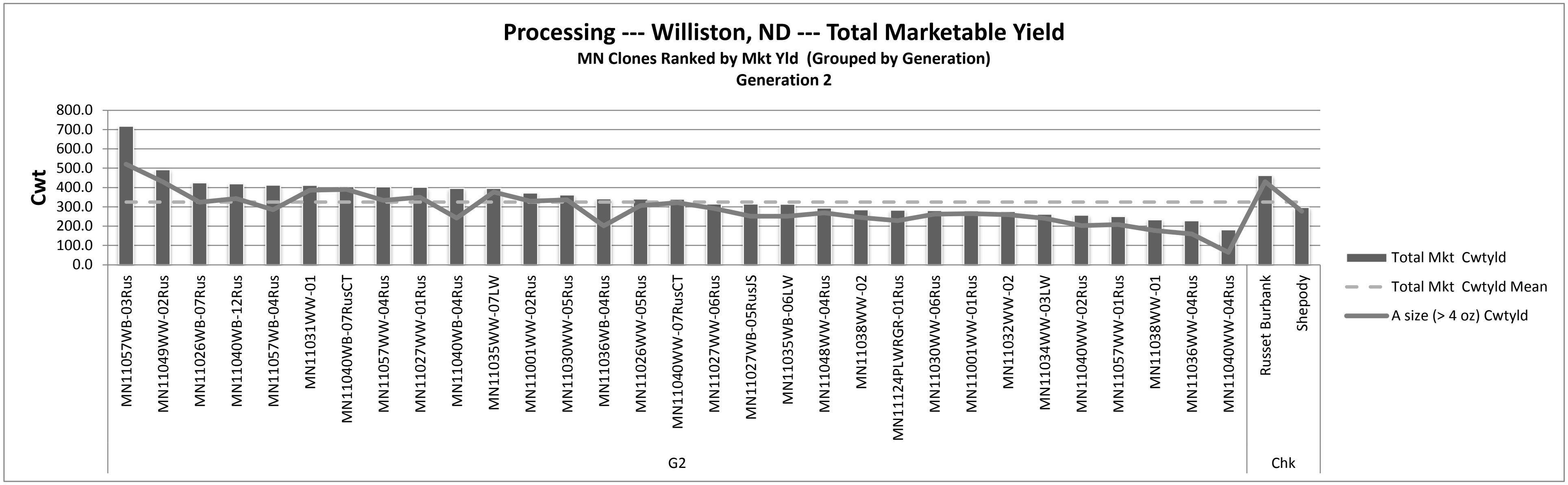
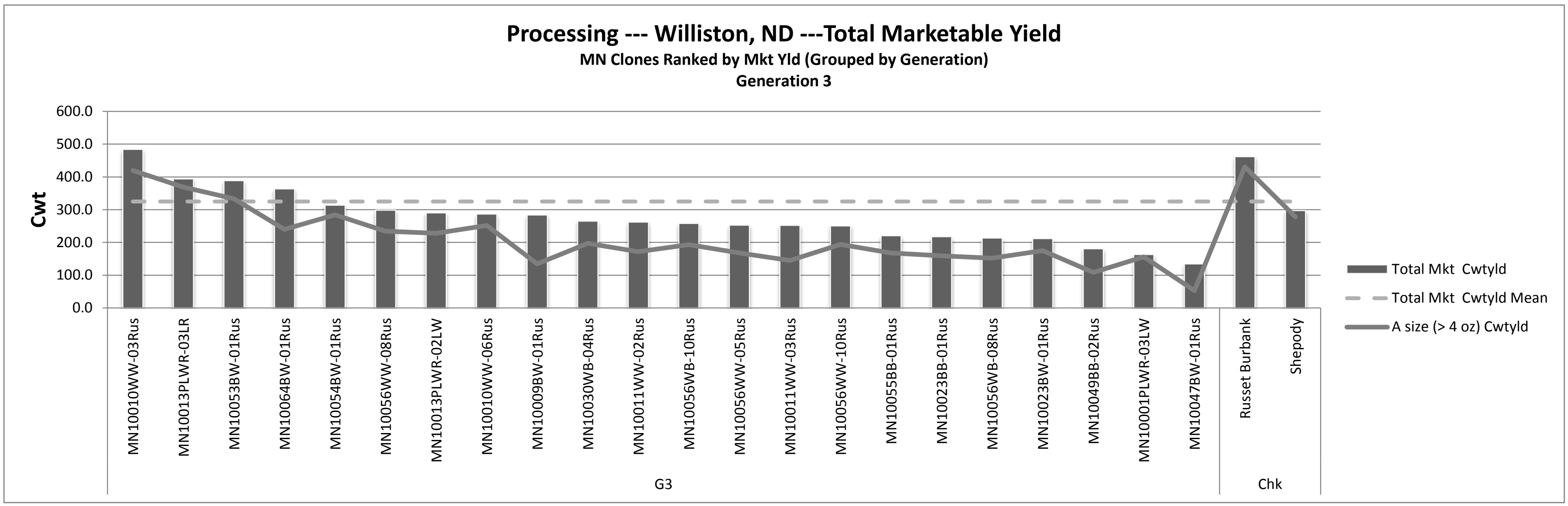


Table 8



Processing --- Williston, ND --- Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Generation 2
Cwt
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN11057WB-03Rus
MN11049WW-02Rus
MN11026WB-07Rus
MN11040WB-12Rus
MN11057WB-04Rus
MN11031WW-01
MN11040WB-07RusCT
MN11057WW-04Rus
MN11027WW-01Rus
MN11040WB-04Rus
MN11035WW-07LW
MN11001WW-02Rus
MN11030WW-05Rus
MN11036WB-04Rus
MN11026WW-05Rus
MN11040WW-07RusCT
MN11027WW-06Rus
MN11027WB-05RusJS
MN11035WB-06LW
MN11048WW-04Rus
MN11038WW-02
MN11124PLWRGR-01Rus
MN11030WW-06Rus
MN11001WW-01Rus
MN11032WW-02
MN11034WW-03LW
MN11040WW-02Rus
MN11057WW-01Rus
MN11038WW-01
MN11036WW-04Rus
MN11040WW-04Rus
Russet Burbank
Shepody
G2
Chk
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
A size (> 4 oz) Cwtyld



Processing --- Williston, ND ---Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Generation 3
Cwt
600.0
500.0
400.0
300.0
200.0
100.0
0.0
MN10010WW-03Rus
MN10013PLWR-03LR
MN10053BW-01Rus
MN10064BW-01Rus
MN10054BW-01Rus
MN10056WW-08Rus
MN10013PLWR-02LW
MN10010WW-06Rus
MN10009BW-01Rus
MN10030WB-04Rus
MN10011WW-02Rus
MN10056WB-10Rus
MN10056WW-05Rus
MN10011WW-03Rus
MN10056WW-10Rus
MN10055BB-01Rus
MN10023BB-01Rus
MN10056WB-08Rus
MN10023BW-01Rus
MN10049BB-02Rus
MN10001PLWR-03LW
MN10047BW-01Rus
Russet Burbank
Shepody
G3
Chk
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
A size (> 4 oz) Cwtyld

Table 8 (cont'd.)

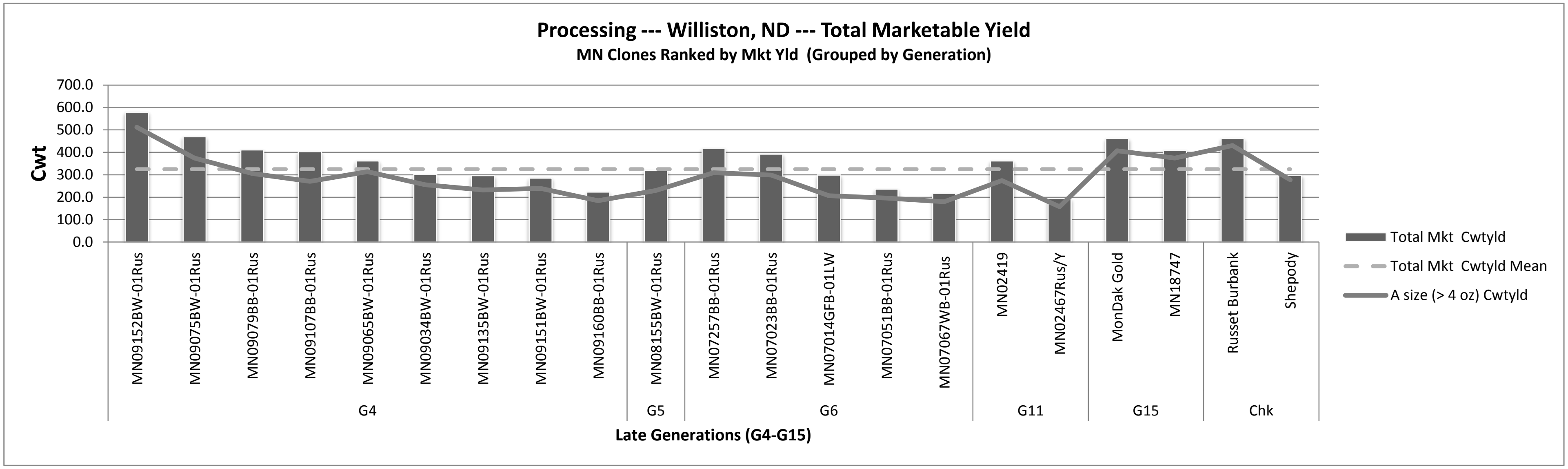
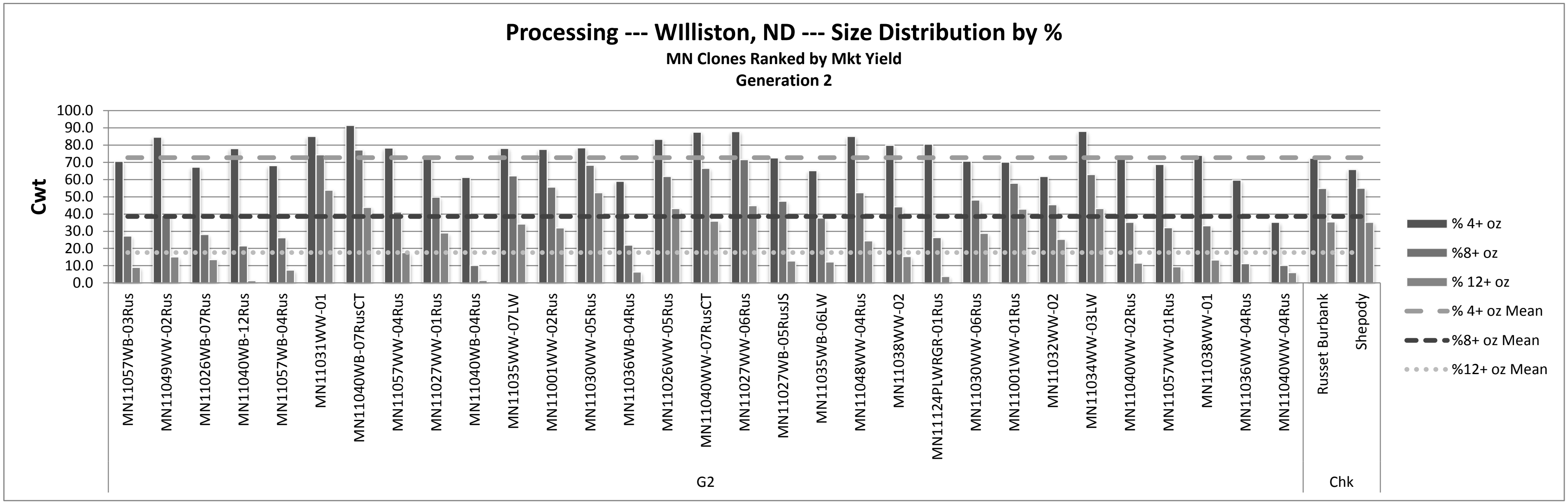


Table 8 (cont'd.)



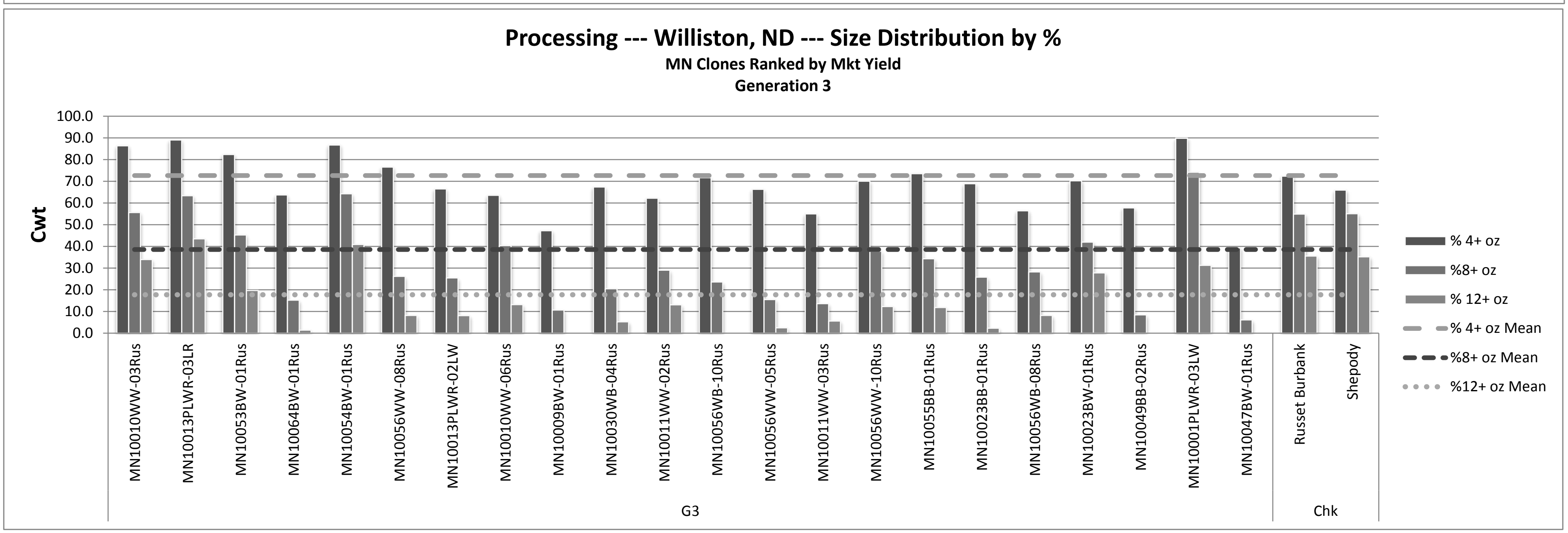
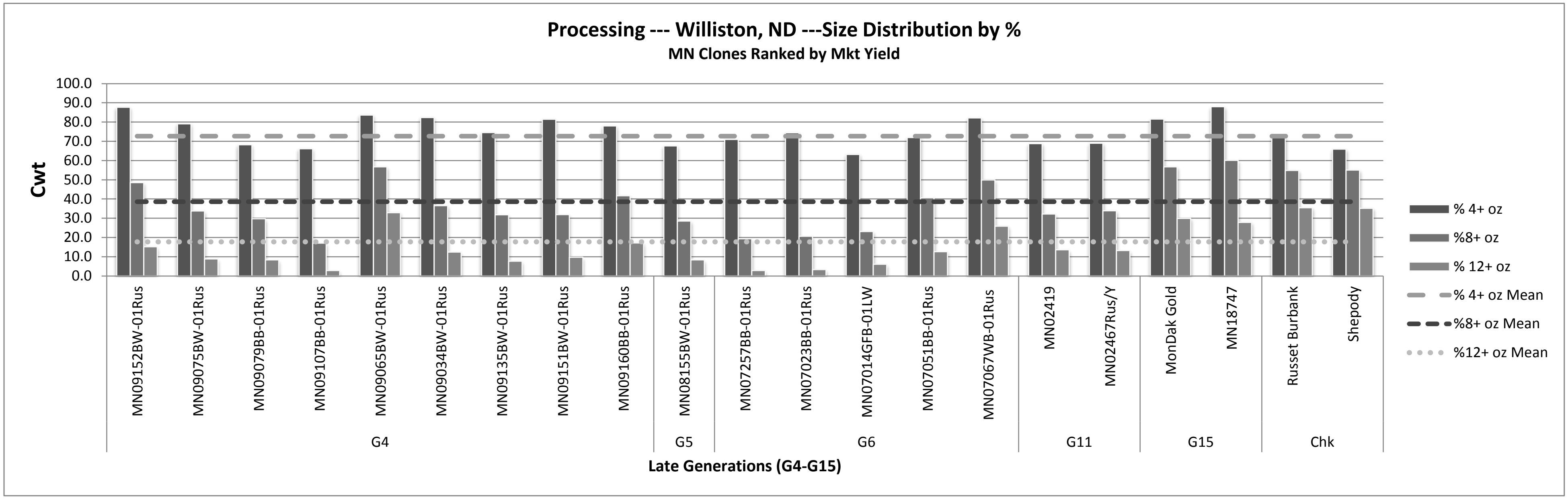


Table 8 (cont'd)



