Proceedings of
Wisconsin's
Annual Potato Meeting
2014

University of Wisconsin-Madison
College of Agricultural and Life Sciences
Research Division
Wisconsin Agricultural Experiment Station

UW Extension

PROCEEDINGS OF WISCONSIN'S ANNUAL POTATO MEETING
February 4-6, 2014

Holiday Inn Hotel & Convention Center
Stevens Point, Wisconsin

WISCCONSIN MUCK CROPS RESEARCH UPDATE
February 5, 2014

Volume 27

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Wisconsin Potato and Vegetable Growers Association

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RESEARCH TRIAL REPORTS

New Directions in Pest Management

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The molecular instructions that determine the growth, development, structure and function of organisms are determined by a code comprised of the four building blocks of DNA in the nucleus of individuals. The ability to determine the order of these letters (nucleic acid sequencing) has revolutionized our understanding of how this code is read, how the information is stored, how it is produced and how it is regulated. Importantly, we are learning how to manipulate these process to achieve specific genetic outcomes. The geometric decline in the cost of DNA sequencing and data analysis in the last several years has accelerated this field and we are now seeing the application of these technologies to human and animal medicine, plant biology and to plant pathogen and pest control. The era of functional genomics has arrived and it is incumbent upon all of us, as citizens, to understand what this involves so that we can make informed decisions with respect to the positive or negative consequences this implies. These decisions may be as pragmatic as will the use of these technologies be profitable or as personal as should my family be exposed to these products.

The idea of genetically modified organisms (GMO) is not new. Currently, about 90% of all corn, soybean and cotton acreage in the U.S. has been modified to express a gene another source to render it resistant to pests or to confer herbicide resistant. There are several other crops of lesser acreage and at least nine different countries are using these materials. The scientific advances that took place in the early 1980's enabled the generation of these plants and has changed agriculture enormously. These technologies involved the insertion of genes from other species, such as bacteria or viruses into plants to achieve the desired outcome. Part of the concern about this process was that it is imprecise…that is the location of the insertion into the host genome (the plant in this example) could not be directed to a specific site creating concerns about disruption of normal processes and the general concern about cross species gene transfer. New technologies of several kinds that use genomic information to modify plants for improved agronomic traits and pest or pathogen control have emerged. I will attempt to describe a few of these in the hopes that it well benefit your sense of curiosity and inform your decision making.

A new form of targeted genetic modification (TagMo) involving zinc finger nucleases (ZFNs) which are engineered proteins that can be designed to make a break at a specific site in DNA and then use the cells own DNA repair machinery to fix the break are now being used This allows for the insertion of a foreign gene into a location with known properties. Further, it is possible to change a few "letters" in the code of an existing gene or even multiple genes and thereby alter its function, to fit a desired purpose. Conveniently, it makes it possible to "knock out' or eliminate the function of a host gene that is problematic. Examples of this might be a gene that when being expressed contributes to bruising, or production of simple sugars that lead undesirable fry color, or a gene involved in the production of a toxic substance or perhaps a gene that a pathogen uses for it development but that is not essential for normal plant growth and development. These are all examples or what is likely to be the major use of this technology: altering one or more genes in an agronomically important plant rather than inserting genes additional genes. (See ref. 1 for a lay language review of this subject).

Using TagMo technologies, it is also possible to transfer a whole gene from a sexually compatible plant into a specific site in a recipient plant. For example, an advanced potato cultivar could have a gene present only in wild species that confers disease resistance species without having to go through numerous breeding cycles. These examples are referred to as Cisgenic Plants because no DNA from another species is involved in their production. These new technologies have address the concerns that some individuals have about the inclusion of "foreign" or "unnatural" DNA into a recipient organism.

Other types of new, fundamentally, genetic approaches rely on the manipulation of downstream aspects of gene expression, that is not by altering inheritance directly but by modification or use of control aspects of the gene expression process. Gene Silencing and RNA interference (RNAi) is a normal biological process in which ribonucleic acid (RNAi) molecules inhibit gene expression, typically by causing the destruction of specific mRNA molecules. In a multicellular organism, such as yourself or an insect, all of the cells have the same genetic information (DNA) but, clearly, all of the cells are not the same. The process by which some cells become different from others and some groups of cells produce different structures and organs, is called differentiation. This happens because different cells express different sets of genetic information. In other words, gene expression is regulated in both a positive and negative manner. To accomplish this, the expression (turning the DNA information into protein) of some information is specifically suppressed as a result of environmental clues. Both mRNA and smaller RNAi molecules are the direct products of genes, and these small RNAs can bind to specific messenger RNA (mRNA) molecules and decrease their activity, for example by preventing an mRNA from producing a protein. This interaction, termed RNA interference (RNAi), also provides a very important role in defending cells against parasitic nucleotide sequences (e.g. plant viruses) by using this normal control process to prevent their gene expression. Only after these processes were fully understood, did it become clear that they could be exploited as a means of plant protection. RNAi has become a valuable research tool, both in cell culture and in living organisms, because synthetic double stranded RNA (dsRNA) which is processed into RNAi, can now be introduced into cells and is selectively able to induce suppression of specific genes of interest. For example, this can be used to artificially suppress the production of a unique gene product essential for development in an insect. It is anticipated that RNAi may be very useful for systematically shutting down genes in pests and pathogens, which can greatly aid in our ability to produce crops sustainably. (see ref 2 for a review)

Repurposing the viral transmission cycle. For many important plant viruses the transmission cycle is initiated when insects ingest virus as they feed from the relevant tissues of infected plants. Virions typically are taken up when they attach to structures (receptors) on gut cells. After the virions move through the gut cells, they breach the basal lamina and are released into the hemocoel. Once the virions enter the hemolymph they must circulate to and penetrate the salivary glands for transmission to occur. Only discrete combinations of viruses and insects can accomplish this process because the virus-vector interaction requires specific virus and insect determinants to culminate into a transmission event. Recent advances in understanding of the molecular mechanisms involved in this process have led to the development of potentially revolutionary insect and virus disease control protocols.

In one such rendition, researchers at Iowa State University have learned that a protein present on the surface of a phloem inhabiting virus (its coat protein) facilitates virus attachment to gut cells and transport into the hemocoel (body cavity) of its aphid vector. They produced this protein in the laboratory and fused it to another protein that is used to trace its location. They showed that the modified coat protein and its cargo (Green fluorescent protein) moved into the heomocoel without benefit of being a part of the viral structure. They have, in effect, produced a system to deliver molecules to the hemocoel of insects that have specific receptors for this virus. By attaching a toxin molecule that is active in the hemocoel, but not the gut, they are then able to specifically kill aphids (but not unrelated insects) by feeding the protein directly. To demonstrate the potential practicality of this approach they showed that the coat protein toxin fusion could be expressed in transgenic plants and was lethal to target insects that fed on them. In so doing, they have created a specific, effective and safe insecticide. (Described in ref 3 and 4)

Another example of co-opting the transmission cycle involves blocking virus acquisition by their vectors. Using Tomato spotted wilt virus (TSWV) and its main thrips vector, researchers at the University of Wisconsin and Kansas State University have devised such a strategy. On the outer surface of TSWV there is a protein that, similar to the example above, is involved in the attachment of the virus to the gut cells in the vector as a prerequisite to it being taken up by and circulated through the insect. When this protein is produced in the laboratory and fed to insects prior to or at the same time as whole virus, the transmission process is inhibited. This likely works because the virus protein attaches to the place on the gut where the whole virus would attach and thus prevents virus binding. Much like welding a key in a lock so the real key cannot be used. Here too, it was shown that this strategy can be deployed by making transgenic plants expressing the TSWV attachment protein that effectively prevents vectors from acquiring and spreading the virus. Since the viral transmission cycle is similar for many types of viruses with many different vectors it seems likely that such strategies will be modified to target other insect pests of humans, domestic animals, and plants of agricultural importance. (See ref 4).

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Field Scale Trials with ESN and manure

Mack Naber, Matt Ruark, and AJ Bussan

On-farm research trials were conducted in 2013 to evaluate alternative nitrogen (N) management practices using ESN and manure. Overall, trials for both potato and sweet corn show increased yield when ESN was included as part of the N management strategy. The 2013 growing season was notable for having 4 inches of rainfall occur between June 22 and 24. Two case studies are reported here which highlight the performance of ESN in combating N loss during these rainfall events.

Case Study #1

The first case study was a split-pivot comparison, where one-half of a potato field received 470 lb/ac of N as various conventional sources, including fertigation, compared to the other half of a pivot that only received 340 lb/ac of N, of which 130 lb/ac was applied as ESN. ESN was applied with other N sources in blends at preplant and hilling. The potatoes (Russet Burbank) were planted April 30th, vine-killed September 3rd and harvested two weeks later. The half pivots receiving ESN or the conventional practice were in two different fields, separated by a road. Both fields were a Richfield loamy sand soil series and it had been at least five years since the previous potato crop for both fields.

Yields in the ESN-based N management resulted in a 130 cwt/ac increase in yield (Table 1). The largest gains in potato yields occurred in the 6-10 ounce tubers and 20 cwt gains were also observed in the 13-16 ounce and >16 ounce categories (Table 2).

Table 1. Russet Burbank marketable yields (Case Study #1) (standard error in parenthesis).

N plan	Overall N rate	Samples	Marketable Yield	Specific gravity
	lb/ac	#	cwt/ac	
Conventional	470	8	646 (43)	1.086
ESN	340	7	767 (44)	1.088

Table 2. Yield distribution across size classes (Case Study #1)

N plan	Samples	Bs	2-4 oz	4-6 oz	6-10 oz	10-13 oz	13-16 oz	>16 oz
	#	----	----	----	cwt/ac	----	----	----
Conventional	8	7	71	133	261	110	30	33
ESN	7	3	73	168	331	88	54	51

Case Study #2

The second cast study was an evaluation of manure and ESN on sweet corn yield. For this trial, three fields were used. The total N rate for each field was the same, the only variation being the percent of the total N applied as manure or ESN. If manure was applied, it was applied to only half the field. ESN fertilizer was applied at rates of 0, 75, and 150 lb-N/ac. Thus, the comparisons between the ESN rates indicate if there are yield gains or reductions with more reliance on ESN and the comparisons of use of manure within each ESN rate indicate if manure helped improve yields as well. The crop was planted on

June 15^{th} and harvested on September 28^{th}. Liquid manure was spring applied and immediately incorporated. ESN was side-dressed and incorporated at V4.

In this case study, the largest yields were determined using both manure and ESN at 150 lb-N/ac (Table 3), indicating there is a positive interaction between these two N sources. Previous work on ESN in sweet corn has resulted in reduced yields. In addition, the more ESN was used in the overall N rate, the greater the yields. About a one ton/ac yield increase was determined between no ESN to 75 lb-N/ac of ESN (Table 3).

Table 3. Sweet corn yields (Case Study #2)

Field	Samples	Manure	ESN rate	Yield
	#		lb-N/ac	ton/ac
Field 1-west	3	Yes	0	12.6
Field 1-east	3	No	0	12.8
Field 2-west	3	Yes	75	13.9
Field 2-east	3	No	75	13.6
Field 3-west	3	Yes	150	15.0
Field 3-east	3	No	150	13.3

Overall, it is clear that the 2013 growing season was favorable for ESN in potato and sweet corn production. These results should be considered within the context of the 2013 season, but does provide evidence that ESN can be a profitable fertilizer product in the Central Sands. However, future and continuing work needs to be conducted to assess how often the benefits of ESN will be realized.

Manure application in potato systems: effects on P fertility

Matt Ruark, Amanda Gevens, Nick Bero, Mack Naber, and Jaimie West

Introduction

There is little research that addresses how manure use in the Central Sands can affect nutrient management strategies. Currently in the Central Sands, manure is expected to be used for corn or corn silage production. Manure use has implications for crop rotations where potato is in rotation with these manure-receiving crops, and more importantly, when potato is grown the following year after manure application. If potato is in the rotation, it is likely that the soil P tests will be elevated and in the high or excessively high soil test category for corn. This means that there is little chance of a yield benefit to P application to corn, although there still would be a benefit to applying P to potato. Therefore, while the N in the manure is beneficial to the corn crop, the P may not. It would be valuable to know if the P that is not needed by the corn crop would carry over into the potato crop year and if growers could apply less P to potato. The objective of this study was to determine if previously applied manure altered optimum P rate for potato.

Materials and Methods

To address the rotational nutrient management concerns we established research plots in 2012 at the Hancock Agricultural Experiment Station. In 2012, corn was grown with the following N inputs: high rate of liquid dairy manure (HLDM) (20,000 ga/ac), low rate of liquid dairy manure (LLDM) (12,000 gal/ac), solid dairy manure (SDM) (35 ton/ac), and no manure (NONE). The liquid and solid dairy manure were separated liquids and solids, respectively. Manure was applied April 27, 2012, and corn was planted on May 15, 2012 at 31,200 seeds/acre. No starter fertilizer was applied to corn. The manure was applied in 30 ft widths and was applied to the length of the field (~450 ft). In 2012, supplemental N was added to all treatments to apply between 198 and 205 lb-N/ac.

Phosphorus treatments. In the potato phase of production, large manure treatment strips were split into three replicated blocks of four P treatments: none, 30 lb/ac of P (a minimum application), 165 lb/ac of P (a maximum application), and a P application that represents the difference between 165 lb/ac of P and the P applied with manure the previous year (i.e. the "balance" treatment). The P rates for the balance treatment in 2013 were: SDM=123 lb-P/ac, LLDM=97 lb-P/ac, and HLDM=51 lb-P/ac. Technically, the balance treatment for the no manure strip would be the 165 lb/ac rate. Four our purposes, we used 67 lb/ac, an in-between rate. The P was applied as MAP and applied by hand after planting, but before row closure. In 2013, the potato variety used was Russet Norkotah.

Results and Discussion

When solid manure was applied the previous year, potato yields increased with increase P rates (Table 1). This indicates that the P applied in solid manure does not provide any carry over value to the next potato crop. With high and low rates of liquid fertilizer, yield gains were observed with the “balanced” P rate, but not with the full 165 lb/ac rate. This would indicate that liquid manure may have some carry-over benefits. Interestingly, when no manure was applied the previous year, we did not detect a benefit to MAP application, but yields were also much lower in this treatment strip. The effects of additional MAP applications were expressed in an increase in petiole P concentrations, but only at 30 and 45 days after emergence. At 60 and 75 days after emergence, there was no difference in petiole P concentrations.

Table 1. Russet Norkotah yields in 2013 at Hancock ARS with different P application rates (SE=standard error).

2012 Manure	2013 P rate	Total Yield Average	SE	Marketable Yield Average	SE
	lb-P_2O_5/ac	-------------------------- cwt/ac		--------------------	
None	0	479	36	398	29
	30	457	30	377	25
	67	429	45	333	47
	165	459	47	382	39
Solid	0	501	16	428	19
	30	513	21	447	26
	123	549	28	475	35
	165	584	17	500	28
Liquid (low)	0	447	15	372	7
	30	487	23	397	26
	97	538	15	465	11
	165	501	17	424	15
Liquid (high)	0	551	50	494	51
	30	589	18	520	23
	51	602	52	538	56
	165	569	22	498	27

Table 2. Petiole P concentrations at 30, 45, 60, or 75 days after emergence in 2013 following different manure applications and four P application rates.

		Petiole P concentrations			
2012 Manure	2013 P rate	30d	45d	60d	75d
	lb-P_2O_5/ac	-------------------- % --------------------			
None	0	0.38	0.24	0.20	0.14
	30	0.54	0.23	0.20	0.15
	67	0.63	0.29	0.20	0.16
	165	0.74	0.45	0.21	0.15
Solid	0	0.47	0.32	0.19	0.15
	30	0.57	0.35	0.21	0.15
	123	0.74	0.41	0.18	0.15
	165	0.83	0.53	0.19	0.17
Liquid (low)	0	0.39	0.39	0.20	0.14
	30	0.41	0.33	0.23	0.11
	97	0.59	0.44	0.19	0.12
	165	0.69	0.59	0.20	0.17
Liquid (high)	0	0.51	0.31	0.18	0.16
	30	0.63	0.34	0.17	0.14
	51	0.61	0.29	0.19	0.14
	165	0.65	0.37	0.19	0.15

National Verticillium Wilt Trial

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This trial is carried out annually at the Hancock Agricultural Experiment Station on a field that has been inoculated with *Verticillium dahliae*. Breeders are asked to submit selections from their breeding programs. Typically, these are advanced lines that may be released as cultivars. Information about Verticillium wilt (VW) resistance is useful when considering the merits of a line as a potential cultivar.

We have not been able to identify a single scoring strategy that effectively characterizes the resistance level of a breeding line. Consequently, we use multiple measures of resistance. First, we look at symptom expression throughout the growing season. Especially early in the season, we are able to see VW symptoms as wilting and yellowing. As the season progresses, though, it becomes increasingly difficult to distinguish between poor plant health due to VW and that due to maturity and other diseases. Another limitation of scoring symptom expression is that it does not identify symptomless carriers of the pathogen. A second scoring criterion is the number of fungal spores (conidia) in the sap of green plants. We collect green stems and squeeze a known amount of sap onto petri dishes containing a medium conducive to growth of the fungal spores. Then, after a two week incubation period, we count the number of colonies that grew. A large number of colonies indicates that the fungus was able to reproduce readily in the living plants. When the plant begins to die at the end of the growing season, the fungus moves from the vascular tissue into adjacent regions and forms resting spores (microsclerotia). So, a third measure of VW resistance is the ability of the fungus to produce these resting spores. They add to the inoculum in the soil, so it is important to identify potato varieties that do not add large numbers of microsclerotia to the soil. We collect stems from dead plants at the end of the season, dry the stems, grind them in a mill and plate the powder on petri dishes containing the selective medium. Again, we count colonies after a two week incubation period. Colony counts from dry stems are typically lower than those from sap. The two values are sometimes, but not always, correlated with each other. Our final measure of VW resistance is yield in the presence versus the absence of the pathogen. We compare yield in our VW screening field with that in an adjacent field that was fumigated before planting. Our small plot sizes (only 5 hills) limit the reliability of this measure, so we only use it for the seven cultivar standards that are in the field every year.

In 2013, the National Verticillium Wilt Trial was planted in three plots were planted on May 8. Each plot consisted of three replications of five-hill units of 60 cultivars and advanced selections from the U.S. potato breeding programs. Plot A was planted on a fumigated field and was used to evaluate yield. It included only the seven cultivar standards. Plot B was planted on a nearby field that was inoculated with *V. dahliae* in 2006 and has been maintained as a VW screening plot. This field was used to evaluate disease symptom expression, yield in the presence of *V. dahliae*, and colonization of dead (dry) stems. Plot C was also planted on the inoculated field and was destructively sampled during the summer to evaluate colonization of sap in green stems.

On July 22 and August 5 and 27, plants in Plot B were scored for percent foliage expressing Verticillium wilt symptoms. On August 5, stems from all clones in Plot C were collected, surface disinfested, and squeezed in a vice to collect sap for plating. For each plot, 100 ul of sap was plated on selective medium and the plates were incubated in the dark for two weeks. After that, they were microscopically examined to determine the number of colony forming units per 100 ul of sap. After vine kill, stems were collected from all clones in the Plot B field and allowed to air dry at room temperature. All main stems from a plot were ground in a Wiley mill and 50 mg per plot was plated on selective medium. On September 11, the seven cultivar standards in Plots A and B were harvested with a single row digger, and tubers from each plot were picked up by hand and weighed. In 2013, variability among trial clones was high for all measures of resistance. Consequently, 2013 was a good year for distinguishing between resistant and susceptible clones.

Symptom, sap and dry stem data from the trial clones are presented in the table below. The entries were placed in two groupings, early to mid-season vine maturity and mid- to late season vine maturity. Late season clones tend to have lower symptom expression due to immature plant resistance. Symptoms were scored as the percent diseased foliage on July 22 (Vrt722), August 5 (Vrt805), and August 27 (Vrt827). The area under the disease progress curve (AUDPC) was calculated based on the three score dates. The average AUDPC of the earlier maturing clones (996) was twice as high as that of the later maturing ones (491). The number of colony forming units per 100 ul sap in green stems (sap) and per 50 mg dead dry stems (dry) was also recorded. It is common to observe differences among replications across the field, likely due in part to variability in pathogen inoculum density. An average across replications may mask these differences, so data from each replication are presented. To the left of the data set, I have indicated clones that appear to have good (*) and very good (**) resistance to VW. These clones have consistently low early season symptom expression and low stem colonization in all three replications. I tend to weight the sap scores more heavily than the others. Clones with very low sap scores in all three replications and low dry stem scores are likely the most resistant. Low symptom scores, especially during the early season, are also important. A high score, even in only one replication, likely indicates the potential to be heavily colonized by the pathogen. The best resistance among the earlier maturing clones was found in CO02024-9W (CSU), MSQ086-3 (MSU), MSS576-05SPL (MSU), W6703-5Y (UW), and W8152-1rus (UW). Among the later maturing clones, the highest levels of resistance were observed in A02424-83LB (USDA-Aberdeen), AF4573-2 (UM), MSS176-1 (MSU), and MSS487-2 (MSU). Earlier maturing clones with good apparent resistance include Accumulator (UW), AF4320-17 (UM), B3054B-24 (USDA-Beltsville), W5015-12 (UW), and later maturing ones include A02507-2LB (USDA-Aberdeen) and B2728-5 (USDA-Beltsville). The program responsible for developing and testing each clone is listed after the clone name (CSU = Colorado State University, UM = University of Maine, MSU = Michigan State University, and UW = University of Wisconsin). It is encouraging that several state and federal programs have advanced selections with potentially high levels of resistance to VW.

It is important to confirm apparent resistance with a second year of testing. Of the potentially resistant clones listed above, CO02024-9W, W8152-1rus, W5015-12, and were evaluated in 2012 and demonstrated resistance in that year as well. It is reasonable to consider these clones resistant to VW. Accumulator, W6703-5Y, AF4320-17, and A02507-2LB were also in the trial in 2012, but were more susceptible in 2012, so resistance is not as stable.

The seven cultivar checks are shown in bold face in the table. Ranger Russet is considered the most resistant check and Russet Norkotah is the most susceptible check. Colonization of stem sap in Russet Norkotah was consistently high in all three replications. Ranger Russet had surprisingly high sap counts in two replications. Dry stem counts were consistently low, though. Several advanced selections appear to have higher levels of VW resistance than the Ranger Russet.

Early to mid-season vine maturity

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
	A05052-3TE (5034)	1	0	0	20	220	14	76
	A05052-3TE (5034)	2	0	0	5	55	2000	8
	A05052-3TE (5034)	3	0	0	25	275	48	0
	A99331-2Y (5005)	1	0	0	60	660	125	108
	A99331-2Y (5005)	2	0	0	50	550	160	148
	A99331-2Y (5005)	3	5	5	15	290	3000	256
*	Accumulator	1	0	15	70	1040	384	380
	Accumulator	2	10	20	60	1090	360	220
	Accumulator	3	10	10	10	360	4	3
	AF4296-3 (1219)	1	0	5	70	860	5000	352
	AF4296-3 (1219)	2	0	10	40	620	5000	2
	AF4296-3 (1219)	3	5	15	70	1075	1200	112
*	AF4320-17 (1221)	1	0	5	70	860	0	580
	AF4320-17 (1221)	2	0	10	70	950	5	2
	AF4320-17 (1221)	3	5	10	70	985	0	20
	AF4463-8 (5021)	1	0	0	40	440	0	
	AF4463-8 (5021)	2	0	5	35	475	412	
	AF4463-8 (5021)	3	0	0	25	275	3000	
	AF4532-8 (5038)	1	10	60	95	2195	4000	
	AF4532-8 (5038)	2	0	40	80	1600	4000	
	AF4532-8 (5038)	3	10	30	80	1490	5000	
	AF4614-2 (5026)	1	0	10	75	1005	400	152
	AF4614-2 (5026)	2	0	15	70	1040	4000	0
	AF4614-2 (5026)	3	0	0	70	770	580	212
	AOTX98152-3RU	1	10	30	95	1655	5000	
	AOTX98152-3RU	2	5	25	95	1530	4000	
	AOTX98152-3RU	3	10	40	90	1780	800	
	Atlantic	1	0	10	40	620	380	0
	Atlantic	2	0	10	60	840	2000	0
	Atlantic	3	0	10	60	840	8	0
	ATX91137-1RU	1	0	5	50	640	5000	0
	ATX91137-1RU	2	0	5	30	420		98
	ATX91137-1RU	3	0	0	60	660	212	212
	B2869-17 (1164)	1	5	50	95	1980	4000	
	B2869-17 (1164)	2	5	60	100	2215	5000	
	B2869-17 (1164)	3	10	60	100	2250	5000	
	B3054A-13 (7415)	1	0	5	50	640	2000	220
	B3054A-13 (7415)	2	0	20	75	1185	2000	9
	B3054A-13 (7415)	3	0	20	90	1350		0
*	B3054B-24 (2162)	1	0	10	35	565	720	0
	B3054B-24 (2162)	2	0	10	30	510	0	17
	B3054B-24 (2162)	3	5	5	30	455	0	40

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
	BTX2332-1R	1	5	25	80	1365	800	44
	BTX2332-1R	2	5	5	50	675	800	4
	BTX2332-1R	3	5	10	80	1095	460	48
**	CO02024-9W	1	5	10	50	765	0	12
	CO02024-9W	2	0	10	40	620	0	0
	CO02024-9W	3	5	20	40	835	0	3
	CO02321-4W	1	0	15	80	1150	3000	80
	CO02321-4W	2	0	5	70	860	3000	52
	CO02321-4W	3	5	20	85	1330	3000	112
	CO03276-5RU	1	5	10	70	985	3000	
	CO03276-5RU	2	0	5	50	640	4000	
	CO03276-5RU	3	5	10	8	303	1720	
**	MSQ086-3	1	0	5	30	420	0	52
	MSQ086-3	2	0	0	30	330	0	0
	MSQ086-3	3	0	0	20	220	0	20
	MSR061-1	1	0	20	80	1240	640	36
	MSR061-1	2	0	10	50	730	2000	0
	MSR061-1	3	0	5	75	915	8	64
	MSS206-2	1	0	0	20	220	61	16
	MSS206-2	2	0	0	20	220	3000	0
	MSS206-2	3	0	0	40	440	660	6
**	MSS576-05SPL	1	0	5	60	750	0	0
	MSS576-05SPL	2	0	5	30	420	48	81
	MSS576-05SPL	3	10	15	60	1000	11	40
	NDTX5438-11R	1	5	35	90	1655	3000	
	NDTX5438-11R	2	5	20	80	1275	4000	
	NDTX5438-11R	3	5	40	95	1800	4000	
	Ranger Russet	1	0	0	60	660	3000	98
	Ranger Russet	2	0	0	40	440	0	35
	Ranger Russet	3	10	10	40	690	540	1
	Red Norland	1	10	30	100	1710	0	104
	Red Norland	2	15	60	100	2285	3000	11
	Red Norland	3	15	75	100	2555	2000	680
	Russet Norkotah	1	5	70	100	2395	3000	1400
	Russet Norkotah	2	10	60	100	2250	3000	3
	Russet Norkotah	3	15	60	100	2285	4000	82
	Sierra Rose	1	5	40	90	1745	0	
	Sierra Rose	2	5	40	95	1800	3000	
	Sierra Rose	3	5	30	95	1620	5000	
	Superior	1	5	50	100	2035	2000	0
	Superior	2	20	80	100	2680	3000	0
	Superior	3	10	60	100	2250	3000	52

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
*	W5015-12	1	0	5	40	530	860	64
	W5015-12	2	0	0	50	550	60	11
	W5015-12	3	0	0	20	220	0	42
	W5015-5	1	0	5	30	420	3000	0
	W5015-5	2	0	0	40	440	560	9
	W5015-5	3	10	10	40	690	396	520
	W6609-3	1	5	20	60	1055	2000	
	W6609-3	2	0	0	50	550	3000	
	W6609-3	3	5	15	70	1075	72	
	W6703-1Y	1	5	15	40	745	3000	262
	W6703-1Y	2	5	20	60	1055	0	1160
	W6703-1Y	3	15	15	60	1035	312	608
**	W6703-5Y	1	0	15	40	710	0	136
	W6703-5Y	2	5	10	40	655	170	1
	W6703-5Y	3	5	5	10	235	35	12
**	W8152-1rus	1	10	15	50	890	0	4
	W8152-1rus	2	15	20	60	1125	0	115
	W8152-1rus	3	5	5	60	785	0	64
	White Pearl	1	0	10	40	620	4000	10
	White Pearl	2	0	15	70	1040	620	300
	White Pearl	3	5	15	85	1240	0	960

Mid- to late season vine maturity

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
**	A02424-83LB 5023)	1	0	0	30	330	14	0
	A02424-83LB 5023)	2	0	0	35	385	50	2
	A02424-83LB 5023)	3	0	0	10	110	0	4
*	A02507-2LB	1	0	0	20	220	248	8
	A02507-2LB	2	0	0	10	110	0	0
	A02507-2LB	3	0	0	10	110	448	0
	A03921-2 (5030)	1	0	25	60	1110	2000	28
	A03921-2 (5030)	2	0	20	50	910	4000	10
	A03921-2 (5030)	3	10	25	75	1345	408	28
	AC03433-1W	1	0	0	20	220	1200	48
	AC03433-1W	2	0	0	15	165	208	1
	AC03433-1W	3	0	0	40	440	248	0
	AF4320-7 (1220)	1	0	0	30	330	0	48
	AF4320-7 (1220)	2	0	5	40	530	2000	720
	AF4320-7 (1220)	3	0	0	0	0	0	56
	AF4342-3 (1223)	1	0	0	15	165	5000	
	AF4342-3 (1223)	2	0	0	40	440	3000	
	AF4342-3 (1223)	3	0	0	25	275	3000	

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
**	AF4573-2 (5025)	1	0	30	60	1200	48	8
	AF4573-2 (5025)	2	0	0	25	275	70	12
	AF4573-2 (5025)	3	0	0	60	660		20
*	B2728-5 (1290)	1	0	0	20	220	640	112
	B2728-5 (1290)	2	0	0	25	275	6	0
	B2728-5 (1290)	3	0	0	5	55	0	0
	BNC244-10 (1263)	1	0	0	80	880	4000	
	BNC244-10 (1263)	2	0	20	70	1130	4000	6
	BNC244-10 (1263)	3	0	0	70	770	5000	
**	MSS176-1	1	0	0	5	55	0	68
	MSS176-1	2	0	0	10	110	0	0
	MSS176-1	3	0	0	10	110	20	4
**	MSS487-2	1	0	10	30	510	0	122
	MSS487-2	2	0	0	10	110	52	17
	MSS487-2	3	0	0	15	165	110	15
	Russet Burbank	1	5	20	95	1440	2000	3
	Russet Burbank	2	0	10	80	1060	225	13
	Russet Burbank	3	5	25	90	1475	3000	10

Stem End Defect Trials 2012-2013

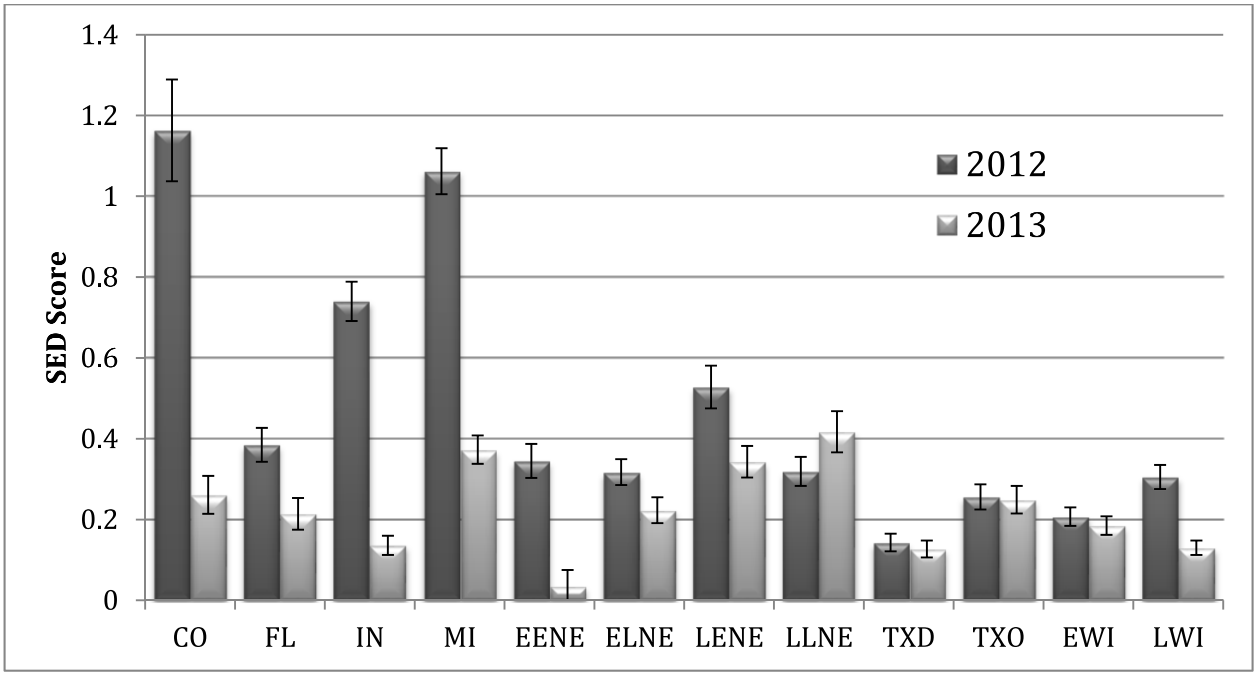
Lynn Dickman, A.J. Bussan, Mike Drilias, Bill Schmitt, and Yi Wang

Introduction: Stem-end chip defect (SED) has become a challenging storage problem for chip growers in the past several years. This is a serious issue for the potato chip industry as entire shipments of chip potatoes are rejected by processing plants due to the dark-colored vasculature and adjacent tissues in the tuber stem-end. The defect is extremely erratic over years, locations, and varieties. This has made it extremely difficult to determine the conditions under which SED develops and to be able to fabricate a model to predict the incidence and severity of the defect. Recent research studies have determined that heat stress is responsible for a portion of the defect's occurrence (Wang et al. 2012) but there are still many other factors contributing that have not been quantified yet.