			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
1	**Russet Burbank**	**BL**	**Chk**	FF	Rus	C	0	0	8	13	13	0	0	8	0	1	1.071
2		**W**					0	0	0	0	20	0	10	0	0	1	1.087
3																	
4	**Shepody**	**BE**	**Chk**	FF	LW	W	6	6	0	0	56	0	0	0	0		1.062
5		**BL**					0	0	4	0	13	0	8	0	4	0	1.076
6		**W**					0	0	0	5	10	0	0	5	5	0	1.083
7																	
8	MN02419	BL	G11	FF	LW	C	0	0	0	0	0	0	8	0	8	1	1.077
9		W					0	0	0	0	0	0	0	0	10	0	1.097
10																	
11	MN02467Rus/Y	BE	G11	FF/FM	Rus	Y	0	0	0	0	50	0	0	0	0		1.070
12		BL					0	0	0	0	0	0	0	0	0	1	1.070
13		W					0	0	0	0	18	0	0	0	0	1	1.083
14																	
15	MN07014GFB-01LW	BL	G6	FF	LW	C	0	0	0	0	0	0	23	0	0	1	1.075
16		W					0	0	0	40	0	0	5	0	45	0	1.087
17																	
18	MN07023BB-01Rus	BL	G6	FF	Rus	C	0	0	8	25	0	0	0	0	25	0	1.062
19		W					0	0	5	10	0	0	0	5	20	0	1.080
20																	
21	MN07051BB-01Rus	BL	G6	FF	Rus	C	0	0	8	8	0	0	17	0	0	0	1.070
22		W					0	0	0	0	0	0	0	0	0	0	1.085
23																	
24	MN07067WB-01Rus	BL	G6	FF	Rus It	C	0	0	0	25	0	0	50	0	25	0	1.075
25		W					0	0	10	25	0	0	10	0	30	1	1.083
26																	
27	MN07257BB-01Rus	BL	G6	FF	Rus	W	0	0	0	0	0	0	0	0	0	1	1.085
28		W					0	0	5	0	5	0	15	0	5	0	1.093
29																	
30	MN08155BW-01Rus	BL	G5	FF	Rus	C	0	0	0	0	0	0	50	0	0	0	1.066
31		W					0	0	0	15	5	0	10	0	15	0	1.084
32																	
33	MN09034BW-01Rus	BL	G4	FF	Rus	C	0	0	0	0	0	0	7	0	8	0	1.062
34		W					0	0	0	10	0	0	0	0	20	0	1.080
35																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
36	MN09065BW-01Rus	BL	G4	FF	Rus	C	0	0	0	0	8	0	8	0	0	0	1.072
37		W					0	0	0	5	45	0	0	0	10	0	1.076
38																	
39	MN09075BW-01Rus	BL	G4	FF	Rus	C	0	0	0	8	0	0	8	0	17	1	1.068
40		W					0	0	0	0	0	0	10	0	10	1	1.084
41																	
42	MN09079BB-01Rus	BL	G4	FF	Rus	W	0	0	0	8	17	0	17	0	8	0	1.073
43		W					0	0	0	10	70	0	0	0	10	1	1.083
44																	
45	MN09107BB-01Rus	BL	G4	FF	Rus	C	0	0	0	0	0	0	8	0	0	0	1.063
46		W					0	0	0	5	0	0	0	0	0	0	1.081
47																	
48	MN09135BW-01Rus	BL	G4	FF	Rus	W	0	0	0	8	0	0	50	0	8	0	1.085
49		W					0	0	0	20	0	0	30	0	15	0	1.089
50																	
51	MN09151BW-01Rus	BL	G4	FF	Rus	C	0	0	0	0	0	0	17	0	0	0	1.089
52		W					0	0	0	5	5	0	0	0	5	0	1.100
53																	
54	MN09152BW-01Rus	BL	G4	FF	Rus	W	0	0	0	0	0	0	0	0	0	0	1.079
55		W					0	0	0	0	30	0	0	0	0	1	1.081
56																	
57	MN09160BB-01Rus	BL	G4	FF	Rus	W	0	0	0	0	0	0	0	0	0	1	1.066
58		W					0	0	0	10	0	0	0	0	10	0	1.079
59																	
60	MN10001PLWR-03LW	BL	G3	FF/FM	LW	W	0	0	8	17	0	0	0	0	25	0	1.061
61		W					0	0	0	20	25	0	8	0	38	1	1.074
62																	
63	MN10009BW-01Rus	BL	G3	FF	Rus	C	0	0	0	0	0	0	0	0	0	0	1.065
64		W					0	0	5	5	0	0	0	0	0	0	1.086
65																	
66	MN10010WW-03Rus	BL	G3	FF	Rus	C	0	0	0	0	8	0	0	0	8	0	1.077
67		W					0	0	0	5	0	0	0	0	15	0	1.077
68																	
69	MN10010WW-06Rus	BL	G3	FF	Rus	C	0	8	0	17	8	0	8	0	0	0	1.070
70		W					0	0	5	0	0	0	5	0	10	0	1.081
71																	

Sort 4	Clone	Loc	2013 Trial	Mkt	Color Skin	Flesh	External Defects Knobs	GC	Grn	Bruise	Internal Defects HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
72	MN10011WW-02Rus	BL	G3	FF	Rus	W	0	0	0	0	17	0	0	0	0	0	1.078
73		W					0	0	5	25	40	0	0	0	25	1	1.069
74																	
75	MN10011WW-03Rus	BL	G3	FF	Rus	W	0	0	0	0	0	0	33	0	0		1.076
76		W					0	0	0	0	0	0	5	0	10	1	1.090
77																	
78	MN10013PLWR-02LW	BE	G3	FF/FM	LW	Y	0	0	6	0	7	0	0	0	0		1.061
79		BL					0	0	0	0	17	0	8	0	0	1	1.069
80		W					0	0	0	10	20	0	0	0	10	0	1.080
81																	
82	MN10013PLWR03LR	BE	G3	FF/FM	LR	C	0	6	0	0	6	0	0	0	0	0 &1	1.058
83		BL					0	8	0	0	0	0	0	0	0	0	1.068
84		W					0	0	0	5	5	0	10	0	15	0	1.075
85																	
86	MN10023BB-01Rus	BL	G3	FF	Rus	C	0	0	8	0	0	0	0	0	0	1	1.079
87		W					0	0	0	0	0	0	0	0	10	1	1.089
88																	
89	MN10023BW-01Rus	BL	G3	FF	Rus	C	0	0	0	0	0	0	8	0	0	1	1.075
90		W					0	0	0	0	0	0	0	0	5	1	1.089
91																	
92	MN10030WB-04Rus	BL	G3	FF	Rus	C	0	0	0	0	0	0	0	0	0	0	1.076
93		W					0	0	5	0	5	0	0	0	0	0	3.071
94																	
95	MN10047BW-01Rus	BL	G3	FF	Rus	W	0	0	0	0	0	0	7	0	0	0	1.076
96		W					0	0	0	0	0	0	0	0	0	0	1.095
97																	
98	MN10049BB-02Rus	BL	G3	FF	Rus	C	0	0	0	8	0	0	8	0	8	0	1.069
99		W					0	0	0	10	0	0	0	0	10	0	1.088
100																	
101	MN10053BW-01Rus	BL	G3	FF	Rus	C	0	0	0	0	25	0	8	0	0	0	1.066
102		W					0	0	0	5	10	0	0	0	0	0	1.080
103																	
104	MN10054BW-01Rus	BL	G3	FF	Rus	C	0	0	8	8	0	0	17	0	17	0	1.064
105		W					0	0	0	0	0	0	13	0	0	0	1.073
106																	
107	MN10055BB-01Rus	BL	G3	FF	Rus	C	0	0	0	17	42	0	0	0	17	0	1.075
108		W					0	0	0	0	45	0	33	0	8	0	1.074

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
109																	
110	MN10056WB-08Rus	BL	G3	FF	Rus	C	0	0	8	8	8	0	17	0	17	1	1.073
111		W					0	0	0	0	8	0	0	0	18	0	1.090
112																	
113	MN10056WB-10Rus	BL	G3	FF	Rus	C	0	0	0	0	0	0	17	0	0	0	1.078
114		W					0	0	0	5	5	0	5	0	0	0	1.089
115																	
116	MN10056WW-05Rus	BL	G3	FF	Rus	C	0	0	0	8	0	0	25	0	8	0	1.077
117		W					0	0	0	0	5	0	5	0	5	1	1.088
118																	
119	MN10056WW-08Rus	BL	G3	FF	Rus	W	0	0	0	0	7	0	14	0	14	0	1.079
120		W					0	0	5	0	5	0	0	0	5	1	1.094
121																	
122	MN10056WW-10Rus	BL	G3	FF	Rus	C	0	0	7	8	0	0	17	0	8	0	1.071
123		W					0	0	5	5	25	0	10	0	5	0	1.083
124																	
125	MN10064BW-01Rus	BL	G3	FF	LW	C	0	0	0	0	0	0	17	0	0	1	1.080
126		W					0	0	0	5	0	0	5	0	5	0	1.091
127																	
128	MN11001WW-01Rus	BL	G2	FF	Rus	C	0	33	0	0	17	0	33	0	0	0	1.041
129		W					0	0	0	0	20	0	0	0	0	1	1.085
130																	
131	MN11001WW-02Rus	BL	G2	FF	Rus	W	0	0	0	0	14	0	0	0	0	0	1.080
132		W					0	0	0	0	40	0	20	0	0	0	1.092
133																	
134	MN11026WB-07Rus	BL	G2	FF	Rus	W	0	0	0	0	0	0	0	0	14	0	1.068
135		W					0	0	0	0	0	0	0	0	0	0	1.078
136																	
137	MN11026WW-05Rus	BL	G2	FF	Rus	C	0	0	17	0	0	0	67	0	0	0	1.060
138		W					0	0	0	0	50	0	0	0	0	0	1.079
139																	
140	MN11027WB-05RusJS	BL	G2	FF	Rus	C	0	0	0	0	0	0	17	0	0	0	1.067
141		W					0	0	0	0	0	0	0	0	30	0	1.078
142																	
143	MN11027WW-01Rus	BL	G2	FF	Rus	W	0	0	14	0	0	0	0	0	0	0	1.071
144		W					0	0	0	0	0	0	0	0	0	0	1.073
145																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
146	MN11027WW-06Rus	BL	G2	FF	Rus	W	0	0	0	17	0	0	0	0	17	0	1.073
147		W					0	0	20	0	0	0	0	0	0	0	1.082
148																	
149	MN11030WW-05Rus	BL	G2	FF	Rus	W	0	0	0	0	17	0	33	0	0	0	1.070
150		W					0	0	0	0	30	0	20	0	0	0	1.088
151																	
152	MN11030WW-06Rus	BL	G2	FF	Rus	W	0	0	0	17	0	0	17	0	17	0	1.070
153		W					0	0	0	0	30	0	0	0	0	1	1.075
154																	
155	MN11031WW-01	BL	G2	FF	Rus	C	0	0	17	0	0	0	17	0	0	0	1.069
156		W					0	0	10	0	10	0	0	0	10	0	1.081
157																	
158	MN11032WW-02	BL	G2	FF	Rus	Y	0	0	0	0	0	0	0	0	0	1	1.066
159		W					0	0	0	0	40	0	0	0	0	2	1.075
160																	
161	MN11034WW-03LW	BL	G2	FF	White	Y	0	0	0	17	0	0	17	0	17		1.065
162		W					0	0	0	0	20	0	0	0	0	4	1.071
163																	
164	MN11035WB-06LW	BL	G2	FF	LW	C	0	0	0	0	0	0	0	0	0	1	1.071
165		W					0	0	0	0	20	0	20	0	10	1	1.089
166																	
167	MN11035WW-07LW	BL	G2	FF	Rus	W	0	0	0	17	0	0	0	0	0	0	1.079
168		W					0	0	0	0	0	0	0	0	0	0	1.094
169																	
170	MN11036WB-04Rus	BL	G2	FF	Rus	W	0	0	0	0	17	0	17	0	0	0	1.077
171		W					0	0	0	0	20	0	0	0	0	0	1.078
172																	
173	MN11036WW-04Rus	BL	G2	FF	Rus	W	0	0	0	0	17	0	17	0	0		1.066
174		W					0	0	0	0	50	0	0	0	0	0	1.073
175																	
176	MN11038WW-01	BL	G2	FF	White	C	0	0	0	0	17	0	0	0	0		1.068
177		W					0	0	0	0	10	0	0	0	20	4	1.097
178																	
179	MN11038WW-02	BL	G2	FF	White	C	0	0	0	14	14	0	0	0	14	0	1.074
180		W					0	0	0	0	0	0	0	0	0	4	1.083
181																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
182	MN11040WB-04Rus	BL	G2	FF	Rus	C	0	0	17	0	0	0	0	33	0	0	1.073
183		W					0	0	0	0	10	0	0	10	0	0	1.083
184																	
185	MN11040WB-07RusCT	BL	G2	FF	Rus	C	0	0	0	0	0	0	0	0	0	0	1.077
186		W					0	0	0	0	20	0	10	0	0	0	1.098
187																	
188	MN11040WB-12Rus	BL	G2	FF	Rus	W	0	33	0	0	0	0	0	0	0	0	1.078
189		W					0	0	0	0	0	0	0	0	0	0	1.092
190																	
191	MN11040WW-02Rus	BL	G2	FF	Rus	W	0	0	0	0	0	0	0	0	0	0	1.067
192		W					0	0	0	0	0	0	0	0	0	1	1.077
193																	
194	MN11040WW-04Rus	BL	G2	FF	Rus	C	0	0	0	0	0	0	0	0	0	0	1.068
195		W					0	0	0	0	0	0	0	0	0	0	1.078
196																	
197	MN11040WW-07RusCT	BL	G2	FF	Rus	C	0	0	0	0	0	0	17	0	0	1	1.077
198		W					0	0	0	0	0	0	0	0	30	0	1.097
199																	
200	MN11048WW-04Rus	BL	G2	FF	Rus	W	0	0	0	0	0	0	0	0	17	1	1.082
201		W					0	0	0	0	10	0	0	0	20	0	1.091
202																	
203	MN11049WW-02Rus	BL	G2	FF	Rus	C	0	0	0	0	0	0	0	0	0		1.068
204		W					0	0	0	10	0	0	0	0	0	1	1.079
205																	
206	MN11057WB-03Rus	BL	G2	FF	Rus	W	0	0	0	0	0	0	0	0	0	1	1.066
207		W					0	0	0	0	0	0	0	0	0	1	1.080
208																	
209	MN11057WB-04Rus	BL	G2	FF	Rus	C	0	0	0	17	0	0	0	0	17	1	1.061
210		W					0	0	0	0	0	0	0	0	0	1	1.081
211																	
212	MN11057WW-01Rus	BL	G2	FF	Rus	C	0	0	0	17	17	0	0	0	17		1.067
213		W					0	0	0	0	10	0	0	0	0	0	1.078
214																	
215	MN11057WW-04Rus	BL	G2	FF	Rus	C	0	0	0	0	0	0	0	0	0		1.063
216		W					0	0	0	0	0	0	0	0	0	0	1.077
217																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	FF[3]	SPGR
							%				%						
218	MN11124PLWRGR-01Rus	W	G2	FF	Rus	C	0	0	0	0	0	0	0	0	0	0	1.081
219																	
220	MN18747	BE	G15	FF/FM	LW	W	0	6	0	0	6	0	6	0	0		1.060
221		BL					0	0	0	0	0	0	8	0	0	0	1.069
222		W					0	0	0	0	0	0	10	5	0	0	1.081
223																	
224	MonDak Gold	BE	G15	FF/FM	Red	Y	0	0	0	0	0	0	0	0	0		1.055
225		BL					0	0	0	0	0	0	8	0	0	1	1.077
226		W					0	0	5	0	0	0	25	0	0	0	1.087
227																	
228	W6234-4rus	BL	NCR	FF	Rus	W	0	0	0	15	0	0	8	0	7	0	1.076
229		BL					0	0	4	0	8	0	0	0	0	1	1.065

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	< 4 oz		4+ oz	4+ oz	8+ oz	8+ oz	12+ oz	12+ oz	A size (> 4 oz)	
Sort 4	**Clone**	**Loc**	**Trial**	**Mkt**	**Skin**	**#/plant**	**Cwtyld**	**cwtyld**	**%**	**Cwtyld**	**Cwtyld**	**%**	**Cwtyld**	**%**	**Cwtyld**	**%**	**Cwtyld**	**%**	**Cwtyld**	**%**
1	**Russet Burbank**	BL	**Chk**	FF	Rus	9.5	437.0	166.4	27.6	603.4	73.3	12.2	363.7	60.3	223.6	37.1	120.3	19.9	363.7	60.3
2		W				7.9	461.9	133.4	22.4	595.3	31.1	5.2	430.9	72.4	326.6	54.9	211.5	35.5	430.9	72.4
3																				
4	**Shepody**	BE	**Chk**	FF	LW	7.8	350.8	0.3	0.1	351.1	80.2	22.9	270.6	77.1	96.1	27.4	28.4	8.1	270.6	77.1
5		BL				6.6	237.0	375.4	61.3	612.3	28.3	4.6	208.7	34.1	125.3	20.5	66.8	10.9	208.7	34.1
6		W				4.7	297.1	123.8	29.4	420.9	19.7	4.7	277.4	65.9	231.7	55.0	148.2	35.2	277.4	65.9
7																				
8	MN02419	BL	G11	FF	LW	11.7	397.3	180.5	31.2	577.8	107.7	18.6	289.6	50.1	104.3	18.1	41.6	7.2	289.6	50.1
9		W				8.9	361.3	37.3	9.4	398.7	87.0	21.8	274.4	68.8	128.3	32.2	54.2	13.6	274.4	68.8
10																				
11	MN02467Rus/Y	BE	G11	FF/FM	Rus	7.8	330.1	1.9	0.6	332.1	88.9	26.8	241.2	72.6	104.1	31.3	40.6	12.2	241.2	72.6
12		BL				8.2	380.2	35.0	8.4	415.2	60.3	14.5	319.9	77.0	168.0	40.5	58.6	14.1	319.9	77.0
13		W				4.6	194.1	34.5	15.1	228.5	36.4	15.9	157.7	69.0	77.6	33.9	30.2	13.2	157.7	69.0
14																				
15	MN07014GFB-01LW	BL	G6	FF	LW	11.1	407.2	31.2	7.1	438.3	133.1	30.4	274.0	62.5	116.1	26.5	54.2	12.4	274.0	62.5
16		W				8.4	299.1	27.7	8.5	326.7	92.5	28.3	206.6	63.2	75.6	23.1	20.1	6.1	206.6	63.2
17																				
18	MN07023BB-01Rus	BL	G6	FF	Rus	11.9	489.9	27.7	5.4	517.6	118.8	22.9	371.2	71.7	156.7	30.3	58.0	11.2	371.2	71.7
19		W				9.7	392.1	9.7	2.4	401.8	93.0	23.1	299.1	74.5	83.0	20.7	13.4	3.3	299.1	74.5
20																				
21	MN07051BB-01Rus	BL	G6	FF	Rus	8.1	426.9	74.9	14.9	501.7	61.5	12.3	365.3	72.8	234.3	46.7	100.8	20.1	365.3	72.8
22		W				5.2	235.6	36.1	13.3	271.7	40.0	14.7	195.6	72.0	110.3	40.6	34.4	12.6	195.6	72.0
23																				
24	MN07067WB-01Rus	BL	G6	FF	Rus lt	7.2	333.3	33.1	9.0	366.4	72.7	19.8	260.6	71.1	140.5	38.4	71.1	19.4	260.6	71.1
25		W				4.2	216.4	2.8	1.3	219.2	36.3	16.6	180.1	82.1	109.4	49.9	56.7	25.9	180.1	82.1
26																				
27	MN07257BB-01Rus	BL	G6	FF	Rus	14.4	692.7	18.4	2.6	711.1	131.4	18.5	561.2	78.9	255.4	35.9	59.6	8.4	561.2	78.9
28		W				10.8	417.9	18.0	4.1	435.9	108.6	24.9	309.3	71.0	84.3	19.3	12.5	2.9	309.3	71.0
29																				
30	MN08155BW-01Rus	BL	G5	FF	Rus	11.9	480.7	9.7	2.0	490.4	139.5	28.4	341.2	69.6	130.1	26.5	49.1	10.0	341.2	69.6
31		W				8.6	320.1	19.0	5.6	339.1	90.6	26.7	229.5	67.7	97.0	28.6	28.3	8.3	229.5	67.7
32																				
33	MN09034BW-01Rus	BL	G4	FF	Rus	8.4	344.1	31.5	8.4	375.6	72.9	19.4	271.1	72.2	112.5	30.0	48.9	13.0	271.1	72.2
34		W				6.0	300.6	8.9	2.9	309.5	45.6	14.7	255.0	82.4	113.2	36.6	38.4	12.4	255.0	82.4
35																				
36	MN09065BW-01Rus	BL	G4	FF	Rus	15.1	598.2	37.2	5.9	635.4	169.3	26.6	428.9	67.5	130.4	20.5	26.6	4.2	428.9	67.5
37		W				6.4	361.9	13.4	3.6	375.3	47.8	12.7	314.2	83.7	212.9	56.7	123.7	33.0	314.2	83.7
38																				
39	MN09075BW-01Rus	BL	G4	FF	Rus	10.2	612.6	30.0	4.7	642.6	72.5	11.3	540.1	84.1	355.0	55.3	180.3	28.1	540.1	84.1
40		W				10.3	469.7	2.9	0.6	472.6	95.9	20.3	373.9	79.1	159.8	33.8	41.9	8.9	373.9	79.1
41																				