Materials and Methods: Trials were conducted in cooperation with Heartland Farms, Walther Farms, and CSS Farms in 2012 and 2013 across eight operations. Locations included Bascom, FL; Olton, TX; Carlisle, IN; Kearney, NE; Wray, CO; Hancock, WI; Three Rivers, MI; and Dalhart, TX. Each trial included 9 varieties. These varieties were Accumulator, Atlantic, Lamoka, Megachip, MSL 292-A, Nicolet, Pike, Snowden, Harley Blackwell (only 2012), and W 5015-12 (only 2013). Evaluations of fry color, stem-end sucrose and glucose, and tuber sucrose and glucose were conducted at harvest and 2, 4, and 8 weeks post harvest. Objectives of the trials were to identify chipping potato varieties tolerant to growing conditions that lead to the development of SED; evaluate SED incidence and severity across multiple locations and years; quantify growing conditions which promote the highest incidence of SED; and determine if there is a correlation between tuber stem-end sucrose or glucose contents and the severity of SED.

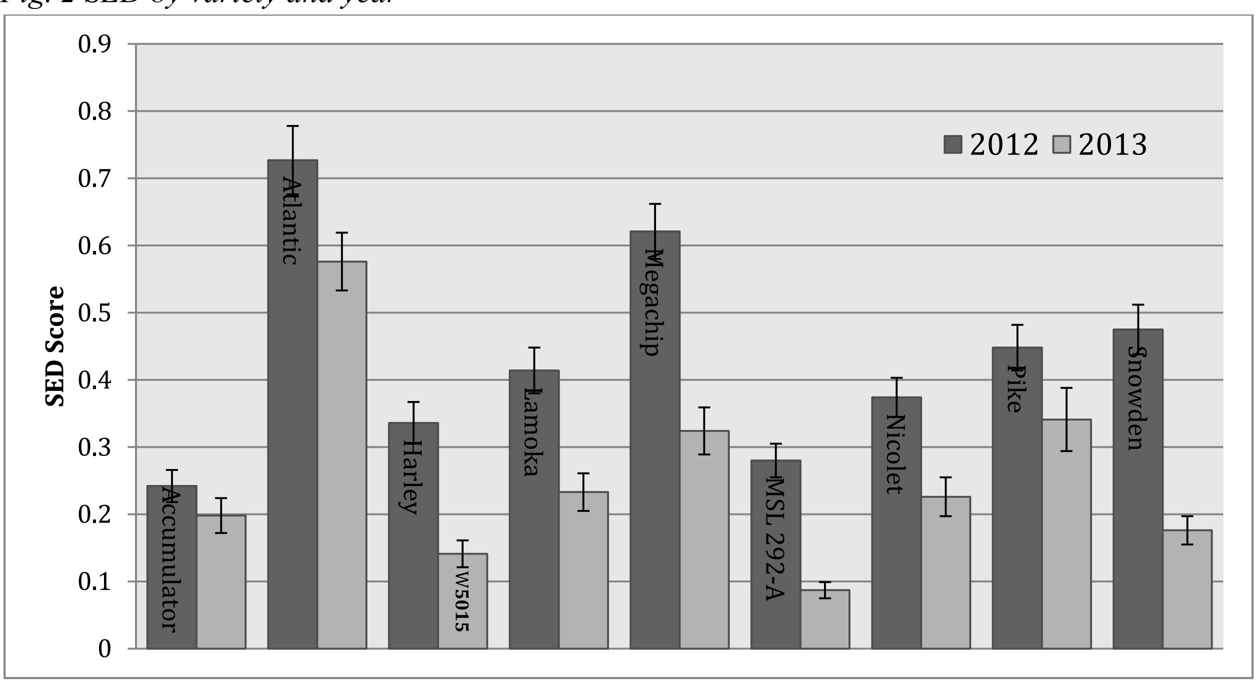
Results: The defect was observed in the 2012 and 2013 trials but at much lower level seen in 2006, 2010, and 2011. Extremely hot, dry weather stifled the majority of the country in 2012 with little to no precipitation. Much cooler weather with a relatively wet spring and dry summer was prevalent in 2013 across the country. Due to these weather differences, SED had a higher incidence across sites in 2012 versus 2013. Michigan and Colorado expressed the highest amount of SED in both years. Late planted and early harvested tubers from Nebraska were also problematic in both years, possibly due to chemical immaturity. Indiana showed strong SED in 2012 while Olton, TX had nearly identical SED in 2012 and 2013.

Fig. 1 SED by location and year



Differences between variety tolerances were documented quite well over the two years. Atlantic, Megachip, and Pike showed the highest susceptibility in both years of the trials. MSL 292-A was the most tolerant to SED out of the varieties trialed.

Fig. 2 SED by variety and year



Senescence sweetening of chip and fry processing potatoes

Amy Wiberley-Bradford and Paul Bethke

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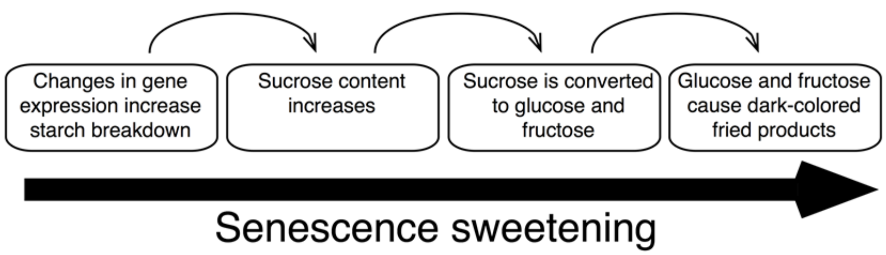
Potato storage makes the crop available over an extended time period, but it increases financial risk to growers and end users. Senescence sweetening limits storage duration for chip and fry processing potatoes because it results in an unacceptable accumulation of reducing sugars that result in dark-colored fried products. Improved methods to monitor crop status in storage have the potential to reduce the risk associated with senescence sweetening.

Sugar accumulation is the defining characteristic of senescence sweetening

Senescence sweetening is characterized by an irreversible accumulation of sucrose and the reducing sugars glucose and fructose. As illustrated in the figure below, it is a multi-step process in which only the final step has an observable effect on processing quality.



Senescence sweetening is developmentally regulated, but it is influenced by environmental conditions during tuber growth and storage. In general, conditions that contribute to accelerated physiological ageing of tubers, such as early tuber initiation, a stressful field season, and relatively warm storage temperatures, decrease the amount of time between harvest and the onset of senescence sweetening. Seed can have an effect on senescence sweetening to the extent that seed age influences the time of tuber initiation. Individual tubers begin to sweeten at different times; this likely reflects their different life histories, including time of initiation and placement in the hill. Chemical sprout inhibitors delay sweetening relative to untreated tubers, but senescence sweetening occurs even when sprout control is effective. Warming stored tubers in an attempt to remove accumulated sugars by reconditioning is unlikely to alleviate senescence sweetening and may make the problem worse. This is one key way in which senescence sweetening differs from cold-induced sweetening. Very little is understood about the genetic, molecular, or biochemical regulation of senescence sweetening.

Senescence sweetening occurs at different times in different varieties

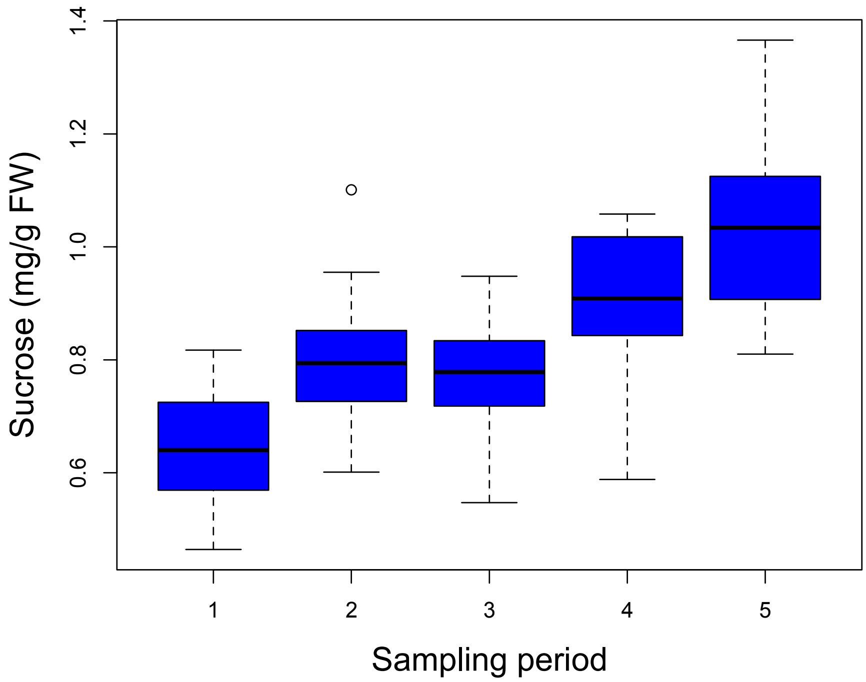
Varieties differ widely in the time at which senescence sweetening may be expected to appear, but there is a characteristic time of sweetening for each variety. For some varieties, sweetening may occur within a month of harvest, but for others it occurs many months later. A typical timeframe is 5-6 months after harvest. A simple relationship between the length of the dormant period and the onset of senescence sweetening does not exist, although sweetening usually begins earlier in varieties with short dormancy. Potato genotypes that have delayed senescence sweetening and maintain acceptable chip or fry processing quality for up to 9 months of storage are highly valued by industry and the potato breeding community. Examples include Russet Burbank, Lamoka, Lelah and FL1879. These genotypes are rare but fill a need for summer potatoes across the Northern tier production region.

Monitoring tubers in storage reduces the risk of defects from senescence sweetening
Regular fry tests can be used to monitor crop status in storage with regard to the development of senescence sweetening. The appearance of chips or fries with dark color in the center of the fried product indicates that senescence sweetening has begun. An advantage of fry tests is that they are amenable to sampling many individual tubers. From this one can determine directly the percentage of tubers that have sweetened in any given week. When senescence sweetening is observed in fry tests, it is recommended that tubers be shipped for processing relatively soon, before defects related to accumulation of reducing sugars result in a loss of crop value.

Sugar monitoring is a well-established method for detecting the onset of senescence sweetening, and it has the potential to identify the onset of sweetening earlier than fry tests. As diagrammed above, an accumulation of sucrose occurs prior to the accumulation of reducing sugars that cause dark-colored fried products. By monitoring tuber sucrose status, it is possible to anticipate changes in fry color. A disadvantage of typical sugar monitoring procedures is that tissue from several tubers is combined for the analysis. This decreases the sensitivity of the assay and makes it difficult to estimate the percentage of tubers undergoing sweetening.

We hypothesize that changes in the expression of genes involved in carbohydrate metabolism can be used to detect the onset of senescence sweetening. Research in this area began in 2012-2013. During the past year we collected sugar (sucrose, glucose and fructose) data every two weeks from 20 individual Snowden tubers grown at Hancock and stored at 48˚F in the Hancock Storage Research Facility. We made chips from the same tubers to assess visible expression of senescence sweetening. Sampling began on March 21, when few chips showed signs of senescence sweetening, and ended on May 16, when some but not all of the chips had sweetened. We also isolated RNA from the same tubers and determined mRNA abundance for 8 genes involved in tuber carbohydrate metabolism.

Sucrose data from this experiment are shown in the boxplots below. Average sucrose increased from 0.65 mg/g fresh weight at the beginning of the experiment, on March 21, to over 1 mg/g fresh weight at the end of the experiment, on May 16. On any sampling date, however, the individual tubers had a wide range of sucrose values, indicating that they differed in physiological age. We found a consistent relationship between increased tuber sucrose and decreased abundance of genes such as *AGPase* that promote starch synthesis. We also observed an increase in expression of the gene for vacuolar invertase, which converts sucrose to reducing sugars. These data indicate that senescence sweetening may result from a decrease in the rate at which starch is resynthesized from sugars in stored tubers. This in turn could shift the flow of carbohydrate toward sucrose formation, with reducing sugar accumulation resulting from invertase activity.



Boxplot of sucrose in Snowden tubers at two-week intervals from March 21 to May 16. Average sucrose values are indicated by dark horizontal bars through the middles of the boxes. Twenty-five percent of the data are above the top of the box and 25% are below the bottom of the box. Thin horizontal lines at the ends of the dashed vertical line indicate maximum and minimum values, excluding the single outlier that is indicated by a small circle in sampling period 2.

Geri Barone, Professional Food Safety - The Future of Food Safety and Preparing for Audits - A Panel Discussion

1:30-1:50
What's trending in Food Safety Audits:
An overview of options for Food Safety Certification, as well as outlining many common non-conformities from audits which can be avoided through proper preparation. Also an update of where the FDA is in passing the FSMA rules.

Certifications available, Common Pitfalls and Mistakes by Auditees, Most Common Non-conformities, FDA Food Safety Modernization Act Timeline/Update

1:50-2:10
Developing a sound and workable Food Safety Plan
Many audits now require a documented Food Safety Plan. This segment outlines the components of a Food Safety Plan.

HACCP/Pre-Requisite Programs/Management Commitment

2:10-2:30
Conducting an Honest Risk Assessment of your operation
Your Food Safety Plan will not be successful if you do not conduct an honest Risk Assessment of your operation. Explores the following areas in relation to risk.
Facility/Land Structure
Sanitation
Employees

How Produce Traceability Initiative (PTI) and Electronic Data Interchange (EDI) Interact

Todd Baggett

President and CEO, RedLine Solutions

In this session RedLine Solutions CEO, Todd Baggett, will provide a brief PTI update including discussion of how the Produce Traceability Initiative (PTI) and Electronic Data Interchange (EDI) Interact. We will also be holding a panel discussion with WPVGA members to learn more about their PTI implementations and the impact within their organizations.

How the PTI and EDI interact

Many retailers are using EDI to streamline procurement and achieve greater efficiencies in their receiving processes. For produce, the larger retailers are using supply chain intermediaries, such as iTradeNetworks™ to assist them with sourcing, procurement, and order management. As part of their services these supply chain intermediaries handle the EDI transactions between the shippers and the retailer. While there are a handful of large shippers with direct integrations, most produce companies receive and send order information via a web portal provided by these supply chain intermediaries.

The Advance Ship Notice (ASN) provides the receiver with order and shipment information as an electronic transaction before they physically receive the product. This transaction, known as the 856 ASN, is where EDI and the PTI intersect. The PTI requires the GTIN and Lot/Batch detail at the case and pallet level. The traceability information provided by the grower gets incorporated with the shipment details contained in the ASN. In this session we will provide an overview of the interaction between the PTI and EDI, and help attendees gain a better understanding of how traceability information flows into ASN.

PTI Panel Discussion

Moderated by WPVGA Director of Promotion, Communication and Consumer Education, Dana Rady, this segment will be an interactive discussion about the PTI deployments with members Doug Bulgrin, Shed Manager for Gumz Muck Farms, Cassie Smith, Administrative & Marketing Assistant for Gumz Muck Farms, Chuck Curl, Sales Operations Manager for RPE and Todd Baggett.

Speaker Bio:

Todd Baggett, President and CEO of RedLine Solutions, has been recognized as an expert in produce traceability for over a decade. He drives RedLine Solutions' strategic direction, including growth initiatives, alliances, and product vision. As the co-chair of the PTI Technology Working Group (TWG), Todd plays a key role in leading the development and updates of PTI Best Practices.

EVALUATION OF SYSTEMIC INSECTICIDES FOR THE CONTROL OF COLORADO POTATO BEETLE, POTATO LEAFHOPPER, AND APHIDS IN POTATO, 2013

Russell L. Groves, Scott A. Chapman, Anders S. Huseth, Kenneth E. Frost, and Linda Crubaugh

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The objective of this experiment was to assess the efficacy of at-plant systemic insecticides to control insect pests in potato. This experiment was conducted at Hancock Agricultural Experiment Station (HAES) located 1.1 mile (1.8 km) southwest of Hancock, Wisconsin on a loamy sand soil in 2013. Potato, *Solanum tuberosum* cv. 'Russet Burbank', seed pieces were planted on 2 May. Seed pieces were spaced 12 inches apart within rows and rows were spaced 3 ft apart. Four-row plots were 12 ft wide by 20 ft long, for a total of 0.006 acres. Two untreated guard rows separated plots. Plots were arranged in an 8 tier design with 12 ft alleys between tiers. All plots were maintained according to standard commercial production practices by HAES staff. Four replicates of 10 experimental treatments and 2 untreated controls were arranged in a randomized complete block design. Seed treatments were applied in 125 ml of water per 50 lb of seed on 29 April using a single nozzle boom applying 10.8 gpa equipped with a Tee Jet XR8002VS flat fan spray tip powered by a CO_2 backpack sprayer at 30psi. In-furrow insecticides were applied at planting with a CO_2 pressurized backpack sprayer operating at 30 psi with a 2 nozzle boom with Tee Jet 8001 flat fan nozzles delivering 11 gpa. Furrows were cut using a commercial potato planter without closing discs attached. Immediately after the in-furrow treatments were applied and all seed piece treatments were placed in open furrows, all seed was covered by hilling.

Stand counts were conducted on 11 June (40 DAP) by counting the number of emerged plants per 20 ft. section of row. Efficacy of CPB control was assessed by counting the number of stadia per plant on 10 randomly selected plants in each plot. Defoliation ratings (% DF) were determined by visual observation of the entire plot. CPBs were recorded in the following life stages: adults (A), egg masses (EM), small larvae (SL), large larvae (LL). Potato leafhoppers were recorded as nymphs (N) or adults (A). Adult PLH were sampled using sweep net techniques (15 sweeps per plot). PLH nymphs and aphids were assessed by visual inspection of 25 leaves per plot. Insect counts occurred on several dates throughout the summer, and insect count averages reflect time periods during the summer when specific life stages peaked in the plots (**Table 1**). Means were separated using ANOVA with a Fisher's Protected LSD means separation test (P=0.05). No signs of phytotoxicity were observed among experimental treatments.

Table 1.

Treatment	Rate	Type[1]	CPB-A 19 Jun	CPB-EM 19 Jun	CPB-SL 1 Jul	CPB-LL 8 Jul	%DF 15 Jul	PLH-A 8 Jul	PLH-N 8 Jul	Aphids 8 Jul
Untreated	-	-	7.0 a	13.8 ab	200.3 ab	153.0 a	55.0 a	0.8 c	6.0 a	2.3 a
Verimark 200 SC	0.47 fl oz/cwt	S	10.3 ab	12.0 abc	163.8 abc	78.8 bc	18.0 cd	1.0 c	0.5 cd	0.0 b
Verimark 200 SC	0.62 fl oz/cwt	S	9.3 ab	20.3 a	179.5 abc	56.3 bc	16.3 c	3.0 bc	2.5 a-d	0.0 b
AdmirePro 4.6 FS	0.35 fl oz/cwt	S	8.3 ab	12.3 abc	167.5 ab	111.3 abc	12.5 cd	1.5 c	0.0 d	0.3 b
Cruiser 5 FS	0.16 fl oz/cwt	S	12.3 a	10.5 bc	280.8 a	109.0 ab	34.3 b	0.5 c	0.0 d	0.0 b
Belay 2.13 SC	0.6 fl oz/cwt	S	11.0 ab	4.3 d	80.5 bc	50.5 cd	11.3 cd	1.0 c	0.0 d	1.0 ab
Platinum 75 SG	2.66 oz wt/a	IF	9.3 ab	7.3 c	53.3 c	26.5 de	3.8 cd	2.8 c	0.8 bcd	0.0 b
Verimark 200 SC	10.3 fl oz/a	IF	10.3 ab	8.3 bc	67.5 c	19.0 e	3.8 cd	8.0 ab	5.3 a	0.0 b
Verimark 200 SC	13.5 fl oz/a	IF	8.0 ab	10.5 bc	60.3 c	22.0 e	3.8 cd	10.5 a	5.0 a	1.0 ab
AdmirePro 4.6 FS	8.7 fl oz/a	IF	7.3 ab	7.0 cd	116.5 abc	55.8 cd	11.8 cd	0.5 c	0.0 d	0.0 b
Belay 2.13 SC	12 fl oz/a	IF	6.0 b	0.8 e	14.5 d	5.0 f	1.3 d	2.8 c	2.0 a-d	0.0 b
Untreated		-	5.5 b	11.5 abc	175.8 ab	161.3 a	37.5 b	1.3 c	5.0 abc	0.5 b
		LSD	0.28	0.25	0.44	0.35	14.63	5.2	4.72	1.6
		P	0.3602	0.0001	0.0001	0.0001	0.0001	0.0054	0.0424	0.1569

Means not follow by the same letter in columns are significantly different (α=0.05).
[1]IF = In furrow, S = Seed treatment

FULL SEASON INSECTICIDE MANAGEMENT PROGRAMS FOR THE CONTROL OF COLORADO POTATO BEETLE IN WISCONSIN POTATO, 2013.

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The purpose of this experiment was to evaluate various full-season, reduced-risk, insecticide programs designed to manage Colorado potato beetle (CPB) on potatoes in Wisconsin. With developing neoicotinoid insecticide resistance among CPB populations in the potato production areas in Wisconsin, several systemic based and foliar based programs were designed to evaluate their effectiveness on managing the CPB on potato. This experiment was conducted in 2013 on a loamy sand soil at Hancock Agricultural Research station (HAES) located 1.1 mile (1.8 km) southwest of Hancock, Wisconsin. Potato, *Solanum tuberosum* cv. 'Russet Burbank', seed pieces were planted on 2 May. Plants were spaced 12 inches apart within rows and rows were spaced 3 ft apart. The 8-row plots were 24 feet wide by 40 feet long, for a total of 0.025 acres/plot. Replicates were separated by a 5 ft border of bare ground. Three replicates of 15 full-season insecticide programs were arranged in a randomized complete block design. Systemic insecticides were applied in-furrow at planting (2 May for treatments 1-6). The first application of Rimon (treatment 7) was made on 14 Jun. The first foliar insecticide applications were applied after peak egg hatch and prior to large larval population development (21 Jun, for treatments 7-15). Subsequent applications were made on 28 Jun (for treatments 7-15) and 25 Jul (for all treatments, including at plant treatments). Treatment information is available in **Table 1**. All in-furrow treatments were applied at 11.0 gpa on 2 May using a two nozzle boom equipped with Tee Jet XR8001 flat fan spray nozzles powered by a CO_2 backpack sprayer at 30psi. Furrows were cut using a commercial potato planter without closing discs attached. Immediately after the in-furrow treatments were applied and all seed piece treatments were placed in open furrows, all seed was covered by hilling. Foliar insecticides were applied using a CO_2 pressurized sprayer with a 24 ft boom operating at 30 psi delivering 20 gpa through 16 Tee Jet XR8002XR flat fan nozzles spaced 18" apart while travelling at 4.0 ft/sec. The efficacy of treatments was assessed by counting the number of egg masses (EM), small larvae (SL), and large larvae (LL) per plant on 10 randomly selected plants in each plot. Percent defoliation (% DF) ratings were taken by visual observation of the entire plot. Potato leafhopper (PLH), *Empoasca fabae,* efficacy was assessed by counting the number of adults collected from 15 sweep net samples in each plot. Aphid and potato leafhopper nymph populations were surveyed by visual assessment of 25 leaves per plot. Insect counts occurred on several dates throughout the summer and reported means were averaged across those dates (**Tables 2 &3**). Insect count averages reflect time periods during the summer when specific life stages peaked in the plots. Yield and quality data were collected after harvest (11 Sep) (**Table 4**). Means were separated using ANOVA with a

Fisher's Protected Least Squared Difference (LSD) mean separation test (P=0.05). No signs of phytotoxicity were observed among treatments.

Table 1.

	1st generation CPB				2nd generation CPB			
Trt	**AppDate**	**Insecticide**	**Rate**	**[†]Type**	**AppDate**	**Insecticide**	**Rate**	**[†]Type**
1	2-May	Platinum 75 SC	2.67 fl oz/a	IF	28-Jun	[a]Besiege 1.25 ZC	9 fl oz/a	F
					25 Jul	[a]Besiege 1.25 ZC	7.5 fl oz/a	F
2	2-May	Belay 2.13 SC	12 fl oz/a	IF	28-Jun	[a]Agri-Mek 0.7 SC	3.5 fl oz/a	F
					25 Jul	[a]Agri-Mek 0.7 SC	3.0 fl oz/a	F
3	26-Apr	[a]Verimark 20 SC	10 fl oz/a	IF	28-Jun	Assail 30 SG	4 oz wt/a	F
	21 Jun	Blackhawk 36 WG	3.3 oz wt/a	F	25-Jul	Assail 30 SG	3 oz wt/a	F
4	26-Apr	Verimark	13.5 fl oz/a	IF	28-Jun	[a]Actara 25 WDG	3 oz wt/a	F
	21-Jun	[b]Agri-Mek 0.7 SC	3.5 fl oz/a	F	25-Jul	[a]Actara 25 WDG	2.5 oz wt/a	F
5	2-May	Admire Pro 4.6SC	8.7 fl oz/a	IF	28-Jun	[b]Radiant 1 SC	8 fl oz/a	F
	21-Jun	Agri-Mek 0.7 SC	3.5 fl oz/a	F	25-Jul	[b]Radiant 1 SC	6 fl oz/a	F
6	2-May	Scorpion 3.24 SC	13.25 fl oz/a	IF	28-Jun	[b]Athena 0.87 SC	17 fl oz/a	F
	21 Jun	Blackhawk 36 WG	3.3 oz wt/a	F	25-Jul	[b]Athena 0.87 SC	17 fl oz/a	F
7	14-Jun	[c]Rimon 0.83 EC	10 fl oz/a	F	25-Jul	[d]Exirel 10 SE	6.75 fl oz/a	F
	21-Jun	[c]Rimon 0.83 EC	7 fl oz/a	F				
	28-Jun	[c]Rimon 0.83 EC	7 fl oz/a	F				
8	21-Jun	[d]Coragen 1.67 SC	5 fl oz/a	F	25-Jul	[c]Admire Pro 4.6SC	8.7 fl oz/a	F
	28-Jun	[d]Coragen 1.67 SC	3.5 fl oz/a	F				
9	21-Jun	[b]Agri-Flex 1.55 EC	8.5 fl oz/a	F	25 Jul	[d]Besiege 1.25 ZC	9 fl oz/a	F
	28-Jun	[b]Agri-Flex 1.55 EC	6 fl oz/a	F				
10	21-Jun	[b]Blackhawk 36 WG	3.3 oz wt/a	F	25-Jul	[d]Exirel 10 SE	5 fl oz/a	F
	28-Jun	[b]Blackhawk 36 WG	2.5 oz wt/a	F				
11	21-Jun	[b]Radiant 1 SC	8 fl oz/a	F	25-Jul	[d]Actara 25WDG	3 oz wt/a	F
	28-Jun	[b]Radiant 1 SC	6 fl oz/a	F				
12	21-Jun	[a]Athena 0.87 EC	17 fl oz/a	F	25-Jul	[b]Admire Pro 550 SC	1.3 fl oz/a	F
	28-Jun	[a]Athena 0.87 EC	14 fl oz/a	F				
13	21-Jun	[d]Actara 25 WDG	3 oz wt/a	F	25-Jul	[d]Besiege 1.25 ZC	9 fl oz/a	F
	28-Jun	[d]Actara 25 WDG	1.5 oz wt/a	F				
14	21-Jun	[b]Belay 2.13 SC	3 fl oz/a	F	25-Jul	[d]Coragen 1.67 SC	5 fl oz/a	F
	28-Jun	[b]Belay 2.13 SC	2.5 fl oz/a	F				
15	21-Jun	[a]Exirel 10 SE	5 fl oz/a	F	25-Jul	[a]Belay 2.13 SC	3 fl oz/a	F
	28-Jun	[a]Exirel 10 SE	3 fl oz/a	F				

[†]F=foliar, IF=In furrow,
[a]MSO 100 L added at 0.25% v/v
[b]NIS 100 L added at 0.25% v/v
[c]Silwet 100 L added at 0.25% v/v
[d]MSO 100L added at 0.5% v/v

Table 2.

Trt	Adults	Egg Masses	Small Larvae	Large Larvae	% Defoliation
1	9.5 a	2.1 a	3.3 e	3.5 cde	0.1 d
2	7.6 a	1.4 a	3.8 cde	5.6 bcd	0.1 d
3	4.9 bc	1.3 a	7.9 abc	4.0 bcd	0.3 bcd
4	2.5 de	0.9 a	2.7 de	0.5 f	0.1 d
5	3.5 de	2.2 a	6.2 abc	1.8 de	0.1 d
6	7.9 ab	1.5 a	18.0 abc	7.9 ab	1.3 a
7	4.7 ab	1.3 a	13.9 ab	5.2 bcd	0.4 bcd
8	6.7 ab	1.6 a	13.5 ab	4.8 bcd	1.1 ab
9	2.2 de	1.5 a	12.5 abc	1.2 ef	0.3 cd
10	6.5 ab	1.3 a	10.3 abc	5.9 bcd	0.4 bcd
11	7.7 ab	1.5 a	12.1 abc	5.2 bcd	0.3 cd
12	6.8 ab	1.0 a	11.4 abc	6.2 a	0.9 abc
13	4.2 bc	1.1 a	5.1 bcd	4.3 bcd	0.2 d
14	3.9 bc	1.5 a	7.2 abc	3.7 bcd	0.4 bcd
15	1.6 e	1.3 a	3.5 cde	1.8 ef	0.2 d
P	0.0001	0.7618	0.0024	0.0001	0.0305
LSD	0.147	0.146	0.185	0.157	0.157

Table 3.

Trt	PLH adults	PLH nymphs	Aphids
1	0.5 de	0.1 cd	0.1 a
2	0.6 de	0.0 d	0.3 a
3	3.5 a	0.5 bc	0.5 a
4	3.5 a	1.4 a	0.4 a
5	0.3 e	0.1 cd	0.0 a
6	0.5 de	0.6 ab	0.5 a
7	2.8 ab	0.2 bcd	0.9 a
8	1.4 a-d	0.2 bcd	0.2 a
9	0.7 de	0.1 cd	0.2 a
10	1.5 b-e	0.2 bcd	1.0 a
11	2.0 abc	0.1 cd	0.6 a
12	0.4 e	0.0 d	1.7 a
13	0.8 de	0.0 d	0.5 a
14	0.9 cde	0.3 bcd	0.2 a
15	2.4 abc	0.2 bcd	0.3 a
P	0.0004	0.0023	0.141
LSD	0.158	0.0800	0.1012

Table 4.

Trt	Total US #1 (lbs)	Proportion US Aphids #1s A	CWT/A
1	98.8 a	85.1 a	38.6 a
2	110.1 a	90.4 a	41.0 a
3	92.6 a	86.3 a	39.2 a
4	81.1 a	78.3 a	35.5 a
5	94.0 a	85.9 a	39.0 a
6	82.8 a	83.3 a	37.8 a
7	96.6 a	86.9 a	39.4 a
8	93.6 a	87.4 a	39.4 a
9	102.2 a	88.6 a	40.2 a
10	91.4 a	88.0 a	39.9 a
11	92.6 a	88.4 a	40.1 a
12	97.3 a	88.7 a	40.2 a
13	99.4 a	86.5 a	39.3 a
14	96.0 a	85.6 a	38.9 a
15	90.3 a	85.7 a	38.9 a
P	0.0959	0.0759	0.0759
LSD	15.4933	5.9718	2.71

REGISTERED AND EXPERIMENTAL FOLIAR INSECTICIDES TO CONTROL COLORADO POTATO BEETLE AND POTATO LEAFHOPPER IN POTATO, 2013

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The objective of this experiment was to assess the efficacy of foliar insecticides applied to control insect pests in potato. The trial consisted of 33 main effect treatments arranged in an randomized complete block design with four experimental replicates. Potato was machine planted on 1 May 2013 at the Hancock Agricultural Research Station in central Wisconsin. Experimental plots consisted of 2 row plots measuring 6 ft (1.8 m) wide and 20 ft (6.1 m) in length with unplanted guard rows on each side. Rows were planted on 36 inch row centers (0.9 m) with 12 inches (0.3 m) between plants with 12 ft (3.6 m) alleys separating replications. All foliar treatments were applied at 20 gpa using a four nozzle, 6 foot (1.8m) boom equipped with an XRVS 8002 flat fan spray tip powered by a CO_2 backpack sprayer operating at 30 psi. Foliar treatments were applied twice in succession when 75-90% of the first generation CPB was within the first and second stadia. Foliar applications of novaluron (Rimon 0.83EC) were initiated 14 June, one week earlier than all other treatments. The first foliar application occurred between 7:45 – 8:30 hours on 21 Jun 2013, and application conditions were recorded as a southwest wind at 9.2 mph (14.8 kph), 60.1^o F (15.6^{o}C), 51% RH, under clear skies. A second application occurred on 28 Jun 2013 between the hours of 7:00 and 8:00. Application conditions were recorded as a west wind at 8.1 mph (13 kph), 64°F (17.8°C), 87% RH, under cloudy skies. All plots were maintained according to standard commercial practices. CPB adults (AD), egg masses (EM), small larvae (SL), large larvae (LL) as well as PLH adults and nymphs were assessed by counting the number of each life stage on 10 randomly selected plants from the center two rows in each plot. CPB counts occurred five times during Jun and Jul. The first set of counts occurred on 24 and 27 Jun (3 and 6 DAT) after the first application. The second set of counts occurred on 1-3 July, 10 and 16 Jul (4-6, 13 and 19 DAT) after the second application. Adult PLH counts were performed on 25 and 27 Jun and the remainder of the counts on the same dates. Count data were log_{10} transformed prior to analysis. Means were separated using the least squared difference option in an ANOVA.

Populations of CPB were already established by the first foliar application, as defoliation estimates approached 5% in most plots. Experimental treatments were often significantly different than untreated check in the control of CPB adult, larval, and associated defoliation, although some treatments were more effective at controlling immature CPB (**Table 1**). Adult PLH pressure was moderate, and the neonicotinoid containing compounds plus the synthetic pyrethroids provided the most effective control of PLH adults. No signs of phototoxicity were observed.

Table 1.

Treatment	Rate	CPB-AD (Jul 16)	CPB-EM (Jun 24)	CPB-SL (Jun 24)	CPB-LL (Jul 3)	% Defoliation (Jul 16)	PLH (AD) (Jul 3)
Untreated	.	0.58 deghj	0.66 cfg	0.92 c-f	0.12 g-i	0.06 c	0.76 adf
Benevia OD	5 oz/a	0.95 bce	0.54 g	1.41 abd	1.32 b	0.37 b	0.66 b-eg
Exirel SE	5 oz/a	0.30 i-k	0.83 a-ch	0.73 c-f	0.0 i	0.08 c	0.93 ab
Exirel SE	5 oz/a	0.24 jk	0.68 cfg	0.76 c-f	0.22 fhi	0.05 c	0.91 ac
Exirel SE	6.75 oz/a	0.44 fhk	0.95 abf	0.54 cef	0.0 i	0.05 c	0.91 ac
Coragen 1.67 SC	4.5 oz/a	0.08 k	0.55 gh	0.75 c-f	0.43 di	0.05 c	0.89 ad
Coragen 1.67 SC	5 oz/a	0.58 deghj	0.66 cg	0.96 c-f	0.17 fhi	0.05 c	0.94 ab
EXP 1	Rate 1	0.08 k	0.76 ag	0.41 ef	0.0 i	0.05 c	1.05 a
EXP 1	Rate 2	0.22 jk	0.90 a-d	1.00 d-f	0.0 i	0.05 c	1.08 a
EXP 1	Rate 3	0.24 jk	0.93 a-c	1.07 bf	0.0 i	0.05 c	0.96 ab
AdmirePro 4.6 FS	1.3 oz/a	0.66 cghj	0.79 ag	1.04 beg	0.25 ehi	0.05 c	0.65 b-eg
Provado 1.6 F	3.8 oz/a	0.63 cghj	0.83 ag	1.01 bf	1.20 bc	0.18 c	0.60 c-eh
Leverage 360 3SC	2.8 oz/a	0.31 gk	0.90 a-d	0.77 c-f	0.58 dh	0.05 c	0.19 jk
Belay 2.13 SC	3 oz/a	1.04 ac	0.84 a-ch	0.34 fg	0.22 fhi	0.05 c	0.89 eik
EXP 2	Rate 1	0.51 ehk	0.94 a-c	1.32 a-c	0.60 d-g	0.05 c	0.71 b-e
EXP 2	Rate 2	0.34 hk	0.95 a-c	1.16 be	0.08 hi	0.05 c	0.60 c-eh
Untreated	.	1.07 ac	1.04 a	1.81 ab	1.90 a	0.47 b	0.57 di
Blackhawk 36 WG	2.5 oz wt/a	0.52 ehk	0.86 a-d	1.30a-c	0.59 dh	0.05 c	0..53 efi
Blackhawk 36 WG	3.3 oz wt/a	0.78 bch	0.83 ag	0.81 c-f	0.66 d-f	0.05 c	0.38 g-ik
Warrior II 2.08 CS	1.92 oz/a	0.74 bcg-i	0.88 a-d	1.14 beg	0.81 bd	0.05 c	0.25 ik
Actara 25 WG	3 oz wt/a	0.73 cg-i	0.99 ab	0.98 c-f	0.25 ehi	0.05 c	0.34 g-ik
Endigo 2.06 ZC	4 oz/a	0.72 cg-i	0.71 beg	0.34 fg	0.29 ehi	0.05 c	0.43 efij
Endigo 2.71 ZC	4 oz/a	0.90 bce	0.81 ag	0.58 cef	0.43 di	0.05 c	0.19 jk
Besiege 1.25 ZC	9 oz/a	0.76 bcgh	0.85 a-d	0.71 c-f	0.32 di	0.05 c	0.08 k
Agri-Flex 1.55 SC	6 oz/a	0.80 bcef	0.94 a-c	0.72 c-f	0.08 hi	0.05 c	0.24 ik

Athena 0.87 EC	13 oz/a	1.03 acd	0.71 bg	0.96 c-f	0.48 di	0.05 c	0.48 efij
Athena 0.87 EC	17 oz/a	0.62 cghj	0.71 beg	0.98 c-f	0.36 di	0.06 c	0.08 k
Gladiator 0.25 EC	12 oz/a	0.76 bcgh	1.00 ae	1.01 bf	1.31 b	0.11 c	0.19 jk
Gladiator 0.25 EC	18 oz/a	0.77 bch	0.61 dgh	0.27 f	0.83 bd	0.09 c	0.34 g-ik
Brigadier 2 EC	6.14 oz/a	0.78 bch	0.73 beg	0.39 ef	0.76 c-e	0.09 c	0.38 g-ik
Untreated	.	1.46 a	0.61 dgh	20.. A	2.04 a	0.88 a	0.31hik
Rimon .083 EC	9,8,7 oz/a	0.81 bcef	0.86 a-d	1.00 bf	0.61 d-g	0.05 c	0.48 efij
Rimon .083 EC	6,6,6,6 oz/a	1.20 ab	0.78 ag	1.31 a-c	0.64 d-f	0.05 c	0.52 efij
	P	<.0001	0.0395	0.0125	<.0001	<.0001	<.0001
	LSD	0.4515	0.2927	0.8176	0.5151	0.1577	0.3328

Means in columns followed by the same letter are not significantly different (Fisher's Protected Least Significance Difference Test, P=0.05).

Environmental fate of soil applied neonicotinoid insecticides in an intensively irrigated agroecosystem.

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Summary of Problem: Most insecticides used for control of Colorado potato beetles (CPB) in the Northeast and Midwest US have failed because of insecticide resistance. Growers now rely heavily on one class of insecticides called neonicotinoids (i.e., imidacloprid, thiamethoxam). Imidacloprid resistance in CPB appeared in NY in 1997, and is now common in the northeast U.S. It appeared in the MI in 2004 and in WI in 2007. Thiamethoxam resistance appeared in 2003 in MA and NY and in MI in 2005. Growers in these regions of the US are experiencing serious problems controlling CPB. This threatens the future effectiveness of neonicotinoids for CPB control and may seriously alter the economics of potato production. We now also know that imidacloprid resistant CPB show cross-resistance to other insecticides. The effectiveness, practicality of application, and cost of alternative insecticides need to be investigated for CPB control. In addition, very little is known about how some of the novel insecticides affect imidacloprid-resistant CPB - a critical issue for the success of potato production in the future. There is growing concern about the environmental fate of pesticides used for agricultural pest management. Environmental Quality staff use data collected from regularly collected groundwater samples to inform regulatory decisions for numerous agrochemical and industrial contaminants. Thus it is important to understand the fate of pesticides in the environment.

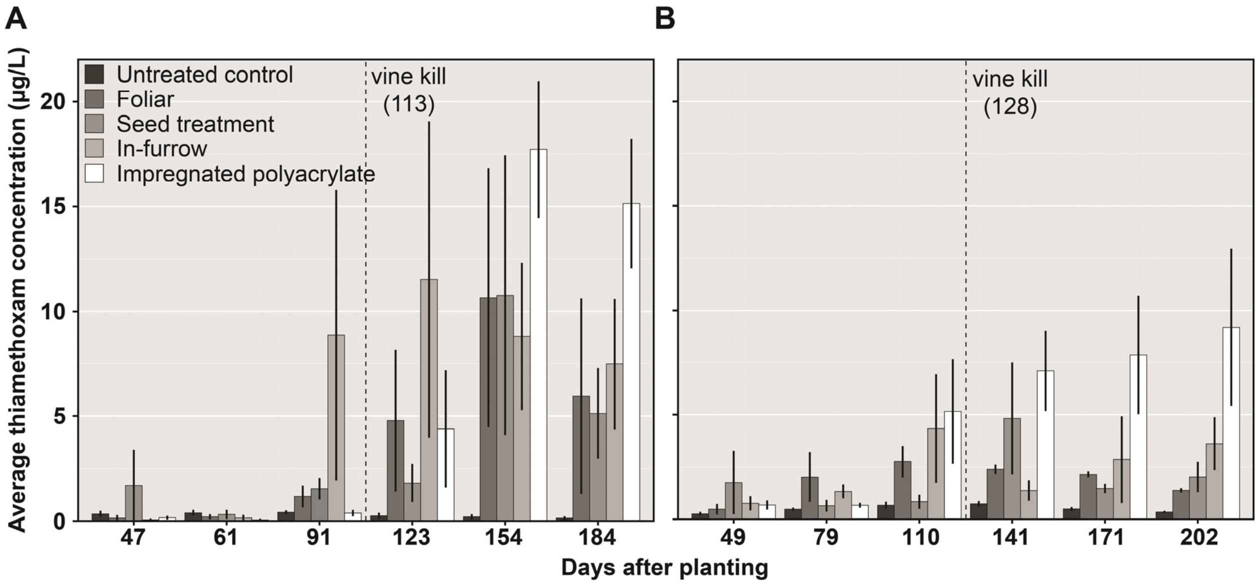
Research Summary. Since 1995, neonicotinoid insecticides have been a critical component of arthropod management in potato, *Solanum tuberosum* (L.). Recent detections of neonicotinoids in groundwater have generated questions about the sources of these contaminants, and the relative contribution from commodities in U.S. agriculture. Delivery of neonicotinoids to crops typically occurs at the time of planting and often as a seed, or in-furrow treatment to manage early season insect herbivores. Applied in this way, these insecticides become systemically mobile in potato and provide adequate control of key pest species. An outcome of this project links these soil insecticide application strategies in crop plants with neonicotinoid contamination of water leaching from the application zone. Our objectives were to document the temporal patterns of neonicotinoid leachate below the planting furrow following common insecticide delivery methods. Leaching loss of thiamethoxam from potato was measured using pan lysimeters from three at-plant treatments and one foliar application treatment. Insecticide concentration in leachate was assessed for six consecutive months using liquid chromatography-mass spectrometry. Findings from this study suggest leaching of neonicotinoids from potato may be greater following harvest of the crop when compared to other times during the growing season. Furthermore, this study documents an indirect neonicotinoid contamination pathway through high capacity irrigation wells back to the crop during watering events. These results demonstrate interactions between a single crop, potato, different neonicotinoid delivery methods, and the potential for contamination of sub-surface water resources.

Experimental Setup Leaching experiments were conducted in Coloma, Wisconsin at a commercial potato farm. A randomized complete block design with four insecticide delivery treatments and an untreated control was established using the potato cultivar, 'Russet Burbank'. Prior to planting in each season, a tension plate lysimeter (25.4 x 25.4 x 25.4 cm) was buried at a depth of 75 cm below field level. Lysimeters were constructed of stainless steel with a porous stainless steel plate affixed to the top to allow water to flow into the collection basin over each sampling interval. Experimental blocks were connected with 9.5 mm copper tubing to a primary manifold and equipped with a vacuum gauge. A predefined, fixed suction was maintained under regulated vacuum at 107±17 kPa (15.5±2.5 lb per in^2) with a twin diaphragm vacuum pump (model UN035.3 TTP, KnF, Trenton, NJ) and a 76 L portable air tank. Data was offloaded with Specware 9 Basic software (Spectrum Technologies, Inc., Plainfield, IL, USA) and aggregated into daily irrigation or rain event totals using the *aggregate* and *dcast* function in R (package: plyr, [20]). Thiamethoxam treatments (Platinum® 75SG, Syngenta, Greensboro, NC) were selected to represent a common, soil-applied insecticide in potato. A second formulation of thiamethoxam was selected to represent a common pre-plant insecticide seed treatment in potato (Cruiser 5FS, Syngenta, Greensboro, NC). Commercially formulated insecticides were applied at maximum labeled rates for in-furrow (140 g thiamethoxam ha^{-1}) and seed treatment (112 g thiamethoxam ha^{-1} at planting density of 1,793 kg seed ha^{-1}) for potato. A novel soil application method, impregnated copolymer granules, was included as another treatment in an attempt to stabilize applied insecticide in the soil. Polyacrylamide horticultural copolymer granules (JCD-024SM, JRM Chemical, Cleveland, OH) were impregnated at an application rate of 16 kg per hectare. Additionally as an alternate delivery method, a series of two, foliar treatments of thiamethoxam (Actara® 25WG, Syngenta, Greensboro, NC) were applied using a CO_2 pressurized backpack sprayer.

Chemical extraction and quantification. Lysimeter leachate was sampled bi-monthly and otal leachate volume was recorded for each plot. Neonicotinoid residues from monthly water samples were extracted using automated solid phase extraction (AutoTrace SPE workstation, Zymark, Hopkinton, MA) with LiChrolut® EN SPE columns (Merk KGaA, Darmstadt, Germany). Sample extracts were analyzed using a Waters 2690 HPLC/Micromass Quattro LC MS/MS (Waters Corporation, Milford, MA). All thiamethoxam residues were identified, quantified, and confirmed by liquid chromatography mass spectrometry (LC/MS) by the Wisconsin Department of Agriculture Trade and Consumer Protection-Bureau of Laboratory Services. Specific conditions for all quantitative procedures follow WI-DATCP Standard Operating Procedure #1009 developed from Seccia et al. [22] and references therein.

Experimental Outcomes. The neonicotinoid insecticide thiamethoxam was included in field experiments to investigate the potential for leaching losses associated with different types of pesticide delivery. We hypothesized that thiamethoxam would be most vulnerable to leaching early in the season when plants were small and episodic heavy rains can be common. Interestingly, we observed the greatest insecticide losses following vine-killing operations which much later in the growing season (Fig. 1). Detections of thiamethoxam in lysimeters varied between treatments through time (treatment x day interaction, F=2.1; d.f.=20,88; P=0.0131) (treatment x day interaction, F=1.8; d.f.=20,87; P=0.0384) over two years. Untreated control plots also yielded low-level detections of thiamethoxam throughout both seasons. To better understand these insecticide detections in control plots, we sampled water directly from the center pivot irrigation system providing irrigation directly to the potato crop.

Figure 1. Thiamethoxam concentration in leachate from potato. Average thiamethoxam (±SD) recovered from in-furrow and foliar treatments in (A) 2011 an (B) 2012. Dotted lines indicate the date that the producer applied vine desiccant prior to harvest. Lysimeter studies continued in undisturbed soil following vine kill.



A
B
Untreated control
Foliar
Seed treatment
In-furrow
Impregnated polyacrylate
vine kill
(113)
vine kill
(128)
Average thiamethoxam concentration (µg/L)
0
5
10
15
20
47
61
91
123
154
184
49
79
110
141
171
202
Days after planting

Bed Planting Potatoes

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Recent trials in Western United States have assessed the value of bed planting in comparison with planting of potatoes in hills. Hills are currently between 30 and 38" apart in Wisconsin production systems. However, a 12' wide bed (10' across the top when allowing for wheel tracks) facilitates planting 5 to 7 rows in the space that would normally hold 4 rows if planted to hills. By decreasing spacing between rows, plant in-row spacing can be increased and maintain same population. Theoretically, bed planting could allow for higher tuber set per plant at the same population in hills. Furthermore, increasing in-row spacing between plants could allow for maintenance of tuber size even though the overall tuber set is higher.

Materials and Methods. Research trials were conducted at the Hancock Ag Research Station during 2012 and 2013 with Russet Norkotah CO-8 line selection and Snowden. Each variety was planted in beds with 5 and 7 rows in 10 and 12' in 2012 and 2013, respectively. In addition, each variety was planted in hills spaced 36" apart. Each variety was planted at four densities in each hill and bed treatment. Crop yield and quality was compared between bed and hill planting across both treatments.

Results. We had mixed results across both years with the Norkotah. In 2012, hill plots yielded higher than bed planted potatoes. In 2013, yields were 50% higher than 2012 and as plant population increased yield was higher in bed planted plots than in hilled plots. B's and culls did not differ much with change in plant population. However, tuber size was much different. Tubers over 10 oz was higher proportionally for hilled plots, but at high populations, bed planted potatoes still had 25% 10 oz and above but had US No. 1 yield 100 cwt/a higher.

Snowden response to bed planting was similar to Norkotah. One difference was response to population in 2013 in bed and hills. Highest yield was at plant population of 18,000 in bed about 100 cwt higher than hills planted at 11,000. Another difference was high proportion of tubers under 4 oz or 2" in diameter in beds. In contrast, the proportion of tubers over 10 oz in hills was also high leading to large proportion of tubers over 4" in diameter.

Russet Norkotah CO8 Bed Hill Population Density 2012

			Plant Pop Plant/A	Total Cwt/A	Cull Cwt/A	Cull % Total	B Cwt/A	B % Total	#1 Cwt/A	#1 % Total
Bed				458.9	18.0	4.0	26.4	5.8	414.5	90.3
Hill				526.5	18.2	3.5	25.0	4.8	483.3	91.7
	LSD			**33.7**	**NS**	**NS**	**NS**	**0.9**	**33.3**	**1.3**
Bed		Density 1	11293	403.3	22.6	5.7	17.8	4.4	362.9	89.9
Hill		Density 1	10890	486.8	18.1	3.7	20.1	4.2	448.6	92.1
Bed		Density 2	13552	469.8	16.3	3.4	25.1	5.4	428.3	91.1
Hill		Density 2	14520	516.4	17.9	3.5	20.2	4.0	478.4	92.5
Bed		Density 3	18070	493.2	14.0	2.8	24.1	4.9	455.1	92.2
Hill		Density 3	19602	535.2	21.2	3.9	23.9	4.5	490.2	91.6
Bed		Density 4	27104	469.3	18.9	4.0	38.6	8.3	411.9	87.8
Hill		Density 4	29040	567.7	15.7	2.8	36.0	6.4	516.1	90.8
	LSD			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Russet Norkotah CO8 Bed Hill Population Density 2012

			% total US #1						Specific
			2-4 oz	4-6 oz	6-10 oz	10-13 oz	13-16 oz	>16 oz	Gravity
Bed			14.6	29.6	41.0	9.4	3.8	1.8	1.0745
Hill			7.0	18.3	40.8	17.1	8.8	8.1	1.0727
	LSD		**1.4**	**2.4**	**NS**	**1.7**	**1.8**	**2.1**	**NS**
Bed		Density 1	10.2	24.5	42.1	16.5	4.6	2.1	1.0720
Hill		Density 1	5.7	16.5	38.4	19.5	10.4	9.5	1.0733
Bed		Density 2	14.3	28.3	40.8	8.9	5.8	2.0	1.0740
Hill		Density 2	5.5	13.9	36.4	19.1	11.5	13.6	1.0723
Bed		Density 3	16.3	30.8	41.5	5.7	3.3	2.5	1.0760
Hill		Density 3	7.7	20.6	43.8	14.8	8.3	4.8	1.0735
Bed		Density 4	17.6	34.7	39.5	6.4	1.4	0.5	1.0760
Hill		Density 4	8.9	22.1	44.6	15.0	5.0	4.4	1.0717
	LSD		**NS**	**NS**	**3.9**	**3.3**	**NS**	**4.2**	**NS**

Russet Norkotah CO8 Bed Hill Population Density 2013

		Plant pop plant/A	Total Cwt/A	Cull Cwt/A	Cull % total	B (<2 oz) Cwt/A	B (<2 oz) % total	US#1 Cwt/A	US#1 % total
Bed			790	21	3	9	1	761	96
Hill			774	21	3	5	1	748	97
LSD			**NS**	**NS**	**NS**	**2**	**0**	**NS**	**NS**
Bed	Density 1	11728	731	25	3	7	1	698	96
Hill	Density 1	11616	761	16	2	2	0	742	98
Bed	Density 2	14520	704	21	3	5	1	678	96
Hill	Density 2	14520	799	22	3	3	0	774	97
Bed	Density 3	19058	794	20	2	10	1	765	96
Hill	Density 3	19360	704	19	3	4	1	681	97
Bed	Density 4	30492	933	19	2	13	1	902	97
Hill	Density 4	29040	831	26	3	9	1	796	96
LSD			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Russet Norkotah CO8 Bed Hill Population Density 2013

		% total US#1							Specific
		2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	Gravity
Bed		10.38	19.52	21.64	16.68	15.02	8.22	8.54	1.0748
Hill		2.77	0.63	7.72	16.59	20.83	17.1	16.95	1.0702
LSD		**1.6**	**2.24**	**2.15**	**NS**	**1.96**	**2.35**	**4.15**	**0.0024**
Bed	Density 1	8.47	18.1	20.9	17.43	15.13	9.37	10.63	1.0753
Hill	Density 1	2.07	0.33	5.7	12.37	17.37	16	19.77	1.0717
Bed	Density 2	7.03	15.13	21.33	17.93	18	8.9	11.67	1.0747
Hill	Density 2	2.93	0.43	8.13	15.83	20.07	17.53	17.8	1.069
Bed	Density 3	12	21.7	23.37	16.83	12.53	8.1	5.47	1.0727
Hill	Density 3	2.77	0.63	7.13	16	23	18.9	14.67	1.0697
Bed	Density 4	14	23.13	20.97	14.53	14.4	6.53	6.4	1.0767
Hill	Density 4	3.33	1.1	9.9	22.17	22.87	15.97	15.57	1.0707
LSD		**3.21**	**NS**	**NS**	**5.2**	**3.91**	**NS**	**NS**	**NS**

Snowden Bed Hill Population Density 2012

		Plant Pop Plant/A	Total Cwt/A	Cull Cwt/A	Cull % Total	B Cwt/A	B % Total	#1 Cwt/A	#1 % Total
Bed			454.4	13.4	3.0	23.4	5.2	417.5	91.8
Hill			484.9	11.0	2.3	14.2	2.9	459.6	94.8
LSD			**30.5**	**NS**	**NS**	**2.7**	**0.6**	**29.3**	**1.2**
Bed	Density 1	11293	432.9	12.8	3.1	17.6	4.0	402.5	92.8
Hill	Density 1	10890	454.5	8.3	1.9	8.7	1.9	437.4	96.2
Bed	Density 2	13552	437.1	13.7	3.1	20.6	4.8	402.8	92.0
Hill	Density 2	14520	486.4	13.3	2.7	12.7	2.6	460.5	94.7
Bed	Density 3	18070	474.9	16.3	3.4	25.3	5.4	433.3	91.1
Hill	Density 3	19602	491.0	13.3	2.8	14.3	3.0	463.5	94.2
Bed	Density 4	27104	472.7	10.9	2.2	30.3	6.5	431.5	91.2
Hill	Density 4	29040	507.6	9.1	1.8	21.3	4.2	477.2	94.0
LSD			**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Snowden Bed Hill Population Density 2012

		% total US#1						Specific
		2-4 oz	4-6 oz	6-10 oz	10-13 oz	13-16 oz	>16 oz	Gravity
Bed		20.1	32.4	36.7	7.8	2.8	0.2	1.0795
Hill		21.2	28.5	36.9	9.2	3.4	0.8	1.0823
LSD		**NS**	**3.5**	**NS**	**NS**	**NS**	**0.5**	**0.0015**
Bed	Density 1	13.2	30.7	39.3	11.6	5.0	0.3	1.0782
Hill	Density 1	12.0	24.5	43.0	14.3	4.8	1.5	1.0807
Bed	Density 2	19.5	30.5	37.7	8.7	2.9	0.6	1.0802
Hill	Density 2	15.9	26.3	41.0	10.9	4.9	1.0	1.0807
Bed	Density 3	23.0	35.0	35.0	5.7	1.5	0.0	1.0808
Hill	Density 3	24.0	30.4	35.1	7.3	3.2	0.0	1.0842
Bed	Density 4	24.6	33.4	34.9	5.1	2.0	0.0	1.0787
Hill	Density 4	33.0	32.6	28.3	4.6	0.9	0.7	1.0835
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Snowden Bed Hill
Population Density 2013

		Plant pop plant/A	Total Cwt/A	Cull Cwt/A	Cull % total	B (<2 oz) Cwt/A	B (<2 oz) % total	US#1 Cwt/A	US#1 % total
Bed			844.2	9.9	1.2	25.72	3.1	808.6	95.8
Hill			836.3	17.7	2.1	11.54	1.4	807.1	96.5
LSD			**NS**	**4.7**	**0.5**	**2.7**	**0.6**	**NS**	**0.7**
Bed	Density 1	11728	680.3	9.2	1.4	10.8	1.6	660.3	97.0
Hill	Density 1	11616	830.3	17.3	2.1	6.2	0.8	806.8	97.2
Bed	Density 2	14520	887.1	7.5	0.8	15.2	1.7	864.5	97.5
Hill	Density 2	14520	867.1	19.4	2.2	8.4	1.0	839.4	96.8
Bed	Density 3	19058	933.1	15.1	1.6	31.6	3.4	886.4	95.0
Hill	Density 3	19360	826.1	20.7	2.5	12.0	1.5	793.4	96.0
Bed	Density 4	30492	876.2	7.7	0.8	45.3	5.4	823.2	93.7
Hill	Density 4	29040	821.6	13.3	1.6	19.6	2.5	788.7	96.0
LSD			**NS**	**NS**	**NS**	**5.4**	**NS**	**NS**	**1.4**

Snowden Bed Hill Population Density 2013

		% total US#1							Specific
		2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	Gravity
Bed		27.3	33.1	20.6	10.9	6.0	1.4	0.8	1.0875
Hill		2.6	1.5	20.9	30.3	24.1	12.9	7.4	1.0824
LSD		**2.9**	**2.5**	**NS**	**1.7**	**1.6**	**1.5**	**1.8**	**0.0033**
Bed	Density 1	20.7	32.6	25.0	12.7	7.7	0.8	0.5	1.0870
Hill	Density 1	2.1	0.8	12.0	26.3	24.7	16.6	12.5	1.0820
Bed	Density 2	18.2	30.4	22.9	15.6	8.1	3.0	1.7	1.0897
Hill	Density 2	2.3	1.0	19.1	29.0	27.3	13.6	8.0	1.0810
Bed	Density 3	32.1	35.4	19.0	8.4	3.7	1.0	0.4	1.0860
Hill	Density 3	2.6	1.5	21.4	33.4	25.0	11.5	5.5	1.0823
Bed	Density 4	38.2	34.1	15.5	6.9	4.4	0.6	0.3	1.0873
Hill	Density 4	3.5	2.7	31.1	32.5	19.3	9.7	3.7	1.0844
LSD		**5.9**	**NS**	**4.1**	**3.4**	**3.1**	**3.1**	**3.6**	**NS**

Drip Irrigation Delivery in Potato: A Comparison of Four Irrigation Systems

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Purpose: The primary purpose of this research is to evaluate the yield and quality response of processing and fresh market potato varieties to four different irrigation management systems including overhead irrigation and drip irrigation at varying levels. The secondary purpose is to evaluate the response of Russet Norkotah yield and quality to varying fertilizer rates under drip and overhead irrigation.

Methods: This experiment was conducted at the Hancock Agricultural Research Station in 2012, 2013 and will be repeated in 2014. This report focuses on results from the 2013 season. The experimental design consisted of whole plot treatments of irrigation method with three replications. Sub plot treatment was potato variety (Russet Norkotah, Snowden, Russet Burbank), and sub-sub plot treatment was nitrogen rate. The 2013 trial was planted May 1st harvested September 16th, and received the standard Hancock production plan.

Irrigation Treatments: Irrigation treatments consisted of overhead irrigation to 100% of actual evapotranspiration (AET) and drip irrigation to 100%, 86% and 75% of AET. Overhead irrigation was applied via a linear overhead system. Drip irrigation delivery was applied in reference to the 100% AET treatment. The 86% and 75% AET treatments were controlled by use of tape with wider emitter spacings of 14” and 16”, respectively, as compared to the 12” in the 100% treatment. All tape has an emitter flow rate of 0.24 gallons per hour. Throughout the season, Campbell Scientific CR10X data loggers recorded volumetric water and soil temperature readings every 15 minutes from each replication of the 100% and 75% AET drip and overhead plots. CS615 water content reflectometer probes were placed at 4” and 8” below the hill and 4” below furrow.

Fertility Treatments: Burbanks and Snowdens received a nitrogen rate of 260 lb N $acre^{-1}$. Russet Norkotahs were planted to three plots per replication and received three different N levels-- 180, 260 and 300 lb N $acre^{-1}$. All plots received 33 lb N $acre^{-1}$ at planting, 75.5 lb N $acre^{-1}$ at hilling, and the remaining nitrogen was split over three supplemental applications. At planting and hilling, fertilizer was side dressed in overhead and drip plots. For subsequent applications, nitrogen (ammonium nitrate) was broadcast applied in overhead block and injected through the drip system

Results: Irrigation

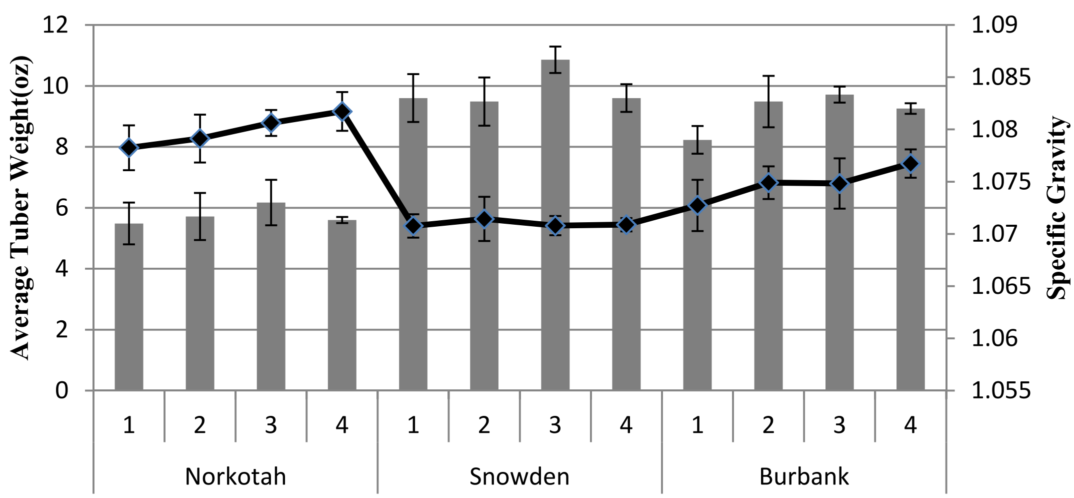
Overall, overhead irrigation yielded higher than the drip irrigation systems, and there was no yield response to drip irrigation level. Of the three varieties, Snowden yielded highest across irrigation systems. There was evidence of a response to irrigation system in Norkotah, but minimal response was seen in Burbank or Snowden. The US #1 yield reflected total yield trends, and more B-sized tubers were seen in Snowden and Burbank than in Norkotah. Average tuber size appeared to contribute to total yield in both Norkotah and Burbank, but this was not true for Snowden. Within varieties, there was not a specific gravity response to irrigation.

Table 1: Influence of Irrigation on yield and size distribution of three varieties during 2013 at Hancock, WI.
Values followed by different letters are significantly different at p<0.05. n.s.= not significant.

	Treatment		US #1		(<1 7/8 in)		Size Distribution for Russets and Rounds					
	Irrigation	Total (cwt/A)	cwt/A	%*	cwt/A	%*	6-10 oz (cwt)	% US #1	> 10 oz (cwt)	% US #1	2-4 in. (cwt)	% US #1
Norkotah	Overhead	758 a	718 a	95	11	1	251	35	362	50		
	Drip 75	649 b	605 b	93	16	2	213	35	291	48		
	Drip 86	619 b	591 b	95	13	2	250	42	213	36		
	Drip 100	601 b	560 b	93	12	2	216	38	224	40		
	LSD (P=0.5)				n.s.		n.s.		n.s.			
Snowden	Overhead	813	735	90	54	7					697	95
	Drip 75	807	725	90	73	9					673	93
	Drip 86	756	678	90	66	9					630	93
	Drip 100	751	686	91	56	8					652	95
	LSD (P=0.5)	n.s.	n.s.		n.s.						n.s.	
Burbank	Overhead	661	610	92	19	3	229	38	209	34		
	Drip 75	678	617	91	30	4	285	46	148	24		
	Drip 86	660	587	89	29	4	252	43	127	22		
	Drip 100	602	543	90	25	4	218	40	105	19		
	LSD (P=0.5)	n.s.	n.s.		n.s.		n.s.		n.s.			
Across all varieties	Overhead	744 a	688 a	92	28	4						
	Drip 75	711 ab	649 ab	91	39	6						
	Drip 86	678 bc	618 b	91	36	5						
	Drip 100	651 c	596 b	92	31	5						
	LSD (P=0.5)				n.s.							

*Refers to % of Total Yield (cwt/a); percentages do not add to 100 as Total Yield includes cull weight

Graph 1: Average Tuber Size and Specific Gravity by Irrigation for Three Varieties
Bars represent average tuber weight, and line represents specific gravity. Treatment 1 was overhead while 2, 3, and 4 was drip irrigation at 75, 86, and 100% of AET.



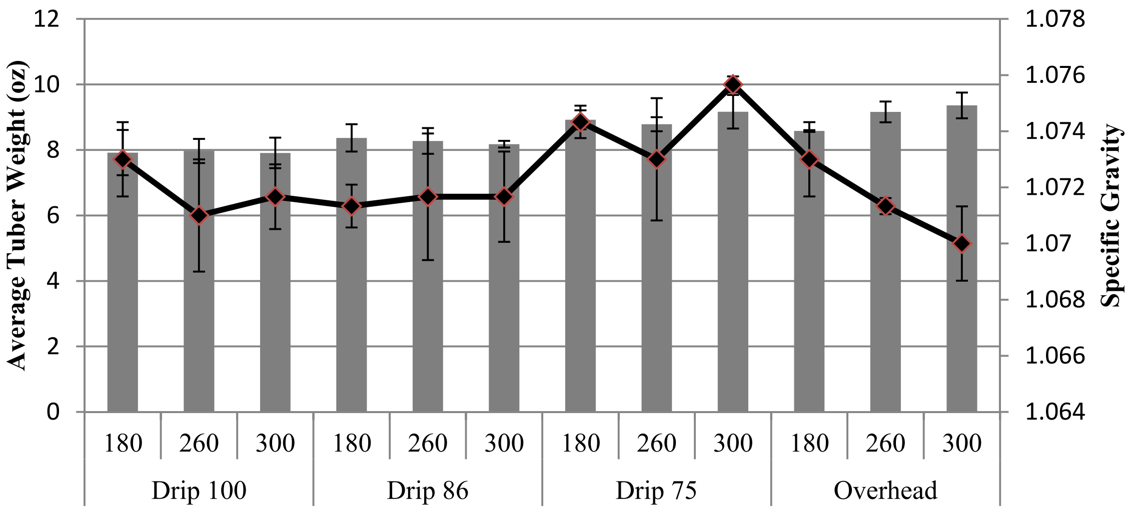
Fertility
For the drip irrigation treatments, there was an upward trend in total yield as fertility rate increased, although it was not significant. There was no such trend in the overhead irrigation treatment. The amount of US#1 or B-sized tubers was not affected by fertility rate in any of the irrigation systems.

Table 2: Influence of N treatment by irrigation on yield and quality of Norkotah for 2013 at Hancock, WI.
Values followed by different letters are significantly different at p<0.05. n.s.= not significant.