Sort 4	Clone	Loc	2013 Trial	Mkt	Color Skin	Tubers #/plant	Mkt Yld Cwtyld	Culls cwtyld	Culls %	Total Yld Cwtyld	< 4 oz Cwtyld	< 4 oz %	4+ oz Cwtyld	4+ oz %	8+ oz Cwtyld	8+ oz %	12+ oz Cwtyld	12+ oz %	A size (> 4 oz) Cwtyld	A size (> 4 oz) %
42	MN09079BB-01Rus	BL	G4	FF	Rus	16.6	739.3	10.9	1.5	750.2	158.6	21.1	580.7	77.4	213.9	28.5	30.9	4.1	580.7	77.4
43		W				10.2	410.5	37.8	8.4	448.3	104.8	23.4	305.8	68.2	133.4	29.7	37.5	8.4	305.8	68.2
44																				
45	MN09107BB-01Rus	BL	G4	FF	Rus	12.4	520.9	10.4	2.0	531.3	149.8	28.2	371.1	69.9	161.0	30.3	45.6	8.6	371.1	69.9
46		W				11.3	402.9	5.7	1.4	408.6	132.5	32.4	270.4	66.2	69.8	17.1	11.6	2.8	270.4	66.2
47																				
48	MN09135BW-01Rus	BL	G4	FF	Rus	10.1	451.0	10.5	2.3	461.5	116.8	25.3	334.2	72.4	187.1	40.6	86.1	18.7	334.2	72.4
49		W				7.3	296.5	14.3	4.6	310.7	64.8	20.8	231.7	74.6	99.0	31.9	24.0	7.7	231.7	74.6
50																				
51	MN09151BW-01Rus	BL	G4	FF	Rus	8.8	380.7	14.5	3.7	395.2	83.8	21.2	296.9	75.1	120.6	30.5	34.5	8.7	296.9	75.1
52		W				6.1	285.0	7.7	2.6	292.7	46.4	15.9	238.6	81.5	93.4	31.9	28.5	9.8	238.6	81.5
53																				
54	MN09152BW-01Rus	BL	G4	FF	Rus	13.1	594.4	17.1	2.8	611.5	124.6	20.4	469.8	76.8	242.1	39.6	116.2	19.0	469.8	76.8
55		W				10.6	579.3	4.1	0.7	583.3	67.8	11.6	511.4	87.7	283.1	48.5	88.7	15.2	511.4	87.7
56																				
57	MN09160BB-01Rus	BL	G4	FF	Rus	7.3	333.9	12.2	3.5	346.1	71.1	20.6	262.8	75.9	115.7	33.4	23.8	6.9	262.8	75.9
58		W				4.6	222.4	14.3	6.0	236.7	37.8	16.0	184.6	78.0	98.8	41.8	40.8	17.2	184.6	78.0
59																				
60	MN10001PLWR-03LW	BL	G3	FF/FM	LW	6.0	241.9	151.0	38.4	392.9	41.3	10.5	200.6	51.0	136.9	34.8	63.4	16.1	200.6	51.0
61		W				2.4	163.3	10.5	6.0	173.8	7.2	4.2	156.1	89.8	128.9	74.2	54.3	31.3	156.1	89.8
62																				
63	MN10009BW-01Rus	BL	G3	FF	Rus	14.4	517.8	20.9	3.9	538.7	168.6	31.3	349.2	64.8	138.1	25.6	48.7	9.0	349.2	64.8
64		W				10.0	283.8	1.3	0.4	285.0	149.1	52.3	134.7	47.2	30.5	10.7	0.0	0.0	134.7	47.2
65																				
66	MN10010WW-03Rus	BL	G3	FF	Rus	7.0	225.9	40.3	15.1	266.2	86.4	32.5	139.5	52.4	51.1	19.2	19.9	7.5	139.5	52.4
67		W				8.5	483.9	1.7	0.3	485.6	64.4	13.3	419.4	86.4	270.0	55.6	164.9	34.0	419.4	86.4
68																				
69	MN10010WW-06Rus	BL	G3	FF	Rus	8.2	437.3	45.3	9.4	482.6	64.0	13.3	373.2	77.3	229.0	47.5	125.1	25.9	373.2	77.3
70		W				6.5	286.7	109.2	27.6	395.8	35.1	8.9	251.5	63.5	159.9	40.4	52.2	13.2	251.5	63.5
71																				
72	MN10011WW-02Rus	BL	G3	FF	Rus	8.4	265.6	21.5	7.5	287.1	115.3	40.2	150.3	52.3	70.0	24.4	24.4	8.5	150.3	52.3
73		W				7.8	261.9	14.0	5.1	275.9	90.2	32.7	171.7	62.2	80.1	29.0	36.1	13.1	171.7	62.2
74																				
75	MN10011WW-03Rus	BL	G3	FF	Rus	11.6	357.9	5.2	1.4	363.1	166.1	45.8	191.7	52.8	63.2	17.4	21.1	5.8	191.7	52.8
76		W				8.5	252.2	12.0	4.5	264.2	107.0	40.5	145.2	55.0	36.0	13.6	14.7	5.6	145.2	55.0
77																				
78	MN10013PLWR-02LW	BE	G3	FF/FM	LW	9.9	254.9	7.8	3.0	262.8	171.5	65.3	83.4	31.7	4.0	1.5	0.0	0.0	83.4	31.7
79		BL				9.5	237.8	42.1	15.0	279.9	133.4	47.6	104.4	37.3	4.1	1.5	0.0	0.0	104.4	37.3
80		W				7.7	290.2	52.5	15.3	342.7	62.5	18.2	227.8	66.5	87.2	25.4	27.8	8.1	227.8	66.5
81																				
82	MN10013PLWR-03LR	BE	G3	FF/FM	LR	5.6	315.0	15.3	4.6	330.3	36.2	11.0	278.9	84.4	146.5	44.3	67.7	20.5	278.9	84.4
83		BL				7.0	443.1	85.0	16.1	528.1	29.7	5.6	413.3	78.3	291.8	55.3	165.0	31.2	413.3	78.3
84		W				5.5	393.9	20.5	5.0	414.4	25.0	6.0	368.9	89.0	262.7	63.4	180.1	43.5	368.9	89.0

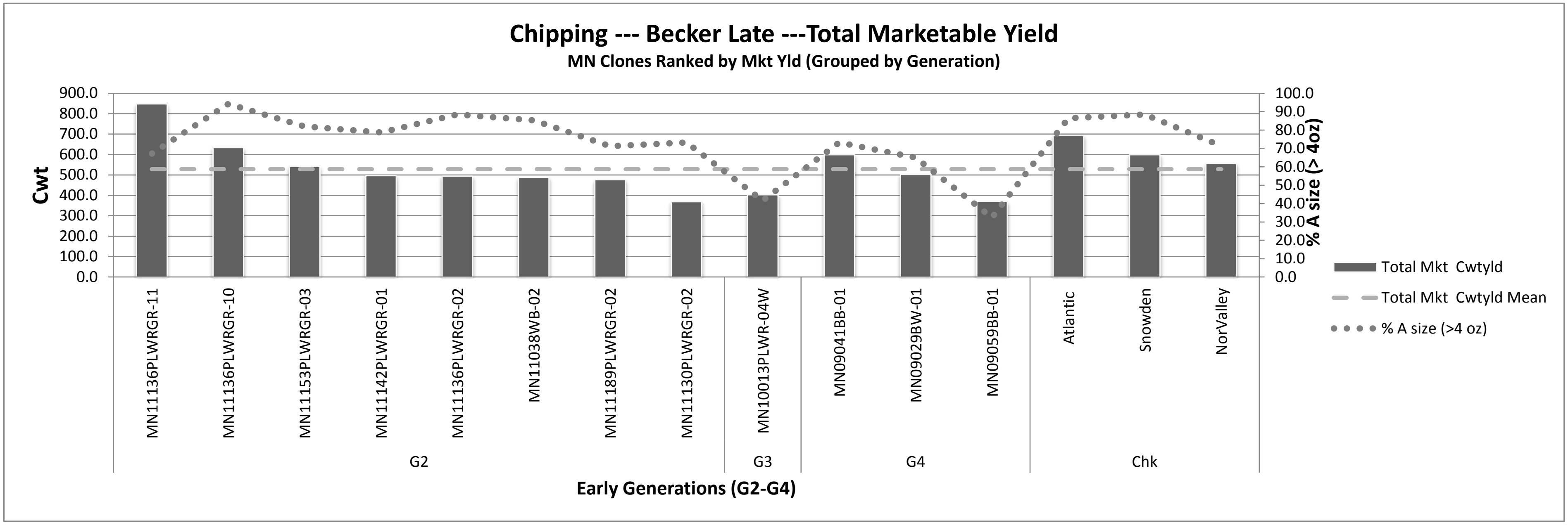
			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	< 4 oz		4+ oz	4+ oz	8+ oz	8+ oz	12+ oz	12+ oz	A size (> 4 oz)	
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	cwtyld	%	Cwtyld	Cwtyld	%	Cwtyld	%	Cwtyld	%	Cwtyld	%	Cwtyld	%
85																				
86	MN10023BB-01Rus	BL	G3	FF	Rus	7.1	342.6	21.3	5.8	363.9	63.8	17.5	278.9	76.6	141.2	38.8	49.1	13.5	278.9	76.6
87		W				5.9	217.5	13.6	5.9	231.2	58.2	25.2	159.4	68.9	59.7	25.8	5.2	2.3	159.4	68.9
88																				
89	MN10023BW-01Rus	BL	G3	FF	Rus	7.3	346.3	92.7	21.1	439.1	50.6	11.5	295.7	67.4	183.8	41.9	90.8	20.7	295.7	67.4
90		W				4.8	211.8	37.3	15.0	249.1	36.9	14.8	174.9	70.2	104.5	42.0	69.2	27.8	174.9	70.2
91																				
92	MN10030WB-04Rus	BL	G3	FF	Rus	10.4	430.4	15.3	3.4	445.7	121.8	27.3	308.5	69.2	122.6	27.5	46.7	10.5	308.5	69.2
93		W				7.5	264.9	27.6	9.5	292.5	67.9	23.2	197.0	67.3	59.9	20.5	15.2	5.2	197.0	67.3
94																				
95	MN10047BW-01Rus	BL	G3	FF	Rus	5.4	154.4	0.8	0.5	155.2	85.9	55.3	68.5	44.2	25.1	16.2	6.2	4.0	68.5	44.2
96		W				5.7	134.6	0.0	0.0	134.6	81.6	60.7	52.9	39.3	8.2	6.1	0.0	0.0	52.9	39.3
97																				
98	MN10049BB-02Rus	BL	G3	FF	Rus	5.5	200.8	48.7	19.5	249.5	52.6	21.1	148.2	59.4	52.8	21.1	18.6	7.5	148.2	59.4
99		W				5.8	180.8	6.8	3.6	187.6	72.6	38.7	108.3	57.7	15.9	8.5	0.0	0.0	108.3	57.7
100																				
101	MN10053BW-01Rus	BL	G3	FF	Rus	9.8	535.4	79.6	12.9	615.0	71.8	11.7	463.5	75.4	314.0	51.1	132.1	21.5	463.5	75.4
102		W				7.8	388.4	16.0	4.0	404.4	55.5	13.7	332.9	82.3	183.2	45.3	79.5	19.7	332.9	82.3
103																				
104	MN10054BW-01Rus	BL	G3	FF	Rus	8.2	519.7	51.7	9.1	571.4	48.8	8.5	470.8	82.4	364.0	63.7	263.4	46.1	470.8	82.4
105		W				4.9	313.7	14.1	4.3	327.7	29.4	9.0	284.3	86.7	210.7	64.3	133.9	40.9	284.3	86.7
106																				
107	MN10055BB-01Rus	BL	G3	FF	Rus	9.4	339.6	9.6	2.7	349.2	111.9	32.0	227.7	65.2	56.1	16.1	6.6	1.9	227.7	65.2
108		W				5.6	220.7	7.7	3.4	228.3	52.7	23.1	168.0	73.6	78.3	34.3	27.1	11.9	168.0	73.6
109																				
110	MN10056WB-08Rus	BL	G3	FF	Rus	11.3	456.1	21.6	4.5	477.7	136.9	28.7	319.2	66.8	123.6	25.9	42.1	8.8	319.2	66.8
111		W				6.5	213.7	55.5	20.6	269.2	61.9	23.0	151.8	56.4	75.9	28.2	22.0	8.2	151.8	56.4
112																				
113	MN10056WB-10Rus	BL	G3	FF	Rus	11.3	522.4	20.5	3.8	542.9	84.6	15.6	437.8	80.6	237.5	43.7	81.3	15.0	437.8	80.6
114		W				6.7	257.9	11.7	4.3	269.5	64.6	24.0	193.2	71.7	63.6	23.6	0.0	0.0	193.2	71.7
115																				
116	MN10056WW-05Rus	BL	G3	FF	Rus	9.4	418.7	10.8	2.5	429.5	96.0	22.3	322.7	75.1	147.4	34.3	40.9	9.5	322.7	75.1
117		W				7.2	252.7	0.0	0.0	252.7	85.1	33.7	167.5	66.3	39.2	15.5	6.4	2.5	167.5	66.3
118																				
119	MN10056WW-08Rus	BL	G3	FF	Rus	11.3	446.8	10.6	2.3	457.4	136.5	29.8	310.3	67.8	124.0	27.1	27.2	5.9	310.3	67.8
120		W				7.1	298.8	7.5	2.4	306.2	64.2	21.0	234.6	76.6	80.2	26.2	25.1	8.2	234.6	76.6
121																				
122	MN10056WW-10Rus	BL	G3	FF	Rus	9.2	460.7	41.4	8.2	502.1	68.5	13.6	392.1	78.1	220.4	43.9	111.5	22.2	392.1	78.1
123		W				6.0	250.6	26.7	9.6	277.3	56.4	20.3	194.2	70.0	104.7	37.7	34.0	12.3	194.2	70.0
124																				
125	MN10064BW-01Rus	BL	G3	FF	LW	14.1	511.8	42.7	7.7	554.6	176.9	31.9	334.9	60.4	108.7	19.6	34.8	6.3	334.9	60.4
126		W				10.6	363.4	13.7	3.6	377.1	123.2	32.7	240.1	63.7	57.5	15.2	5.4	1.4	240.1	63.7
127																				