			US #1		B (<1 7/8 in)		Size Distribution			
Irrigation	Nitrogen (lb/A)	Total (cwt/A)	cwt/A	%*	cwt/A	%*	6-10 oz (cwt/A)	% US #1	> 10 oz (cwt/A)	% US #1
Drip 100	180	618	572	93	15	2	208	36	243	42
	260	601	560	93	12	2	216	38	224	40
	300	644	610	95	15	2	231	38	262	43
	LSD (P=0.05)	n.s.	n.s.		n.s.		n.s.		n.s.	
Drip 86	180	608	570	94	16	3	232	41	222	39
	260	619	591	95	13	2	250	42	213	36
	300	636	585	92	16	3	241	41	206	35
	LSD (P=0.05)	n.s.	n.s.		n.s.		n.s.		n.s.	
Drip 75	180	654	608	93	14	2	211	35	287	47
	260	649	605	93	16	2	213	35	291	48
	300	673	631	94	13	2	213	34	304	48
	LSD (P=0.05)	n.s.	n.s.		n.s.		n.s.		n.s.	
Overhead	180	726	701	97	8	1	261	37	322	46
	260	758	718	95	11	1	251	35	362	50
	300	734	679	93	16	2	203	30	365	54
	LSD (P=0.05)	n.s.	n.s.		n.s.		n.s.		n.s.	
Across all irrigation treatments	180	652	613	94	13	2	228	37	269	44
	260	657	618	94	13	2	232	38	273	44
	300	672	626	93	15	2	222	35	248	40
	LSD (P=0.05)	n.s.	n.s.		n.s.		n.s.		n.s.	
Across all N treatments	Overhead	740 a	699 a	95	12	2	238	34	349 a	50
	Drip 75	659 b	615 b	93	14	2	213	35	294 ab	48
	Drip 86	621 b	582 b	94	15	2	241	41	214 c	37
	Drip 100	621 b	581 b	94	14	2	218	38	243 bc	42
	LSD (P=0.05)				n.s.		n.s.			

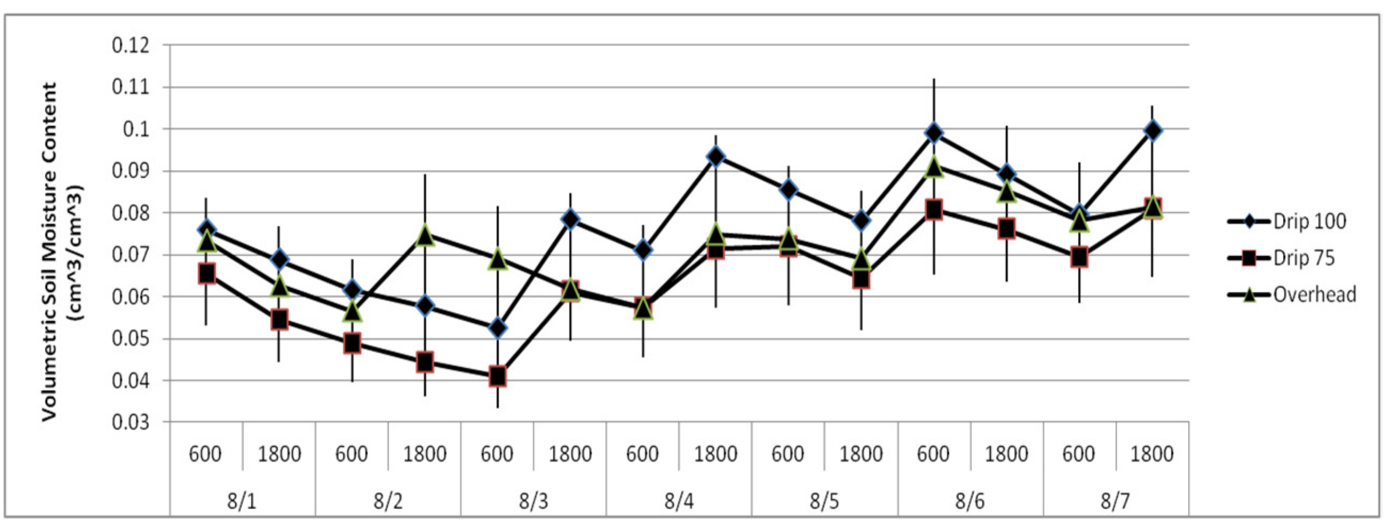
*Refers to percent of total yield. Percentages do not add to 100 as the total yield (cwt/A) includes cull weight.

Graph 2: Average Tuber Size and Specific Gravity of Russet Norkotah by Irrigation Treatment for Three N Rates
Bars represent average tuber weight, and line represents specific gravity.

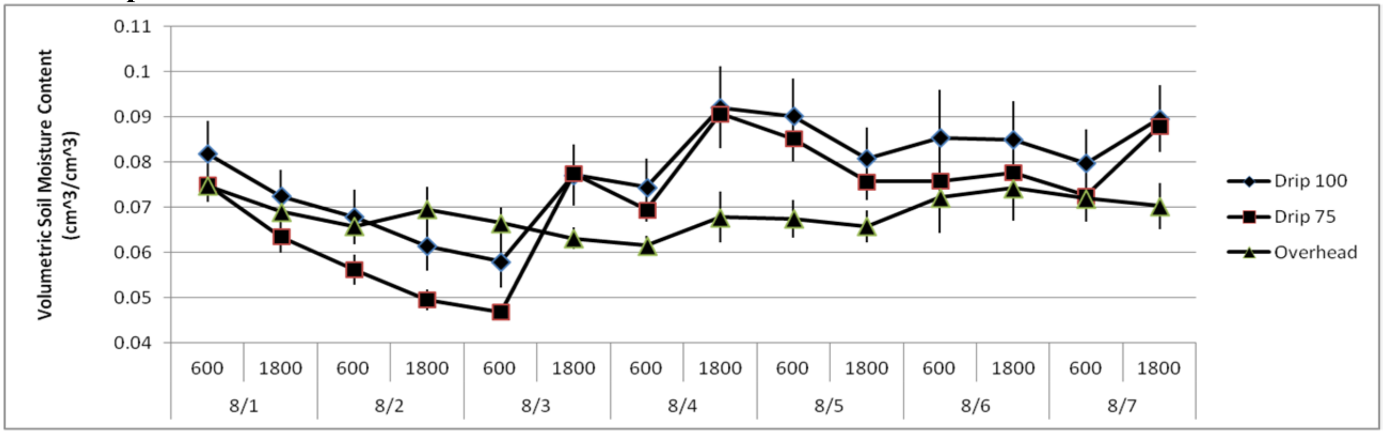


Soil Moisture Data
The following graphs show volumetric soil moisture data over a one week span from August 1st through 7th. Six hour averages at two time points (600 and 1800 hrs) are shown. During this time period, there appears to be a volumetric soil moisture response to irrigation treatment. The 100 AET drip treatment appears to have greater soil moisture at 4" and 8" below the hill. The overhead treatment has higher moisture content at 4" below the furrow. A season-long data set is currently being analyzed. Field capacity at Arlington has been estimated at 14%.

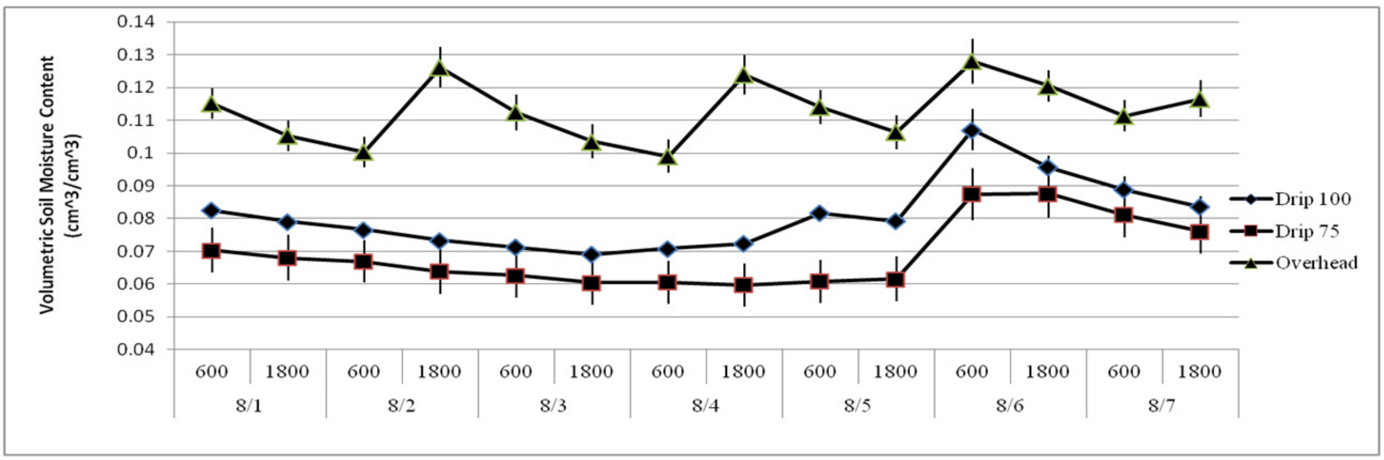
Graph 3: Volumetric Soil Moisture Content 4" Below Hill



Graph 4: Volumetric Soil Moisture Content 8" Below Hill



Graph 5: Volumetric Soil Moisture Content 4" Below Furrow



Discussion: Observationally, there was no physical wilting in the 100% AET drip treatment, but there was in the 86% and 75% AET drip treatments. This is not reflected in the yield data. Observed physical wilting and low soil moisture content in drip treatments suggests that the soil moisture profile never fully recharged which likely contributed to the yield response seen in the drip treatments. There may also have been an issue with calibration of the water content reflectometer probes during the season.

Shape and specific gravity of Russet Burbanks was ideal across all irrigation treatments. This suggests that, despite observed wilting and extreme low moisture, moisture status had a small impact on crop quality. The unexplained productivity in the drip irrigation treatments may suggest that this system is able to mitigate water stress; however, in general, the overhead plots yielded best.

We must also acknowledge that crop history between overhead and drip irrigation was not consistent. Drip irrigation plots were established on previously planted snap bean and were planted to potato 2 years previous. Overhead irrigated plot area was also snap bean the previous year, but may have not been planted to potato.

Additional Research: Further research is being conducted simultaneously to evaluate petiole nitrogen content, tuber N recovery and post harvest quality. Petiole samples were collected every 10 days 5 times a season from all plots. Russet Norkotah tuber samples will be used to evaluate tuber N recovery under irrigation and fertility treatments. Additionally, subsamples from each plot will be used to evaluate for sugar-end defect (Burbank, Norkotah) and stem-end chip defect (Snowden). Stem and bud ends are also evaluated separately for reducing sugar content.

Evaluation of Vine Desiccation Management of Potato Crops

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Purpose:
The purpose of this experiment was to evaluate vine desiccation management practices and their influences on shrink and dry matter content of potato tubers. Management practices that were evaluated include vine desiccation technique, vine desiccation timing, and their effects during long-term storage.

Materials and Methods:
This experiment was conducted from 2011 to 2013 at the Hancock Agricultural Research Station and was composed of both field and storage research trials. The study evaluated changes in dry matter content and shrink rates of four common potato varieties (Russet Burbank, Goldrush, Russet Norkotah, and Nicolet). The study encompassed two distinct phases; the first phase evaluated the period from application of vine desiccant to harvest and the second phase evaluated the period from harvest until removal from storage.

The field research trial utilized a randomized complete block design with a split plot treatment arrangement. This experiment received the standard Hancock ARS production plan, including continued overhead irrigation after vine desiccation.

Vine desiccation treatments included early chemical, late chemical, mechanical, and natural senescence. Both the early and late chemical treatments consisted of two applications of 473 ml diquat dibromide, 473 ml non-ionic surfactant, and 53g Agro-10 per acre. The early chemical application was applied using an overhead boom 35 days before anticipated harvest date. The late chemical application was applied using an overhead boom 21 days before anticipated harvest date. The mechanical treatment consisted of mechanically removing the vines with a flail beater 21 days before anticipated harvest date. A control treatment was implemented in which plots were allowed to senesce naturally without the aid of a vine desiccant. Potatoes were evaluated for changes in dry matter content 21 days before harvest, 7 days before harvest, and at harvest.

The plots were harvested with a single row lifter and tubers were placed into plastic mesh bags by hand. The bags were then placed into crates and stored at the Hancock Potato & Vegetable Storage Research Facility. A standard facility protocol of preconditioning and ramping to set point was followed. Russet Burbank and Nicolet were stored at a set point of 8.8°C. Goldrush and Russet Norkotah were stored at a set point of 3.3°C. Potatoes were removed from storage and evaluated for total weight loss and changes in dry matter content at intervals of 0, 60, 185, and 275 days post harvest. The weights of the tubers were recorded at harvest and upon removal from storage.

Results and Discussion:
Pre-Harvest:
Dry matter content fluctuated from the time of vine-kill to time of harvest across all varieties and treatments. A general trend of decreased dry matter content with time was observed in 2011 and 2013. However, tubers had slight increase in dry matter content 7 days pre-harvest before returning to similar levels 21 d pre-harvest when the crop was dug. There were significant differences between vine desiccation treatments at -7 days pre harvest in 2012 and at harvest in 2013 (Table 1). The fluctuation in dry matter content suggests the tubers were gaining water or dehydrating (2012) from the field or losing

carbohydrates due to respiration. Russet Burbank and Nicolet had the highest amount of dry matter content across all years, while Goldrush and Russet Norkotah had the lowest.

Post-Harvest:
Post-harvest dry matter content closely resembled the pattern of pre-harvest changes. There was only one incidence of significant differences between vine desiccation treatments, +60 days in 2012 (Table 2). Russet Burbank and Nicolet had the highest amount of dry matter content across all years, while Goldrush and Russet Norkotah had the lowest, as expected. Dry matter content displayed a steady increase from the time of harvest through storage due to slow dehydration of tubers.

Total weight loss during the storage season did not show significant differences between vine desiccation treatments (Table 3). Shrink rates in storage were greatest for the variety Goldrush and lowest for varieties Nicolet and Russet Burbank across all years.

Future Research:
Variety selection is a key factor affecting shrink rates and total dry matter content. Additionally, we hypothesize that the fluctuations that occur in dry matter content between vine desiccation and harvest are a result of changes in soil moisture. The continued management of irrigation through harvest is likely to have substantial impacts on changes in dry matter content and weight loss potential during storage.

Additional research is currently underway with a focus on understanding factors that contribute to increased shrink, specifically water evaporation from the tuber and respiration. This research includes the evaluation of vine kill method, condition of tubers at harvest, variety, and storage temperature on respiration and shrink.

Table 1: Pre-Harvest Changes in Dry Matter Content

Pre-Harvest Changes in Dry Matter Content

	2011			2012			2013		
	-21 Days	-7 Days	Harvest	-21 Days	-7 Days	Harvest	-21 Days	-7 Days	Harvest
Goldrush	0.140 b	0.134 b	0.130 b	0.118 b	0.129 c	0.118 c	0.143 c	0.148 c	0.132 b
Nicolet	0.174 a	0.173 a	0.149 a	0.147 a	0.165 a	0.136 a	0.157 b	0.160 b	0.137 b
R. Burbank	0.166 a	0.166 a	0.157 a	0.160 a	0.173 a	0.163 a	0.179 a	0.178 a	0.169 a
R. Norkotah	0.137 b	0.141 b	0.132 b	0.122 b	0.139 b	0.130 b	0.162 b	0.147 b	0.136 b
E. Chemical	--	--	--	--	0.157 a	0.137 a	--	0.157 a	0.140 b
L. Chemical	--	0.152 a	0.145 a	--	0.146 c	0.139 a	--	0.157 a	0.148 a
Mechanical	--	0.153 a	0.136 a	--	0.155 ab	0.134 a	--	0.159 a	0.145 ab
Natural	0.154	0.156 a	0.145 a	0.137	0.148 bc	0.136 a	0.160	0.162 a	0.141 b
Goldrush									
E. Chemical	--	--	--	--	0.130	0.114	--	0.147	0.133
L. Chemical	--	0.136	0.133	--	0.126	0.123	--	0.146	0.132
Mechanical	--	0.125	0.128	--	0.129	0.120	--	0.148	0.132
Natural	0.140	0.141	0.130	0.118	0.132	0.116	0.143	0.152	0.130
Nicolet									
E. Chemical	--	--	--	--	0.178	0.141	--	0.154	0.133
L. Chemical	--	0.165	0.155	--	0.152	0.131	--	0.161	0.141
Mechanical	--	0.176	0.143	--	0.177	0.135	--	0.170	0.141
Natural	0.174	0.178	0.149	0.147	0.153	0.136	0.157	0.171	0.134
R. Burbank									
E. Chemical	--	--	--	--	0.181	0.163	--	0.181	0.159
L. Chemical	--	0.164	0.164	--	0.177	0.169	--	0.174	0.178
Mechanical	--	0.166	0.146	--	0.168	0.156	--	0.176	0.170
Natural	0.166	0.166	0.162	0.160	0.168	0.163	0.179	0.177	0.169
R. Norkotah									
E. Chemical	--	--	--	--	0.140	0.130	--	0.147	0.135
L. Chemical	--	0.141	0.128	--	0.130	0.134	--	0.146	0.142
Mechanical	--	0.144	0.128	--	0.147	0.125	--	0.146	0.137
Natural	0.137	0.137	0.140	0.122	0.138	0.130	0.162	0.148	0.132

Table 1: PRE-HARVEST Dry matter (g/g) for potato varieties under different post-vine desiccation treatments over time in 2011, 2012 and 2013.
Means followed by same letter within a column do not significantly differ (P=0.05)

Table 2: Post Harvest Changes in Dry Matter Content

Post-Harvest Changes in Dry Matter Content

	2011				2012			
	Harvest	+60 Days	+185 Days	+275 Days	Harvest	+60 Days	+185 Days	+275 Days
Goldrush	0.130 b	0.150 b	0.142 b	0.160 c	0.118 c	0.134 d	0.142 c	0.141 c
Nicolet	0.149 a	0.177 a	0.169 a	0.198 a	0.136 a	0.166 b	0.170 b	0.183 a
R. Burbank	0.157 a	0.176 a	0.178 a	0.184 b	0.163 a	0.185 a	0.184 a	0.188 a
R. Norkotah	0.132 b	0.152 b	0.146 b	0.160 c	0.130 b	0.151 c	0.151 c	0.156 b
E. Chemical	--	--	--	--	0.137 a	0.156 ab	0.155 a	0.161 a
L. Chemical	0.145 a	0.168 a	0.164 a	0.177 a	0.139 a	0.163 a	0.166 a	0.170 a
Mechanical	0.136 a	0.161 a	0.162 a	0.176 a	0.134 a	0.155 b	0.160 a	0.168 a
Natural	0.145 a	0.162 a	0.163 a	0.178 a	0.136 a	0.163 a	0.163 a	0.170 a
Goldrush								
E. Chemical	--	--	--	--	0.114	0.133	0.135	0.130
L. Chemical	0.133	0.154	0.140	0.168	0.123	0.145	0.149	0.144
Mechanical	0.128	0.139	0.142	0.154	0.120	0.127	0.142	0.143
Natural	0.130	0.156	0.143	0.158	0.116	0.132	0.143	0.148
Nicolet								
E. Chemical	--	--	--	--	0.141	0.163	0.167	0.179
L. Chemical	0.155	0.182	0.172	0.198	0.131	0.168	0.174	0.173
Mechanical	0.143	0.180	0.166	0.198	0.135	0.165	0.159	0.192
Natural	0.149	0.168	0.170	0.200	0.136	0.169	0.179	0.190
R. Burbank								
E. Chemical	--	--	--	--	0.163	0.175	0.168	0.181
L. Chemical	0.164	0.183	0.181	0.180	0.169	0.187	0.190	0.200
Mechanical	0.146	0.178	0.176	0.188	0.156	0.184	0.190	0.185
Natural	0.162	0.167	0.178	0.184	0.163	0.195	0.189	0.187
R. Norkotah								
E. Chemical	--	--	--	--	0.130	0.153	0.151	0.155
L. Chemical	0.128	0.152	0.144	0.163	0.134	0.150	0.152	0.162
Mechanical	0.128	0.148	0.150	0.152	0.125	0.143	0.150	0.153
Natural	0.140	0.157	0.143	0.165	0.130	0.157	0.148	0.153

Table 2: POST-HARVEST Dry matter (g/g) for potato varieties under different post-vine desiccation treatments over time in 2011 and 2012.
Means followed by same letter within a column do not significantly differ (P=0.05)

Table 3: Post-Harvest Total Weight Loss

Post-Harvest Changes in Total Tuber Weight

	2011			2012		
	+60 Days	+185 Days	+275 Days	+60 Days	+185 Days	+275 Days
Goldrush	1.8% b	4.8% a	6.7% a	3.0% a	5.8% a	8.0% a
Nicolet	2.0% a	2.8% c	3.6% c	2.2% a	3.6% b	5.0% b
R. Burbank	1.5% c	2.4% d	3.1% d	2.3% a	3.7% b	4.9% b
R. Norkotah	1.3% d	3.3% b	4.6% b	2.3% a	5.5% a	7.7% a
E. Chemical	--	--	--	2.3% a	4.5% a	6.5% a
L. Chemical	1.6% a	3.4% a	4.6% a	2.4% a	4.7% a	6.5% a
Mechanical	1.7% a	3.3% a	4.6% a	2.7% a	4.7% a	6.2% a
Natural	1.7% a	3.3% a	4.3% a	2.4% a	4.7% a	6.4% a
Goldrush						
E. Chemical	--	--	--	2.4%	5.5%	8.0%
L. Chemical	1.8%	5.2%	7.3%	2.7%	5.8%	8.1%
Mechanical	1.8%	4.7%	7.0%	4.2%	6.2%	7.9%
Natural	1.7%	4.4%	5.8%	2.6%	5.8%	8.2%
Nicolet						
E. Chemical	--	--	--	2.2%	3.7%	5.3%
L. Chemical	1.7%	3.0%	3.6%	2.4%	3.6%	4.8%
Mechanical	2.0%	2.4%	3.5%	2.2%	3.4%	5.0%
Natural	2.2%	3.1%	3.7%	2.2%	3.8%	5.0%
R. Burbank						
E. Chemical	--	--	--	2.2%	3.9%	4.8%
L. Chemical	1.4%	2.1%	3.0%	2.3%	3.9%	5.4%
Mechanical	1.6%	2.8%	3.3%	2.5%	3.6%	4.7%
Natural	1.6%	2.5%	3.1%	2.3%	3.3%	4.6%
R. Norkotah						
E. Chemical	--	--	--	2.3%	5.1%	7.8%
L. Chemical	1.4%	3.5%	4.4%	2.3%	5.6%	8.0%
Mechanical	1.4%	3.3%	4.7%	2.1%	5.6%	7.3%
Natural	1.2%	3.2%	4.6%	2.4%	5.4%	7.9%

Table 3: POST-HARVEST Total Weight Loss (%) for potato varieties under different post vine desiccation treatments over time in 2011 and 2012.
Means followed by same letter within a column do not significantly differ (P=0.05)

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Table 4: Post-Storage Effects Analysis

Post-Storage Effects Analysis

	2011			2012		
	Dry Matter	Shrink	Skin Set	Dry Matter	Shrink	Skin Set
Goldrush	0.160 c	6.7% a	--	0.141 c	8.0% a	3.14 ab
Nicolet	0.198 a	3.6% c	--	0.183 a	5.0% b	2.56 c
R. Burbank	0.184 b	3.1% d	--	0.188 a	4.9% b	2.80 bc
R. Norkotah	0.160 c	4.6% b	--	0.156 b	7.7% a	3.17 a
E. Chemical	--	--	--	0.161 a	6.5% a	3.13 a
L. Chemical	0.177 a	4.6% a	--	0.170 a	6.5% a	2.83 a
Mechanical	0.176 a	4.6% a	--	0.168 a	6.2% a	3.01 a
Natural	0.178 a	4.3% a	--	0.170 a	6.4% a	2.71 a
Goldrush						
E. Chemical	--	--	--	0.130	8.0%	3.18
L. Chemical	0.168	7.3%	--	0.144	8.1%	3.13
Mechanical	0.154	7.0%	--	0.143	7.9%	3.20
Natural	0.158	5.8%	--	0.148	8.2%	3.08
Nicolet						
E. Chemical	--	--	--	0.179	5.3%	3.03
L. Chemical	0.198	3.6%	--	0.173	4.8%	2.45
Mechanical	0.198	3.5%	--	0.192	5.0%	2.28
Natural	0.200	3.7%	--	0.190	5.0%	2.50
R. Burbank						
E. Chemical	--	--	--	0.181	4.8%	2.83
L. Chemical	0.180	3.0%	--	0.200	5.4%	2.65
Mechanical	0.188	3.3%	--	0.185	4.7%	3.05
Natural	0.184	3.1%	--	0.187	4.6%	2.68
R. Norkotah						
E. Chemical	--	--	--	0.155	7.8%	3.50
L. Chemical	0.163	4.4%	--	0.162	8.0%	3.10
Mechanical	0.152	4.7%	--	0.153	7.3%	3.50
Natural	0.165	4.6%	--	0.153	7.9%	2.58

Table 4: POST-STORAGE ANALYSIS upon removal of storage. 275 days post-harvest.
Dry Matter: Dry Matter Content (g/g)
Shrink: Total Weight Loss (%)
Skin Set: (1/10) NewtonMetre
Means followed by same letter within a column do not significantly differ (P=0.05)

Efficacy of Fungicides and Ozone for Control of Potato Diseases in Storage

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A trial was established 15 Dec 2012 at the Hancock Agricultural Research Station-Storage Research Facility in Hancock, WI to evaluate fungicide efficacy for control of potato tuber pink rot (PR), late blight (LB) and Fusarium dry rot (FDR) in storage. Forty asymptomatic tubers grown for storage research at the Hancock Research Station were used in each of 4 replicates. Replications were completely randomized within the storage area and maintained at 55±2°F and relative humidity of 97%. To simulate rough harvest conditions which result in wounding and promote disease, tubers were subjected to 3 minutes in a modified cement mixer. Inoculation immediately followed simulated wounding. To prepare PR inoculum, 2 isolates of *Phytophthora erythroseptica* (1 mefenoxam sensitive and 1 mefenoxam resistant) were incubated on clarified V8 juice agar for 2 weeks. A slurry was prepared with 100 culture plates (50 each isolate) of agar and pathogen (5.9-in-diameter plates) blended in 0.53 gal of water and diluted to a total volume of 5 gal. Inoculum for LB was prepared by growing a culture of a US23 isolate of *Phytophthora infestans* on leaves of late-blight-susceptible tomato cultivars, raised in a disease-free growth chamber. The leaves were rinsed with sterile DI water and the concentration of sporangia was adjusted to 5000 sporangia per ml of water with a total volume of 5 gal. The inoculum for FDR was prepared using an isolate of *Fusarium sambucinum* cultured on 1/4 strength potato dextrose agar for 2 weeks and prepared by making a slurry of the contents of 20 culture plates (5.9-in-diameter plates) blended in 2 liter of water. The inoculum preparation was then added to water for a final volume of 5 gal. For all three diseases, tubers were dipped into the 5 gal inoculum on 15 Dec 2012 and allowed to dry prior to fungicide treatment. Fungicide treatments were applied to tubers in a carrier volume of 2.37 fl oz of water using a 1gal handheld pump sprayer. Coverage of all tuber sides was ensured by rotating tubers during application. Ozone treatment (10 ppm) was applied in storage through the humidification system of select bins for 8 hr/day for the duration of the trial. Disease evaluations for PR and LB took place on 13 Feb 2013 (60 days-post-inoculation [DPI]) while disease evaluation for FDR took place on 13 Apr (120 DPI). Disease evaluation was conducted on 10 randomly selected tubers from each replicate. For the PR assessment, tubers were sampled by cutting the tuber in half and allowing 30 minutes to pass for pink coloration to form. Pink rot incidence and % symptomatic surface area (presented as % severity) were recorded for each assessment. For the LB assessment, three disease evaluations were made: 1) incidence and 2) severity (% tissue symptomatic) of late blight symptoms from external surface of intact tubers, and 3) severity (% tissue symptomatic) of late blight on cut surface of tubers sliced in half. For the FDR assessment, tubers were peeled and the presence of FDR was measured as the incidence (percentage of tubers with FDR symptoms) and number of lesions per tuber.

Of the treatments, only Stadium and Ozone with Phostrol significantly controlled the incidence and severity of all three diseases when compared to the non-treated inoculated control. Ozone by itself had limited efficacy in controlling the oomycete diseases (PR and LB), but had excellent control for FDR. Phostrol, on the other hand, was excellent for PR and LB control, but did not significantly control FDR. A9859 (the fludioxonil component of Stadium) by itself was effective in reducing FDR and PR, but was less effective in controlling LB. A12705 (the azoxystrobin component of Stadium) was very good for PR and LB control, but had limited efficacy in managing FDR. A8574 (the difenoconazole component of Stadium) was not effective in managing FDR, but it had some efficacy in controlling LB and PR.

	Pink Rot		Late Blight		Fusarium Dry Rot	
Treatment and rate/ton	Incidence (%)	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)	Lesions Per Tuber
Untreated, non-inoculated control…	0.0a*	0.0a	0.0a	0.0a	60.0a	0.8a
Untreated, inoculated control………	52.5d	52.5c	100.0d	49.6e	92.7c	3.0d
Ozone 10 ppm………………………	25.0c	25.0b	87.5d	30.8d	64.1ab	1.2a
Phostrol 6.4 fl oz……………………	12.5b	1.5a	25.0b	3.0a	80.0bc	2.0b
Ozone 10 ppm + Phostrol 6.4 fl oz…	0.0a	0.0a	0.0a	0.0a	64.1ab	1.1a
Stadium 34.78SC 1.0 fl oz…………	0.0a	0.0a	0.0a	0.0a	62.5ab	0.8a
A9859 (fludioxonil) 230SC 0.6 fl oz	0.0a	0.0a	35.0b	10.0b	62.5ab	0.8a
A12705 (azoxystrobin) 250SC .6 fl oz	10.0ab	10.0a	5.0a	0.6a	80.0bc	2.3bc
A8574 (difenoconazole) 360FS .3 fl oz	7.5ab	7.5a	62.5c	17.6c	95.0c	3.0cd

*Column numbers followed by the same letter are not significantly different at P=0.05 as determined by Fisher's Least Significant Difference test.

Evaluation of Stadium fungicide with chlorpropham (CIPC) for control of late blight of potato in storage

A storage trial was established on 15 Dec 2012 to determine the effect of CIPC, a sprout inhibitor, on the efficacy of Stadium fungicide for the control of potato tuber late blight. Three potato cultivars were used for the trial and included, 'Russet Burbank,' 'Dark Red Norland,' and 'Snowden.' Forty asymptomatic tubers were used in each of 4 replicates per treatment. Replications were randomized within the storage area and maintained at 55±2°F, relative humidity of 97%, with appropriate airflow for proper potato tuber storage. To simulate rough harvest conditions which result in wounding and promote disease, tubers were subjected to 3 min. in a modified cement mixer. Inoculation immediately followed simulated wounding. *Phytophthora infestans* inoculum was grown on leaves of late-blight-susceptible tomato cultivars, raised in a disease-free growth chamber. Tubers were dip-inoculated on 15 Dec 2012 in a suspension of 5000 sporangia per ml of water. After inoculation, tubers were allowed to dry prior to fungicide treatment. Stadium fungicide at a rate of 1.0 fl oz/ton was applied in a carrier volume of 2.37 fl oz using a 1 gal handheld pump sprayer. For CIPC treatment, crates of tubers were placed in storage bins with humidification systems shut off. CIPC was applied at a rate of 24 ppm using a Nelson Thermal Fogger designed by Dale Nelson of Nelson Vegetable Storage Systems, Inc. Humidification systems were turned on 24 hrs following the application. Ten tubers were randomly selected and evaluated for the incidence and severity of late blight infection from each replicate at 30 days post-inoculation (DPI), or 15 Jan. Three disease evaluations were made: 1) incidence and 2) severity (% tissue symptomatic) of late blight symptoms from external surface of intact tubers, and 3) severity (% tissue symptomatic) of late blight on cut surface of tubers sliced in half. Statistical analyses were conducted separately for each cultivar.

Stadium significantly reduced the incidence and severity of late blight in inoculated tubers across varieties. The inclusion of a CIPC treatment did not reduce the efficacy of Stadium treatments, regardless of variety. CIPC by itself did not offer significant control of late blight.

Variety and Treatment		Disease Severity of infected Tubers (%)	
	Incidence (%)	Outer Surface	Inner Surface
Russet Burbank			
Untreated, non-inoculated control............	0.0a*	0.0a	0.0a
Untreated, inoculated control……………	100.0b	40.5b	45.0b
Stadium ………………………………....	0.0a	0.0a	0.0a
Stadium + CIPC………………………….	10.0a	1.5a	0.5a
CIPC…………………………………...	90.0b	33.5b	42.0b
Dark Red Norland			
Untreated, non-inoculated control............	0.0a	0.0a	0.0a
Untreated, inoculated control……………	90.0b	29.0b	19.5b
Stadium ………………………………....	10.0a	1.0a	1.0a
Stadium + CIPC………………………….	0.0a	0.0a	0.0a
CIPC……………………………………	100.0b	32.0b	20.0b
Snowden			
Untreated, non-inoculated control............	0.0a	0.0a	0.0a
Untreated, inoculated control……………	100.0b	33.5b	42.0c
Stadium ………………………………....	0.0a	0.0a	0.0a
Stadium + CIPC………………………….	10.0a	1.5a	0.5a
CIPC…………………………………..	90.0b	50.0c	27.5b

*Column numbers followed by the same letter are not significantly different at P=0.05 as determined by Fisher's Least Significant Difference test.

Preliminary results of a first year of bulk bin ozone research for disease control at the Hancock Agricultural Research Station Storage Research Facility.

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Two bulk bins of 'Russet Bannock' at the UW-Hancock Agricultural Research Station Storage Research Facility were loaded on 3 and 4 October of 2012 to initiate a storage research project to investigate the impact of ozone on pink rot, late blight, silver scurf, and Pythium leak. The first bin was our standard control receiving standard conditioning and humidification. The second bin also received standard conditioning in addition to ozone treatment through the humidification system. Some tubers loaded into the top of the ozonated bin exhibited frost damage. This condition was carefully monitored but did not cause rapid breakdown in the pile. Symptomatic potato tubers (artificially inoculated with the pathogens causing pink rot, late blight, silver scurf, and Pythium leak) were placed into 40 lb mesh sacks and were situated in the two piles to receive standard conditions with and without ozone. Four quadrants were designated within each pile such that quadrant 1 held silver scurf inoculated tubers at depths of 0 (bottom of pile), 6, 12, and 18 ft (top) in the pile. Quadrant 2 held late blight inoculated tubers at the previously described 4 depths. Quadrant 3 held pink rot inoculated tubers and quadrant 4 held Pythium inoculated tubers. Pink rot and Pythium inoculated tubers were placed at just a single depth of 18 ft because both diseases can progress very rapidly in storage and we desired a longer term storage trial. Sacks were replicated 3 times for each disease and depth. Ozone treatments significantly limited secondary silver scurf infection by roughly 26% compared to the non-ozonated control bin. While there were no significant differences between ozone and non-ozonated treatments for control of late blight, numerically, late blight incidence was less with ozone at 0.5% compared to no ozone at 5%. Pythium leak and pink rot were numerically reduced by ozone treatment. The depths of stored tubers did not impact ozone efficacy or disease development. Both bins of potatoes were successfully stored until early March of 2013. Ozone applied through the humidification system for 8 hours a day limited disease incidence of silver scurf, late blight, pink rot, and Pythium. We intend to repeat this study for a second year.

Distribution and Characterization of Late Blight in 2013 and Outlook for 2014

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Tomato and potato late blight was confirmed in 16 Wisconsin counties in 2013 from both tomato and/or potato. For all but 2 samples (that were US-8), the pathogen genotype was US-23 (Table 1 & Figure 2). Nationally, the US-23 genotype predominated disease outbreaks, with few determinations of US-7, US-8, and at least one novel type. By production season's end, most of the late blight samples coming in through our lab from Wisconsin were from home garden tomatoes (Table 1). Given the understood nature of the pathogen in state at this time, the early hard frosts should have aided in our late season late blight control as dead plants=dead pathogen.

Table 1. Characterization of late blight from Wisconsin in 2013.

County	Host	Genotype	Date of 1st Confirmation in County
Adams	Potato	US-23	28 Jun
Juneau	Potato	US-23	29 Jun
Sauk	Tomato	US-23	2 Jul
Dunn	Potato	US-23	29 Jul
Portage	Potato	US-8/US-23	29 Jul/6 Aug
Brown	Potato+Tomato	US-23	6 Aug
Langlade	Potato	US-23	6 Aug
Racine	Tomato	US-23	8 Aug
Waushara	Potato	US-23	8 Aug
Milwaukee	Tomato	US-23	22 Aug
Forest	Tomato	US-23	28 Aug
Marinette	Tomato	US-23	10 Sep
Oconto	Tomato	US-23	10 Sep
Walworth	Tomato	US-23	10 Sep
Waukesha	Tomato	US-23	20 Sep
Polk	Tomato	US-23	3 Oct

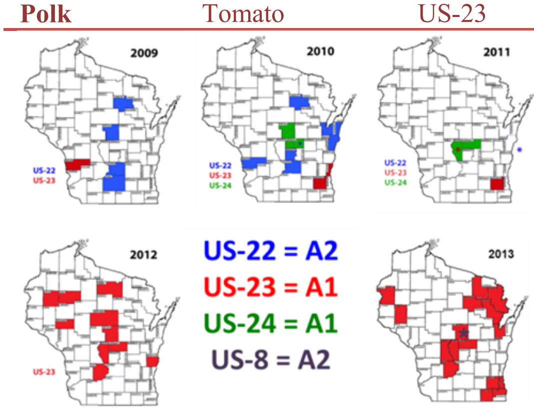

Figure 2. Distribution and character of late blight detected in Wisconsin during production seasons of 2009 to 2013.

Late blight is the most limiting disease to potato production worldwide and has been recognized as a significant agricultural concern since the Irish potato famine in the late 1840s (1,2). In addition, recent strains or genotypes of the pathogen have also been problematic on tomato – a crop with less significant acreage in Wisconsin than potato – but a crop with great distribution around the state. Two mating types are needed to produce sexual, persistent soil-borne oospores. The population is largely clonal outside its center of origin in the Toluca Valley of Mexico, relying on production of asexual sporangia for persistence. Nationally, US-1 (A1) was the predominant clonal lineage until the late 1980s-early 1990s, when US-8 appeared. US-8 was the opposite mating type (A2) and was insensitive to mefenoxam, a fungicide with exceptional activity against oomycetes, but with a specific mode of action that effectively selects for insensitivity.

Leaf symptoms appear as pale green, water-soaked spots that often begin at the leaf edges or tips where water from rain and dew accumulates. Lesions can be circular or irregular and bordered by pale yellow to green blending into healthy tissue. They enlarge rapidly (expanding ¼ to ½ inch per day) turning brown to black over time. When relative humidity is in excess of 90% leaf lesions are often surrounded by cottony white mold on the lower leaf surface (Figure 3). This white, cottony growth distinguishes late blight from several other foliar diseases of potatoes and tomatoes. Infected stems and petioles turn brown to black and may also be covered with white masses of sporangia. Stem lesions frequently appear first at the junction between the stem and leaf, or at the cluster of leaves at the top of the stem. Entire vines may be killed very rapidly. A characteristic odor similar to that produced by green tissue after a severe frost can be detected. Visit the UW-Vegetable Pathology website http://www.plantpath.wisc.edu/wivegdis/ for additional late blight photos and links to other late blight information and identification resources.

After 2002, Wisconsin growers enjoyed a 6-year respite from this disease, until it appeared in 2009, and in each of the subsequent years including 2013. In these years, isolates were collected from potato and tomato from across the state. Allozyme genotype was resolved using cellulose acetate electrophoresis (3). This revealed 3 banding patterns which profiled US-22, US-23, and US-24. All isolates of US-22 and US-23 were sensitive to mefenoxam, while isolates of US-24 showed partial insensitivity. US-22 isolates were of the A2 mating type, and US-23 and US-24 isolates were of the A1 mating type. In 2013, we also detected US-8, an older genotype with resistance to mefenoxam and an A2 mating type status.

While possible under laboratory conditions, to date, opposite mating types have not been identified in the same field within the same production year in Wisconsin. Oospores have not been identified in late blight infected plant tissues in samples submitted for diagnostic services. Ongoing studies are designed to better understand the overwintering and germination potential of oospore. Constant monitoring and managing of late blight through use of varietal resistance and well-timed and –selected fungicides is essential in order to efficiently and effectively control late blight and maintain geographical separation of mating types.

***Management Considerations for fungicide programs to manage late blight*:** There is not one recommended fungicide program for all late blight susceptible potato fields in Wisconsin. Fungicide selections may vary based on type of inoculum introduction, proximity to infected fields, crop stage, late blight strain, and other diseases that may be in need of management. This article provides general guidance to assist in development of your fungicide program.

Under high late blight pressure, fungicide programs with Revus Top, Forum, Curzate 60DF, Ranman, Tanos, Gavel, Previcur Flex, or Omega should be used. Mefenoxam containing fungicides such as Ridomil Gold SL can also be highly effective in controlling late blight caused by the pathogen strain US-23. This strain was identified in most WI cases in 2013. Zampro is a newly registered late blight fungicide offering a novel mode of action fungicide in an effective pre-mix for late blight control. Brief comments on each of these fungicides are listed below.

Revus Top contains mandipropamid (Group 40) for late blight and difenoconazole (Group 3) for early blight; excellent protectant on leaf blight; rainfast; translaminar and contact activity.

Forum contains dimethomorph (Group 40) for late blight; can be applied after vine kill; good protectant on leaf blight; good antisporulant; rainfast; translaminar activity.

Curzate 60DF contains cymoxanil (Group 27) for late blight; locally systemic; excellent curative activity; good protectant on leaf blight; rainfast in 2 hours.

Ranman contains cyazofamid (Group 21) for late blight; excellent protectant for leaf and tuber blight; rainfast; contact activity.

Tanos contains cymoxanil (Group 27) for late blight and famoxadone (Group 11) for early blight; excellent curative activity; good protectant on leaf blight; rainfast; translaminar and contact activity.

Gavel (zoxamide, Group 22+mancozeb, Group M3) is best used as a protectant and has been reported to reduce tuber blight; excellent protectant on leaf blight; rainfast; contact activity.

Previcur Flex contains propamocarb hydrochloride (Group 28); good protectant on leaf, new growth, and stem blight; good curative and antisporulant activity; excellent rainfast activity; systemic and contact activity.

Omega is a broad spectrum fungicide (fluazinam, Group 29) and especially effective at controlling the tuber phase of late blight (with added benefit of white mold control); excellent protectant on leaf blight; good protection against tuber blight; rainfast; contact activity. Has special label for powdery scab in WI as of 2011.

Ridomil Gold SL contain mefenoxam (Group 4); excellent systemic movement in plant; curative activity; excellent control of stem, leaf, and tuber late blight; rainfast; can only be effective if you are controlling a sensitive strain such as US-23, US-22.

Zampro contains ametoctradin (Group 45) and dimethomorph (Group 40) both with activity on late blight; good preventative disease control; systemic and protective activity.

In Wisconsin, the QoI inhibitors Headline (pyraclostrobin, Group 11), Quadris (azoxystrobin, 11), and Reason (fenamidone, 11) have offered good late blight control at high label rates under moderate late blight pressure and should be used in a manner which mitigates pathogen resistance development - in tank-mix with protectant fungicides such as mancozeb or chlorothalonil-based products and do not apply in consecutive applications.

Headline, Quadris, Reason, Revus Top, and Tanos, also provide good control of early blight in most potato fields in Wisconsin. There are fields/areas where the early blight pathogen population may have some resistance to the QoI fungicide group (11), but generally, this group of fungicides is still effective.

Phosphorous acid formulations such as Crop-phite, Fosphite, Phostrol, Prophyt, and Rampart can increase tuber protection to late blight and pink rot. However, rates must be high and multiple applications must be made for significant tuber protection. Post-harvest treatments can aid in storage late blight development and progress.

Mancozeb used as a tank-mix partner in the final fungicide applications can provide some additional tuber late blight production. Research conducted in Washington and published in 2006 by Porter, Cummings, and Johnson indicated that soil application of mancozeb greatly reduced the incidence of tuber blight when compared to other fungicides. Additionally, in our early blight fungicide trial work at the Hancock Research Station we have often seen yield increases when we use mancozeb as the base protectant tank-mix partner in our final 2 applications.

In years when weather conditions do not favor severe late blight, programs based on chlorothalonil formulations and EBDCs can be adequate to reduce risk of late blight. The addition of TPTH 80WP to any of the protectant programs can enhance disease control particularly towards the end of the growing season. Our current weather conditions, while very hot, can promote disease development due to periods of rainfall, high humidity, and moderate overnight temperatures.

Timing and frequency of fungicide applications are critical elements in an effective disease control program. As in previous years, our program offers Blitecast information which indicates timing for initial preventative fungicide applications for late blight control. Blitecast uses accumulated environmental conditions from crop emergence to determine risk thresholds and has been very reliable in recent years in pre-empting late blight epidemics. Five to seven day applications are needed to protect the crop under conditions of rapid growth and high disease pressure. Once late blight has been detected in WI, protectant programs should be maintained in areas near affected fields until the end of the growing season to limit late season infection and the tuber phase of the disease.

In fields with late blight 'hot spots,' crop destruction is recommended to limit disease development and production of inoculum. A conservative approach to reducing spread from a hot spot includes destruction of 30 rows on either side of the newest lesions at the border of the late blight locus and 100 feet along the row (either side) are killed with Reglone or with Gramoxone (generic). Although harsh, trials at MSU have shown that the latent period between infection and symptom development is about seven days and although not visible, plants within this area are already infected. Fields with very few lesions across a broad acreage, must be intensively managed and consideration for early vine kill and harvest should be made to reduce overall risk.

Listing of 2013 WI potato late blight fungicides:
http://www.plantpath.wisc.edu/wivegdis/pdf/2013/Potato%20Late%20Blight%20Fungicides%202013.pdf

The 2014 A3422 Commercial Vegetable Production in Wisconsin guide is available for purchase or download through the UW Extension Learning Store website (updated annually): http://learningstore.uwex.edu/Commercial-Vegetable-Production-in-Wisconsin2013-P540.aspx

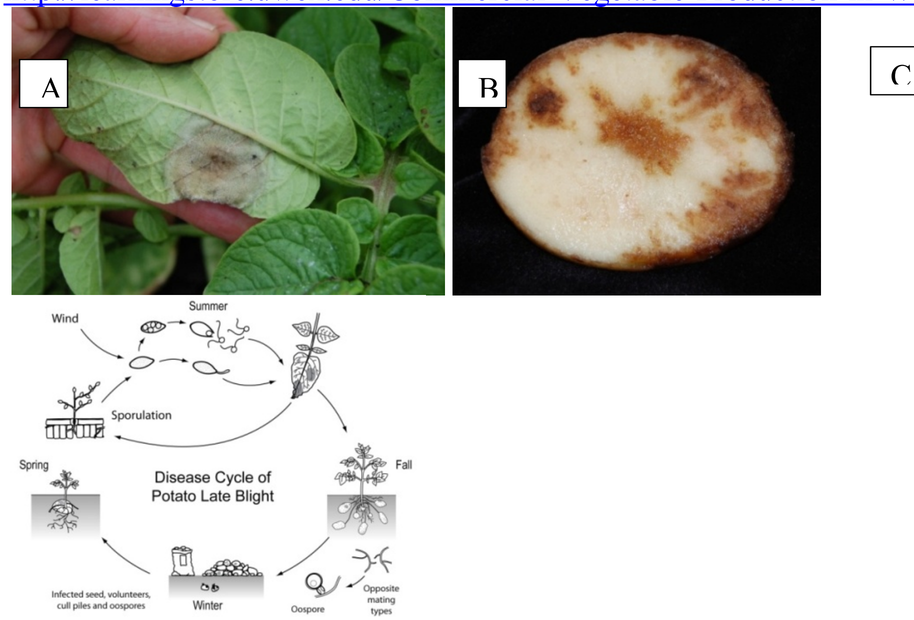

Figure 3. Potato late blight symptoms and disease cycle. A) Lesion on potato leaf displaying pathogen sporulation on underside. B) Internal late blight symptoms on potato tuber. C) Potato late blight disease cycle.

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Late blight forecasting and simulations among genotypes

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Research Overview. *Phytophthora infestans* populations have continued to evolve, with unique clonal lineages arising which differ in pathogen fitness and pathogenicity. This project is directed at further enhancing our understanding of late blight epidemiology with a focus on identifying the phenotypic characteristics that influence the composition of *P. infestans* clonal lineages in Wisconsin vegetable crops. The objectives of this research were to: 1) determine the relative fitness of the US-22, US-23, and US-24 clonal lineages of *P. infestans* and 2) examine if relative fitness among clonal lineages provides an explanation for the relative abundance of *P. infestans* clonal lineages in observed Wisconsin. To complete these objectives, we measured the effect of temperature on mycelial growth and sporangia production of the US-22, US-23, and US-24 clonal lineages of *P. infestans* on potato and tomato. Simulation modeling was used to examine how the measured differences in growth and/or sporulation among clonal lineages could affect the composition of clonal lineages observed in the field and to determine which clonal lineage is likely to impact Wisconsin vegetable crops in the future.

Methods. ***Effect of temperature on growth.*** *P. infestans* isolates were collected from infected Wisconsin potato and tomato tissues in 2009, 2010, or 2011: Five isolates each of US-22, US-23, and US-24 selected for this experiment. The growth rate of each isolate was measured at 4, 8, 12, 16, 18, 20, 24, and 28° C on a detached tomato leaf and on Rye A media. The growth rates and relative growth rates were calculated and plotted versus temperature. Polynomial regression was then used to model the relative lesion growth rate as a function of temperature.

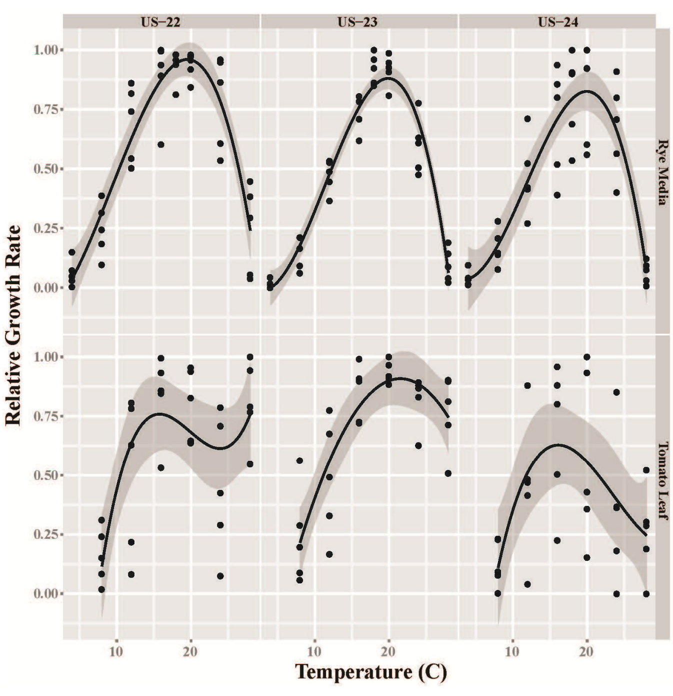

Figure 1) Growth curves for the US-22, US-23, and US-24 clonal lineages of *P. infestans* on rye A media and tomato leaves. Each curve is an average of five isolates from each clonal lineage

Results. Optimal growth rates were varied between Rye A media and Tomato leaves. Overall, optimal growth of the clonal lineages occurred at a similar temperature on Rye A media, 20°C for all lineages. However, on tomato leaves, optimal growth occurred at 16 °C , 21°C, and 16°C for the US-22, US-23, and US-24 clonal lineages, respectively (Fig. 1).

Differential Sporulation. Eight tomato and potato leaf disks were inoculated with 10-µl of an inoculum suspension prepared from isolates of US-22, US-23, and US-24. Nine days post-inoculation, four sporulating leaf disks were placed in 25-ml plastic centrifuge tubes containing 2 ml of sterile distilled water and 1 drop of Tween 20. The spore suspensions were agitated and sporangia were quantified within one hour using a hemacytometer. The number of sporangia produced per square meter of leaf area was calculated and the average number of sporangia for each lineage was divided by 6.5 (9 days – 2.5 day latent period) to obtain sporangia production per square meter per day. This experiment was performed at 20° C and the relative sporulation rate curve of the LATEBLIGHT model was used to estimate the maximum sporulation rate (SR) that occurs at approximately 16° C.

Table 1) Maximum lesion growth rate (m day) and sporulation rate (sporangia mday) used in the LATEBLIGHT model.

Clonal lineage	Host	Mean Sporulation (x 10^8 m^{-2} day^{-1})	Adj. Mean (x 10^8)
US-22	Tomato	1.22	2.41
	Potato	1.62	3.20
US-23	Tomato	1.85	3.64
	Potato	2.24	4.42
US-24	Tomato	0.88	1.72
	Potato	2.02	3.98
		LGR (x10^{-3})	Adj. LGR (x10^{-3})
US-22	Tomato	4.80	6.33
US-23	Tomato	4.65	5.86
US-24	Tomato	2.52	4.01

Results. Sporulation of the clonal lineages depended on the host, potato or tomato, on which the assay was conducted (Table 1). US-23 had the highest sporulation rates on both potato and tomato. US-22 readily infected both tomato and potato – total sporulation was less than the other clonal lineages. US-24 had the highest sporulation rate on potato and the lowest sporulation rate of the lineages on tomato.

Epidemic simulation. Simulations were driven by integrated surface weather data (2009 to 2012) from Stevens Point, WI obtained from the NOAA integrated surface database of hourly weather data (Station ID: USAF-WBAN 726426-04895). Initially, simulations were run using the default pathogen parameters (i.e. EC-1 clonal lineage, a *P. infestans* clonal lineage from South America) that were programed into the software. In subsequent simulations the parameters for sporulation rate (SR) and/or lesion growth rate (LGR) and relative lesion growth rate (rLGR) were changed to reflect the new information obtained for each clonal lineage in the experiments above.

Results. Measures of epidemic severity were calculated for each simulation and expressed relative to the epidemic summary of the default simulation settings (i.e. relative to the EC-1 clonal lineage). Relative severity measures were averaged over year and treatment (i.e. changes to SR and/or LGR and rLGR). Simulated epidemics for the US-23 clonal lineage consistently progressed at a higher rate and were more severe than the simulated epidemics of either the US-22, US-24, or US-8 clonal lineages.

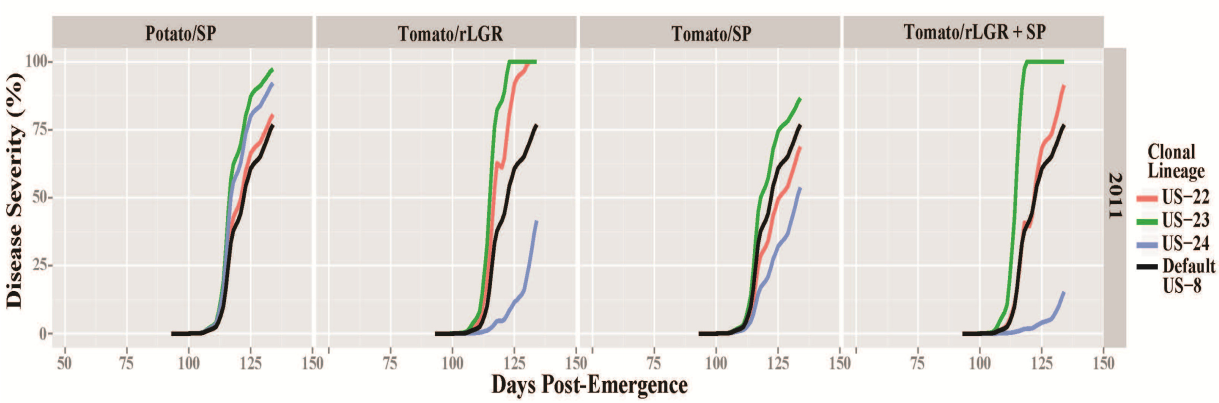

Figure 2) Simulated epidemics of the default (US-8), US-22, US-23, and US-24 clonal lineages of *P. infestans* using 2011 weather data from Stevens Point, WI.

Table 2) Measures of epidemic severity were calculated for each simulation and expressed relative to the epidemic summary of the default simulation settings

Clonal Lineage	Host	Relative Epidemic Length	Relative Severity (AUDPC)	Relative rate (logistic)	Relative rate (exponential)
US-22	Potato	0.97	1.03	1.04	1.02
	Tomato	1.07	1.04	1.06	0.90
US-23	Potato	**0.91**	**1.16**	**1.20**	**1.03**
	Tomato	**0.88**	**1.23**	**1.50**	**1.28**
US-24	Potato	0.94	1.12	1.09	1.03
	Tomato	1.58	0.53	0.76	0.89

Discussion. Changes in the biology of plant pathogens can have specific impacts on epidemic progression. Some of the most obvious of these may be the development of insensitivity to fungicides or changes to the composition of genotypic races in the population, as these often have an immediate and sometimes marked impact on the efficacy of management strategies. Subtle changes in other biological characteristics, such as sporangial size or production or optimal temperatures for lesion expansion, may be harder to quantify in a field setting and simulation modeling can provide insight into the effect of these changes in the pathogen population. In the current study, US-23 had the highest sporulation rates on both potato and tomato, US-22 readily infected both hosts, but sprorulation by this lineage was overall less, and the US-24 lineage, while having a high sporulation rate on potato, had the lowest sporulation rate of the lineages tested on tomato. When parameters in the LATEBLIGHT model were modified to reflect the experimentally determined lesion growth rates and sporulation rates of the three lineages, simulated epidemics for the US-23 clonal lineage consistently progressed at a higher rate and were more severe than the simulated epidemics of either the US-22, US-24, or EC-1 (default) clonal lineages regardless of environmental conditions.

The rate of progression and severity of the simulated epidemics on both potato and tomato suggest that US-23 is the most fit lineage and is the most likely lineage to predominate the pathogen population. Indeed, this has been observed in Wisconsin and across the U.S. in the past several years. In Wisconsin, the US-23 lineage first appeared in a single location in 2009. Over the following three years, the proportion of late blight samples collected that yielded the US-23 lineage steadily increased and the prevalence of the US-22 and US-24 lineages decreased until by 2012 US-23 was the only lineage collected. Similarly, across the U.S., US-22 was the predominant lineage reported in 2009, but by 2012 almost all of the reports of late blight were caused by US-23. That US-23 is simulated to do well in short or long seasons and over a range of environmental conditions and on both tomato and potato suggests that this lineage may likely persist in the U.S. pathogen population for many years.

Future work. . Differences in the average sporangial size of the US-22, US-23, and US-24 lineages exits, but it is not known if sporangial size affects epidemic progression. We would like to determine if smaller spores may be lifted from the leaf surface, escape the plant canopy, and travel farther on air currents more easily than large spores.

Acknowledgements. We thank Dr. Stephen Jordan, Amilcar Sanchez Perez, and Abigail Mitchell for technical laboratory assistance in conducting this work. This work was, in part, funded by a UW-Madison Hatch Grant project, a WI Specialty Crop Block grant, and the Wisconsin Potato and Vegetable Growers Association.

Carrot foliar disease forecasting

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Research Overview. Alternaria leaf blight, caused by the fungus *Alternaria dauci*, and Cercospora leaf spot, caused by the fungus *Cercospora carotae*, infect leaves and petioles of carrot and are the most prevalent foliar diseases of carrot worldwide. These foliar blight pathogens reduce yield by limiting the plant's photosynthetic capacity and by weakening the petioles needed for mechanical harvest. Typically, carrots are harvested by implements that loosen the soil and simultaneously grasp the foliage while lifting the roots out of the soil; blighted petioles break when gripped by the mechanical harvester and carrots are left in the soil. Environmental conditions greatly influence the occurrence and progression of these foliar diseases of carrot and the anticipation of heightened disease risk through the identification and monitoring of critical environmental factors, such as, relative humidity and temperature, can enhance disease management by optimizing the timing of fungicide applications. However, implementation of the weather-based models is difficult because, typically, each field requires a customized forecast that is dependent on disease severity, weather conditions, and fungicide program, factors that are field-specific. A goal of this research is to provide a set of generalized recommendations for managing foliar diseases of carrot that can be used for the majority of WI fields without the need for grower investment in weather stations.

Table 1) TOM-CAST model logic for scoring a daily severity value. Under the current scheme, a fungicide application would be recommended after the accumulation of 20 severity values over consecutive davs.

Mean Temp (C)	Leaf-wetting time (hr) required to produce daily disease severity values (S) of:				
	0	1	2	3	4
13-17	0-6	7-15	16-20	21+	
18-20	0-3	4-8	9-15	16-22	23+
21-25	0-2	3-5	6-12	13-20	21+
26-29	0-3	4-8	9-15	16-22	23+

Methods. ***Weather data and modified TOM-CAST model.*** Computers housed in the Dept. of Plant pathology at UW-Madison ingested daily gridded weather predictions from the North American Meso-scale weather model (NAM 12km) from the National Weather Service (NWS). Weather data were organized and uploaded to a relational database created to house the forecasted weather predictions and disease forecasts. Computer code was written to organize and utilize the gridded data and a filing system was created to facilitate rapid data loading. Computer code was written to implement a modified version of the TOM-CAST model (Table 1) based on the NAM 12km weather predictions. The running of this disease model was automated so that risk predictions were updated daily following the download of the weather data. This model assumes that air temperature and relative humidity (i.e. a surrogate for leaf wetness) are the two primary weather factors that lead to disease occurrence/or progression. The model scores a severity value for each day based combinations of relative humidity and temperature and accumulates the severity values either from crop emergence or the last fungicide application. The accumulation of 20 disease severity values triggers a fungicide application. ***Results.*** Model predictions are currently output daily for research purposes and we have been posting static figures of DSV forecasts for Wisconsin at the vegetable pathology website (see <http://www.plantpath.wisc.edu/wivegdis/> for updates). General infrastructure improvements to improve grower accessibility are ongoing and include, 1) updating the computing hardware that currently ingest, house, and calculate the weather-based disease forecasts, 2) updating the computer software that is currently used for database management and 3) continued development of applications (i.e. writing the computer programs) for the GUI that growers can use to access the weather database directly from their home computers.

2013 field evaluation. In 2013, the modified TOM-CAST model was being evaluated in field trials for the management of *A. dauci* and *C. carotae*, respectively. Research plots were established at the UW-Hancock Agricultural Research Station and on a commercial farm in a randomized complete block design with four replicates. Plots were scouted for disease from mid-July to early September and experiments at both locations contained a standard calendar-based fungicide program (Table 2). Experimental treatments were established based on fungicide application 1) initiation – fungicide programs were initiated based on the number of days after emergence or the occurrence of the first disease symptom and 2) interval – fungicides were applied according to DSV accumulations calculated based on in-field weather stations or calculated using the NAM 12 km weather model. Bravo Weather Stik was the sole fungicide used in these experiments and was applied at 2 pints per acre when an application was prescribed. ***Results.*** In 2013, we experienced low foliar disease pressure at both experimental locations. This resulted in similar disease control among all fungicide treatments (Figure 1); at Hancock, all fungicide programs performed significantly better than the untreated control and there was no difference in foliar disease control among fungicide programs. Additionally, there were no differences in yield among fungicide programs (F=1.99; d.f. = 5,18; P = 0.15). Thus, at Hancock, WI, all fungicide programs provided the same foliar disease control – those with fewer applications provided equivalent control. For the experiment conducted on-farm, no differences in yield (F=0.94; d.f. = 5,18; P = 0.48) nor disease severity (F=0.79; d.f. = 5,18; P = 0.57) were observed among fungicide programs.

Table 2) Experimental treatments, at the Hancock, WI location, used to evaluate the TOM-CAST model based on in-field weather data and NAM 12km weather data.

Trt	Program	Initiation	Initiation	Fungicide Apps.	Rate	Field EIQ[1]
1	UTC	NA	-	-	-	-
2	Calendar	First Symptom	July 17	6	2.0 pint / acre	242
3	In-field DSV	First Symptom	July 17	6	2.0 pint / acre	242
4	In-field DSV	Calendar	July 17	4	2.0 pint / acre	162
5	NAM-based DSV	First Symptom	Aug 7	4	2.0 pint / acre	162
6	NAM-based DSV	Calendar	Aug 7	3	2.0 pint / acre	121

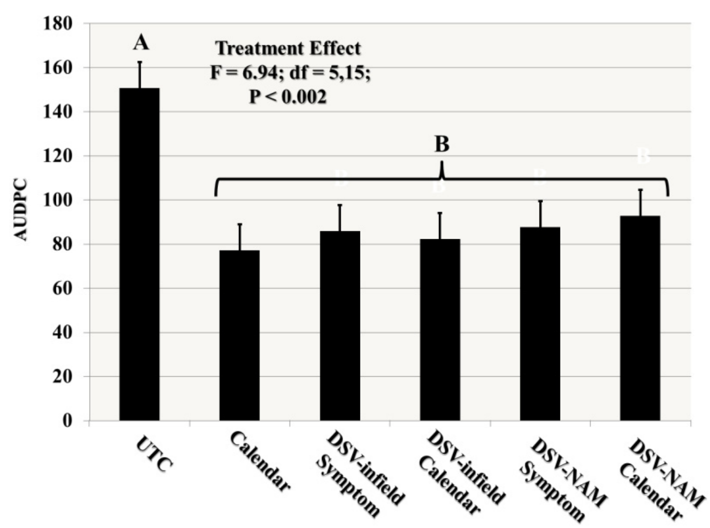

Figure 1) Average area under the disease progress curve (AUDPC) for experimental treatments at Hancock, WI in 2013.

Future work. *Model validation and optimization.* To optimize the large scale pest and disease forecasts, model predictions that have been calculated using NWS weather data, specific to field location, will be compared to model predictions that have been calculated using field-observed data. Regression analysis will be used to determine if there is a discrepancy between the action thresholds calculated using NWS weather data and those using field-based weather data. Finally, a correction factor will be developed so that model predictions made over large geographic areas can be (mathematically) mapped to field-level predictions. ***GUI development and information dissemination.*** Currently, efforts are being focused on the development of an internet-based graphical user interface to automate the functionality of the database and to make disease forecasts available to vegetable growers in WI. Stay tuned as there may be a web application coming on-line in the Spring <http://www.plantpath.wisc.edu/wivegdis/>.

Discussion. Disease forecasting systems that inform the timing of fungicide application based on environmental conditions may be useful for managing pathogens that cause foliar diseases of carrot. A typical fungicide program in Wisconsin is initiated when disease symptoms are first detected by scouting and subsequent fungicide applications typically follow a calendar-based spray schedule. However, fungicide reapplication may not be necessary if environmental conditions do not favor disease progression; the severity of disease epidemics largely depends on environmental conditions, dictated primarily by wind and weather patterns. Thus, the application of fungicide informed by a weather-based disease forecasting system could control disease while reducing the number of pesticide applications, thereby improving profitability for vegetable growers and reducing environmental impact. The implementation of the weather-based models to inform spray programs requires a customized forecast for each field that is based on disease severity, weather conditions, and fungicide program, factors that are field-specific. The primary goal of our research is to provide a decision tool for the management of carrot foliar diseases that can be used for the majority of fields and doesn't require grower investment in a weather station for each field.

Acknowledgements. Many thanks to Paul Miller Farms of Hancock, WI for setting up the carrot field trials at the UW-Hancock Agricultural Research Station (HARS) in 2013. We appreciate the crop management efforts of the UW-HARS staff, specifically, Glenn Carlson and Paul Sytsma. Funding for this project was provided, in part, by the WI Specialty Crop Block Grant project entitled "Implementing pest and disease forecasting for enhanced management of vegetable crops grown on muck soils" in addition to support from the Wisconsin Potato and Vegetable Growers Association, the Wisconsin Fresh Market Vegetable Growers Association, and the Midwest Food Processors Association.

Potato virus Y Resistance Breeding for the Wisconsin Potato Industry

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Summary

- A number of breeding clones available to the UW Potato Breeding Program carry *Potato virus Y* (PVY) resistance genes derived from different wild relatives of cultivated potato.
- The molecular markers RYSC3 for detection of the Ry_{adg} resistance gene and YES3-3B for detection of the Ry_{sto} resistance gene correlate well with the resistance phenotype and were used to identify resistant parents that were later crossed with susceptible parents that have desirable traits.
- Molecular marker data analysis indicates that the resistance genes Ry_{adg} and Ry_{sto} are single dominant genes, found in simplex (Rrrr) in the evaluated tetraploid populations.
- The Ry_{chc} gene has also been identified in certain breeding clones. Genome sequencing data of one of these plants is being used to develop a molecular marker to be used as a tool for incorporating this third source of resistance into Wisconsin potato varieties.