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	< 4 oz		4+ oz	4+ oz	8+ oz	8+ oz	12+ oz	12+ oz	A size (> 4 oz)	
Sort 4	**Clone**	**Loc**	**Trial**	**Mkt**	**Skin**	**#/plant**	**Cwtyld**	**cwtyld**	**%**	**Cwtyld**	**Cwtyld**	**%**	**Cwtyld**	**%**	**Cwtyld**	**%**	**Cwtyld**	**%**	**Cwtyld**	**%**
128	MN11001WW-01Rus	BL	G2	FF	Rus	4.9	330.5	5.3	1.6	335.9	27.6	8.2	302.9	90.2	223.5	66.5	143.1	42.6	302.9	90.2
129		W				4.8	279.5	98.2	26.0	377.8	14.4	3.8	265.1	70.2	218.9	57.9	161.8	42.8	265.1	70.2
130																				
131	MN11001WW-02Rus	BL	G2	FF	Rus	7.5	417.5	17.9	4.1	435.4	50.2	11.5	367.3	84.4	211.5	48.6	95.3	21.9	367.3	84.4
132		W				7.0	371.2	54.5	12.8	425.6	41.1	9.7	330.0	77.5	236.9	55.7	136.2	32.0	330.0	77.5
133																				
134	MN11026WB-07Rus	BL	G2	FF	Rus	17.0	610.0	60.0	9.0	670.0	183.8	27.4	426.2	63.6	151.8	22.7	37.2	5.6	426.2	63.6
135		W				10.8	424.2	57.3	11.9	481.5	100.4	20.8	323.8	67.3	135.8	28.2	65.4	13.6	323.8	67.3
136																				
137	MN11026WW-05Rus	BL	G2	FF	Rus	4.8	119.8	85.2	41.6	204.9	38.4	18.7	81.4	39.7	27.6	13.5	18.2	8.9	81.4	39.7
138		W				5.9	340.5	26.9	7.3	367.3	34.1	9.3	306.4	83.4	227.1	61.8	158.7	43.2	306.4	83.4
139																				
140	MN11027WB-05RusJS	BL	G2	FF	Rus	8.3	497.8	28.0	5.3	525.7	52.3	10.0	445.5	84.7	259.2	49.3	130.9	24.9	445.5	84.7
141		W				7.2	314.7	32.2	9.3	346.8	62.9	18.1	251.8	72.6	164.8	47.5	44.4	12.8	251.8	72.6
142																				
143	MN11027WW-01Rus	BL	G2	FF	Rus	11.0	557.1	78.3	12.3	635.4	94.2	14.8	462.9	72.8	264.2	41.6	126.2	19.9	462.9	72.8
144		W				7.2	401.9	79.6	16.5	481.4	51.6	10.7	350.3	72.8	240.2	49.9	139.8	29.0	350.3	72.8
145																				
146	MN11027WW-06Rus	BL	G2	FF	Rus	7.2	537.7	0.0	0.0	537.7	38.8	7.2	498.9	92.8	407.9	75.9	258.2	48.0	498.9	92.8
147		W				4.4	315.3	17.4	5.2	332.6	23.0	6.9	292.3	87.9	238.3	71.6	149.3	44.9	292.3	87.9
148																				
149	MN11030WW-05Rus	BL	G2	FF	Rus	4.5	261.3	97.7	27.2	359.0	18.9	5.3	242.4	67.5	191.8	53.4	98.7	27.5	242.4	67.5
150		W				5.4	361.4	67.2	15.7	428.5	25.3	5.9	336.0	78.4	293.1	68.4	224.9	52.5	336.0	78.4
151																				
152	MN11030WW-06Rus	BL	G2	FF	Rus	8.2	415.3	108.3	20.7	523.6	54.8	10.5	360.6	68.9	220.9	42.2	123.4	23.6	360.6	68.9
153		W				5.0	281.0	90.5	24.4	371.5	18.3	4.9	262.7	70.7	179.0	48.2	107.1	28.8	262.7	70.7
154																				
155	MN11031WW-01	BL	G2	FF	Rus	6.4	499.3	63.5	11.3	562.8	19.9	3.5	479.4	85.2	378.2	67.2	216.7	38.5	479.4	85.2
156		W				5.0	411.8	41.9	9.2	453.8	25.8	5.7	386.0	85.1	337.8	74.4	244.7	53.9	386.0	85.1
157																				
158	MN11032WW-02	BL	G2	FF	Rus	5.1	239.6	55.9	18.9	295.5	40.9	13.8	198.7	67.3	110.4	37.4	53.1	18.0	198.7	67.3
159		W				4.9	275.6	144.1	34.3	419.6	16.2	3.9	259.3	61.8	191.0	45.5	106.4	25.4	259.3	61.8
160																				
161	MN11034WW-03LW	BL	G2	FF	White	5.7	358.1	82.8	18.8	440.9	19.5	4.4	338.6	76.8	242.8	55.1	94.3	21.4	338.6	76.8
162		W				4.1	261.8	11.9	4.3	273.7	20.9	7.6	240.9	88.0	172.3	63.0	118.4	43.3	240.9	88.0
163																				
164	MN11035WB-06LW	BL	G2	FF	LW	12.6	715.5	48.0	6.3	763.5	105.1	13.8	610.3	79.9	379.1	49.7	208.9	27.4	610.3	79.9
165		W				7.4	313.7	71.7	18.6	385.4	62.6	16.2	251.1	65.2	145.2	37.7	47.0	12.2	251.1	65.2
166																				
167	MN11035WW-07LW	BL	G2	FF	Rus	8.6	339.6	346.1	50.5	685.6	42.4	6.2	297.2	43.3	173.9	25.4	36.3	5.3	297.2	43.3
168		W				5.8	395.6	87.0	18.0	482.6	18.5	3.8	377.1	78.1	300.1	62.2	165.4	34.3	377.1	78.1
169																				

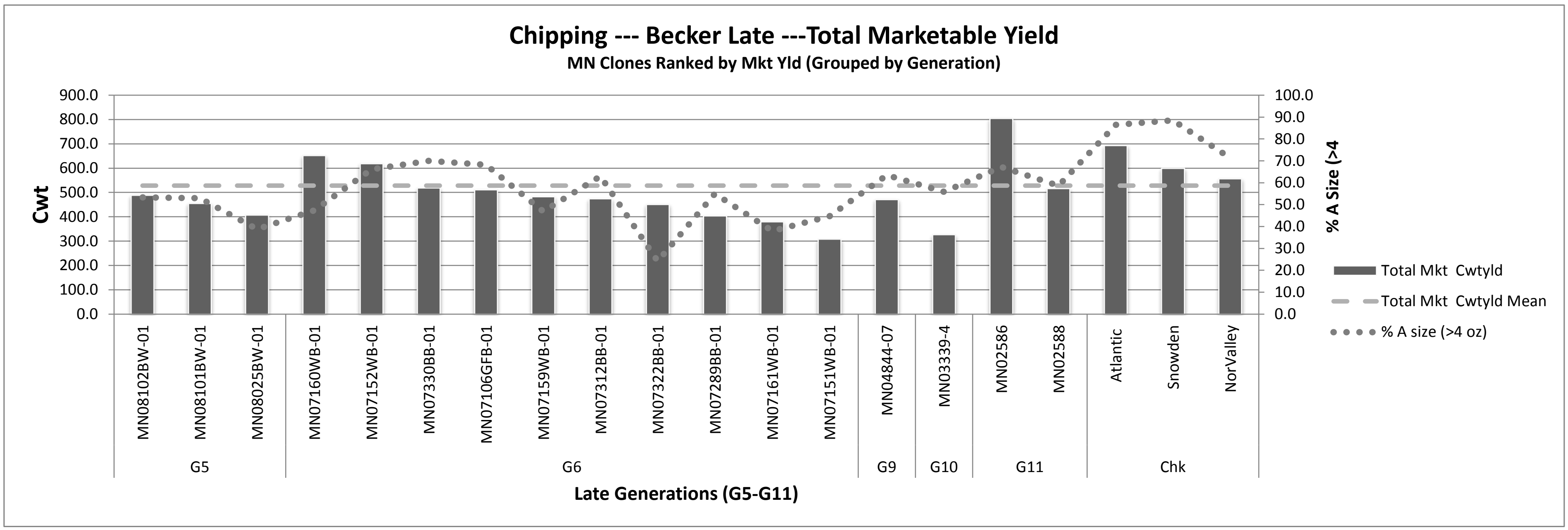
			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	< 4 oz		4+ oz	4+ oz	8+ oz	8+ oz	12+ oz	12+ oz	A size (> 4 oz)	
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	cwtyld	%	Cwtyld	Cwtyld	%	Cwtyld	%	Cwtyld	%	Cwtyld	%	Cwtyld	%
170	MN11036WB-04Rus	BL	G2	FF	Rus	13.8	599.3	104.5	14.8	703.8	115.2	16.4	484.1	68.8	198.4	28.2	83.1	11.8	484.1	68.8
171		W				9.8	341.4	0.0	0.0	341.4	139.8	41.0	201.5	59.0	75.1	22.0	22.0	6.5	201.5	59.0
172																				
173	MN11036WW-04Rus	BL	G2	FF	Rus	9.3	463.9	60.9	11.6	524.8	62.3	11.9	401.7	76.5	224.6	42.8	97.4	18.6	401.7	76.5
174		W				6.8	228.5	39.8	14.8	268.2	68.4	25.5	160.1	59.7	30.0	11.2	0.0	0.0	160.1	59.7
175																				
176	MN11038WW-01	BL	G2	FF	White	12.2	539.3	15.2	2.7	554.5	114.7	20.7	424.7	76.6	210.4	37.9	45.2	8.2	424.7	76.6
177		W				5.6	233.0	7.3	3.0	240.2	55.0	22.9	177.9	74.1	79.7	33.2	32.2	13.4	177.9	74.1
178																				
179	MN11038WW-02	BL	G2	FF	White	6.5	427.3	6.0	1.4	433.3	34.7	8.0	392.6	90.6	260.5	60.1	139.0	32.1	392.6	90.6
180		W				5.7	285.3	20.6	6.7	305.9	40.9	13.4	244.4	79.9	135.4	44.3	47.0	15.4	244.4	79.9
181																				
182	MN11040WB-04Rus	BL	G2	FF	Rus	16.5	576.9	15.2	2.6	592.1	199.2	33.6	377.7	63.8	103.6	17.5	25.6	4.3	377.7	63.8
183		W				12.9	395.8	0.0	0.0	395.8	153.1	38.7	242.7	61.3	40.5	10.2	6.0	1.5	242.7	61.3
184																				
185	MN11040WB-07RusCT	BL	G2	FF	Rus	6.5	414.0	46.4	10.1	460.5	37.9	8.2	376.1	81.7	261.5	56.8	151.7	33.0	376.1	81.7
186		W				5.0	404.6	22.4	5.2	427.0	13.9	3.3	390.7	91.5	329.8	77.2	187.7	44.0	390.7	91.5
187																				
188	MN11040WB-12Rus	BL	G2	FF	Rus	13.1	498.1	92.4	15.6	590.5	123.9	21.0	374.1	63.4	104.9	17.8	18.9	3.2	374.1	63.4
189		W				10.0	419.9	20.0	4.5	439.9	76.8	17.5	343.2	78.0	95.0	21.6	5.8	1.3	343.2	78.0
190																				
191	MN11040WW-02Rus	BL	G2	FF	Rus	6.7	292.1	168.8	36.6	460.9	45.3	9.8	246.8	53.5	159.5	34.6	73.0	15.8	246.8	53.5
192		W				5.8	257.4	21.8	7.8	279.2	54.8	19.6	202.6	72.6	98.5	35.3	32.4	11.6	202.6	72.6
193																				
194	MN11040WW-04Rus	BL	G2	FF	Rus	9.3	298.4	0.0	0.0	298.4	133.0	44.6	165.4	55.4	38.7	13.0	5.7	1.9	165.4	55.4
195		W				7.4	181.2	0.0	0.0	181.2	117.3	64.7	63.9	35.3	18.6	10.2	11.1	6.1	63.9	35.3
196																				
197	MN11040WW-07RusCT	BL	G2	FF	Rus	4.6	282.9	0.0	0.0	282.9	35.6	12.6	247.3	87.4	172.8	61.1	81.0	28.6	247.3	87.4
198		W				4.9	339.9	26.5	7.2	366.4	18.9	5.2	321.0	87.6	243.9	66.6	131.6	35.9	321.0	87.6
199																				
200	MN11048WW-04Rus	BL	G2	FF	Rus	8.7	499.5	10.6	2.1	510.1	51.5	10.1	448.1	87.8	243.0	47.6	82.3	16.1	448.1	87.8
201		W				5.2	293.6	22.3	7.1	316.0	24.8	7.9	268.8	85.1	165.5	52.4	77.3	24.4	268.8	85.1
202																				
203	MN11049WW-02Rus	BL	G2	FF	Rus	11.2	589.4	33.6	5.4	623.0	80.1	12.9	509.3	81.7	246.7	39.6	104.5	16.8	509.3	81.7
204		W				9.2	492.1	15.4	3.0	507.5	62.3	12.3	429.8	84.7	199.1	39.2	77.2	15.2	429.8	84.7
205																				
206	MN11057WB-03Rus	BL	G2	FF	Rus	11.0	494.4	7.8	1.6	502.2	107.0	21.3	387.4	77.1	167.3	33.3	88.9	17.7	387.4	77.1
207		W				18.4	717.5	20.6	2.8	738.2	196.3	26.6	521.2	70.6	201.6	27.3	67.3	9.1	521.2	70.6
208																				
209	MN11057WB-04Rus	BL	G2	FF	Rus	11.5	522.8	15.7	2.9	538.5	115.3	21.4	407.5	75.7	195.8	36.4	79.9	14.8	407.5	75.7
210		W				10.9	412.4	7.2	1.7	419.6	126.7	30.2	285.7	68.1	110.1	26.2	31.5	7.5	285.7	68.1
211																				

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	< 4 oz		4+ oz	4+ oz	8+ oz	8+ oz	12+ oz	12+ oz	A size (> 4 oz)	
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	cwtyld	%	Cwtyld	Cwtyld	%	Cwtyld	%	Cwtyld	%	Cwtyld	%	Cwtyld	%
212	MN11057WW-01Rus	BL	G2	FF	Rus	6.9	456.7	55.7	10.9	512.4	35.5	6.9	421.2	82.2	306.6	59.8	201.1	39.3	421.2	82.2
213		W				6.2	250.5	53.1	17.5	303.5	41.7	13.7	208.8	68.8	97.4	32.1	28.8	9.5	208.8	68.8
214																				
215	MN11057WW-04Rus	BL	G2	FF	Rus	9.3	619.6	13.9	2.2	633.5	57.4	9.1	562.2	88.7	391.4	61.8	260.2	41.1	562.2	88.7
216		W				8.5	403.1	22.9	5.4	425.9	69.5	16.3	333.6	78.3	175.6	41.2	75.0	17.6	333.6	78.3
217																				
218	MN11124PLWRGR-01Rus	W	G2	FF	Rus	6.5	283.2	0.0	0.0	283.2	55.1	19.4	228.2	80.6	74.7	26.4	11.0	3.9	228.2	80.6
219																				
220	MN18747	BE	G15	FF/FM	LW	9.7	458.6	2.1	0.4	460.7	98.3	21.3	360.3	78.2	143.3	31.1	52.1	11.3	360.3	78.2
221		BL				10.8	650.0	38.6	5.6	688.6	58.5	8.5	591.4	85.9	386.2	56.1	159.6	23.2	591.4	85.9
222		W				6.7	408.9	16.8	4.0	425.8	34.0	8.0	374.9	88.1	255.9	60.1	118.5	27.8	374.9	88.1
223																				
224	MonDak Gold	BE	G15	FF/FM	Red	11.0	304.3	6.9	2.2	311.2	181.2	58.2	123.1	39.6	11.9	3.8	0.0	0.0	123.1	39.6
225		BL				12.5	415.2	61.9	13.0	477.0	151.8	31.8	263.4	55.2	78.6	16.5	25.6	5.4	263.4	55.2
226		W				8.1	461.6	37.0	7.4	498.6	55.0	11.0	406.6	81.5	282.9	56.7	149.5	30.0	406.6	81.5
227																				
228	W6234-4rus	BL	NCR	FF	Rus	9.1	568.2	31.5	5.3	599.7	54.6	9.1	513.6	85.6	354.2	59.1	186.5	31.1	513.6	85.6
229		BL				9.2	635.8	39.5	5.8	675.3	45.8	6.8	590.1	87.4	456.7	67.6	291.1	43.1	590.1	87.4

Table 11

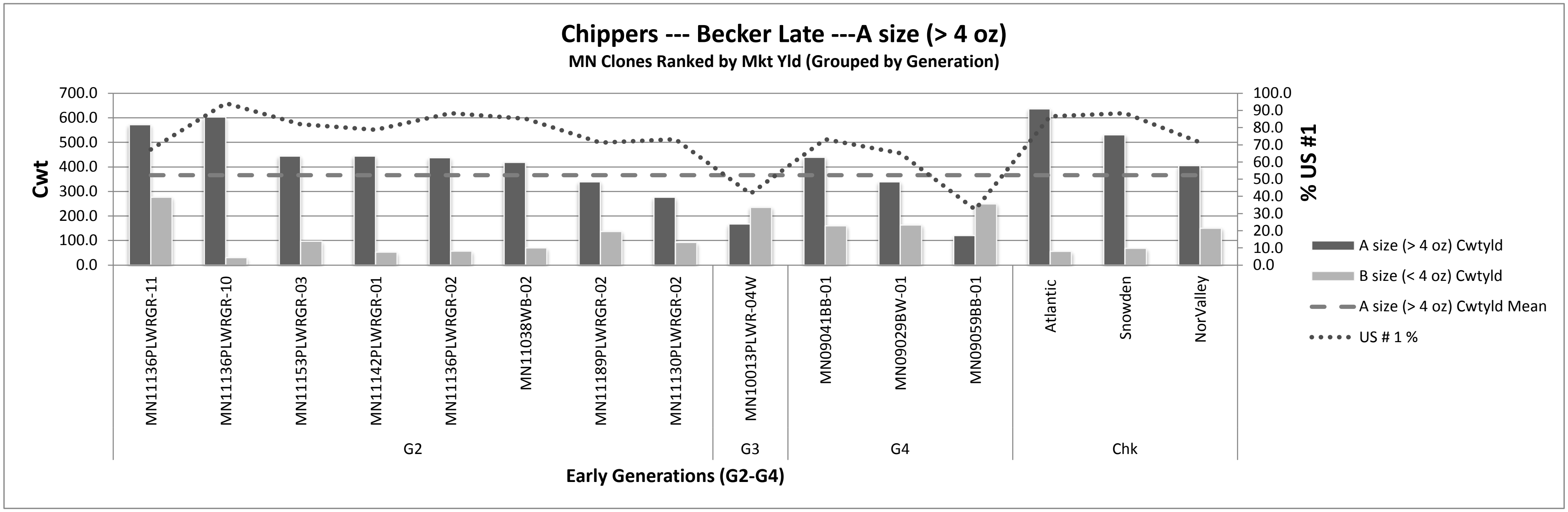


Chipping --- Becker Late ---Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Cwt
% A size (> 4oz)
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
MN11136PLWRGR-11
MN11136PLWRGR-10
MN11153PLWRGR-03
MN11142PLWRGR-01
MN11136PLWRGR-02
MN11038WB-02
MN11189PLWRGR-02
MN11130PLWRGR-02
MN10013PLWR-04W
MN09041BB-01
MN09029BW-01
MN09059BB-01
Atlantic
Snowden
NorValley
G2
G3
G4
Chk
Early Generations (G2-G4)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
% A size (>4 oz)



Chipping --- Becker Late ---Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Cwt
% A Size (>4
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
MN08102BW-01
MN08101BW-01
MN08025BW-01
MN07160WB-01
MN07152WB-01
MN07330BB-01
MN07106GFB-01
MN07159WB-01
MN07312BB-01
MN07322BB-01
MN07289BB-01
MN07161WB-01
MN07151WB-01
MN04844-07
MN03339-4
MN02586
MN02588
Atlantic
Snowden
NorValley
G5
G6
G9
G10
G11
Chk
Late Generations (G5-G11)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
% A size (>4 oz)

Table 11 (cont'd)