Introduction

Viruses are among the most common plant pathogens and are easily spread through vegetative propagation. Over 30 viruses are known to infect potato. *Potato virus Y* (PVY) is the most economically important disease problem for production of seed potatoes in many areas of the world (Gray et al., 2010). In the last decade, PVY has been the cause 97% of rejections of Wisconsin seed lots due to plant pathogens (Frost et al., 2013). Detection of PVY in potatoes mostly relies on visual inspection of plants in the field and identification of symptoms. Infected plants show symptoms that range from mild to severe mosaic, leaf drop, leaf crinkle, leaf chlorosis, leaf necrosis, cracking and necrotic rings on tubers (Gray et al., 2010).

The UW Potato Breeding Program, like other potato breeding programs across the country, has traditionally used the method of phenotypic recurrent selection to develop new cultivars. This method begins with the selection of diverse, desirable tetraploid parents, selected based on their phenotype, and crosses are made between the parents with complementary traits (Carputo and Frusciante, 2011). PVY has been a problem for breeding due to the necessary vegetative propagation of tubers for subsequent selection cycles (Douches et al., 1996). During the breeding process, virus-infected plants are identified by their symptoms, but certain cultivars do not express them clearly (Ottoman et al., 2009). In addition, necrotic (PVY^{NTN}) and recombinant ($PVY^{N:O}$) of PVY cause mild foliar symptoms, increasing the difficulty of detection by visual inspection. The most effective way to control PVY incidence is by the use of resistant cultivars. However, development of a resistant cultivar is difficult under phenotypic selection because breeders select disease resistant materials by subjecting them to high disease pressure and evaluating their performance, and further testing by serological or polymerase chain reaction (PCR) methods, which can be time consuming and expensive. For this reason, breeding programs have adopted the use of molecular markers as tools to screen for disease resistance and predict the response to viral infection. In 2010, the UW Potato Breeding Program began its efforts to create a marker-assisted selection strategy for incorporating PVY resistance into new cultivars.

A molecular marker is a specific DNA sequence found in a specific place of the genome and can be easily identified. Some markers are located near a gene of interest, such as a resistance gene, and are transferred with the gene from parents to progeny by standard laws of inheritance. The linkage of these markers to genes of interest is useful for breeders because it allows them to quickly and easily identify plants that carry resistance genes without having to screen for disease in the field. Additionally, molecular markers can be useful for introducing two or more resistance genes into cultivars, a strategy that prevents the virus from rapidly overcoming plant resistance. Several genes conferring extreme resistance to PVY have been found and markers have been developed for their detection (Table 1). Ottoman et al. (2009) used markers for selecting PVY resistant clones and suggest they are an efficient tool for reducing the number of PVY-susceptible clones retained for further field evaluations, while increasing the chances of generating PVY-resistant cultivars.

Table 1. PVY resistance genes, sources, and associated markers.

Gene	Wild potato source	Markers*	Reference
Ry_{chc}	*Solanum chacoense*	38-530, CT220	Hosaka et al., 2001; Sato et al., 2006.
Ry_{sto}	*Solanum stoloniferum*	GP122, STM0003, YES3-3B	Song et al., 2005; Song and Schwarzfischer, 2008; Valkonen et al., 2008.
Ry_{adg}	*Solanum tuberosum* ssp. *andigena*	ADG BbvI, RYSC3, RYSC4	Kasai et al., 2000; Sorri et al., 1999.

*A subset of available markers is listed.

Objectives

The overall goal of this project is to increase the tools that the potato breeding team at UW-Madison has to make progress towards developing PVY-resistant cultivars. Three specific objectives have been defined:

- To identify available PVY-resistant germplasm.
- To identify or develop useful molecular markers that correlate with resistance to PVY.
- To develop and evaluate breeding populations carrying the identified markers.

Approach and Results

Fifty potato breeding clones, provided by the UW Potato Breeding Program, were screened for resistance to PVY. Sprouts were planted in 6-inch pots and plants were maintained in the greenhouse. Rub-inoculations were performed four weeks after planting. Two weeks post-inoculation, dot-blot immunoassays (DBIA) and enzyme-linked immunosorbent assays (ELISA) were used to detect the virus. Plants that were negative for PVY infection were re-inoculated and the serological assays were done after two weeks. For those plants that were negative for the second time, inoculation and detection assays were repeated once more. Additionally, DNA from each clone was extracted and PCR was used to determine the presence or absence of published molecular markers for detection of Ry_{adg} and Ry_{sto}. Two markers were selected for use in further screening, RYSC3 for detection of Ry_{adg} (Kasai et al., 2000) and YES3-3B for detection of Ry_{sto} (Song and Schwarzfischer, 2008). Two clones were found to carry the RYSC3 marker and YES3-3B was found in 11 clones (Table 2).

Table 2. Partial results of PVY inoculation assay and marker screening on potato breeding clones provided by the UW Potato Breeding program.

Clone	Phenotype	RYSC3	YES-3B
Divina	Susceptible	No	No
Fabula	Susceptible	No	No
Ranger Rus	Susceptible	No	No
Satina	Susceptible	No	No
CHC 39-7	Resistant	No	No
CHC 40-3	Resistant	No	No
A93575-4	Resistant	Yes	No
Tacna	Resistant	Yes	No
A96949-4	Resistant	No	Yes
A96953-13	Resistant	No	Yes
Cyclamen	Resistant	No	Yes
Daisy	Resistant	No	Yes
EHR	Resistant	No	Yes
PA92A08-17	Resistant	No	Yes
Pushkinets	Resistant	No	Yes
Snowflake	Resistant	No	Yes
Stobrawa	Resistant	No	Yes
W8946-1 Rus	Resistant	No	Yes
White Lady	Resistant	No	Yes

The UW Potato Breeding Program developed F1 populations using clones identified as resistant and carrying either RYSC3 or YES3-3B, and other susceptible breeding materials with known desirable agronomic traits. The cultivars Eva and NY121, reported to carry Ry_{adg}, were also used as resistant parents. The progeny from these crosses was screened with the RYSC3 and YES3-3B markers (Table 3). Some populations were selected for further evaluation and selection (year-2 clones) at the Rhinelander breeding farm in 2012. Leaf tissue was collected from each plant and screened with RYSC3 and YES3-3B. Chi-square analysis of the data showed a 1:1 segregation of the marker in most populations, suggesting that Ry_{adg} and Ry_{sto} are single, dominant genes found in simplex (Rrrr) in the resistant parents (Table 3).

CHC 39-7 and CHC 40-3 (Table 2) are clones of the diploid wild species *Solanum chacoense*. They were found to carry the Ry_{chc} gene and showed phenotypic resistance in a large screen of wild potato species, performed by Cai et al. (2011). Resistant and susceptible *S. chacoense* and susceptible *S. berthaultii* breeding clones were screened with the 38-530 marker for detection of Ry_{chc} (Hosaka et al., 2001) and no polymorphisms were observed, suggesting that the marker has limited utility across populations (Figure 1). CHC 39-7 was crossed with a susceptible *S. tuberosum* clone. From the progeny, a diploid adapted fertile clone, named XD3 and resistant to PVY, was selected and used in further crosses with different susceptible germplasm to develop F1 populations. More recently, the genome of CHC 39-7 was sequenced and work is underway to develop a molecular marker to detect Ry_{chc} by PCR-based methods and incorporate this new source of PVY resistance in breeding materials for the Wisconsin industry.

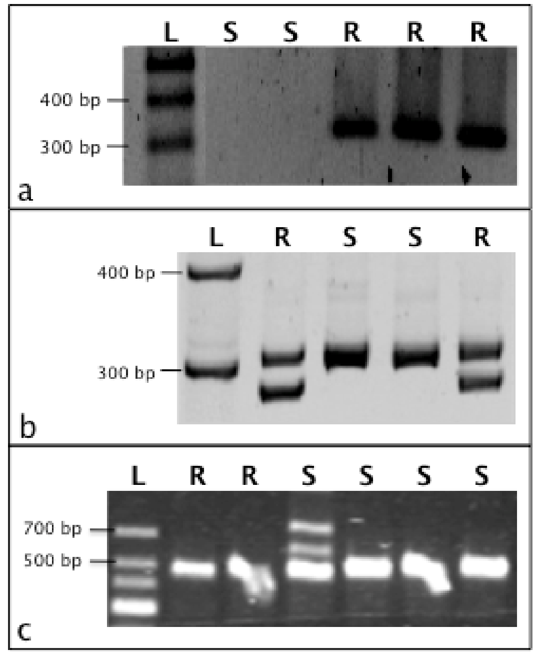

Figure 1. Molecular marker analysis of PVY-resistant and susceptible germplasm. a) RYSC3 amplified fragments (321 bp in resistant germplasm); b) YES3-3B amplified fragments (284 bp in resistant germplasm); c) 38-530 (520 bp expected in resistant germplasm). L: ladder, R: resistant, S: susceptible.

Table 3. Segregation ratios of molecular markers RYSC3 or YES3-3B in breeding populations generated by crossing PVY-resistant and susceptible parents.

Cross	Marker	Segregation ratio present:absent	Chi-Square statistic	p-value
F1 populations (Year 1)				
White Lady X Nicolet	YES3-3B	92:99	0.2565	0.6125
White Lady X Tundra	YES3-3B	52:51	0.0097	0.9215
Tacna X (Superior X Silverton)	RYSC3	28:32	0.2667	0.6056
Year 2 - clones				
White Lady X Nicolet	YES3-3B	18:9	3.0	0.08326
White Lady X Tundra	YES3-3B	20:18	0.1053	0.7456
White Lady X K3206-1	YES3-3B	20:20	0.0	1
Snowflake X W2717-5	YES3-3B	18:18	0.0	1
Eva X Nicolet	RYSC3	14:17	0.2903	0.59
Eva X Tundra	RYSC3	9:10	0.0526	0.8185

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Deficit/Deferred Irrigation

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Central Wisconsin contains one of the largest continuous potato and vegetable production regions in the United States and around the globe. Within a seven county area, irrigated vegetables are produced on 75,000 to 85,000 ha with approximately 48,000 acre potato, 45,000 acre snap bean, 18,000 acre green peas, 55,000 acre of sweet corn, and 6,000 to 11,000 acre of other irrigated vegetables (includes cucumbers, carrots, red beets, and other crops). In addition, there were over 50,000 ha of soybean and corn. The Central Sands are comprised of stratified sand and gravel and are ideal for producing high quality vegetable crops with consistent yield. Consistent production of high quality vegetable crops is the basis for a $6 billion specialty crop industry in Wisconsin (Arledge-Keene and Mitchell, 2011). Irrigation source is groundwater contained in an 80 to 200 foot thick aquifer that resides within 5 to 20 feet below the soil surface across much of the region.

Nearly all of the irrigation water in Central Wisconsin is derived from groundwater. Recently, the impact of irrigation on depth to groundwater has become increasingly scrutinized. In part, this has been triggered by observed declines in surface water levels throughout the region. The Little Plover River dried up during summer of 2006 and 2007 resulting in the death of trout within the stream. Long Lake near Plainfield, WI, has almost completely dried up and other lakes in the region have seen substantial decline in water depth leading to reduced property values for rural residents. Kraft (2009) has estimated that the consumptive water use by irrigated crops of 2 to 6" would result in increased depth to the water table that would correspond to decreased stream flow rates in Little Plover River and other surface water bodies. Consumptive water use is the difference between evapotranspiration and groundwater recharge between field crops and native plant communities (primarily tall grass prairie and pine forest) in the region. Kraft et al. (2012) estimated consumptive water use of 2 to 10" based on observed changes in groundwater depths in monitoring wells in Central Wisconsin relative to wells outside of the region. Furthermore, Kraft estimated groundwater dropped up to 4' in the most intensively irrigated section of the Central Sands. Kung estimated the Wisconsin River flow has decreased from Tomahawk to Wisconsin Dells (through Central Wisconsin including the irrigated production area of the Central Sands) due to 2" increase in ET (Kung 2011).

Groundwater is a critical resource that must be preserved for long-term viability of the vegetable industry and the local economy. Groundwater is the source for all irrigation and must be preserved for long term sustainability of the vegetable industry. In addition, groundwater serves as the drinking water source for communities and rural residents throughout Central Wisconsin. Finally, groundwater feeds the streams and lakes in the region. Wisconsin potato and vegetable systems continually evolve to reduce the environmental impacts of crop production. Wisconsin Growers are committed to environmental protection as evident by the nationally recognized Healthy Grown Potato program (USDA Secretary Award in 2011). Healthy Grown personnel have documented changes in pesticide use to lower risk products, increased IPM by 50%, and the restoration and enhancement of several hundred acres of non-cropland. Improved water management will be critical for preservation of the groundwater in the region. Improved irrigation scheduling, monitoring of groundwater depths, management of surface runoff, and adoption of new nutrient management strategies will be essential components to new water management systems essential for preserving the groundwater resources. Finally, documented water use and assessment of water and nutrient management practices will be important pieces for improved sustainability within the vegetable management systems of Central Wisconsin.

Irrigation research on potato throughout the country and across irrigation systems (sprinkler, flood, drip) has repeatedly shown that deficit irrigation during late bulking has substantial yield and quality responses. Irrigation deficits reduced yield of Gem Russet, a variety selected for drought tolerance, by 15% compared to 30+% yield reductions in Russet Burbank. A 15% yield reduction sounds almost acceptable until evaluating the crop value which can reach well over $1,000/acre. This sum can equate to profit potential for a number of production fields. During 2012, Russet Burbank yield varied from 450 to >800 cwt/a across different experiments across the Hancock Ag Research Station. These yield variations differed due to multiple factors including soil disease pressure, planting date, and fertility, but irrigation was the single largest factor that appeared to have an effect on potato productivity.

Irrigation is critical for potato growth for multiple reasons, but chief among them is to maintain stomatal conductance and cooling of the field. Stomatal conductance is primarily driven by water status within the crop and allows for carbon dioxide entry into the plant. When stomatal conductance is reduced, carbon dioxide becomes limiting and reduces growth. Drought stress during tuber initiation and early bulking, yield can be reduced by over 50% due to the important tuber growth process ongoing during this phase of development as compared to 25 or 30% during late bulking.

In addition to effects on carbon dioxide uptake into the plants, irrigation is crucial for cooling the soils and the plants especially during periods when temperatures exceed 85 F. High temperatures decrease specific gravity, increase sugar end in processing potatoes, increases stem end in chip potatoes, and numerous other factors. Evapotranspiration cools soils and keeps the temperature surrounding developing tubers near the minimum temperature for the day. During drought stress, soils warm by 10 to 15 F due to increased light penetration to the soil surface, but more important lack of cooling of soils by the evaporation process.

Despite the potential impacts of water deficit on potato quality and productivity, the potato industry must search for varieties and potential mechanisms to improve water use in potato. We know that early maturing varieties such as Norkotah or Gold Rush use 2 to 4” less per summer than Russet Burbank or Bannock Russet, but these varieties must continue to be irrigated to optimize storage. University of Idaho research showed Bannock Russet could be irrigated with up to 2” less water over the last 3 to 5 weeks of growth with less than 10% reduction on yield, but its long growing season offsets potential improvements in water use efficiency. We also know more intense irrigation during tuber initiation and early bulking can improve productivity of some varieties. How well do we understand water use by potato? Are there varieties that can use less water yet still have same yield and quality potential? Can we decrease irrigation with minimal yield and quality impacts?

Goals and Objectives: The goal of this research is to evaluate and potentially improve water use efficiency of potato production in Wisconsin. Specific objectives include: 1) estimation of adjusted ET based on canopy closure, maintenance, and closure during the growing season, 2) calculate productivity in terms of water use per unit production, and 3) quantify yield and quality response to different irrigation regimes implemented during late tuber bulking phase of crop growth. These trial results focus on objective 3.

Materials and Methods: Multiple fresh market, chipping, and processing varieties were grown in a factorial experiment with 8 replications. Whole plots were full and deficit irrigation. Second whole plot factor was fumigation or no fumigation, but these results have not been completely analyzed at time of publication. Deficit irrigation was implemented changing irrigation capacity between treatments at the time of Hancock Potato Field Day. Deficit irrigated plots were renozzled to deliver only 75% of full irrigation treatments. The full treatment received approximately 6.5" between July 24 and September 10 whereas the deficit irrigation plots received only 4.5" resulting in irrigation deficit of 1.5". Results are presented for round white and russet varieties. No red skinned potatoes were included in this trial.

Results: Results were surprising. Previous research on deficit irrigation has suggested up to 25 or 30% yield reduction when implemented during late bulking. However, yield reductions in this trial were less than 10% only in round white potatoes with conservation of 1.5" of irrigation. There were no varietal difference in response to irrigation treatment, but trends did occur with varieties like Gold Rush showing no yield response whereas others showed up to 100 cwt/a yield reduction.

Round White Irrigation - 2013

Variety	Irrigation	Total Cwt/A	Cull Cwt/A	Cull % Total	B Cwt/A	B % Total	US#1 Cwt/A	US#1 % Total
	Normal	585.9	12.5	2.3	3.2	0.6	570.3	97.2
	Deficit	536.9	14.1	2.8	3.5	0.7	519.4	96.5
LSD		**36.5**	**NS**	**NS**	**NS**	**NS**	**36.7**	**NS**
Lamoka*		376.7	11.7	3.3	3.2	0.9	361.9	95.9
Megachip		695.7	16.2	2.3	2.6	0.4	677.0	97.3
Nicolet		499.9	17.9	3.6	3.6	0.7	478.4	95.7
Snowden		744.8	11.4	1.5	7.1	1.0	726.3	97.5
FL 01		498.6	7.5	1.5	3.9	0.8	487.2	97.8
FL 02		618.6	7.9	1.3	1.9	0.3	608.9	98.4
FL 03		495.5	20.3	4.2	1.2	0.2	474.0	95.5
LSD		**68.2**	**8.4**	**1.7**	**1.6**	**0.4**	**68.6**	**1.8**
Lamoka	Normal	381.8	8.5	2.4	2.9	0.8	370.5	96.9
Lamoka	Deficit	371.7	14.9	4.1	3.5	1.0	353.4	94.9
Megachip	Normal	702.3	13.4	1.9	1.9	0.3	687.1	97.9
Megachip	Deficit	689.1	19.0	2.8	3.3	0.5	666.9	96.7
Nicolet	Normal	535.0	19.0	3.7	4.0	0.7	512.0	95.6
Nicolet	Deficit	464.9	16.8	3.5	3.2	0.7	444.8	95.8
Snowden	Normal	784.2	13.9	1.8	6.7	0.9	763.5	97.3
Snowden	Deficit	705.4	8.8	1.3	7.4	1.1	689.1	97.7
FL 01	Normal	520.1	10.2	2.0	3.7	0.7	506.3	97.4
FL 01	Deficit	477.1	4.7	1.0	4.2	0.9	468.2	98.2
FL 02	Normal	674.1	7.6	1.2	1.9	0.3	664.6	98.6
FL 02	Deficit	563.1	8.1	1.4	1.9	0.4	553.1	98.2
FL 03	Normal	503.8	14.7	3.0	1.3	0.3	487.9	96.8
FL 03		487.1	26.0	5.5	1.1	0.2	460.0	94.3
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

***Note: Lamoka had emergence issues in all studies except bulking plots which were planted first**

Round White
Irrigatin - 2013

Variety	Irrigation	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	Specific Gravity
		% total US#1 yield							
	Normal	11.2	21.8	23.3	18.0	16.0	6.5	3.3	1.0847
	Deficit	12.9	23.2	23.2	16.6	14.0	6.6	3.6	1.0847
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Lamoka		11.8	22.3	25.1	20.9	13.0	4.9	2.1	1.0836
Megachip		7.4	16.5	24.2	20.5	21.0	7.8	2.6	1.0901
Nicolet		11.8	19.3	21.1	17.8	17.6	8.5	4.0	1.0814
Snowden		19.7	34.3	24.5	12.6	7.6	1.2	0.2	1.0853
FL 01		21.4	34.3	26.5	11.0	5.8	1.1	0.0	1.0884
FL 02		8.7	21.5	26.3	20.2	16.0	5.7	1.6	1.0803
FL 03		3.5	9.3	15.3	17.9	23.8	16.9	13.4	1.0838
LSD		**3.8**	**4.1**	**4.3**	**3.6**	**4.7**	**2.5**	**3.3**	**0.0023**
Lamoka	Normal	12.5	22.1	24.8	22.6	13.3	2.4	2.4	1.0838
Lamoka	Deficit	11.1	22.5	25.5	19.3	12.6	7.3	1.9	1.0835
Megachip	Normal	6.8	16.1	22.5	20.9	21.9	8.8	3.1	1.0890
Megachip	Deficit	8.0	17.0	26.0	20.2	20.1	6.7	2.1	1.0913
Nicolet	Normal	10.9	18.9	21.7	17.8	17.2	9.4	4.2	1.0820
Nicolet	Deficit	12.7	19.7	20.5	17.8	18.1	7.6	3.9	1.0807
Snowden	Normal	19.3	35.2	24.9	11.6	7.7	1.2	0.1	1.0872
Snowden	Deficit	20.0	33.5	24.1	13.6	7.5	1.2	0.2	1.0833
FL 01	Normal	18.4	32.8	28.0	12.2	7.5	1.1	0.0	1.0868
FL 01	Deficit	24.4	35.7	25.0	9.8	4.0	1.1	0.0	1.0900
FL 02	Normal	6.6	17.6	25.6	22.3	19.0	7.4	1.6	1.0800
FL 02	Deficit	10.8	25.4	27.0	18.2	13.1	4.1	1.6	1.0805
FL 03	Normal	3.9	9.7	15.8	18.6	25.2	15.3	11.6	1.0840
FL 03	Deficit	3.0	8.9	14.8	17.3	22.4	18.5	15.2	1.0835
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**3.5**	**NS**	**NS**

Russet Irrigation - 2013

Variety	Irrigation	Total Cwt/A	Cull Cwt/A	Cull % Total	B Cwt/A	B % Total	US#1 Cwt/A	US#1 % Total
	Normal	558.1	25.5	4.7	4.5	0.9	528.1	94.4
	Deficit	526.7	20.0	3.9	4.5	0.9	502.2	95.2
LSD		**NS**	**4.7**	**NS**	**NS**	**NS**	**NS**	**NS**
Bannock		550.7	31.2	5.7	5.3	1.0	514.2	93.4
Burbank		576.4	21.7	3.8	5.4	1.0	549.4	95.3
Goldrush		452.1	21.0	4.6	6.6	1.5	424.5	93.9
Innovator		434.6	24.2	5.8	3.0	0.7	407.5	93.5
Norkotah CO8		545.4	14.6	2.7	3.0	0.6	527.8	96.7
Silverton		620.2	12.7	2.0	5.1	0.9	602.4	97.1
Umatilla		617.7	33.8	5.5	3.4	0.6	580.5	93.9
LSD		**68.4**	**8.8**	**1.6**	**1.7**	**0.4**	**67.4**	**1.6**
Bannock	Normal	559.9	33.6	6.0	5.0	0.9	521.4	93.1
Bannock	Deficit	541.4	28.8	5.4	5.6	1.0	506.9	93.7
Burbank	Normal	584.6	26.5	4.5	4.8	0.9	553.3	94.6
Burbank	Deficit	568.1	16.8	3.0	5.9	1.1	545.4	96.0
Goldrush	Normal	446.0	24.1	5.4	7.3	1.7	414.5	93.0
Goldrush	Deficit	458.3	17.9	3.9	5.8	1.3	434.6	94.9
Innovator	Normal	455.2	25.2	5.8	3.8	0.9	426.2	93.4
Innovator	Deficit	414.1	23.2	5.9	2.2	0.6	388.7	93.7
Norkotah CO8	Normal	569.7	13.8	2.5	3.0	0.6	552.9	97.0
Norkotah CO8	Deficit	521.2	15.5	3.0	3.1	0.6	502.7	96.5
Silverton	Normal	679.1	15.7	2.4	4.1	0.6	659.2	97.1
Silverton	Deficit	561.3	9.6	1.7	6.1	1.1	545.6	97.2
Umatilla	Normal	612.5	39.4	6.3	3.8	0.7	569.2	93.0
Umatilla	Deficit	622.8	28.2	4.6	3.0	0.5	591.7	94.9
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Russet Irrigation - 2013

Variety	Irrigation	2-4 oz	4-6 oz	6-8 oz	8-10 oz	10-13 oz	13-16 oz	>16 oz	Specific Gravity
		% total US#1 yield							
	Normal	9.9	18.5	21.7	16.8	17.0	8.9	7.1	1.0733
	Deficit	11.2	20.6	21.6	18.2	15.4	7.2	5.8	1.0739
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Bannock		11.9	19.8	21.2	18.1	17.6	6.5	4.9	1.0741
Burbank		12.8	23.8	22.4	16.2	14.6	6.2	4.0	1.0803
Goldrush		15.3	23.1	21.9	15.5	13.4	6.5	4.2	1.0700
Innovator		9.7	19.3	23.3	16.9	16.0	8.9	5.8	1.0718
Norkotah CO8		7.6	13.6	17.9	18.1	17.0	12.5	13.2	1.0698
Silverton		8.2	18.1	22.6	20.2	17.4	8.2	5.3	1.0669
Umatilla		8.5	19.0	22.4	17.5	17.3	7.7	7.7	1.0824
LSD		**2.9**	**4.5**	**NS**	**NS**	**NS**	**3.5**	**4.5**	**0.0029**
Bannock	Normal	11.6	19.8	20.2	17.3	17.1	7.4	6.6	1.0748
Bannock	Deficit	12.1	19.9	22.2	19.0	18.2	5.5	3.1	1.0735
Burbank	Normal	11.0	23.3	23.6	16.3	16.5	6.7	2.6	1.0798
Burbank	Deficit	14.6	24.3	21.1	16.2	12.8	5.7	5.4	1.0807
Goldrush	Normal	15.2	21.8	21.5	15.6	15.4	6.6	4.0	1.0677
Goldrush	Deficit	15.4	24.4	22.3	15.4	11.5	6.5	4.5	1.0723
Innovator	Normal	9.6	19.1	23.9	13.3	15.7	10.6	7.7	1.0712
Innovator	Deficit	9.9	19.5	22.7	20.6	16.3	7.2	3.9	1.0723
Norkotah CO8	Normal	5.7	10.6	17.9	18.1	17.3	15.2	15.4	1.0705
Norkotah CO8	Deficit	9.6	16.7	18.0	18.1	16.8	9.7	11.1	1.0690
Silverton	Normal	6.3	14.1	20.3	20.4	21.0	10.4	7.6	1.0675
Silverton	Deficit	10.2	22.1	24.9	20.0	13.8	6.1	3.1	1.0663
Umatilla	Normal	10.2	21.0	24.9	16.7	15.9	5.4	6.1	1.0817
Umatilla	Deficit	6.9	17.1	19.9	18.2	18.6	10.1	9.3	1.0830
LSD		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Potato sustainability in Wisconsin: Results of an industry-wide sustainability assessment in 2013

Deana Knuteson and Jeff Wyman (UW-Madison, NISA Program) and Duane Maatz (WPVGA)

Abstract: The Wisconsin potato industry is taking a proactive approach to documenting the sustainability of their growers. The industry is working with the National Initiative for Sustainable Agriculture (NISA), to assess the sustainability of practices currently being used on potato farms across the state. The Wisconsin Potato and Vegetable Growers Association (WPVGA) is employing an entry level assessment approach developed by NISA to ensure maximum grower engagement in the sustainability arena. This assessment process is used to determine a baseline for the industry, and to communicate where the industry currently stands in adopting within farm gate practices that encourage sustainable agricultural systems. The results of this assessment define the baseline for the 2013 potato production year. The industry will re-assess within 5 years to evaluate continuing advancement.

The following 2-page document is an example of the communication piece which resulted from this effort.

Potato sustainability in Wisconsin

Determining the sustainability of practices used by potato growers in 2013

The Wisconsin potato industry is being proactive in documenting the sustainability of their growers while ensuring grower engagement in the process. Working through the Wisconsin Potato and Vegetable Growers Association (WPVGA), in partnership with the National Initiative for Sustainable Agriculture (NISA), the industry has assessed the sustainability of the practices currently used on potato farms throughout the state. The assessment used an entry-level NISA approach to generate maximum grower engagement in the sustainability arena. Seventy-one growers returned assessments representing 56,785 acres of potatoes (90% of the total Wisconsin acreage). Growers from the fresh (20,400 acres), chip (17,900 acres), frozen (10,400 acres), and seed markets (7,400 acres) participated in the assessment to provide an accurate representation of the industry as a whole. This assessment represented over 200,000 total farmland acres, with the farms being active for an average of over 53 years. All results were received from family owned farms, with an average of 2-3 generations actively working and involved in the farming operations.

Results: The data shown (see other side) demonstrates the percentage of growers using practices that encourage sustainable agricultural advancements.

Ensuring Grower Involvement: The current industry-wide assessment expands grower engagement in sustainability to all segments of potato production in Wisconsin by providing a base-tier assessment that involves a broad spectrum of growers. This base-tier assessment compliments Wisconsin's existing Healthy Grown® assessment which is a mid-tier, market-based standard. The advancements highlighted on the following page clearly demonstrate how Wisconsin potato growers are pushing the envelope in sustainability, and will continue to improve!

Wisconsin potato growers are committed to advancements along the sustainability continuum. Each year, they allocate a portion of their potato sales to support short- and long-term research at the University of Wisconsin and beyond.

What's Next: The WPVGA and NISA will re-assess the industry every few years to show continued advancements and implementation of new and cutting edge practices.

NISA National Initiative for Sustainable Agriculture

HOME GROWN WISCONSIN POTATOES

College of Agricultural & Life Sciences UNIVERSITY OF WISCONSIN–MADISON

For more information, contact

dmaatz@wisconsinpotatoes.com

Highlights of assessment results

ECONOMIC

- 100% of farms are multi-generational family farms ensuring economic stability.
- 88% grow multiple crops to maintain economic diversity.
- 70% have risk management plans.
- 64% have succession plans in place.

ENVIRONMENTAL

- **Soil conservation.** To preserve structure, 81% employ a 3 year rotation and 81% use practices to avoid compaction; to prevent erosion, 59% use conservation tillage, 70% plant winter cover crops and 87% use living windbreaks.
- **Water use.** 57% use computer-based irrigation scheduling, 90% retain water use records.

ENVIRONMENTAL

- **Biodiversity.** Over 30% work with an ecologist to identify native habitat types and implement practices to enhance biodiversity, 52% use pest-specific insecticides to preserve natural enemies.
- **Energy.** Over 70% use at least 4 different approaches to conserve energy and 80% recycle.
- **Improving production efficiency.** 100% calibrate planters and 86% use auto-steer to improve land use efficiency. 94% attend annual educational meetings and 61% conduct on-farm research with scientists.
- **Using nutrients efficiently.** 97% sample soil to determine crop need, 82% split nitrogen applications or use slow release formulations and 67% use leaf petiole sampling to determine need for supplemental nitrogen.
- **Pest management.** 96% scout fields to determine pest levels and treat only at thresholds to reduce environmental impact.

  90% rotate mode of action to manage resistance.

  73% use at least 4 non-chemical approaches to manage weeds.

  60% use at least 4 non-chemical approaches to manage insects.

  74% use at least 8 non-chemical approaches to manage diseases.

SOCIAL

- 70% purchase inputs and supplies locally.
- 77% have employee benefits and 52% provide educational opportunities.
- 45% are actively involved in community service organizations.
- 93% have the ability to trace product from field to consumer.
- 78% conduct GAP and other food safety assessments annually.
- 90% use field practices to reduce contamination during handling and packaging.
- 83% use storage practices to reduce contamination and to ensure quality and food safety.

Wisconsin Healthy Grown® Potato Program

The Wisconsin potato industry has long worked to improve their production while advancing sustainable practices. This is illustrated by the award winning and nationally recognized Wisconsin Healthy Grown® Potato Program—involving 15% of the state's fresh potato production. Healthy Grown®, a mid-tier sustainability assessment, has been at the forefront of environmental potato production in the US for more than a dozen years and has documented impressive improvements while continuing to push the sustainability envelope.

Assessing the value of rescue N applications to potato

Matt Ruark, Jaimie West, and Mack Naber
Dept. of Soil Science, University of Wisconsin-Madison

Introduction

Most often the largest cause of a reduction in nitrogen (N) use efficiency are the additions of N later in the growing season (i.e. post tuberization). These late N applications are often a necessity to keep the plants growing or stimulate tuber bulking due to leaching of previously applied N. Petiole nitrate sampling is often used a guide to asses plant N status, but little information is available to that addresses if the supplemental applications actually increase yields.

The objectives of this study were to: (1) evaluate the necessity of additional N applications (above recommended rates) for potato receiving conventional and PCU fertilizer and (2) to determine the N release rate of PCU urea.

Materials and Methods

This research was conducted at the Hancock Agricultural Experiment Station in 2013 and the test cultivar was Russet Burbank. The experimental design was a randomized complete block, split plot design with 4 experimental blocks and 25 plots per experimental block. Treatment plots were 12 ft x 20 ft. The treatments included split applications of ammonium sulfate [AS; $(NH_4)_2SO_4$] and ammonium nitrate (AN; NH_4NO_3) (indicated as AS/AN) or application of ESN® (Agrium, Inc; Calgary, AB) applied all at emergence. The split plot treatments will be 0, 30, or 60, or 90 lb/ac of N applied late in the growing season (simulated fertigation). The 60 lb/ac treatment was applied over two applications and the 90 lb/ac treatment was applied over three applications (30 lb-N/ac for each application). The late-season N was applied as urea.

To determine the amount of N release from the PCU during the growing season, ESN® will be weighed and placed into mesh bags. The bags will be placed in the potato hill. At times corresponding to petiole sampling, the bags will be removed and weighed. Differences in weight will correspond to the amount of N released by the ESN®.

Table 1. Whole plot treatments (in-season N applications) used in the 2013 experiment.

Source	Timing	Rate (lb-N ac^{-1})
None	No fertilizer applied	
AS/AN	1/3 of N applied as $(NH_4)_2SO_4$ at emergence 2/3 of N applied as NH_4NO_3 at tuberization	200, 250, 300
ESN®	100% of N applied at emergence	200, 250, 300

Results and Discussion

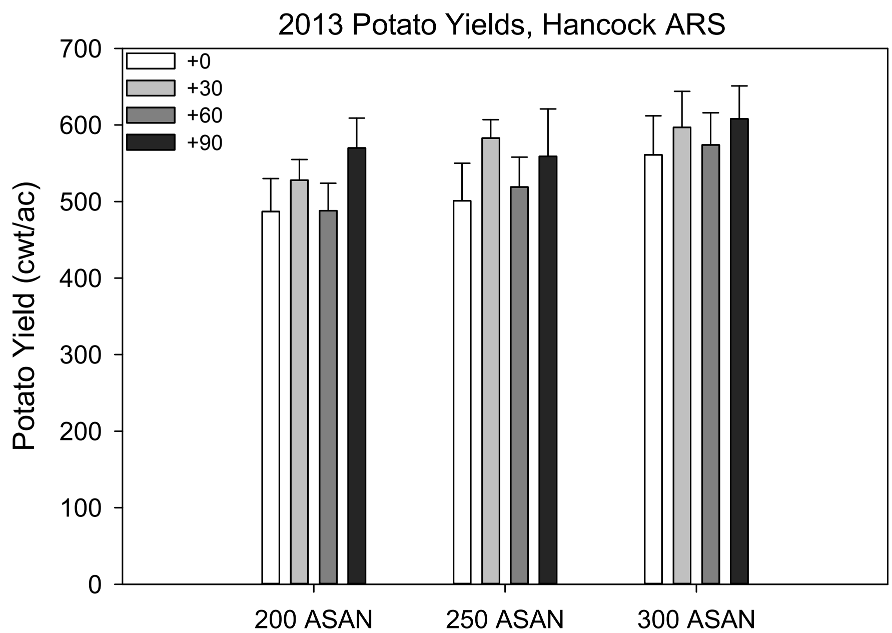


Figure 1. Potato yields (total) with three rates of a split application of ammonium sulfate and ammonium nitrate and with up to three additional applications of N.

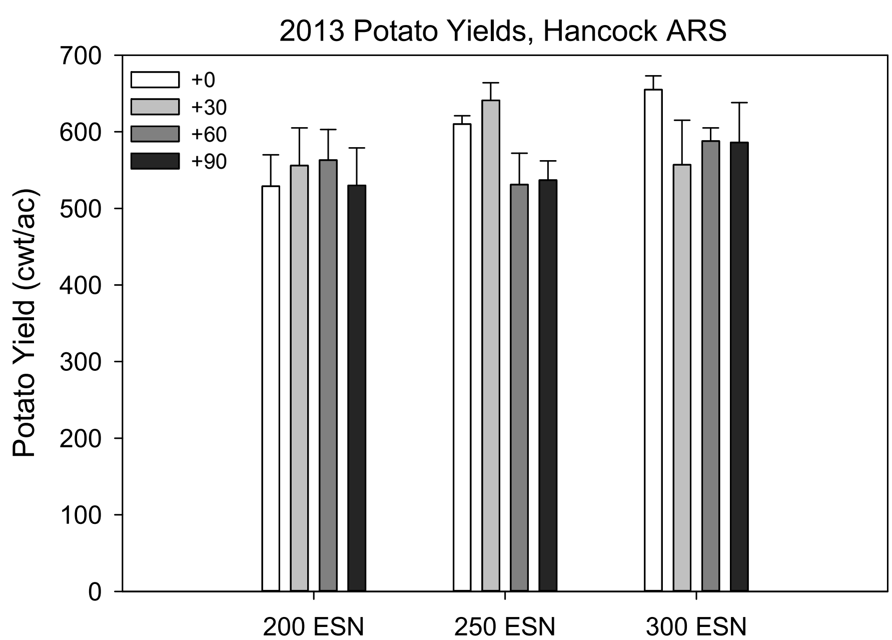


Figure 2. Potato yields (total) with three rates of a split application of ammonium sulfate and ammonium nitrate and with up to three additional applications of N.

For the 2013 growing season, with AS/AN applications, yields increased with additional early season applications of N (Fig. 1). In addition, there appeared to be an additional yield increase with at least one application of additional 30 lb-N/ac. Additional N beyond 30 lb-N/ac did not result in yield increases. Yields with ESN were greater than that with AS/AN fertilizer. With 250 lb/ac of N as ESN, an additional application of 30 lb-N/ac slightly increased yields, but additional N applications lowered yields (Fig. 3). When 300 lb/ac of N was applied as ESN, any additional applications of N decreased yield.

Table 1. Petiole nitrate-N concentrations in 2013.

		Petiole nitrate concentrations			
Treatment	Extra N	30d	45d	60d	75d
	lb/ac	-------------------- NO_3-N % --------------------			
200ASAN	0	3.57	1.44	0.73	0.15
	30		1.81	1.21	0.27
	60				0.49
250ASAN	0	2.74	1.71	0.86	0.25
	30		2.10	1.37	0.58
	60				0.69
300ASAN	0	3.13	1.97	1.50	0.52
	30		1.96	2.16	0.78
	60				0.79
200ESN	0	2.29	1.23	1.16	0.29
	30		1.45	1.35	0.44
	60				0.70
250ESN	0	2.96	1.51	1.26	0.36
	30		1.56	1.60	0.52
	60				0.94
300ESN	0	2.20	1.83	1.43	0.70
	30		2.15	2.03	1.00
	60				1.28
None	0	1.33	0.20	0.47	0.02

Petiole nitrate concentrations also show the benefit of the first application of 30 lb-N/ac, as nitrate concentrations increased under most treatments (Table 1). The second application of 30 lb-N/ac (resulting in a total application of 60 lb-N/ac) also increased petiole nitrate concentrations, but yields shown in Figures 1 and 2 indicate that yield gains were not realized.

The release of ESN in 2013 was more typical than the fast released measured in 2012. About 60% of the N in the ESN had been released by 60 days after planting and about 70% had been released 80 days after planting (Fig. 3). Thus, there was still protected N in the coating after the rainfall events in June and July. This is likely the reason that no yield benefit to supplemental N was seen for the ESN plots.

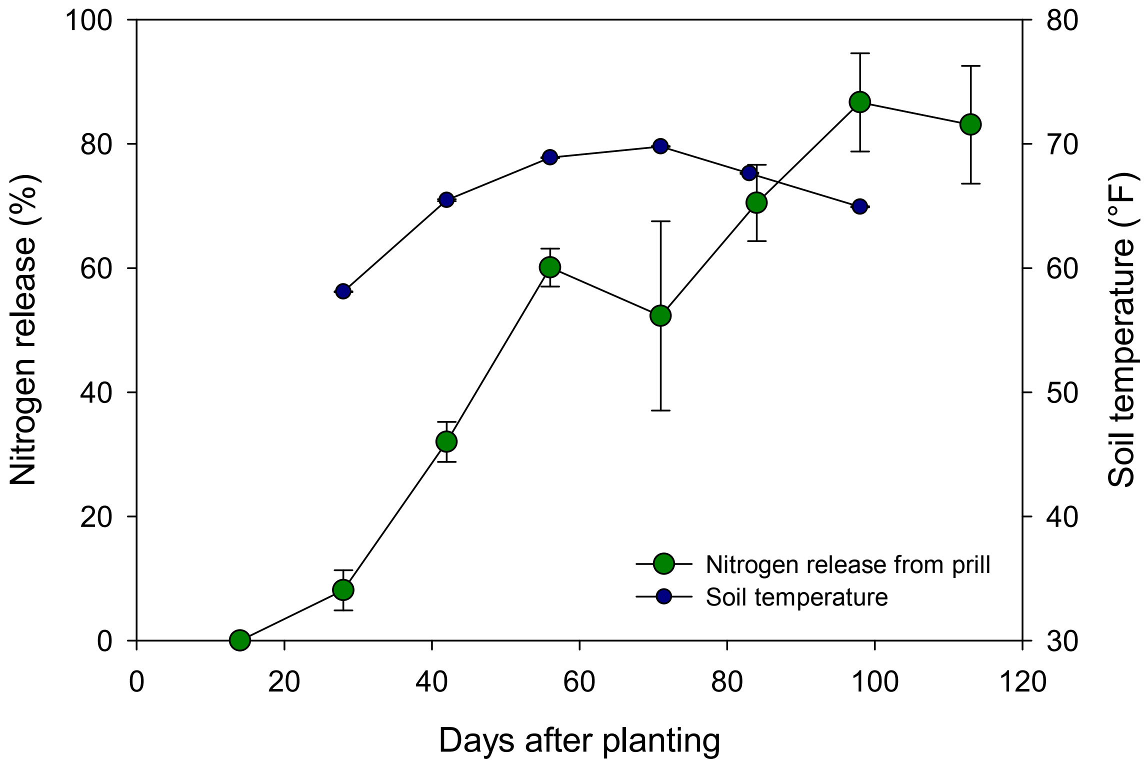


Figure 3. Nitrogen release from ESN® and soil temperature in 2013 at Hancock ARS. Planting date was April 30th, 2013 and ESN® was applied at first hilling on May 15th, 2013. Soil temperature was collected Error bars represent standard error.

Nematode Pests of Potato – Status and Management Updates

Ann MacGuidwin, UW-Plant Pathology

Nematode damage in our research plots at the Hancock Research Station (HRS) was lower in 2013 than in 2012. Yield loss is related to nematode population densities at planting and is further modified by weather and crop stress during May and June. Overwinter mortality of Root Lesion nematodes at HRS was 15% in 2013 so there was nematode pressure in our trials, but their impact was mitigated by above-average precipitation in May and June. Damage due to Root Lesion and other nematodes can often be detected as a lag in canopy closure. This symptom, as well as yield loss, was mild at HRS in 2013.

Important Nematode Pests of Potato in Wisconsin

More than 800 soil samples were assayed by the UW Diagnostic Service in 2013. Plant parasitic nematodes were detected in every sample, but many samples had population densities unlikely to cause yield loss. Population densities of nematode pests cycle over time and there is always the potential to build to damaging levels so growers should have their fields assayed if crop yields decline or new cultivars fail to reach their yield potential.

Northern Root Knot Nematode (*Meloidogyne hapla*): Root Knot nematodes were detected in less than 1% of the samples tested in 2013, but fields positive for Root Knot were experiencing yield loss. Infected crops in 2013 included soybean, basil, and mint. Research by the MacGuidwin lab (1) and others have shown yield loss of potato by *M. hapla* so soil fumigation or nematicides are advised for potato planted in infested fields. Rotation with nonhost crops such as corn or small grains is effective at reducing population densities of *M. hapla*. An increase of Root Knot nematodes following corn should be investigated as this might indicate the presence of the Columbia Root Knot nematode, *M. chitwoodi*.

Stubby Root Nematode (*Paratrichodorus spp*): Stubby Root nematodes were rarely detected in 2013 (3%), but this nematode can be difficult to capture by soil sampling and we think it is more prevalent that the data suggest. Stubby Root does not enter roots and is quite mobile in the soil profile so population densities are sometimes greatest at depths of 12 inches or more. It is also very sensitive to physical forces and the sharp edges of sand particles can kill Stubby Root if soil samples are thrown or handled roughly. Stubby Root nematodes vector the tobacco rattle virus to cause the Corky Ringspot Disease so fields infested with this pest should be monitored for symptoms of the virus. Only high population densities (>500 per 100 cc soil) of Stubby Root have been related to yield loss, so management is usually not necessary unless the virus is present.

Root Lesion Nematode (*Pratylenchus penetrans*, *P. neglectus*, *P. scribneri*): Root Lesion nematodes are the most common nematode pest in Wisconsin and 95% of the samples assayed in 2013 were positive for this pest. Population densities sufficient to cause yield loss were detected in about 12% of the samples. Root Lesion, especially *P. penetrans*, is harmful to potato at initial densities of 200 nematodes per 100 cc soil regardless of the presence of Verticillium (3). In combination with Verticillium, even low population densities of Root Lesion can cause the

Potato Early Dying Disease (PED) (2). Our research effort is directed to Root Lesion because virtually every potato field in Wisconsin is at risk of damage due to the nematode alone or to the nematode-fungus interaction of the PED.

Important Nematode Pests of Potato not present in Wisconsin

An important role of the UW Diagnostic Service is to collect data that supports claims that certain regulated nematode pests do not occur in Wisconsin. The three nematode pests below remain undetected in Wisconsin.

Potato Cyst Nematode (*Globodera rostochiensis*) and Pale Potato Cyst Nematode (*G. pallida*): Two cyst nematode pests of potato are subject to quarantine regulations. *Globodera rostochiensis* was first detected in New York the 1940's and has been successfully contained within that state for more than sixty years. *Globodera pallida* was detected in Idaho in 2006 and The USDA Animal Plant Health Inspection Service moved quickly to delimit the infestation and initiate survey activities in and outside of Idaho. As of October 1, 2013 almost 500,000 soil samples have been collected from Idaho to look for the Pale Potato Cyst nematode (4). At this time, about 13,000 acres of farmland in Idaho are regulated for this pest including the 2,300 acres known to be infested (4). The Wisconsin Seed Certification Program, tested 1230 soil samples for cyst nematodes of potatoes in 2013 (persnl. comm. Dr. Amy Charkowski) and no samples were positive for these pests. The UW Diagnostic Service collects crop history on samples and is alert for cyst nematodes from any field used to grow potato. The Soybean Cyst Nematode, Lambsquarters Cyst Nematode, and the Knotweed Cyst Nematode are detected regularly in potato production fields but these species are not harmful to potato or of regulatory concern.

Columbia Root Knot Nematode (*Meloidogyne chitwoodi*): The Columbia Root Knot nematode causes blemish of fresh market and chipping potatoes in the Pacific Northwest, California, New Mexico, Nevada, Utah, Texas, Colorado, and Virginia. Damage thresholds for this pest are very low and management recommendations are easy to find on the internet and trade periodicals. Wisconsin producers should be alert when reading these materials because many of the products and practices effective for the Columbia Root Knot Nematode have the opposite effect on Root Lesion Nematodes and can accelerate the buildup of population densities. The Columbia Root Knot nematode has not been reported from Wisconsin, but it's known geographic range and life history traits indicate that it may be only a matter of time before it is detected.

Management Options for Root Lesion Nematode

Soil fumigation remained the gold standard for reducing Root Lesion nematode population densities in 2013. Select fields at the HRS have been monitored throughout the entire rotation and there has been a consistent and dramatic decline in nematode numbers following fumigation with metam sodium. However, it should be noted that fumigation cannot eradicate Root Lesion so there is always a residual population remaining in the field. Some crops, such as soybean, are excellent hosts for Root Lesion and population densities can reach levels so high that even a 95% reduction can leave sufficient numbers to damage potato and other crops. The major benefit of fumigation is that other pests and pathogens, such as *Verticillium dahliae*, are also controlled.

Nematicides available for potato in Wisconsin are Mocap, Furadan, and Vydate. These chemicals have been on the market for many years and there is efficacy data for potato and other crops for Root Lesion nematodes. Our research has shown the potential for two benefits of nematicides – an increase in yield and a reduction in nematode numbers at the end of the season to carry over to the next susceptible crop. The insecticide-nematicide Movento has a mode of action designed to suppress activity rather than to kill nematodes. Efficacy data for Root Lesion on potato is still sparse for this product.

The nematicidal (lethal) and nematistatic (inhibitory) seed treatments of Avicta, and VoTivo respectively, are not available for potato, but can be used on other crops during the rotation. Our research to date has shown seed treatments have the potential to increase yield of the treated crop, but do not suppress the build-up of nematode population densities to protect the next crop.

Two other chemistries targeted for nematodes can be used on potato in Wisconsin. Azadirachtin is a chemical derived from the Neem plant. This botanical nematicide has been used for years in the tropics as oil and cake formulations with reported success for some nematodes. Azadirachtin is sold in the U.S. as Azaguard, Molt-X, and Ecozin and published data for nematode pests of potato is sparse. Harpin proteins marketed for protection against nematodes include Messenger, ProAct, and Employ. Published data for potato is mainly for the Columbia Root Knot nematode and most studies test it in combination with a nematicide.

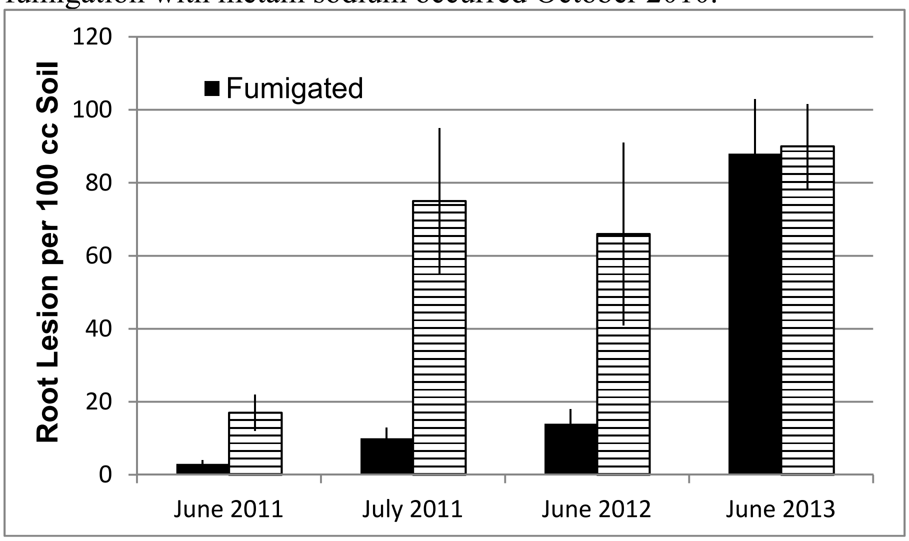
The primary cultural control for Root Lesion nematode is cover crops. Our research has shown that Forage Pearl Millet (*Pennisetum glaucum*) and African marigold (*Tagetes erecta*) can be suppressive to Root Lesion nematodes regardless of the timing or management of the crop. Crops containing chemicals lethal to nematodes, such as rapeseed (*Brassica napus*), can be effective if grown and chopped into a green manure following prescribed methods and schedule, with the caveat that a misstep can increase population densities of Root Lesion nematodes. Most cover crops used for purposes other than nematode management, such as daikon radish, are hosts for Root Lesion and provide opportunity for nematodes to reproduce at a time when they are usually dormant.

Root Lesion Nematode Management Research in 2013

Three projects focused on managing Root Lesion nematodes will be presented at the 2014 conference: 1.) Multi-season effect of metam sodium for Root Lesion control, 2.) Suppressing nematode damage and reproduction using seed treatments on corn as a rotation crop, and 3.) Suppressing nematode damage and reproduction using forage pearl millet in soybean as a rotation crop.

Multi-season effect of metam sodium: In collaboration with Dr. Amanda Gevens, we are following Root Lesion nematodes throughout the potato rotation in a field at the HRS that was lightly infested with Root Lesion and Verticillium pathogens at the start of the study. Half of the field was fumigated with metam sodium in the fall of 2010 prior to planting potato in 2011. The field was cropped to corn in 2012, snap bean in 2013, and will be planted with potato in 2014. Other management practices being evaluated in the field are rye, tillage radish, and white mustard cover crops planted after harvesting potato (2011) and snap bean (2013) and vine removal for the potato crop (2011). Potato vine removal has no direct impact on Root Lesion nematodes and the effect of cover crops on nematodes won't be evident until spring 2014, but the impact of fumigation on nematodes was immediate and sustained for almost two years (Figure 1). Samples collected at the same time each year showed a significant (P = 0.05) impact of fumigation on early season population densities of Root Lesion in 2011 (potato crop) with a carry-over benefit in 2012. The field was not fumigated in 2014 in order to evaluate the increasingly common practice of planting tillage radish preceding potato as a soil conditioner and the use of white mustard as a biofumigant for PED pathogens.

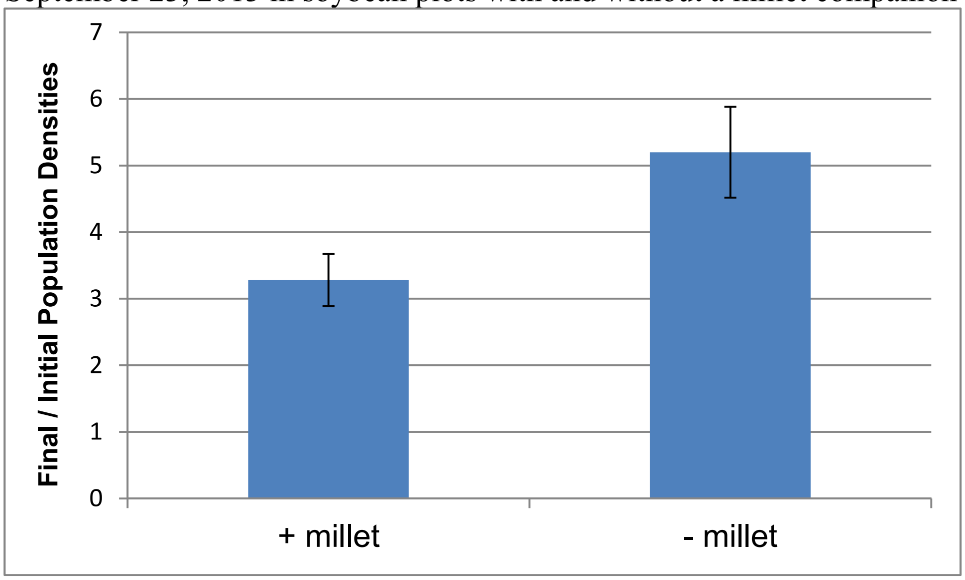
Figure 1. Average number of Root Lesion nematodes per 100 soil during the first week of June during the potato (2011), corn (2012), and snap bean (2013) years of the rotation. Soil fumigation with metam sodium occurred October 2010.



Impact of corn seed treatments on Root Lesion Nematodes: Nematode seed treatments of corn were studied at the HRS. There are no nematode seed treatments for potato so the purpose of this study was to determine if targeting nematodes during the corn rotation year decreases the damage potential of nematodes for potato. Five corn hybrids were used to compare seed treated with fungicide, insecticide, and nematicide versus seed treated with fungicide and insecticide only. The products Avicta (Syngenta) and Votivo (Bayer) were evaluated in combination with their respective insecticides and a common fungicide. In 2012 we found the nematicide Avicta increased yield by 5% averaged across all hybrids ($P < 0.05$), with yield increases of individual hybrids ranging from 0 to 10%. In 2013 we did not find a difference in the "plus nematicide" versus "minus nematicide" treatments for any hybrid. Yields in all plots were excellent and the favorable spring growing conditions mitigated early season nematode damage to corn. As was the case in 2012, nematode seed treatments did not slow the rate of nematode increase on the corn crop. End-of-season population densities were increased 4-fold from the initial levels regardless of seed treatment.

Intercropping forage pearl millet in soybean for Root Lesion suppression: It is common in Wisconsin for soybean to be the crop preceding potato. There are no soybean cultivars resistant to Root Lesion, but there are other crops known to be suppressive to nematodes that could be planted with soybean. For this experiment, forage pearl millet (Johnny's Seeds hybrid *Pennisetum glaucum*) was seeded between rows of soybean planted on a 30-inch spacing at the HRS. A paired treatment design was used with a "with millet" plot planted next to a "without millet" plot. The soybeans were Roundup-Ready and the millet grew at about the same rate as soybean until it was killed by the glyphosate application. The at-plant nematode population density in the field was high (441 Root Lesion per 100 cc soil) so the field was at high risk for nematode-induced damage. Sixty plots (30 with and 30 without forage pearl millet) were sampled at plant, V4, and before harvest. All plots had high population densities by the end of the season, but the "with millet" plots supported significantly less ($P = 0.02$) nematode reproduction during the soybean year (Figure 2). The plots were affected by the White Mold disease and there was no difference in yield among the treatments. This experiment illustrates the excellent host status of soybean for Root Lesion as the superior "with millet" treatment still resulted in a 3-fold increase in nematode population densities. More important, this experiment showed that the rate of nematode increase can be slowed using a cultural approach. The experiment will be repeated in 2014.

Figure 2. Average increase of Root Lesion nematodes per 100 cc soil from April 23 to September 23, 2013 in soybean plots with and without a millet companion crop.



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3. MacGuidwin, A. E., D. L. Knuteson, T. Connell, W. L. Bland, and K. D. Bartelt. 2012. Manipulating inoculum densities of *Verticillium dahliae* and *Pratylenchus penetrans* with green manure amendments and solarization influence potato yield. Phytopathology 102:519-527.

4. http://www.aphis.usda.gov/plant_health/plant_pest_info/potato/downloads/pcndocs/surveyupdates/3rd-Quarter-2013.pdf

Surface Blemish Diseases of Potato

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INTRODUCTION

Potato tubers develop in soil over the course of six weeks or more and during this time, they are exposed to thousands of species of diverse bacteria and fungi in the soil. Very few of these microbes cause disease on potato tubers; there are only five genera that commonly cause surface blemishes on potato tubers. This suggests that potato tubers effectively defend themselves from most soil microbes and/or causing surface blemishes on potato is a difficult trait for most microbes to acquire.

The fungi that cause tuber surface diseases appear to depend in plant cell wall degrading enzymes for virulence, while the bacterium *Streptomyces*, which causes common scab depends on toxins. How *Spongospora subterranea* (powdery scab) causes symptoms remains unknown. Overall, we know very little about how tuber surface pathogens cause disease.

Those few microbial species that do cause tuber blemish diseases have become widespread and are present in most fields with a history of potato. Resistance to these pathogens is not generally present in cultivated potato and is rare or not found in wild potato. These ever-present diseases are challenging to control and require a multi-pronged effort to reduce their incidence in potatoes.

In the 1990s and early 2000s, PCR-based detect methods for these pathogens were developed and these methods have been useful for both detection and disease epidemiology. Recent genomic and field studies provide some new information on how these pathogens cause disease, new sources of resistance, and methods for disease control.

SILVER SCURF – *Helminthosporium solani*

Symptoms: The fungus that causes silver scurf kills just the top few layers of cells on a tuber, which causes the tuber periderm to turn grey. The symptoms are most evident on red and blue potatoes and are most evident when the potatoes are wet. Symptom severity worsens as the tubers are left in the soil; the longer potatoes are left in soil after vine kill, the worse silver scurf symptoms will become. Symptoms can also develop over time in storage, but because this is a very slow growing fungus, symptom development in storage will occur slowly. Healthy-appearing tubers are often colonized or contaminated with this fungus at harvest.

This diseases in increasing in importance and incidence. There are no potato varieties that are resistant to silver scurf and silver scurf disease control methods are limited in effectiveness. This pathogen does not affect yields, but lots of tubers with high disease incidence may be rejected for processing, since chips produced from infected tubers may have burnt edges, and for fresh use, since tubers with silver scurf are unattractive.

Similar diseases: Silver scurf symptoms resemble black dot symptoms. The margins on silver scurf lesions may be better defined than those of black dot lesions, but since these two diseases often occur together on the same tuber, the symptoms may be difficult to distinguish.

Life cycle: Tubers can become infected in the field and *H. solani* on both seed potatoes and soil can serve as inoculum. In fields with long rotations (greater than three years), seed tubers are likely to be the main source of inoculation. The fungus grows on the developing tubers, but the majority of symptom development occurs after vine kill. Dry conditions can cause severe symptoms even on young tubers.

Spores form on tubers in storage when the humidity is above 90% and the temperature is above 38F. The spores are spread through warehouse ventilation systems and can infect otherwise healthy tubers. Tubers can also become infected with silver scurf in storage through contact with diseased tubers. Tubers that are infected, but asymptomatic at harvest are common and these tubers can develop symptoms in storage or after washing just prior to sale.

The fungus grows on debris from many plants, including debris from crops commonly rotated with potato and it may survive in soil by colonizing rotation crop debris.

Seed potatoes: In general, silver scurf incidence increases with the number of years a seed lot has been multiplied in field soil. Planting seed of a lower generation may result in a lower incidence of silver scurf.

Other hosts: This slow-growing fungus has only been reported to cause disease on potato tubers. It does not infect other root and tuber crops commonly grown in Wisconsin, such as sweet potato, carrots, parsnips, beets, or turnips. It grows well on many other substrates, including plant debris, wood, and paper. It can grow on wooden storage boxes and wood in potato warehouses. Most wild potato species are susceptible to silver scurf, but a few wild potato species have a lower level of sporulation when infected with this fungus.

Cultural control: No single cultural control method will eliminate silver scurf, but a combination of efforts may reduce the incidence of this disease. Growers may choose to:

1. Not replant lots with a high incidence of silver scurf.
2. Build storages with separate ventilation systems so that lots with a low incidence of silver scurf, particularly early generation lots, can be stored separately from lots with a higher incidence of this disease.
3. Sanitize equipment and storages between crops to remove inoculum from warehouses and equipment.
4. Increase the length of rotations to at least three years. Even longer rotations will reduce the incidence of this disease.
5. Harvest tubers as soon as the skin has set. Leaving the tubers in soil after vine kill increases incidence and severity of silver scurf. If vines die earlier than expected due to other diseases or damage, consider harvesting the tubers earlier than scheduled to reduce silver scurf disease.

6. Dig representative samples prior to harvest to estimate incidence of silver scurf and other diseases. This information can be used to make decisions on where and how long to store the harvested tubers.
7. Not sell only a portion of a lot that is highly infested partway through the winter and then attempt to store the rest of the lot. Disturbing the tubers in storage dislodges spores and spreads them to otherwise healthy tubers through warehouse ventilation systems.
8. Not spread or dump infested tubers on future potato fields, since they will serve as an inoculum source.

Biocontrol: ***Use only products labeled for silver scurf and contact your local extension agent if you need recommendations about products appropriate for your region.*** Multiple biocontrol microbes have been tested for control of silver scurf with mixed results, thus these biocontrol microbes do not appear to provide consistent control of silver scurf.

Chemical control: ***Use only products labeled for silver scurf and follow all label directions when using the product. Contact your local extension agent if you need recommendations about products appropriate for your region.*** Broad spectrum pre-plant fungicides that are phenyl pyrrole-based can provide some control of silver scurf. These fungicides, which contain fludioxonil, include products such as Maxin MZ, Dynasty, and Stadium.

The broad spectrum fungicide thiabendazole (class: benzimidazole; product name Mertect) has been used for silver scurf control, but it is no longer recommended or labeled for this disease since resistance has developed. A single mutation in a single *H. solani* gene is sufficient to provide resistance to thiabendazole, and resistant isolates are present in North America. Repeated use of this fungicide on a farm will select for resistant isolates of *H. solani*.

General biocides, such as chlorine dioxide or ozone, are not effective against silver scurf since the fungus that causes this disease grows within the periderm layer. In order to kill the fungus, the biocide must also kill the top few layers of the potato tuber, which causes more damage to the potato that silver scurf itself.

Organic salts, some of which are widely used in food (potassium sorbate and sodium carbonate, for example), can provide some control of silver scurf, as do some plant derived volatiles and essential oils. These methods have not yet been developed for large scale use.

Resistant varieties: Commercial cultivars are not resistant to *H. solani*. Cultivars vary in the amount of spores produced or in the visibility of the symptoms on the tuber. Tolerance has been found in wild potato species and the Verticillium resistant line C287 may also have useful tolerance to silver scurf.

Detection, diagnosis, and identification: Silver scurf symptoms are very similar to black dot symptoms, but there are no other common tuber diseases easily mistaken for silver scurf. The fungus is very slow growing and it is difficult to isolate from soil, debris, or asymptomatic tubers since other fungi that are also present over-grow *H. solani* on culture media. The fungus forms characteristic conidiophores that resemble pine trees on tuber surfaces, but these are usually only evident after the tubers have been incubated in a humid chamber for one month or more.

Unfortunately, the required incubation favors fast-growing decay pathogens and tubers often rot before the slow-growing *H. solani* fungus forms spores. PCR primer sets for detection of this fungus has been published and these assays can be used to detect the fungus in soil and on tubers.

Recent discoveries: Despite its importance, very little research has been conducted on silver scurf or *H. solani* over the past decade. We do not know how this fungus causes symptoms or have a complete picture of its life cycle. This is in part because *H. solani* grows very slowly compared to most fungal pathogens and few research tools are available for this fungus. For example, there is no simple method for making mutations or for following this fungus in the environment, so epidemiological and genetic research with *H. solani* is slow and difficult.

The *H. solani* genome sequence was recently decoded and this will provide in-roads into research. For example, we now have a comprehensive list of potential virulence genes, so researchers may be able to determine how this fungus attacks potato tubers. With this information, we may be able to develop simpler screens for resistance or tolerance. The genome sequence also provides information required for development of additional, simpler detection tools.

Silver Scurf Bibliography
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BLACK DOT - *Colletotrichum coccodes*

Symptoms: The fungus that causes black dot causes symptoms similarly to *H. solani* (silver scurft) in that it kills just the top few layers of cells on a tuber, which causes the tuber periderm to turn grey. As with silver scurf, the symptoms are most evident on red and blue potatoes and are most evident when the potatoes are wet. The symptoms are often difficult to see on russet potatoes. Healthy-appearing tubers are often colonized or contaminated with this fungus at harvest.

There are no potato varieties that are resistant to black dot and control methods are limited in effectiveness. This pathogen does not affect yields, but lots of tubers with high disease incidence may be rejected for processing.

Similar diseases: Black dot symptoms on potato tubers resemble silver scurf symptoms. The margins on silver scurf lesions may be better defined than those of black dot lesions, but since these two diseases often occur together on the same tuber, the symptoms may be difficult to distinguish. *C. coccodes* also causes foliar and stem symptoms similar to early dying and it may play a minor part in the potato early dying disease complex.

Life cycle: Tubers can become infected in the field from spores that have formed on potato stems or from sclerotia that have survived in the soil. The small black dots that give this disease its name are fungal sclerotia and they are visible on stems, stolons, and tubers. The sclerotia can survive for several years in the soil and long crop rotations show little effect in reducing disease.

Unlike silver scurf, black dot does not spread easily in potato warehouses. Tubers that are infected, but asymptomatic at harvest are common and these tubers can develop symptoms in storage or after washing just prior to sale.

Surprisingly, day length may affect black dot severity, which could explain some of the conflicting reports on the importance of this disease. Black dot is more severe under short days than long days.

Seed potatoes: The incidence of black dot on seed tubers is poorly correlated with severity and loss due to this disease in the harvested potatoes. Soil-borne inoculum appears to be more significant than seed-borne inoculum for this disease.

Other hosts: In addition to potato, *C. coccodes* infects other solanaceous plants, such as tomato and nightshide. It can also infect crops commonly rotated with potato, such as mustard, canola, and legumes and it infects weeds, such as nightshade and velvet leaf.

Cultural control: No single cultural control method will eliminate black dot, but a combination of efforts may reduce the incidence of this disease. Growers may choose to:

1. Not replant lots with a high incidence of black dot.
2. Sanitize equipment and storages between crops to remove inoculum from warehouses and equipment.

3. Control solanaceous weeds, such as nightshade, and do not include solanaceous crops in rotation with potato.
4. Monitor soil fertility since very high or low levels of nitrogen may increase disease severity.
5. Harvest tubers after vine kill as soon as skin has set since longer times in soil may increase disease severity.
6. Use fall tillage to plow under crop debris. This will aid in debris decomposition and will reduce soil-borne *C. coccodes* inoculum.
7. Not spread or dump infested tubers on future potato fields, since they will serve as an inoculum source.