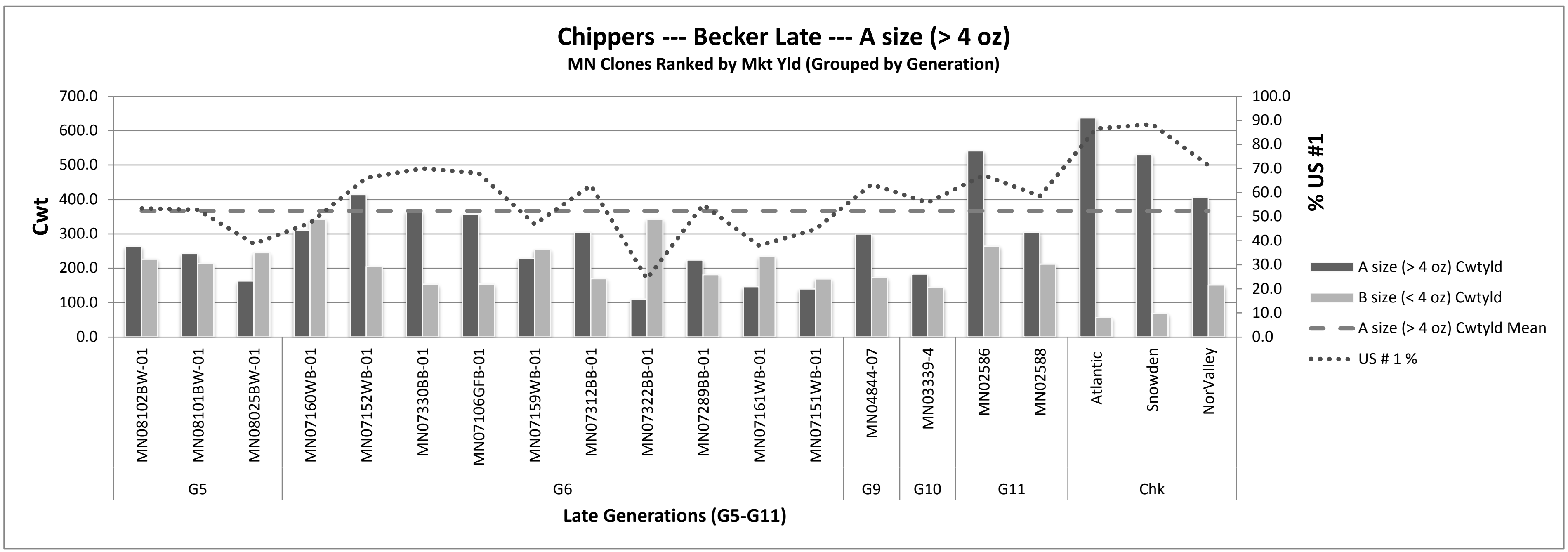
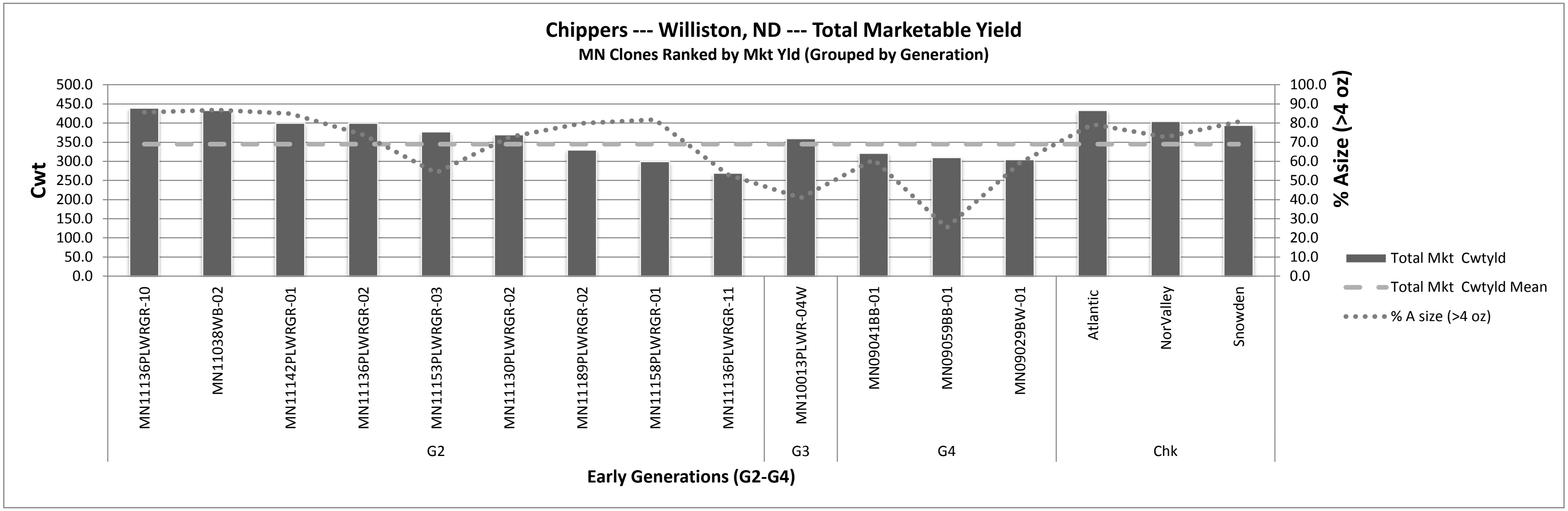
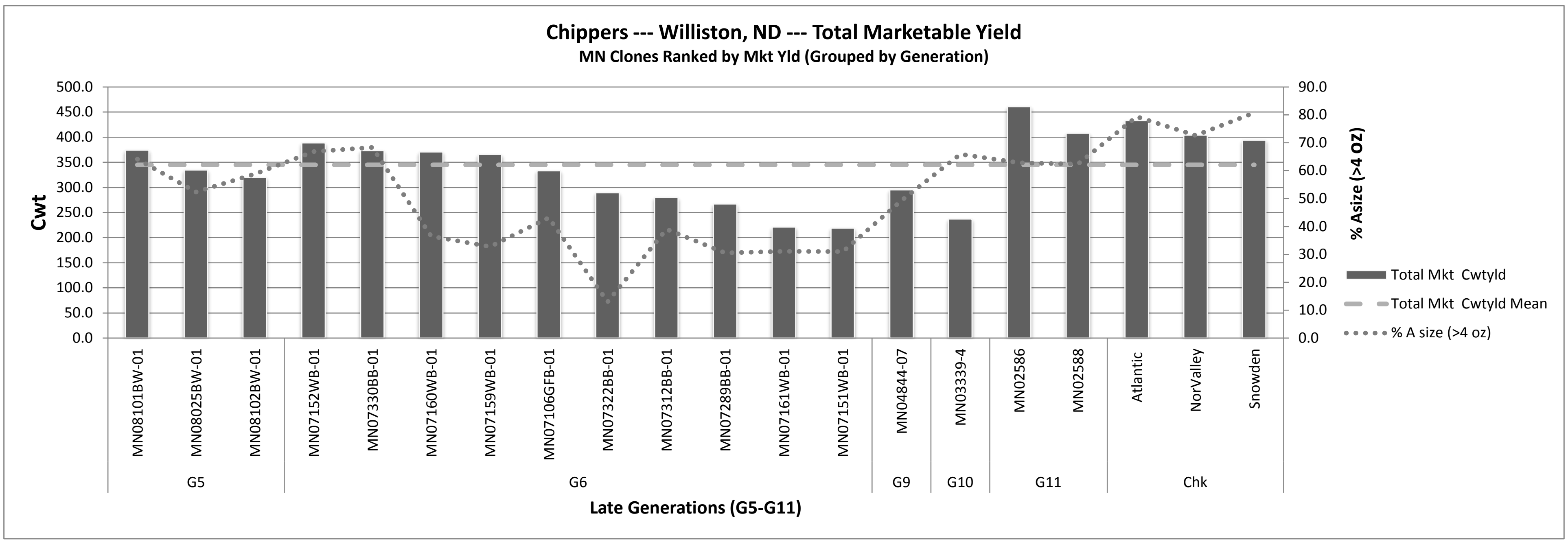


Table 12

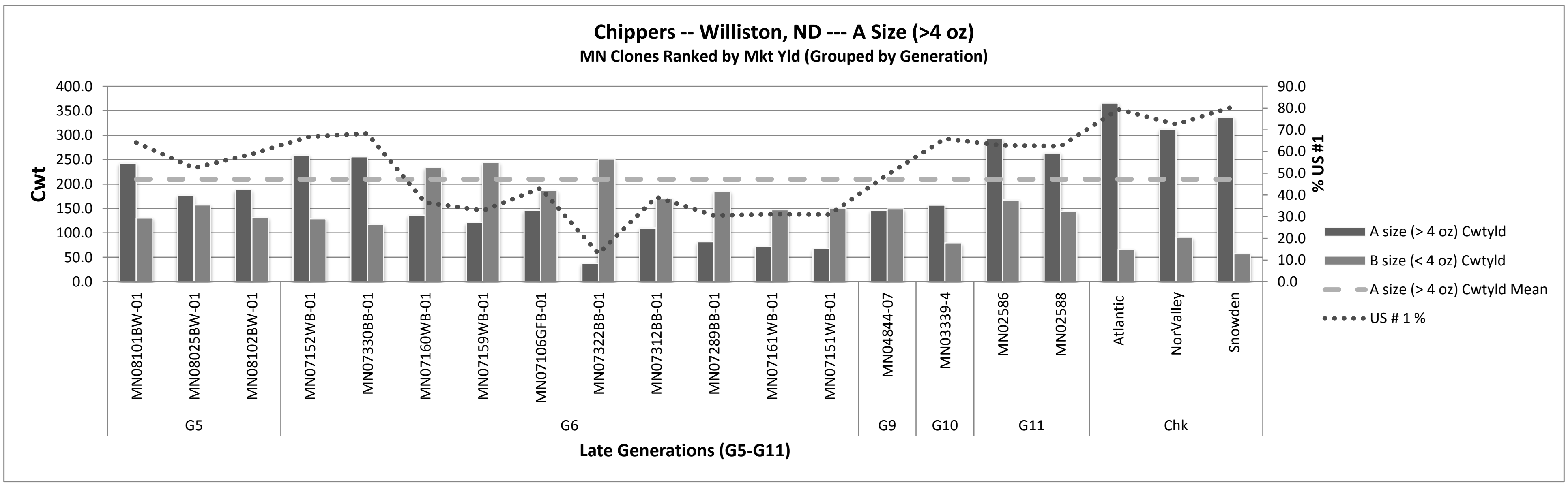


Chippers --- Williston, ND --- Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Cwt
% Asize (>4 oz)
MN11136PLWRGR-10
MN11038WB-02
MN11142PLWRGR-01
MN11136PLWRGR-02
MN11153PLWRGR-03
MN11130PLWRGR-02
MN11189PLWRGR-02
MN11158PLWRGR-01
MN11136PLWRGR-11
MN10013PLWR-04W
MN09041BB-01
MN09059BB-01
MN09029BW-01
Atlantic
NorValley
Snowden
G2
G3
G4
Chk
Early Generations (G2-G4)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
% A size (>4 oz)



Chippers --- Williston, ND --- Total Marketable Yield
MN Clones Ranked by Mkt Yld (Grouped by Generation)
Cwt
% Asize (>4 oz)
MN08101BW-01
MN08025BW-01
MN08102BW-01
MN07152WB-01
MN07330BB-01
MN07160WB-01
MN07159WB-01
MN07106GFB-01
MN07322BB-01
MN07312BB-01
MN07289BB-01
MN07161WB-01
MN07151WB-01
MN04844-07
MN03339-4
MN02586
MN02588
Atlantic
NorValley
Snowden
G5
G6
G9
G10
G11
Chk
Late Generations (G5-G11)
Total Mkt Cwtyld
Total Mkt Cwtyld Mean
% A size (>4 oz)

Table 12 (cont'd)



			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip[3]	SPGR
							%				%						
1	**Atlantic**	**BL**	**Chk**	**C**	**W**		0	0	4	13	50	4	0	8	8	3	1.082
2		**W**					0	0	0	0	5	0	0	0	0	2	1.104
3																	
4	**NorValley**	**BL**	**Chk**	**C**	**W**	**W**	0	0	4	11	4	0	0	4	11	3	1.077
5		**W**					0	0	5	0	15	0	0	0	0	1.5	1.081
6																	
7	**Snowden**	**BL**	**Chk**	**C**	**W**	**C**	0	0	0	0	17	0	4	0	4	1.5	1.083
8		**W**					0	0	5	0	5	0	0	0	0	1.5	1.096
9																	
10	CV02321-1	BL	NCR	C	W	C	0	0	0	0	8	0	0	17	0	1.5	1.075
11		BL					0	4	4	13	17	0	0	4	8	2.5	1.081
12																	
13	MN02586	BE	G11	FM/C	W	Y	0	0	0	0	6	0	0	0	0		1.072
14		BL					0	0	0	8	0	0	0	0	0	2.5	1.084
15		W					0	0	0	0	0	0	15	0	0	2.5	1.092
16																	
17	MN02588	BL	G11	C	W	W	0	0	0	0	17	0	50	0	0	3	1.083
18		W					0	5	5	5	5	0	0	0	5	1	1.088
19																	
20	MN03339-4	BL	G10	C	W	W	0	0	0	17	0	0	0	8	17	1.5	1.078
21		W					0	0	10	5	25	0	10	0	5	1.5	1.094
22																	
23	MN0484407	BE	G9	FM/C	W	Y	0	0	0	0	44	0	0	0	0		1.071
24		BL					0	0	0	0	32	0	38	0	0	2	1.081
25		W					0	0	0	0	10	0	10	0	0	1.5	1.095
26																	
27	MN07106GFB-01	BL	G6	C	W	C	0	0	0	0	8	0	25	0	0	1.5	1.073
28		W					0	0	0	0	0	0	0	0	0	1	1.086
29																	
30	MN07151WB-01	BL	G6	C	W	W	0	0	0	0	0	0	0	0	0	1	1.085
31		W					0	0	0	0	5	0	0	5	0	1.5	1.096
32																	
33	MN07152WB-01	BL	G6	C	W	C	0	0	0	0	8	0	0	0	0	2.5	1.085
34		W					0	0	0	5	0	0	0	0	5	1	1.088
35																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip[3]	SPGR
36	MN07159WB-01	BL	G6	C	W	C	0	0	0	0	0	0	8	0	8	1	1.079
37		W					0	0	0	5	0	0	0	0	0	1	1.091
38																	
39	MN07160WB-01	BL	G6	C	W	W	0	0	0	8	0	0	0	0	8	1.5	1.085
40		W					0	0	0	0	0	0	0	0	0	1.5	1.092
41																	
42	MN07161WB-01	BL	G6	C	W	C	0	0	0	0	17	0	17	8	0	1	1.082
43		W					0	0	0	0	5	0	0	0	5	1.5	1.089
44																	
45	MN07289BB-01	BL	G6	C	W	C	0	0	0	8	0	0	0	0	8	1.5	1.088
46		W					0	0	0	5	5	0	0	0	5	1	1.103
47																	
48	MN07312BB-01	BL	G6	C	W	C	0	0	0	0	0	0	0	0	0	1.5	1.073
49		W					0	0	0	0	0	0	0	0	0	1	1.088
50																	
51	MN07322BB-01	BL	G6	C	W	W	0	0	8	0	0	0	8	0	0	1	1.087
52		W					0	0	5	0	0	0	0	0	0	1	1.099
53																	
54	MN07330BB-01	BL	G6	C	W/Red splash	W	0	0	0	0	17	0	0	0	0	1	1.076
55		W					0	0	0	0	0	0	0	0	0	1.5	1.090
56																	
57	MN08025BW-01	BL	G5	C	W	C	0	0	0	8	50	0	0	0	17	2.5	1.073
58		W					0	0	5	10	20	0	0	0	5	1	1.087
59																	
60	MN08101BW-01	BL	G5	C	W	W	0	0	0	0	33	0	0	0	0	2	1.083
61		W					0	0	5	0	20	0	0	0	0	1.5	1.093
62																	
63	MN08102BW-01	BL	G5	C	W	C	0	0	8	17	83	0	0	0	0	2	1.069
64		W					0	0	5	5	0	0	5	0	5	1.5	1.101
65																	
66	MN09029BW-01	BL	G4	C	W	C	0	0	0	8	17	0	33	0	8	2.5	1.083
67		W					0	0	0	10	0	0	0	0	10	1.5	1.095
68																	
69	MN09041BB-01	BL	G4	C	W	W	0	0	0	0	8	0	0	0	0	3.5	1.081
70		W					0	0	0	5	0	0	0	0	5	2.5	1.092
71																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip[3]	SPGR
72	MN09059BB-01	BL	G4	C	W	W	0	0	0	0	0	0	0	0	17	1	1.083
73		W					0	0	0	0	0	0	0	0	0	1	1.088
74																	
75	MN10013PLWR-04W	BL	NCR/G3	C	W	C	0	0	0	0	27	0	13	0	11	3	1.080
76		W					0	0	0	0	20	0	0	0	15	2.5	1.086
77																	
78	MN11038WB-02	BL	G2	C	W	W	0	0	0	0	17	0	0	0	0	4.5	1.077
79		W					0	0	0	0	10	0	20	0	0	3.5	1.086
80																	
81	MN11130PLWRGR-02	BL	G2	C	W	Y	0	0	0	17	0	0	67	0	17	2.5	1.079
82		W					0	0	0	0	10	0	0	0	10	1.5	1.100
83																	
84	MN11136PLWRGR-02	BL	G2	C	W	C	0	0	0	0	29	0	0	29	14	2	1.073
85		W					0	0	0	0	40	0	0	0	10	2	1.077
86																	
87	MN11136PLWRGR-10	BL	G2	C	W	C	0	0	0	0	0	0	0	0	0	2.5	1.081
88		W					0	0	0	0	0	0	0	0	0	2	1.085
89																	
90	MN11136PLWRGR-11	BL	G2	C	W	C	0	0	17	0	17	0	0	0	0	2.5	1.078
91		W					0	0	10	0	0	0	10	0	10	2	1.086
92																	
93	MN11142PLWRGR-01	BL	G2	C	W	C	0	0	0	0	33	0	0	0	0	2	1.072
94		W					0	0	0	0	0	0	0	0	0	1.5	1.082
95																	
96	MN11153PLWRGR-03	BL	G2	C	W	C	0	0	0	17	17	0	0	17	17	3	1.072
97		W					0	0	0	0	0	0	0	0	10	2	1.085
98																	
99	MN11158PLWRGR-01	W	G2	C	W	W	0	10	0	10	0	0	0	0	0	1	1.084
100																	
101	MN11189PLWRGR-02	W	G2	C	W	C	0	0	10	0	0	0	10	0	0	2	1.072
102																	
103	MSJ126-9Y	BL	NCR	C	W	C	0	0	0	4	0	0	13	0	4	1	1.080
104																	
105	MSQ089-1	BL	NCR	C	W	C	0	0	0	0	7	0	4	0	0	2.5	1.070
106																	
107	MSS165-2Y	BL	NCR	C	W	C	0	0	0	0	9	0	0	4	9	2	1.083
108																	

			2013		Color		External Defects				Internal Defects						
Sort 4	Clone	Loc	Trial	Mkt	Skin	Flesh	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise	Chip[3]	SPGR
109	MSS576-05SPL	BL	NCR	C	W	W	0	0	0	4	4	0	4	4	4	3	1.076
110																	
111	ND7799c-1	BL	NCR	C	W	W	0	0	4	4	8	0	0	8	4	1	1.068
112																	
113	W5015-5	BL	NCR	C	W	C	0	0	0	4	33	0	21	25	4	2.5	1.086
114																	
115	W5955-1	BL	NCR	C	W	W	0	0	0	0	21	0	25	0	0	2	1.080

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	Size Distribution B size (< 4 oz)		Size Distribution A size (> 4 oz)		US #1
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	cwtyld	%	Cwtyld	Cwtyld	%	Cwtyld	%	%
1	**Atlantic**	BL	**Chk**	C	W	11.0	693.3	42.8	5.8	736.1	56.5	7.7	636.8	86.5	86.5
2		W				9.1	432.6	28.6	6.2	461.3	66.5	14.4	366.2	79.4	79.4
3															
4	**NorValley**	BL	**Chk**	C	W	13.4	556.3	12.2	2.1	568.5	150.7	26.5	405.6	71.4	71.4
5		W				9.5	403.9	26.7	6.2	430.6	91.3	21.2	312.6	72.6	72.6
6															
7	**Snowden**	BL	**Chk**	C	W	10.1	599.2	0.8	0.1	599.9	68.5	11.4	530.7	88.5	88.5
8		W				7.7	394.1	23.2	5.6	417.4	57.1	13.7	337.1	80.8	80.8
9															
10	MN03339-4	BL	G10	C	W	10.1	327.0	0.0	0.0	327.0	144.3	44.1	182.7	55.9	55.9
11		W				6.7	237.0	1.4	0.6	238.4	79.9	33.5	157.1	65.9	65.9
12															
13	MN02586	BE	G11	FM/C	W	14.5	329.0	0.5	0.1	329.4	240.6	73.0	88.3	26.8	26.8
14		BL				20.8	804.9	0.0	0.0	804.9	263.8	32.8	541.0	67.2	67.2
15		W				13.4	460.8	6.0	1.3	466.7	167.7	35.9	293.0	62.8	62.8
16															
17	MN02588	BL	G11	C	W	15.5	516.4	3.7	0.7	520.1	211.7	40.7	304.7	58.6	58.6
18		W				12.3	407.7	15.7	3.7	423.5	143.6	33.9	264.1	62.4	62.4
19															
20	MN11038WB-02	BL	G2	C	W	9.9	488.3	2.5	0.5	490.9	69.9	14.2	418.4	85.2	85.2
21		W				7.5	432.9	5.3	1.2	438.2	52.2	11.9	380.7	86.9	86.9
22															
23	MN11130PLWRGR-02	BL	G2	C	W	9.1	369.1	8.8	2.3	377.8	92.3	24.4	276.8	73.3	73.3
24		W				9.5	369.1	0.0	0.0	369.1	101.0	27.4	268.1	72.6	72.6
25															
26	MN11136PLWRGR-02	BL	G2	C	W	8.7	494.5	0.0	0.0	494.5	57.2	11.6	437.3	88.4	88.4
27		W				10.4	399.3	0.0	0.0	399.3	104.0	26.1	295.3	73.9	73.9
28															
29	MN11136PLWRGR-10	BL	G2	C	W	8.2	634.1	6.8	1.1	641.0	30.3	4.7	603.9	94.2	94.2
30		W				8.5	439.1	10.1	2.3	449.3	54.3	12.1	384.8	85.7	85.7
31															
32	MN11136PLWRGR-11	BL	G2	C	W	22.8	848.3	2.3	0.3	850.6	276.5	32.5	571.9	67.2	67.2
33		W				8.2	269.1	0.0	0.0	269.1	126.3	46.9	142.9	53.1	53.1
34															
35	MN11142PLWRGR-01	BL	G2	C	W	8.3	496.8	67.6	12.0	564.4	52.6	9.3	444.3	78.7	78.7
36		W				8.3	399.4	0.0	0.0	399.4	60.0	15.0	339.4	85.0	85.0
37															
38	MN11153PLWRGR-03	BL	G2	C	W	10.5	541.7	0.0	0.0	541.7	97.6	18.0	444.0	82.0	82.0
39		W				12.1	377.0	9.8	2.5	386.9	168.2	43.5	208.9	54.0	54.0

			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	Size Distribution B size (< 4 oz)		Size Distribution A size (> 4 oz)		US #1
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	cwtyld	%	Cwtyld	Cwtyld	%	Cwtyld	%	%
40	MN11158PLWRGR-01	W	G2	C	W	6.2	299.2	20.2	6.3	319.4	37.8	11.8	261.3	81.8	81.8
41															
42	MN11189PLWRGR-02	BL	G2	C	W	12.0	477.0	0.0	0.0	477.0	137.4	28.8	339.6	71.2	71.2
43		W				7.1	329.3	4.2	1.3	333.5	62.9	18.9	266.4	79.9	79.9
44															
45	MN09029BW-01	BL	G4	C	W	13.3	502.7	18.4	3.5	521.1	163.7	31.4	339.0	65.1	65.1
46		W				9.1	304.2	0.0	0.0	304.2	124.2	40.8	180.0	59.2	59.2
47															
48	MN09041BB-01	BL	G4	C	W	14.4	599.5	0.6	0.1	600.2	160.3	26.7	439.2	73.2	73.2
49		W				9.7	320.9	1.2	0.4	322.1	124.5	38.7	196.4	61.0	61.0
50															
51	MN09059BB-01	BL	G4	C	W	15.0	370.3	2.9	0.8	373.2	249.5	66.9	120.8	32.4	32.4
52		W				13.7	309.8	2.3	0.7	312.1	230.9	74.0	78.9	25.3	25.3
53															
54	MN08025BW-01	BL	G5	C	W	16.2	407.4	12.1	2.9	419.4	244.8	58.4	162.6	38.8	38.8
55		W				11.6	334.8	3.7	1.1	338.5	157.5	46.5	177.2	52.4	52.4
56															
57	MN08101BW-01	BL	G5	C	W	14.6	455.5	2.7	0.6	458.2	213.0	46.5	242.5	52.9	52.9
58		W				11.0	374.0	5.0	1.3	379.0	130.8	34.5	243.2	64.2	64.2
59															
60	MN08102BW-01	BL	G5	C	W	15.9	489.0	4.1	0.8	493.0	225.8	45.8	263.1	53.4	53.4
61		W				10.1	320.2	0.0	0.0	320.2	131.8	41.2	188.3	58.8	58.8
62															
63	MN07106GFB-01	BL	G6	C	W	13.0	511.5	13.0	2.5	524.5	154.0	29.4	357.5	68.2	68.2
64		W				12.9	333.1	6.5	1.9	339.5	186.7	55.0	146.3	43.1	43.1
65															
66	MN07151WB-01	BL	G6	C	W	10.7	308.4	4.5	1.4	312.8	168.5	53.9	139.9	44.7	44.7
67		W				9.0	219.0	0.5	0.2	219.5	151.0	68.8	68.0	31.0	31.0
68															
69	MN07152WB-01	BL	G6	C	W	16.4	618.5	6.8	1.1	625.3	204.6	32.7	413.9	66.2	66.2
70		W				10.6	388.5	0.0	0.0	388.5	128.9	33.2	259.6	66.8	66.8
71															
72	MN07159WB-01	BL	G6	C	W	17.3	482.7	4.5	0.9	487.2	254.3	52.2	228.5	46.9	46.9
73		W				16.0	365.5	3.7	1.0	369.2	244.4	66.2	121.1	32.8	32.8
74															
75	MN07160WB-01	BL	G6	C	W	22.8	651.9	4.5	0.7	656.4	341.1	52.0	310.7	47.3	47.3
76		W				15.6	370.7	4.4	1.2	375.1	233.9	62.4	136.8	36.5	36.5
77															
78	MN07161WB-01	BL	G6	C	W	15.2	379.8	5.0	1.3	384.9	233.6	60.7	146.2	38.0	38.0
79		W				9.3	220.8	14.3	6.1	235.2	147.8	62.8	73.1	31.1	31.1
80															

												Size Distribution			
			2013		Color	Tubers	Mkt Yld	Culls		Total Yld	B size (< 4 oz)		A size (> 4 oz)		US #1
Sort 4	Clone	Loc	Trial	Mkt	Skin	#/plant	Cwtyld	cwtyld	%	Cwtyld	Cwtyld	%	Cwtyld	%	%
81	MN07289BB-01	BL	G6	C	W	13.0	404.4	2.2	0.5	406.6	180.9	44.5	223.4	55.0	55.0
82		W				11.3	266.9	1.2	0.5	268.1	185.0	69.0	81.9	30.6	30.6
83															
84	MN07312BB-01	BL	G6	C	W	13.0	474.0	9.9	2.0	483.9	169.2	35.0	304.8	63.0	63.0
85		W				10.1	280.0	2.2	0.8	282.2	169.9	60.2	110.1	39.0	39.0
86															
87	MN07322BB-01	BL	G6	C	W	19.9	451.2	4.0	0.9	455.2	341.3	75.0	109.9	24.2	24.2
88		W				16.4	289.5	2.1	0.7	291.6	251.7	86.3	37.8	13.0	13.0
89															
90	MN07330BB-01	BL	G6	C	W/Red spl	13.1	519.1	3.7	0.7	522.8	153.3	29.3	365.8	70.0	70.0
91		W				10.4	373.3	1.5	0.4	374.9	117.3	31.3	256.1	68.3	68.3
92															
93	MN04844-07	BE	G9	FM/C	W	10.4	299.0	0.0	0.0	299.0	163.4	54.7	135.6	45.3	45.3
94		BL				13.2	471.4	0.0	0.0	471.4	172.3	36.6	299.0	63.4	63.4
95		W				10.2	295.2	1.6	0.5	296.8	149.0	50.2	146.2	49.3	49.3
96															
97	CV02321-1	BL	NCR	C	W	11.0	493.8	9.5	1.9	503.3	101.4	20.1	392.5	78.0	78.0
98															
99	CV98173-4	BL	NCR	C	W	14.8	777.7	22.4	2.8	800.1	117.2	14.7	660.5	82.6	82.6
100															
101	MSJ126-9Y	BL	NCR	C	W	12.8	492.1	2.8	0.6	494.8	158.2	32.0	333.8	67.5	67.5
102															
103	MSQ089-1	BL	NCR	C	W	9.7	462.7	2.4	0.5	465.1	83.7	18.0	379.0	81.5	81.5
104															
105	MSS165-2Y	BL	NCR	C	W	15.8	545.4	19.4	3.4	564.8	203.1	36.0	342.3	60.6	60.6
106															
107	MSS576-05SPL	BL	NCR	C	W	15.4	833.0	10.8	1.3	843.9	108.9	12.9	724.1	85.8	85.8
108															
109	ND7799c-1	BL	NCR	C	W	10.9	597.5	15.1	2.5	612.6	82.0	13.4	515.4	84.1	84.1
110															
111	W5015-5	BL	NCR	C	W	11.4	582.9	11.6	2.0	594.5	86.9	14.6	496.0	83.4	83.4
112															
113	W5955-1	BL	NCR	C	W	9.9	508.3	9.8	1.9	518.1	84.8	16.4	423.5	81.7	81.7
114															
115	MN10013PLWR-04W	BL	NCR/G3	C	W	14.3	403.1	0.7	0.2	403.7	235.3	58.3	167.7	41.5	41.5
116		W				13.4	359.0	0.0	0.0	359.0	211.9	59.0	147.0	41.0	41.0

Peterson Farms

Big Lake, MN

Table 15

	B Size < 4 oz		A size > 4 oz		Culls		Total Yield
Clone	**%**	**Cwt**	**%**	**Cwt**	**%**	**Cwt**	**Cwt**
MN02419	46.9	38.71	48.5	40.09	4.57	3.78	82.57
MN02467Rus/Y	47.1	62.23	52.9	70.01	1.42	1.88	132.25
MN02574	79.0	199.42	21.0	52.93	0.00	0.00	252.34
MN02586	51.3	177.55	48.3	167.19	0.38	1.33	346.07
MN02588	81.3	150.37	18.7	34.52	0.00	0.00	184.89
MN02616R/Y (rep1)	41.4	90.48	56.8	124.06	1.86	4.06	218.60
MN02616R/Y (rep 2)	41.3	75.12	52.7	95.88	5.99	10.89	181.89
MN10001PLWR-03LW	11.1	5.52	71.3	35.52	17.64	8.79	49.82
MN10001PLWR-14R	17.4	39.63	80.0	182.30	2.60	5.93	227.86
MN10003PLWR-02R	61.7	107.89	36.8	64.25	1.48	2.59	174.73
MN10003PLWR-03R	49.2	69.03	50.8	71.33	0.00	0.00	140.36
MN10003PLWR-06R	22.1	26.79	76.8	93.19	1.11	1.35	121.33
MN10003PLWR-07R	42.2	58.66	57.2	79.54	0.59	0.83	139.02
MN10008PLWR-07R	32.5	30.69	64.7	61.01	2.77	2.62	94.32
MN10011PLWR-01R	23.3	38.46	72.5	119.82	4.20	6.94	165.22
MN10013PLWR-03LR	37.5	41.29	59.5	65.45	2.95	3.24	109.98
MN10013PLWR-04W	89.7	132.74	10.3	15.25	0.00	0.00	148.00
MN10018PLWR-08R	52.7	30.68	47.3	27.49	0.00	0.00	58.17
MN10020PLWR-04R	41.5	88.94	55.6	119.32	2.87	6.16	214.42
MN10020PLWR-05R	25.5	5.40	74.5	15.76	0.00	0.00	21.17
MN10020PLWR-08R	20.3	51.02	78.5	196.89	1.16	2.90	250.81
MN10025PLWR-07R	18.7	4.90	81.3	21.25	0.00	0.00	26.15
MN18747	11.5	17.27	87.2	130.63	1.31	1.96	149.86
MonDak Gold	60.1	71.92	36.1	43.19	3.74	4.47	119.58

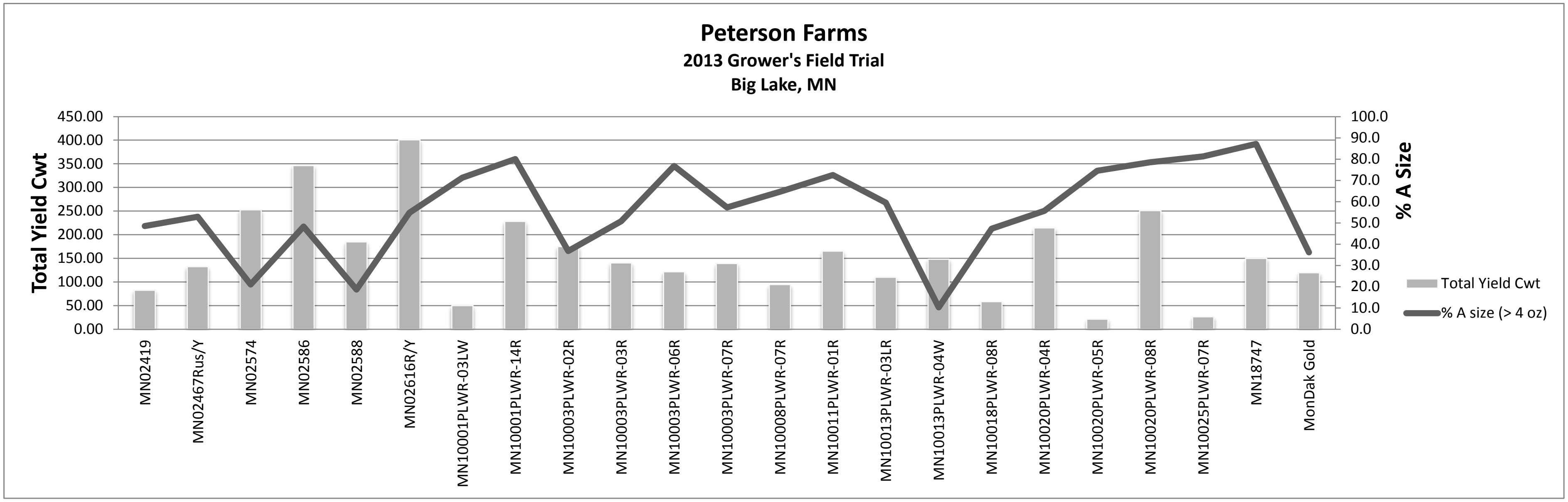
Dechene Farms

Big Lake, MN

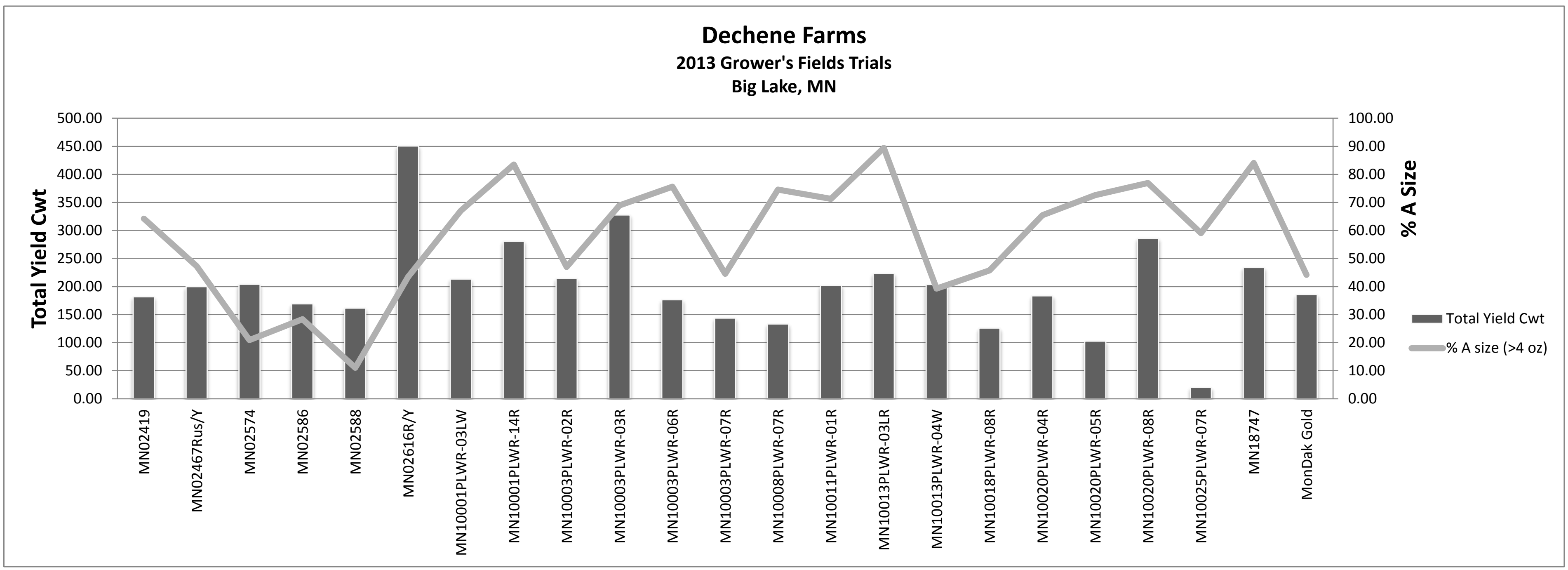
Table 16

	B Size		A size		Culls		Total Yield
Clone	**%**	**Cwt**	**%**	**Cwt**	**%**	**Cwt**	**Cwt**
MN02419	32.20	58.50	64.25	116.72	3.55	6.45	181.67
MN02467Rus/Y	50.13	100.17	47.25	94.43	2.62	5.24	199.85
MN02574	78.12	159.44	20.94	42.73	0.95	1.93	204.11
MN02586	70.63	119.41	28.37	47.97	0.99	1.67	169.05
MN02588	88.40	142.93	11.03	17.84	0.57	0.92	161.69
MN02616R/Y	45.34	90.84	47.51	95.18	7.15	14.33	200.36
MN02616R/Y	57.84	144.78	39.25	98.26	2.91	7.28	250.32
MN10001PLWR-03LW	8.97	19.15	67.04	143.03	23.99	51.18	213.36
MN10001PLWR-14R	12.51	35.14	83.52	234.60	3.97	11.16	280.90
MN10003PLWR-02R	53.00	113.63	47.00	100.77	0.00	0.00	214.40
MN10003PLWR-03R	28.27	92.67	68.90	225.83	2.83	9.26	327.76
MN10003PLWR-06R	21.86	38.56	75.62	133.40	2.52	4.44	176.40
MN10003PLWR-07R	53.87	77.49	44.51	64.03	1.62	2.33	143.85
MN10008PLWR-07R	17.85	23.79	74.54	99.36	7.61	10.15	133.30
MN10011PLWR-01R	23.89	48.31	71.26	144.09	4.85	9.80	202.19
MN10013PLWR-03LR	8.63	19.27	89.45	199.81	1.92	4.29	223.36
MN10013PLWR-04W	58.44	119.13	39.26	80.04	2.29	4.68	203.85
MN10018PLWR-08R	53.66	67.54	45.78	57.62	0.56	0.70	125.86
MN10020PLWR-04R	22.56	41.37	65.46	120.03	11.98	21.96	183.37
MN10020PLWR-05R	21.42	21.97	72.60	74.45	5.97	6.12	102.55
MN10020PLWR-08R	22.09	63.21	76.90	220.10	1.01	2.89	286.20
MN10025PLWR-07R	32.47	6.51	59.05	11.83	8.48	1.70	20.04
MN18747	12.36	28.91	84.12	196.82	3.53	8.26	233.98
MonDak Gold	51.95	96.38	44.20	82.01	3.85	7.15	185.54

Table 17



Peterson Farms
2013 Grower's Field Trial
Big Lake, MN
Total Yield Cwt
% A Size
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Total Yield Cwt
% A size (> 4 oz)
MN02419
MN02467Rus/Y
MN02574
MN02586
MN02588
MN02616R/Y
MN10001PLWR-03LW
MN10001PLWR-14R
MN10003PLWR-02R
MN10003PLWR-03R
MN10003PLWR-06R
MN10003PLWR-07R
MN10008PLWR-07R
MN10011PLWR-01R
MN10013PLWR-03LR
MN10013PLWR-04W
MN10018PLWR-08R
MN10020PLWR-04R
MN10020PLWR-05R
MN10020PLWR-08R
MN10025PLWR-07R
MN18747
MonDak Gold



Dechene Farms
2013 Grower's Fields Trials
Big Lake, MN
Total Yield Cwt
% A Size
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Total Yield Cwt
% A size (>4 oz)
MN02419
MN02467Rus/Y
MN02574
MN02586
MN02588
MN02616R/Y
MN10001PLWR-03LW
MN10001PLWR-14R
MN10003PLWR-02R
MN10003PLWR-03R
MN10003PLWR-06R
MN10003PLWR-07R
MN10008PLWR-07R
MN10011PLWR-01R
MN10013PLWR-03LR
MN10013PLWR-04W
MN10018PLWR-08R
MN10020PLWR-04R
MN10020PLWR-05R
MN10020PLWR-08R
MN10025PLWR-07R
MN18747
MonDak Gold

2013 Williston Spacing Trial

MonDak Gold

Table 18

Yield Data

Clone	Skin	Flesh	Cwt						
			<4oz	4-6 oz	6-10 oz	10+	culls	Mkt Yld	Total Yld
			Mean	Mean	Mean	Mean	Mean	Mean	Mean
MonDak Gold @ 4.5"	LR	Y	48.61	63.70	126.41	214.11	32.21	452.83	485.04
MonDak Gold @ 6"	LR	Y	51.19	55.61	119.88	133.93	19.53	360.62	380.15
MonDak Gold @ 9"	LR	Y	79.28	98.17	150.65	142.44	46.30	470.53	516.83
MonDak Gold @ 12"	LR	Y	57.86	72.01	133.79	191.02	18.41	454.68	473.08
Russet Burbank @ 6"	Rus	C	53.34	55.70	102.76	69.26	104.03	281.06	385.09
Russet Burbank @ 9"	Rus	C	112.09	76.50	112.17	115.51	109.72	416.27	525.98
Russet Burbank @ 12"	Rus	C	43.85	33.26	58.26	128.73	66.38	264.10	330.48

Defect Data

Clone	External				Internal					Fry	SPGR
	Knobs	GC	Grn	Bruise	HH	IN	VD	BC	Bruise		
	%				%						
MonDak Gold @ 4.5"	0	0	0	0	0	0	0	0	11	1	1.088
MonDak Gold @ 6"	0	0	0	6	0	0	6	0	11	1	1.087
MonDak Gold @ 9"	0	0	6	11	0	0	0	0	11	1	1.089
MonDak Gold @ 12"	0	6	6	6	0	0	6	6	6	1	1.088
Russet Burbank @ 6"	0	0	8	8	0	0	8	0	8	0	1.077
Russet Burbank @ 9"	0	0	8	25	1	0	0	0	25	0	1.085
Russet Burbank @ 12"	0	0	25	8	0	0	0	17	8	0	1.076

2013 Williston Strip Trial
Williston, ND

Table 19

Clone	Skin	Flesh	Cwt Yield 4-6 oz	Cwt Yield 6-10 oz	Cwt Yield 10+ oz	Cwt Yield Culls	Cwt Yield Total	B Size < 4oz Cwt	B Size < 4oz %	A Size > 4 oz Cwt	A Size > 4 oz %	US #1's %
MN018747	W	W	30.6	88.0	256.2	7.5	395.3	20.5	5.2	374.8	94.8	94.8
MN02467Rus/Y	Rus	C	39.9	50.8	30.3	0.6	161.6	40.6	25.1	121.0	74.9	74.9
MN02616R/Y	R	Y	111.9	152.3	44.0	2.0	384.2	76.0	19.8	308.2	80.2	80.2
MN04844-07	W	Y	66.3	33.4	2.5	0.0	292.6	190.4	65.1	102.2	34.9	34.9
MN07112WB-01W/P	W/P	Purple	90.2	81.0	15.5	0.0	360.8	174.0	48.2	186.7	51.8	51.8
MN10001PLWR-03LW	LW	W	29.6	103.6	242.3	26.7	391.7	16.2	4.1	375.5	95.9	95.9
MN10013PLWR-02LW	LW	W	75.7	70.8	18.3	38.3	223.4	58.6	54.0	164.8	146.0	146.0
MN10013PLWR-03LR	R	W	49.0	136.1	231.3	10.4	444.7	28.3	6.4	416.4	93.6	93.6
MN99380-1Y	W	Y	124.4	77.1	10.6	0.0	429.6	212.1	49.4	212.1	49.4	49.4
Mondak Gold	R	Y	52.9	122.6	156.7	34.7	419.2	47.2	11.3	336.2	80.2	80.2

Clone	Skin	Flesh	External Defects (%) Knobs	External Defects (%) GC	External Defects (%) Grn	External Defects (%) Bruise	Internal Defects (%) HH	Internal Defects (%) IN	Internal Defects (%) VD	Internal Defects (%) BC	Internal Defects (%) Bruise	Chip	SGPR
MN018747	W	W	0	0	0	17	0	0	0	0	33	0	1.077
MN02467Rus/Y	Rus	C	0	0	0	0	14	0	14	0	0	1	1.080
MN02616R/Y	R	Y	0	0	0	0	0	0	0	0	0		1.079
MN04844-07	W	Y	0	0	0	0	0	0	0	0	0	1	1.088
MN07112WB01W/P	W/P	Purple	0	0	17	0	0	0	0	0	0		1.085
MN10001PLWR03-LW	LW	W	0	0	0	33	0	0	0	0	33	0	1.063
MN10013PLWR-02LW	LW	W	0	0	0	0	33	0	0	0	0	0	1.077
MN10013PLWR-03LR	R	W	0	0	0	0	0	0	0	0	0	0	1.072
MN99380-1Y	W	Y	0	0	0	0	0	0	0	0	0	3	1.080
MonDak Gold	R	Y	0	0	0	0	0	0	67	0	67	1	1.087

MN10001PLWR-03LW
Inspection Report

U of M Test Lots

Grower: University of Minnesota

Date Sampled: 01-Nov-13
Date Inspected: 13-Nov-13

GROSS WEIGHT: 343

Field Number: MN10001PLWR-03LW
Storage Number: 0

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	343.0	336.4	3.4	333.0	10.0
%			1.0%		2.9%

	Graded Weight	Unus-able	Size Breakdown: Under Size	US No 2 for Processing: 4oz	6 oz	10 oz+	Unusables Breakdown: Soft Rot	Freeze Dmg	*Symptoms Scored	*Symptoms Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	236.4	33.6	1.8	15.0	65.0	121.0	0.4	0.0	24.7	0.0	0.3	0.0	8.2	0.0	0.0
Internal		36.1		0.0	8.7	27.4									
Total:	236.4	69.7	1.8	15.0	56.3	93.6	0.4	0.0	24.7	0.0	0.3	0.0	8.2	0.0	0.0
%	100.0%	29.5%	0.8%	6.3%	23.8%	39.6%	0.2%	0.0%	10.4%	0.0%	0.1%	0.0%	3.5%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%
6 oz +	15.0	0.0	0.0	2.0	0.0	0.0	0.0	2.0	2.8
		0.0%	0.0%	13.3%	0.0%	0.0%	0.0%	13.3%	18.7%
10 oz +	30.0	0.0	0.0	6.8	0.0	0.0	0.0	6.8	7.2
		0.0%	0.0%	22.7%	0.0%	0.0%	0.0%	22.7%	24.0%

	Lbs.	%
Bruise	32.0	39.2%
Bruise Free	49.6	60.8%
Total	81.6	100.0%

INTERNAL UNUSABLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	36.1	0.0	0.0	0.0	43.2
%	0.0%	15.3%	0.0%	0.0%	0.0%	18.3%

Fry Color Analysis

	0	1	2	3	4	SE	HS	DE	Strips	Fry Points
Strips	31	22	7	0	0	6	0	0	60	18
%	52%	37%	12%	0%	0%	10%	0%	0%		

Specific Gravity Measurements ***CPP*** ***Avg Temp***

1.0786
1.0797
1.0783

Water 47
Tuber 57

Uncorrected Average Specific Gravity: 1.0789
Specific Gravity Correction: 0.0004
Corrected Average Specific Gravity: **1.0793**

Ticket #:

Comments: MN10001PLWR-03LW

Sample Method: Submitted

***Symptoms = Characteristics of Late Blight/Pink Rot/ Pink Eye**
Nonscorable symptoms are not included in Unusables

MN10013PLWR-02LW

Inspection Report

Grower: University of Minnesota

U of M Test Lots

Date Sampled: 01-Nov-13

Date Inspected: 13-Nov-13

GROSS WEIGHT: 104

Field Number: MN10013PLWR-02LW

Storage Number: 0

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	104.0	103.2	1.0	102.2	1.8
%			1.0%		1.8%

	Graded Weight	Unus-able	Size Breakdown: Under Size	US No 2 for Processing: 4oz	6 oz	10 oz+	Unusables Breakdown: Soft Rot	Freeze Dmg	*Symptoms Scored	*Symptoms Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	78.2	6.4	8.8	35.0	25.0	3.0	0.6	0.0	1.7	0.0	0.9	0.0	3.2	0.0	0.0
Internal		6.4		1.4	5.0	0.0									
Total:	78.2	12.8	8.8	33.6	20.0	3.0	0.6	0.0	1.7	0.0	0.9	0.0	3.2	0.0	0.0
%	100.0%	16.4%	1.3%	43.0%	25.6%	3.8%	0.8%	0.0%	2.2%	0.0%	1.2%	0.0%	4.1%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	10.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	2.3
		0.0%	0.0%	4.0%	0.0%	0.0%	0.0%	4.0%	23.0%
6 oz +	5.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	2.2
		0.0%	0.0%	20.0%	0.0%	0.0%	0.0%	20.0%	44.0%
10 oz +	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	Lbs.	%
Bruise	8.1	48.5%
Bruise Free	8.6	51.5%
Total	16.7	100.0%

INTERNAL UNUS. BLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	6.4	0.0	0.0	0.0	19.1
%	0.0%	8.2%	0.0%	0.0%	0.0%	24.4%

Fry Color Analysis

	0	*1*	*2*	*3*	*4*	*SE*	*HS*	*DE*	*Strips*	*Fry Points*
Strips	34	1	0	0	0	0	0	0	35	1
%	97%	3%	0%	0%	0%	0%	0%	0%		

Specific Gravity Measurements ***CPP*** ***Avg Temp***

1.0689
1.0744
1.0656

Water 51

Tuber 57

Uncorrected Average Specific Gravity: 1.0696 **Ticket #:**

Specific Gravity Correction: 0.0004

Corrected Average Specific Gravity: **1.0700**

Comments: MN10013PLWR-02LW

Sample Method: Submitted

***Symptoms = Characteristics of Late Blight/Pink Rot/ Pink Eye**
Nonscorable symptoms are not included in Unusables

MN018747

Grower: University of Minnesota **Inspection Report**

Date Sampled: 01-Nov-13
Date Inspected: 13-Nov-13

GROSS WEIGHT: 328

Field Number: MN018747
Storage Number: 0

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	328.0	322.6	3.2	319.4	8.6
%			1.0%		2.6%

	Graded Weight	Unus-able	Under Size (Size Breakdown)	US No 2 for Processing 4oz	6 oz	10 oz+	Soft Rot (Unusables Breakdown)	Freeze Dmg	*Symptoms Scored	*Symptoms Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	222.6	28.0	4.6	23.0	48.0	119.0	0.4	0.0	24.2	0.0	0.3	0.0	3.1	0.0	0.0
Internal		0.0		0.0	0.0	0.0									
Total:	222.6	28.0	4.6	23.0	48.0	119.0	0.4	0.0	24.2	0.0	0.3	0.0	3.1	0.0	0.0
%	100.0%	12.6%	2.1%	10.3%	21.6%	53.5%	0.2%	0.0%	10.9%	0.0%	0.1%	0.0%	1.4%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6 oz +	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10 oz +	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	Lbs.	%
Bruise	39.3	45.0%
Bruise Free	48.1	55.0%
Total	87.4	100.0%

INTERNAL UNUSABLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	0.0	0.0	0.0	0.0	0.0
%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Fry Color Analysis

	0	1	2	3	4	SE	HS	DE	Strips	Fry Points
Strips	59	1	0	0	0	2	0	0	60	1
%	98%	2%	0%	0%	0%	3%	0%	0%		

Specific Gravity Measurements ***CPP*** ***Avg Temp***

1.0709
1.0697
1.0723

Water 46
Tuber 57

Uncorrected Average Specific Gravity: 1.0710
Specific Gravity Correction: 0.0004
Corrected Average Specific Gravity: **1.0714**

Ticket #:

Comments: MN018747

Sample Method: Submitted

***Symptoms = Characteristics of Late Blight/Pink Rot/ Pink Eye**
Nonscorable symptoms are not included in Unusables

MonDak Gold

Grower: University of Minnesota

Inspection Report

Date Sampled: 01-Nov-13
Date Inspected: 13-Nov-13

GROSS WEIGHT: 346

Field Number: MG Strip Trial
Storage Number: 0

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	346.0	342.4	3.4	339.0	7.0
%			1.0%		2.0%

	Graded Weight	Unus-able	Size Breakdown: Under Size	US No 2 for Processing: 4oz	6 oz	10 oz+	Unusables Breakdown: Soft Rot	Freeze Dmg	*Symptoms Scored	*Symptoms Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	242.4	79.7	14.7	32.0	52.0	64.0	0.0	0.0	76.2	0.0	0.5	0.0	3.0	0.0	0.0
Internal		2.2		0.0	0.0	2.2									
Total:	242.4	81.9	14.7	32.0	52.0	61.8	0.0	0.0	76.2	0.0	0.5	0.0	3.0	0.0	0.0
%	100.0%	33.8%	6.1%	13.2%	21.5%	25.5%	0.0%	0.0%	31.4%	0.0%	0.2%	0.0%	1.2%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6 oz +	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10 oz +	20.0	0.0	0.0	0.0	0.0	0.7	0.0	0.7	0.0
		0.0%	0.0%	0.0%	0.0%	3.5%	0.0%	3.5%	0.0%

	Lbs.	%
Bruise	27.7	32.7%
Bruise Free	57.1	67.3%
Total	84.8	100.0%

INTERNAL UNUSABLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	0.0	0.0	2.2	0.0	0.0
%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%

Fry Color Analysis

	0	1	2	3	4	SE	HS	DE	Strips	Fry Points
Strips	55	0	0	0	0	0	0	0	55	0
%	100%	0%	0%	0%	0%	0%	0%	0%		

Specific Gravity Measurements — ***CPP*** — ***Avg Temp***

1.0818
1.0811
1.0822

Water 48
Tuber 55

Uncorrected Average Specific Gravity: 1.0817
Specific Gravity Correction: 0.0004
Corrected Average Specific Gravity: **1.0821**

Ticket #:

Comments: MG Strip Trial- Symptoms (characteristic of late blight).

Sample Method: Submitted

***Symptoms = Characteristics of Late Blight/Pink Rot/ Pink Eye**
Nonscorable symptoms are not included in Unusables

MN10013PIWR-03LR
Inspection Report

Grower: University of Minnesota

Date Sampled: 01-Nov-13
Date Inspected: 13-Nov-13

GROSS WEIGHT: 296

Field Number: MN10013PIWR-03LR
Storage Number: 0

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	296.0	290.6	2.9	287.7	8.3
%			1.0%		2.8%

	Graded Weight	Unus-able	Size Breakdown: Under Size	US No 2 for Processing: 4oz	6 oz	10 oz+	Unusables Breakdown: Soft Rot	Freeze Dmg	*Symptoms Scored	*Symptoms Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	230.6	14.8	5.8	26.0	66.0	118.0	0.9	0.0	6.0	0.0	1.8	0.0	6.1	0.0	0.0
Internal		5.9		0.0	0.0	5.9									
Total:	230.6	20.7	5.8	26.0	66.0	112.1	0.9	0.0	6.0	0.0	1.8	0.0	6.1	0.0	0.0
%	100.0%	9.0%	2.5%	11.3%	28.6%	48.6%	0.4%	0.0%	2.6%	0.0%	0.8%	0.0%	2.6%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6 oz +	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10 oz +	20.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	2.6
		0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	5.0%	13.0%

	Lbs.	%
Bruise	12.9	27.0%
Bruise Free	34.9	73.0%
Total	47.8	100.0%

INTERNAL UNUSABLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	5.9	0.0	0.0	0.0	15.3
%	0.0%	2.6%	0.0%	0.0%	0.0%	6.7%

Fry Color Analysis

	0	1	2	3	4	SE	HS	DE	Strips	Fry Points
Strips	53	7	0	0	0	0	0	0	60	4
%	88%	12%	0%	0%	0%	0%	0%	0%		

Specific Gravity Measurements | ***CPP*** | ***Avg Temp***

1.0740
1.0745
1.0729

Water 50
Tuber 58

Uncorrected Average Specific Gravity: 1.0738
Specific Gravity Correction: 0.0007
Corrected Average Specific Gravity: **1.0745**

Ticket #:

Comments: MN10013PIWR-03LR

Sample Method: Submitted

***Symptoms = Characteristics of Late Blight/Pink Rot/ Pink Eye**
Nonscorable symptoms are not included in Unusables

MN02467Rus Y

Grower: University of Minnesota

Inspection Report

Date Sampled:	01-Nov-13
Date Inspected:	13-Nov-13
Field Number:	MN02467Rus Y
Storage Number:	0

GROSS WEIGHT: 109

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	109.0	104.8	1.0	103.8	5.2
%			1.0%		4.8%

			Size Breakdown				***Unusables Breakdown***								
	Graded Weight	Unus-able	Under Size	US No 2 for Processing 4oz	6 oz	10 oz+	Soft Rot	Freeze Dmg	*Symptoms Scored	Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	79.8	4.6	12.2	29.0	26.0	8.0	0.2	0.0	0.3	0.0	0.3	0.0	3.8	0.0	0.0
Internal		0.0		0.0	0.0	0.0									
Total:	79.8	4.6	12.2	29.0	26.0	8.0	0.2	0.0	0.3	0.0	0.3	0.0	3.8	0.0	0.0
%	100.0%	5.8%	5.3%	36.3%	32.6%	10.0%	0.3%	0.0%	0.4%	0.0%	0.4%	0.0%	4.8%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6 oz +	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%
10 oz +	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	70.0%

	Lbs.	***%***
Bruise	6.5	36.5%
Bruise Free	11.3	63.5%
Total	17.8	100.0%

INTERNAL UNUSABLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	0.0	0.0	0.0	0.0	7.3
%	0.0%	0.0%	0.0%	0.0%	0.0%	9.2%

Fry Color Analysis

	0	***1***	***2***	***3***	***4***	***SE***	***HS***	***DE***	***Strips***	***Fry Points***
Strips	45	0	0	0	0	0	0	0	45	0
%	100%	0%	0%	0%	0%	0%	0%	0%		

Specific Gravity Measurements ***CPP*** ***Avg Temp***

1.0840
1.0825
1.0809

Water 51
Tuber 56

Uncorrected Average Specific Gravity: 1.0825 **Ticket #:**
Specific Gravity Correction: 0.0004
Corrected Average Specific Gravity: **1.0829**

Comments: MN02467 RusY

Sample Method: Submitted

***Symptoms = Characteristics of Late Blight/Pink Rot/ Pink Eye**
Nonscorable symptoms are not included in Unusables

Russet Burbank

Grower: University of Minnesota

Inspection Report

Date Sampled: 01-Nov-13
Date Inspected: 13-Nov-13

GROSS WEIGHT: 303

Field Number: Russet Burbank
Storage Number: 0

	Total Exam	Washed Weight	Water Gain	Net Sample Weight	FM Dirt
Lbs.	303.0	290.7	2.9	287.8	15.2
%			1.0%		5.0%

	Graded Weight	Unus-able	*Size Breakdown* Under Size	US No 2 for Processing 4oz	6 oz	10 oz+	*Unusables Breakdown* Soft Rot	Freeze Dmg	*Symptoms Scored	Non	Sun Burn	Insect Dmg	Other	Pitted Scab	Pink Eye
Lbs.	190.7	23.7	14.0	36.0	59.0	58.0	0.9	0.0	0.0	0.0	5.1	0.0	17.7	0.0	0.0
Internal		17.2		1.4	7.1	8.7									
Total:	190.7	40.9	14.0	34.6	51.9	49.3	0.9	0.0	0.0	0.0	5.1	0.0	17.7	0.0	0.0
%	100.0%	21.5%	7.3%	18.1%	27.2%	25.9%	0.5%	0.0%	0.0%	0.0%	2.7%	0.0%	9.3%	0.0%	0.0%

Size	Lbs Exm	I.B.S.	Brn Cen	H.H.	Net Nec	VRB	Other	Total	T.H.H.
4 oz +	15.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6	1.4
		0.0%	0.0%	4.0%	0.0%	0.0%	0.0%	4.0%	9.3%
6 oz +	20.0	0.0	0.0	2.4	0.0	0.0	0.0	2.4	3.7
		0.0%	0.0%	12.0%	0.0%	0.0%	0.0%	12.0%	18.5%
10 oz +	20.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0	4.1
		0.0%	0.0%	15.0%	0.0%	0.0%	0.0%	15.0%	20.5%

	Lbs.	*%*
Bruise	8.9	12.9%
Bruise Free	59.9	87.1%
Total	68.8	100.0%

INTERNAL UNUSABLES BREAKDOWN

	I.D.	H.H.	Net	VRB	Other	T.H.H.
Lbs.	0.0	17.2	0.0	0.0	0.0	26.2
%	0.0%	9.0%	0.0%	0.0%	0.0%	13.7%

Fry Color Analysis

	0	*1*	*2*	*3*	*4*	*SE*	*HS*	*DE*	*Strips*	*Fry Points*
Strips	38	22	0	0	0	23	0	0	60	11
%	63%	37%	0%	0%	0%	38%	0%	0%		

Specific Gravity Measurements

CPP ***Avg Temp***

1.0779
1.0814
1.0798

Water 52
Tuber 56

Uncorrected Average Specific Gravity: 1.0797
Specific Gravity Correction: 0.0004
Corrected Average Specific Gravity: **1.0801**

Ticket #:

Comments: Russet Burbank-no ticket in tote.

Sample Method: Submitted

Strip Trial --- Fry Colors --- Williston, ND

MN10001PLWR-03LW

MN10013PLWR-02LW

MN18747

MonDak Gold

Strip Trial --- Fry Colors --- Williston, ND

MN10013PLWR-03LR

MN02467Rus/Y

Russet Burbank

Potato Breeding and Cultivar Development for the Northern Plains
North Dakota State University
2013 Summary

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Potato is the most important vegetable and horticultural crop grown in North Dakota and is one of the most important vegetable crops grown in Minnesota. The NDSU potato breeding program offers a venue via conventional breeding efforts to address germplasm enhancement, breeding, selection of superior genotypes, evaluation, and development of improved cultivars for potato producers and the potato industry in North Dakota, Minnesota, and beyond. Improvements include high yield, durable pest and stress resistance, improved nutrient-use efficiency, and enhanced nutritional and quality attributes to meet consumer needs.

In order to meet the needs of producers, industry, and consumers, we have established the following research objectives:
1) Develop potato (*Solanum tuberosum* Group Tuberosum L.) cultivars for North Dakota, the Northern Plains, and beyond, using traditional hybridization, that are genetically superior for yield, market-limiting traits, and processing quality.
2) Identify and introgress into adapted potato germplasm, genetic resistance to major disease, insect, and nematode pests, causing economic losses in potato production in North Dakota and the Northern Plains.
3) Identify and develop enhanced germplasm with resistance to environmental stresses and improved quality characteristics for adoption by consumers and the potato industry.

Germplasm enhancement and dedicated crossing blocks are used in hybridizing efforts to develop resistance to biotic and abiotic stresses, and in improving quality attributes. In 2013, 364 new hybrid families were created using 152 parental genotypes. Of these families, 61% included late blight resistance breeding, 27% Colorado potato beetle (CPB) resistance breeding, 26% chip processing and 23% frozen processing with cold sweetening resistance breeding.

At Langdon, 39,266 seedlings, representing 227 families, were evaluated; 677 selections were retained. Unselected seedling tubers were shared with the breeding programs in Idaho, Maine, Colorado and Texas. Unselected seedling tubers received from cooperating programs were grown at Larimore and Hoople, ND. In 2013, 641 second, 50 third year, and 379 fourth year and older selections, were produced in maintenance and increase lots at Absaraka, ND, and Baker, MN.

Yield and evaluation trials, totaling 30, were grown at eight locations in North Dakota and Minnesota, five irrigated (Larimore, Oakes, Inkster, Williston, Park Rapids) and three non-irrigated locations (Hoople, Crystal and Grand Forks). Twenty-four entries were grown in the chip trial at Hoople, including 15 advancing selections from the NDSU program, and nine standard chipping cultivars. In the preliminary chip trial 120 entries were grown and will be evaluated to more rapidly and efficiently determine what early selections should continue. The National Chip Breeders Trial (NCBT), with the goals to rapidly identify and develop clones to replace Atlantic for southern production areas, and Snowden from storage, initiated by the USPB and regional chip processors, had 93 entries in the unreplicated trial, and 62 in the replicated trial. At Crystal, our state fresh market trial was lost to flooding. The preliminary fresh market trial had 75 entries were evaluated, including 61 advanced selections and 14 industry standards.

Four trials were grown at the NPPGA Research Farm south of Grand Forks. They included seedling family evaluation for Colorado Potato Beetle (CPB) resistance (information used during selection at Langdon in September), along with three others where individual clones were assessed for defoliation twice weekly throughout the summer. Two were projects with graduate students, assessing germplasm with two different mechanisms for CPB control, glandular trichomes and glycoalkaloid mediated resistance. CPB pressure was not as great in 2014 as 2013. However, results of Dr. Ian McRae in assessing local COB populations emphasize the need for host-plant resistance for managing beetle populations as the CPB is quickly developing resistance to previously efficacious insecticides.

Twenty-four selections and commercially acceptable cultivars were grown in the Oakes processing trial, 24 in the Larimore processing trial, and 24 in the Williston processing trial; 16 advanced NDSU selections in each. The preliminary processing trial at Larimore had 91 entries. As with the preliminary chip trial, this trial gives a rapid assessment providing the breeding program with information on processing quality, so that lines may be continued, fast tracked if exceptional, or discarded from further evaluation. The NFPT is an industry driven trial with evaluations in WA, ID, ND, WI and ME. There were 79 clones evaluated (seven lines from NDSU); clones are evaluated for sugar, asparagine and acrylamide levels. One hundred sixty-four clones selected from out-of-state seedlings in 2012, and 30 third year and older selections were grown in maintenance plots. Trials at Inkster ranged from the chip processing yield trial with 30 entries, the regional trials (irrigated), and evaluation of genotypes for resistance to Verticillium wilt in collaboration with Drs. Neil Gudmestad and Ray Taylor (21 clones across all market types). A processing trial with 18 entries, including 12 NDSU advancing selections) was grown at Park Rapids, in collaboration with RDO/Lamb-Weston. Due to the large number of trials conducted under one project umbrella, results of individual trials will be submitted to the Valley Potato Grower magazine and will become available on our website.

Four entries from NDSU were evaluated in the North Central Regional Potato Variety Trial (NCRPVT), including ND6002-1R, ND7132-1R and ND7982-1R, promising fresh market red selections, and ND7799c-1, a cold chipping selection. The NCRPVT sites are Crystal (fresh market), Hoople (chip processing), Larimore (processing), and Inkster (fresh market, chip and processing).

Our focus continues to be identification of processing (both chip and frozen) germplasm that will reliably and consistently process from long term cold storage. As we grade, chip processing selections are sampled, ‘field chipped’, stored at 42F and 38F (5.5C and 3.3C) for eight weeks, while a fourth set is evaluated the following June from 42F storage. Frozen processing selections are evaluated after grading and from 45F (7.2C) storage for eight weeks and again in June. All trial entries are evaluated for blackspot and shatter bruise potential.

In 2013, Dr. Gary Secor's program evaluated seedling families using a detached leaf assay in the greenhouse; resistant selections are retained for field evaluations in 2014. Collaborative field trials for late blight foliar and tuber evaluations with Dr. Secor were lost due to wet field conditions post planting. Dr. Secor's program evaluated 44 families in the summer greenhouse, totaling nearly 44,000 individuals, using the detached leaf assay for identifying genotypes possessing resistance to late blight. Sixteen selections were evaluated by Dr. Gudmestad and Dr. Taylor for resistance to pink rot, *Phytophthora nicotianae,* and Pythium leak. Most selections were rated as resistant or moderately resistant to pink rot and *Phytophthora nicotianae*. Identifying resistant lines to Pythium leak has been more difficult.

Sucrose rating, invertase/ugpase analysis, and serial chipping of chip and frozen processing selections is conducted by Marty Glynn (USDA-ARS) at the USDA-ARS Potato Worksite in East Grand Forks, MN. Many entries were submitted for cooperative trials with various producers, industry, and research groups across North America.

The most promising advancing red fresh market selections continue to include ND4659-5R, ND8555-8R, AND00272-1R, ND6002-1R and ND7132-1R. Dual-purpose russet selections, ND8068-5Russ and several hybrids between Dakota Trialblazer and Dakota Russet possess excellent appearance, yield, and processing qualities. ND7519-1 and ND8304-2, advancing chip processing selections, possess excellent appearance and cold sweetening resistance. The standout chip selection in 2013 has been ND7799c-1. Additionally, several specialty selections with unique colored flesh and skin are advancing through the program.

The NDSU potato breeding program is supported by Dick (Richard) Niles (research specialist), and Dr. Rob Sabba, post doctoral research fellow. Rob's work primarily involves marker assisted selection work. We hope to have an additional research specialist on board prior to planting. Johanna Ruiz is working with the tissue culture clone bank and assisting with greenhouse production. Adriana Rodriguez, MSc. candidate from Puerto Rico, is completing her thesis on glandular trichome mediated resistance to Colorado potato beetle resistance. Whitney Harchenko, MSc. candidate and NDSU graduate, is completing her thesis on use of marker assisted selection for PVY resistance in a breeding program. Part of her work was establishment of a 'fast track' program similar to the one we have with Potato Pathology for late blight resistant genotypes. She is working in private industry as an assistant wheat breeder. Juan Calle-Belido, Ph.D. candidate from Peru, has left our program to pursue cocoa breeding and is completing his dissertation on developing a molecular marker for Fusarium dry rot resistance. Irene Roman, MSc. candidate also from Puerto Rico, graduated in December after successfully defending her thesis on glycoalkaloid mediated resistance to Colorado potato beetle. Using results of her work, several parental genotypes with low tuber glycoalkaloid levels, but minimal defoliation levels in the field, have been included in the 2014 crossing block.

Goals for 2014 continue to include developing improved potato cultivars for ND, MN, the Northern Plains and beyond, using traditional hybridization, and utilizing early generation selection techniques including emphasis on the use of marker assisted selection and greenhouse screening procedures for rapid identification of genetically superior germplasm. Our focus will be on resistance to major insect, disease and nematode pests, and to environmental stresses, with an emphasis on improved quality characteristics, addressing shortcomings of currently commercially accepted cultivars, and with greater emphasis on economic and environmental sustainability. We are working closely with Dr. Gudmestad and Secor breeding and screening for resistance to new and emerging pests. In 2014, I hope to participate in training in order to employ SNP genotyping as a new tool in rapid identification of clones possessing resistance traits or improved quality attributes, for example. We will continue working with the NDSSD and MN Department of Agriculture to improve our seed increase efforts in order to produce high quality certified seed.

We are grateful for the opportunity to conduct cooperative and interdisciplinary research with members of the NDSU potato improvement team, the USDA-ARS programs in Fargo and East Grand Forks, the North Central and other research programs across the globe, and potato producers and industry in ND, MN, and beyond. Thank you to our grower, industry and research cooperators in Minnesota, North Dakota and beyond. We are very grateful for your continued support and cooperation in providing resources of land, certified seed, research funds, and equipment.