Chemical control: ***Contact your local extension agent if you need recommendations about products appropriate for your region.*** There has been limited effort in developing fungicides to control black dot and available fungicides are not very effective against *C. coccodes*. Some fungicides are labeled for this pathogen, such as Serenade Max and Quadris Ridomil Gold SI, but their efficacy may be limited. These fungicides will reduce disease caused by other pathogens Limited studies show that fumigation reduces disease incidence.

Resistant varieties: Commercial cultivars are not resistant to *C. coccodes*. Cultivars vary in the visibility of the symptoms on the tuber, with symptoms being much less visible on russet tubers. There has been limited screening of wild potato and potato breeding lines. A recent screen of 40 wild potato accessions and 46 potato breeding lines found partial resistance in several accessions or lines, suggesting that additional screening would be worthwhile and that increased resistance to black dot can be introduced into cultivated potato.

Detection, diagnosis, and identification: Black dot symptoms on tubers are similar to those caused by silver scurf, but there are no other common tuber diseases easily mistaken for black dot. The fungus forms characteristic sclerotia on tubers, which are visible as small black dots in the silvery lesions. PCR primer sets for detection of *C. coccodes* are available and these assays can be used to detect the fungus in soil and on tubers.

Recent discoveries: Relatively little research has been conducted on black dot on potato, in part due to controversy over its importance as a potato disease. Only recently, was its widespread nature in lesions formerly considered to be silver scurf symptoms recognized.

These two fungi, *C. coccodes* and *H. solani*, make a fascinating comparison since both cause almost identical symptoms on nearly all potato varieties and since one is a broad host range pathogen and the other a narrow host range pathogen. Comparison of the virulence strategies of these two fungi should reveal what is required to cause surface blemishes on potato and should reveal why only one of the two is a broad host range pathogen. Genome sequences are now available for both species, making this comparison possible.

Black dot bibliography

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BLACK SCURF – *Rhizoctonia solani*

Symptoms: The fungus forms sclerotia on tuber surfaces that resembles dirt, but it does not wash off. The black sclerotia are usually several millimeters across, unevenly shaped, and easy to see without magnification. Tubers with a large number of sclerotia have a characteristic mushroom smell. The fungus can also form masses of white mycelia underneath the tuber periderm.

There are no potato varieties that are resistant to *R. solani* and control methods are limited in effectiveness. *R. solani* can kill developing sprouts and weaken stem bases. Losses to this pathogen are much higher when the soil is cold and wet. Its ability to aggressively infect sprouts and stems differentiates it from other tuber surface pathogens.

Similar diseases: Black scurf symptoms on tubers are distinctive and not easily mistaken for other diseases.

Life cycle: Both seed tubers and soil serve as a source of inoculum. The sclerotia can survive for several years in soil, so short crop rotations do little to limit disease. Symptoms may worsen after vine kill, so tubers should be harvested as soon as the skin has set. This fungus rarely produces spores and mainly spreads through sclerotia or mycelia.

Unlike silver scurf, black scurf does not spread easily in potato warehouses. Also, unlike silver scurf and black dot, symptoms do not become worse in storage.

Seed potatoes: Since *R. solani* can kill developing sprouts, tubers with a high incidence of black scurf should not be planted.

Other hosts: *R. solani* has a broad host range, including crops commonly rotated with potato. It will infect other solanaceous crops and weeds and legumes.

Cultural control: No single cultural control method will eliminate black scurf, but a combination of efforts may reduce the incidence of this disease. Growers may choose to:

1. Not replant lots with a high incidence of black scurf.
2. Sanitize equipment and storages between crops to remove inoculum from warehouses and equipment.
3. Not to plant into cold (below 46F) and damp soil.
4. Not spread or dump infested tubers on future potato fields, since they will serve as an inoculum source.
5. Harvest tubers after vine kill as soon as skin has set since longer times in soil may increase disease severity.

Chemical control: ***Contact your local extension agent if you need recommendations about products appropriate for your region.*** Several fungicides are labeled as seed treatments for *R. solani,* such as Cruisermaxx, Moncut 70-df, and Mon Coat Mz.

Resistant varieties: Commercial cultivars are not resistant to *R. solani*, but some are more tolerant than others.

Detection, diagnosis, and identification: Black scurf symptoms are distinctive and easily identified. PCR primer sets for detection of *R. solani* are available and these assays can be used to detect the fungus in soil and on tubers.

Recent discoveries: The genomes of multiple *Rhizoctonia* are now available. Most work with this fungus is on easier to study plants, such as the model plant Arabidopsis. Researchers are just beginning to understand how this fungus infects plants and how some plants resist infection. Recent studies have also identified Pythium and Pseudomonas species that may serve as biocontrol microbes for *R. solani*.

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COMMON SCAB – *Streptomyces* species

Symptoms: This bacterium causes surface blemishes and pits on the potato tuber. Sometimes fluffy masses of bacterial cells can be seen in these lesions in freshly dug tubers. The bacterium makes geosmin, which is responsible for the smell usually associated with soil and geosmin can also be detected on infected tubers. The symptoms only form on developing tubers and do not get worse or spread in storage.

Potato varieties vary significantly in resistance / tolerance to common scab. Losses to this pathogen are much higher when the soil pH is high or when the soil is too dry during tuber formation. Common scab incidence is also correlated with soil nutrient characteristics, although the correlations vary by soil type. Acid scab is sometimes used to refer to symptoms caused by *Streptomyces acidiscabies,* a type of scab-causing bacterium that can cause scab in low pH soils.

Similar diseases: *Streptomyces* species cause many types of surface blemishes and it can sometimes be unclear if the blemishes are caused by this bacterium. The deep pitted scab sometimes caused by *Streptomyces* is distinctive and not easily mistaken for other diseases.

Life cycle: Both seed tubers and soil serve as a source of inoculum. The bacterium can survive for several years in soil and grows well in association with plant debris. The pathogen infects tubers shortly after tuber initiation and causes symptoms by interfering with periderm development. Symptoms are generally more severe in soils with high pH or when irrigation is not sufficient, but managing soil pH and irrigation may not be sufficient for disease control. High symptom severity is also correlated with use of manure on fields. The symptoms do not get worse once tubers have fully developed and the disease does not spread in storage.

Multiple species of Streptomyces cause common scab and the relative importance of the different species varies by location. Scab suppressive fields exist, but the mechanism by which these fields suppress common scab is still under investigation. All plant pathogenic isolates of *Streptomyces* produce the toxin thaxtomin and some produce additional plant toxins.

Seed potatoes: Tubers with a high incidence and severity of common scab should not be planted since they may introduce a high amount of new strains into a field and they may not for robust sprouts if the scab lesions have affected tuber eye development.

Other hosts: *Streptomyces* infects several other root and tuber crops, including beets, radishes, and sweet potatoes.

Cultural control: No single cultural control method will eliminate common scab, but a combination of efforts may reduce the incidence of this disease. Growers may choose to:

1. Not replant lots with a high incidence of common scab.
2. Sanitize equipment and storages between crops to remove inoculum from warehouses and equipment.
3. Not to plant into soils with high pH.

4. Monitor soil moisture and maintain it near field capacity for two to six weeks following tuber initiation.
5. Not spread or dump infested tubers on future potato fields, since they will serve as an inoculum source.
6. Use acid-producing fertilizers (ammonium sulphate) to lower soil pH.
7. Not use lime and manure, which may raise soil pH, directly before a potato crop.

Soil characteristics and crop rotations have been correlated with common scab, but the correlations do not hold across soil types. This may be because multiple *Streptomyces* species cause this disease and the different bacterial species react differently to changes caused by crop rotations and soil properties. Farmers can assess their own fields over time to determine if they may have scab suppressing or scab enhancing fields and whether crop rotations appear to affect scab on each field.

Chemical control: ***Contact your local extension agent if you need recommendations about products appropriate for your region.*** Manzate as a seed treatment or the fumigants Pic-clor 60 or Strike 85cp may be used to control common scab.

Resistant varieties: Some commercial cultivars are tolerant of common scab, while others are highly susceptible. Of the varieties commonly grown in Wisconsin, Silverton Russet and related varieties tend to be tolerant to common scab. Many heirloom varieties, such as Green Mountain, are highly susceptible to common scab.

Detection, diagnosis, and identification: Some variants of common scab symptoms are distinctive and easily identified, but mild symptoms may or may not be caused by common scab. Determining whether the symptoms are caused by the bacterium is complicated since the pathogen is easily isolated from both healthy and diseased tubers and from soil. PCR primer sets for *Streptomyces* detection are available and these assays can be used to detect the fungus in soil and on tubers.

Recent discoveries: The genomes of multiple *Streptomyces* species are available and researchers have been identifying the numerous toxins produced by these species. The main virulence genes for this pathogen are present on a large gene cluster that can be transferred among *Streptomyces* species, meaning that new pathogen variants are likely to arise in soil.

One of the biggest challenges in working with this pathogen is developing repeatable virulence assays that reflect the complex situation that exists in field soils. To identify resistance, potato lines must be assessed in multiple field sites over multiple years. The lack of simple virulence assays has made identifying resistance genes in cultivated and wild potato complicated. Despite this, resistance to common scab has been mapped in potato. Therefore, future varieties may contain useful levels of common scab resistance.

Advances have been made toward biocontrol of common scab. Non-pathogenic *Streptomyces* and *Bacillus* species, both of which are common in soil, can reduce scab incidence and severity when used as seed treatments or soil drenches.

Common scab bibliography

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POWDERY SCAB – *Spongospora subterranea*

Symptoms: This pathogen, which was long included with the fungi, is actually a protozoan. It forms nodules on potato roots and small spore-filled pustules on potato tubers.

There are no potato varieties that are resistant to *S. subterranea*, but russet potato varieties tend to only develop root nodules and not tuber symptoms. In contrast, red potato varieties are highly susceptible to tuber symptoms. Losses to this pathogen are much higher when the soil is cool and wet since this pathogen swims through wet soil to reach tubers. Disease incidence may be sporadic, even in infested soils.

Unlike other tuber surface pathogens, *S. subterranea* can vector a virus, Potato MopTop Virus (PMTV), which can itself, cause tuber necrosis.

Similar diseases: Common scab symptoms can sometimes resemble those caused by *S. subterranea,* making it difficult to differentiate these diseases.

Life cycle: Both seed tubers and soil serve as a source of inoculum. The spore balls survive for several years in soil, so crop rotations do little to limit disease. Disease development can be sporadic, even in infested soils, and depends much upon soil moisture. Because this pathogen infects both roots and tubers, it can cause yield loss by reducing root health. If conditions are favorable to disease development, even low spore numbers can cause a significant amount of disease and yield loss.

S. subterranea is an obligate pathogen, meaning that it can only be grown on growing potato roots or tubers. Therefore, this is a very difficult disease to work with and few pathologists have experience in working with this pathogen.

Seed potatoes: *S. subterranea* spreads on diseased seed potatoes. If your field is not already infested with powdery scab, the best control is to not plant infested tubers. Unfortunately, it can be difficult to tell if low levels of the pathogen are present on seed tubers.

Other hosts: *S. subterranea* is mainly a potato pathogen, but because its spore balls survive for many years in soil, crop rotation does little to control this disease. Lack of crop rotation, however, can quickly increase soil inoculum of this pathogen.

Cultural control: No single cultural control method will eliminate powdery scab, but a combination of efforts may reduce the incidence of this disease. Growers may choose to:

1. Not replant lots with a powdery scab.
2. Sanitize equipment and storages between crops to remove inoculum from warehouses and equipment and to reduce spread of inoculum from infested fields.
3. Not to overwater potatoes after tuber initiation.
4. Not spread or dump infested tubers on future potato fields, since they will serve as an inoculum source.

Unfortunately, control recommendations for common scab and powdery scab are in opposition. High soil moisture suppresses common scab, but can promote powdery scab.

Chemical control: ***Contact your local extension agent if you need recommendations about products appropriate for your region.*** The only fungicide currently labeled for Spongospora in Wisconsin is the seed treatment Moncut 70-df.

Resistant varieties: Commercial cultivars are not resistant to *S. subterranea*, but some russet varieties do not develop tuber lesions with this pathogen. Russet Norkotah is resistant to this pathogen, while smooth skinned white, red, and yellow lines, such as Shepody, Red Norland selections, Kennebec, and Yukon Gold are susceptible.

Detection, diagnosis, and identification: Powdery scab symptoms are somewhat distinctive and tuber lesions contain characteristic spore balls that can be identified via microscopy. PCR primer sets for detection of *S. subterranea* are available and these assays can be used to detect the fungus in soil and on tubers.

Recent discoveries: This is a very difficult to work with pathogen and as a result, despite its importance, very few researchers have ever worked with *S. subterranea*. There is a significant need for a better understanding of how this pathogen infects plants and for cultural and biocontrol methods for powdery scab.

Powdery scab bibliography

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Potato Breeding Program Research Update Field Year 2013

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Wisconsin Seed and Commercial Potato Growers-On Farm Variety Testing

Potato Breeding Program Research Update Field Year 2013

Abstract: The goal of the UW Potato Breeding Program is to develop potato cultivars that are genetically superior and that satisfy or exceed the standard for yield and grade in the fresh and processing markets. To achieve these objectives, parental lines with desired traits are crossed and progenies are evaluated emphasizing early selection evaluation in Central WI and other environments. In last few years we have made significant progress towards selecting superior varieties for long storability, processing ability from cold storage for chip stocks, processing russets for French fries, fresh market russets and reds. Exciting developments include the naming of Pinnacle, Tundra, Accumulator and Lelah. Accumulator, a short storage chipper, is arguably the highest yielding chip variety in the US and Lelah is probably the WI variety with the best capacity for long term cold storage, usually a month longer than Snowden. In 2013 we named Pinnacle. Pinnacle is also a long term storage chipper. These varieties are being evaluated by the USPB-Fast-Track project at the semi-commercial level. In 2013 we evaluated over 81,000 single hills and nearly half of those came from our collaborators. As in the past year we maintain all lines starting Year 2 at Rhinelander. We evaluated at Hancock Station 749 Year 3 clones, 98 Year 4 and 56 Year 5 advance clones. In addition we evaluated 17 SpudPro clones. Six clones were entered into the NCRT trials and four clones in the SFA trials. We also collaborated with 12 growers to evaluate 27 elite clones from our program. We are making progress in selection for resistance to PVY in collaboration with Amy Charkowski. In addition we participated in the National Verticillium wilt trial conducted by Shelley Jansky. In 2013 Wisconsin seed growers harvested 689 acres of certified seed of twelve clones. We are also making progress on selection for resistance to scab. In addition we also continue to make progress on two ongoing research projects. One is on understanding genetics of cold storage chip quality. In this project we have created two segregating populations parents with contrasting cold induced sweetening resistance. These populations have been evaluated for cold storage chip quality for the last two seasons. The data will be used to map traits controlling cold storage chip quality. The second project is on understanding genetics of tuber internal quality**.** In this project we have created populations from reciprocal crosses made between Atlantic and Superior. These populations are segregating for many commercially important traits and data are being used to understand the genetics of these traits.

Objectives:

The main objectives of the UW-Potato Breeding Program are as follow:

i. **Development of Processing and Dual Purpose Processing/Fresh Market Russet Varieties.**
ii. **Development of Fresh Market Russet Varieties.**
iii. **Development of Long Storage Chippers as Potential Snowden Replacements.**
iv. **Development of Early Chippers as Potential Atlantic Replacements**.
v. **Development of Fresh Market Red Skin and Specialty Varieties**.

Overall Scope of the UW Breeding Program in 2013

Figure 1. Breeding scheme used by the UW - Potato Breeding Program 2013

Program Stage	Clones
Parents	80
Seedling tubers from WI	43,327
Seedling tubers from Collaborators	38,377
Year 1 (1H), Rhinelander	81,704
Year 2 (8H), Rhinelander	2,309
Year 3 (20H), Rhinelander & (8H),Hancock	749
Year 4 Replicated Trials, Hancock	98
Year 5 Replicated Trials, Hancock	56
USPB National Chip Process Trial (NCPT)	24
USPB National Fry Process Trial (NFPT)	8
Year 6 - 10: Hancock	
SpudPro Trial	17
WI State and Regional Trials	8
North Central Regional Trial (NCRT)	6
USPB Snack Food Association Trial (SFA)	4
Agronomic & Storage Profiling	4
On Farm Trials: 12 Growers	27

The overall scope of our potato breeding program for the 2013 year is outlined in Figure 1. We evaluated over 81,000 single hills and nearly half of those came from our collaborators. As in the past year we maintain all lines starting Year 2 at Rhinelander. We evaluated at Hancock Station 749 Year 3 clones, 98 Year 4 and 56 Year 5 advance clones. In addition we evaluated 17 SpudPro clones. Six clones were entered into the NCRT trials and four clones in the SFA trials. We also collaborated with 12 growers to evaluate 27 elite clones from our program. As in the past years we also conducted separate screening of our advance clones for incidence and severity of scab. We are making progress in selection for resistance to PVY in collaboration with Amy

Charkowski. In addition we participated in the National Verticillium wilt trial conducted by Shelley Jansky.

Our breeding program is also a site for the USPB funded national chip (NCPT) and fry (NCFT) trials. In addition to evaluating clones from all over the country we entered 24 clones in the NCPT and 8 clones in the NFPT trials.

National Chip Processing Trial (NCPT)

The NCPT is a nationally coordinated trial designed to identify new potato breeding lines with broad adaptation and potential as chip varieties. The 2013 trial had 170 entries and was planted in 10 different states, including Wisconsin. The UW breeding program contributed 28 lines to the trial and evaluated the entire group of 170 at the Hancock Research Station. Total yield, tuber shape and appearance, specific gravity, and internal defects (e.g., hollow heart, brown spots, bruising) were recorded after harvest. Overall fry color and stem-end defects were measured after 3 months of storage at 47^{o}F and will be recorded again after 6 months.

Figure 2 shows the two-year averages (2012–2013) for yield and specific gravity of the UW breeding lines across four northern sites (OR, WI, MI, NY). Snowden and Atlantic are included as standards in the figure. The vast majority of these lines have acceptable fry color off the field or after short-term storage, but very few have the combination of high specific gravity (> 1.080) and high yield (comparable to Atlantic and Snowden) needed for a successful potato chip variety. The high yielding potato labeled W2324-1 in the figure was named Accumulator and released by the breeding program in 2012. Based on the results from 2013, five UW breeding lines were identified as having superior merit and will be tested again in 2014. In addition, 19 new lines from the breeding program will be entered in the NCPT for the first time in 2014.

National Fry Processing Trial (NFPT)

The NFPT is a nationally coordinated trial designed to find new russet potato breeding lines with broad adaption and potential as fry processing varieties. The 2013 trial had 76 entries, plus Russet Burbank and Ranger Russet as standards, and was planted in five states, including Wisconsin. The UW breeding program contributed 13 lines to the trial and evaluated the entire group of 78 at the Hancock Research Station. Tubers were graded by weight to calculate marketable yield (> 4 oz., minus culls) as well as 4–6 oz., 6–10 oz., and > 10 oz. categories. A 50 lb. sample of harvested tubers for each trial entry was shipped to East Grand Forks, MN, for visual rating by a group of experienced potato growers, breeders, and processors. These tubers will be monitored for up to 8 months in cold storage and tested for raw tuber glucose as well as acrylamide in finished fries. Based on their superior shape, appearance and agronomic data, three UW breeding lines (W6234-4, W9519-1, W9433-1) were selected for further analysis by two fry processing companies. At 2–3 time points over the next 8 months, fries will be made from the breeding lines and evaluated for numerous physical and sensory attributes by experts.

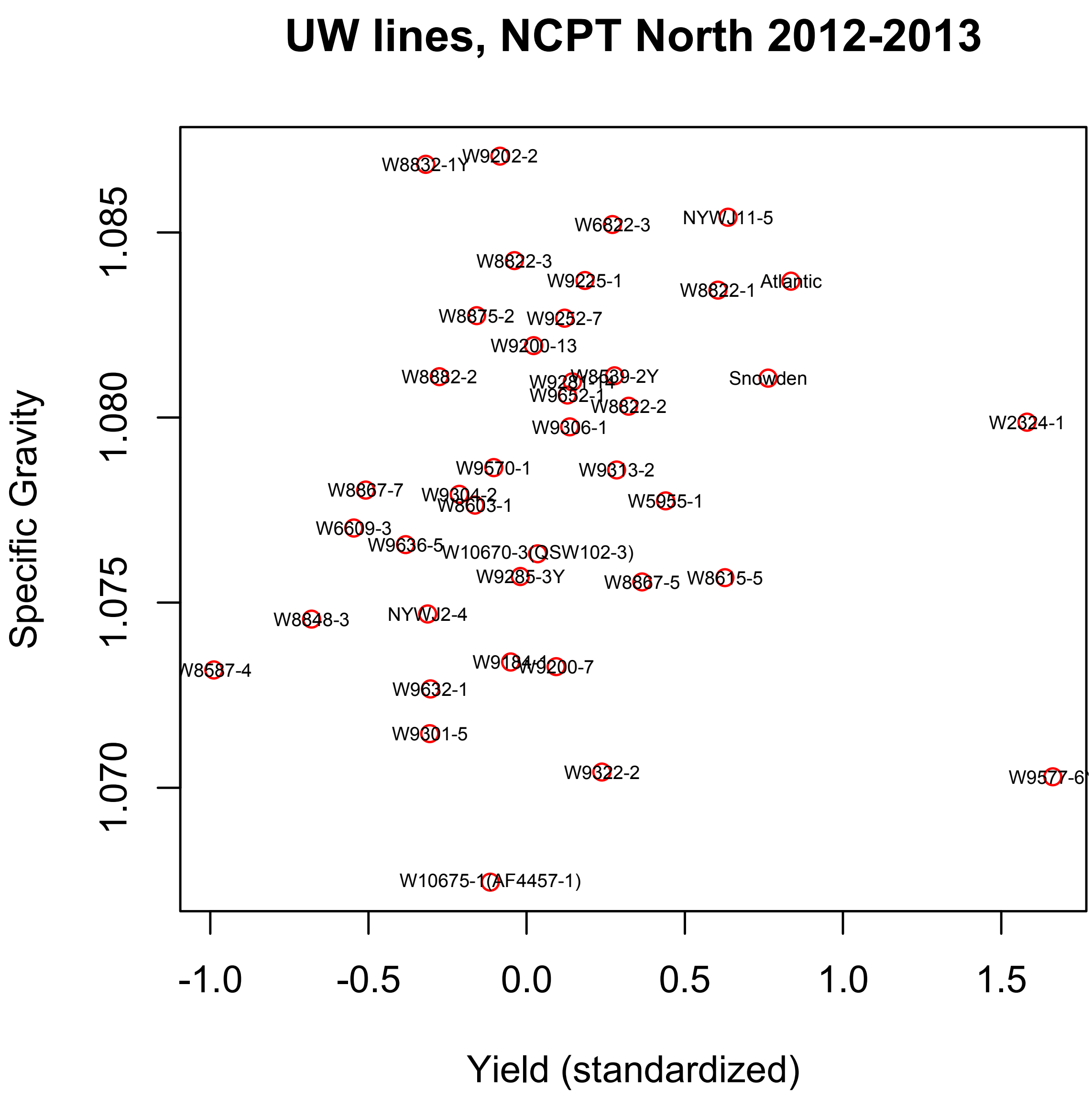


Figure 2. Adjusted means for yield (standardized) and specific gravity of UW breeding lines across four northern sites (WI, MI, OR, NY) of the NCPT. Lines may have been present in either one or both years for the period 2012–2013.

Impact of New Clones as Measured by Certified Seed Acreage

Certified seed acreage planted with our recent releases was about 600 acres (Figure 3). Megachip had the largest acres planted (Table 1). However number of new varieties including Lelah, Nicolet, Tundra and Accumulator had significant acres planted (Table 1).

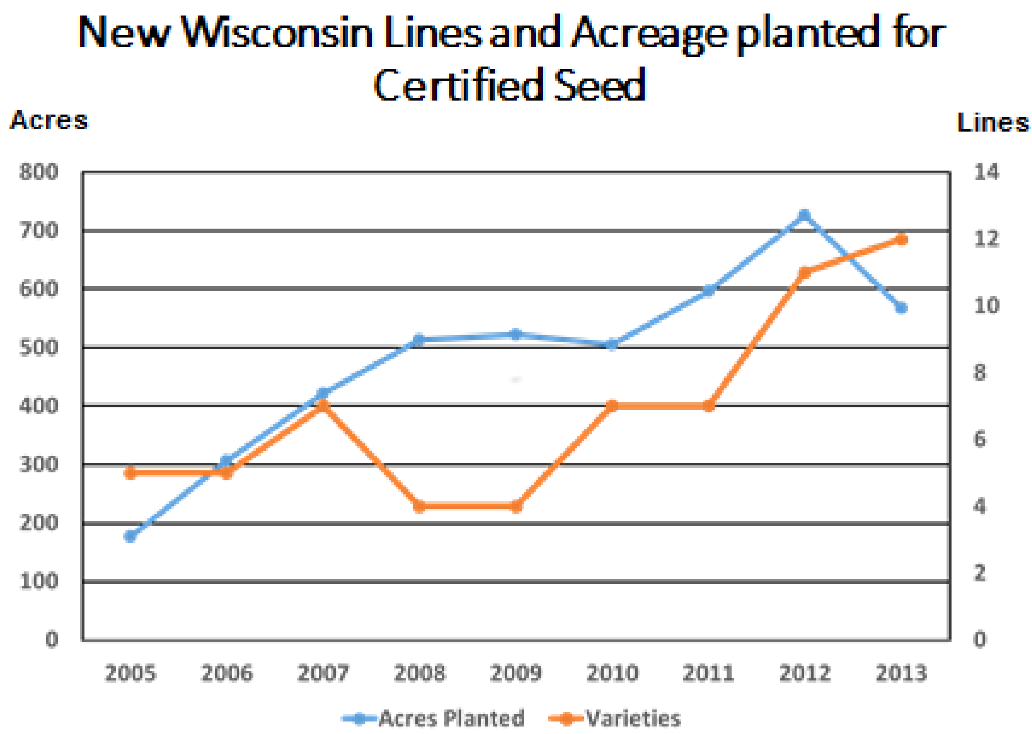


Figure 3. Certified seed acreage (2005-13) of new Wisconsin clones

Table 1. Certified acres planted with new Wisconsin varieties

Variety	Seed Acres Entered For Certification							
	2013	2012	2011	2010	2009	2008	2007	2006
MegaChip	401	462	385	349	382	361	278.7	133
Nicolet	63	87	55	20				
Accumulator	35	67	56					
White Pearl	17	22	22	3	0	19	24.6	24
Lelah	17	5	1					
Freedom	13	13	56	108	128	112	106.9	59
Tundra	13	18	1	16				
Villetta Rose	2	11	22	9	7	21	18.12	67
W6234-4rus	2							
W6703-1Y	2	1						
W5015-12	1							
W6002-1R	1	1						
Total Acres	567	687	598	505	517	513	428	283
Number of Varieties	12	10	8	6	4	4	4	4

SpudPro Breeding Lines Promoted to Virus Cleaning and Seed Multiplication

Following table provides an updated status of clones evaluated and promoted by the SpudPro committee.

Table 2. SpudPro promotion and seed production schedule, WI clones

Variety	2013	2014	2015	2016	2017	2018
Tundra	SG	SG/Com	Graduated from SPUDPRO			
Nicolet	SG	SG/Com	Graduated from SPUDPRO			
Accumulator	SG/Com	SG/Com	Graduated from SPUDPRO			
Lelah	SG/Com	SG/Com	Graduated from SPUDPRO			
W6234-4rus	E2/SG	SG/Com				
W5015-12	E2/SG	SG/Com				
W6002-1R	E2	SG	SG/Com			
W6703-1Y	E1	E2	SG	SG/Com		
W6609-3	E1	E2	SG	SG/Com		
W5955-1	E1	E2	SG	SG/Com		
W5015-5	MT	E1	E2	SG	SG/Com	
W8405-1R	MT	E1	E2	SG	SG/Com	
W8152-1rus	VC/TC	MT	E1	E2	SG	SG/Com
W9133-1rus	TC	MT	E1	E2	SG	SG/Com
W8886-R	TC	MT	E1	E2	SG	SG/Com
W8893-1R	TC	MT	E1	E2	SG	SG/Com

Clones promoted by SpudPro to seed cleaning. Kept in TC until promoted to seed production

W8516-1rus	VC/TC	TC				
W8722-1rus	VC/TC					
W9161-3rus	VC/TC	TC				
W6822-3	VC/TC					
W8822-3	VC/TC	TC				
W9553-2	VC/TC					
W9576-11Y	VC/TC					
W9576-13Y	VC/TC					
W9576-27Y	VC/TC					
W9553-2rus		VC/TC				
W9577-6Y		VC/TC				

Note: VC = Virus Cleaning, TC = Tissue Culture, MT = Mini-tuber production in greenhouse pots or NFT

E1, E2 = Field Generation at the Lelah Starks Foundation Seed, SG = Seed grower, Comm = Commercial production

Note: VC = Virus cleaning, TC = Tissue Culture, MT = mini-tuber production in greenhouse pots or NFT,
E1, E2 = Field Generations at the Lelah Starks Foundation Seed, SG = Seed grower, Com = Commercial production

The information in Table 2 is to help seed and commercial growers develop plans for seed production for the clones promoted in WI breeding program.. Outside this scheme, seed growers can make additional orders to start mini-tubers, E1 or E2 foundation seed production at the Seed Farm. The scheme outlined in Table 2, only include an initial wave of seeds for on-farm experience. Growers interested in additional orders should arrange for mini-tuber production to be initiated according to seed and commercial production plans.

Update on New Varieties and Elite Clones in the Pipeline:

Pinnacle (W5015-12): Long Storage Chipper

Pinnacle is the most recent named variety from the WI breeding program. It was named in December 2013.

Parentage: Brodick x White Pearl
Developers: University of Wisconsin - Madison
Plant Variety Protection: Application to be submitted in 2014
Strengths: High yield potential. Stores at 48°F with light fry color for six months or more, typically several weeks longer than Snowden. Specific gravity is similar to Snowden, consistently over 1.080.
Weaknesses: Susceptible to common scab, tendency toward flat tuber shape
Seed Availability: Certified seed from Wisconsin seed producers will be available in 2014 (2013 WI seed directory).

Morphological Characteristics
Plant: Large canopy, semi-erect with strong vines, tolerant to *Verticillium wilt*
Tubers: Round-oval, somewhat flattened, uniform shape and size profile

Agronomic Characteristics
Vine Maturity: Medium late to full season
Yield Potential: Very high at high-yielding locations; similar to Snowden at low to moderate yield locations.
Utilization: Chipstock
Specific Gravity: High, 1.080-1.095
Pests/Disorders: Tolerant to *Verticillium* wilt, susceptible to common scab
Storability: Medium-long dormancy (similar to Snowden)

Tundra (W2310-3): Long storage chipping variety with consistent high gravity

Parentage: Pike x S440. **Strengths**: Long storage potential producing good chip quality from 48°-50°F storage and warmer for 6-9 months. Specific gravity equal or higher than Snowden.

Incentives for production: Potential for long storage better than Snowden, low tuber internal and external defects, moderate scab resistance, high solids. **Tubers**: Uniform tuber shape and medium size profile. Medium set (9-10 tubers/hill), round-oval shape. Moderately netted skin and moderate eye depth. **Specific Gravity:** High, usually >1.084 and higher than Atlantic. Moderate tolerance to common scab, better than Snowden and Atlantic. **Vine Maturity:** Full-season cultivar (similar to Snowden). **Seed Status**: SpudPro foundation seed available at Seed Farm and Wisconsin seed growers.

Nicolet (W2133-1): **Parentage:** Snowden x S440

Strengths: High yield potential, good internal quality, very good tuber size and appearance. Medium to long storage chipper from 47ºF. **Incentives for production:** Yield comparable with Snowden and Atlantic, with better tuber shape uniformity. Fry products show high resistance to stem end discoloration. **Specific Gravity:** High gravity, consistently over 1.080, usually between Snowden and Atlantic. **Vine Maturity:** Full-season cultivar (similar to Snowden). **Processing:** Good chip color after harvest from 48°F-50°F storage through seven months of storage when storage is managed properly. Fry products show high resistance to stem end discoloration. Glucose values may remain low while Snowden sugars increase after long cold storage. **Seed Status**: SpudPro foundation seed available at Seed Farm and Wisconsin seed growers.

Lelah (W2717-5): Long term and cold storage chipper

Parentage: S440 x ND3828-15. **Strengths**: Attractive round-oval tubers with smooth skin finish. Very uniform tuber size profile, and high specific gravity. Cold sweetening resistance through 9 months at 47°F. **Incentives for production:** High and consistent specific gravity (1.080-1.090). Long storage chipping ability. Very low glucose and sucrose profile through 9 months (A-II basal invertase +). **Tubers:** Medium size, 6 to 8oz, very uniform size and round-oval shape and very shallow eyes. **Maturity:** Medium-Early, 14 days earlier than Snowden. **Yield:** Medium; lower than Snowden. Yield data suggest that it yields among the best in low yielding conditions. Commercial fry quality can be extended at least 45 days longer than Snowden under cold storage**. Foundation seed status:** Some seed growers and USPB Fast-track

Accumulator (W2324-1): Very high yield short storage chipper, potential Atlantic replacement.

Parentage: Snowden x S438**. Strengths:** Accumulator is arguably the highest yielding chip potato variety in the US; usually 20% above comparable varieties. It also has large and vigorous vines that result in early row closure and weed control. High tuber set and solids similar or better than Snowden. Very good tuber internal quality. Commercial chip quality from field through three to four months of storage is very good. **Incentives for production:** Very high yield, consistently high specific gravity and very low tuber internal raw or chip defects and potential for reduced nitrogen input. **Tubers:** Medium to large in size, high set, 10-16 tubers/plant Oval/blocky tuber shape that has somewhat variable contour and profile. Moderately netted tuber skin; eye depth is intermediate, with occasional folded bud end. **Maturity:** Full-season cultivar (similar to Snowden). **Yield:** In the Snack Food Trial, this variety has yielded up to 38% more than the average of varieties tested, and 24% more yield than Atlantic over 9 testing sites. **Specific Gravity:** Consistently high; similar or higher than Snowden. **Diseases:** Tolerant to early blight and Verticillium wilt. *More susceptible to common scab than Atlantic and Snowden*. **Storability:** Good chip color after harvest and from 48°F cold storage through January. **Seed Status**: SpudPro foundation seed available at Seed Farm, and Wisconsin seed growers.

W5955-1: Long Storage Chip Variety with Common Scab Tolerance

Parentage: Pike x C31-5-120. Strengths: Stable tolerance to common scab under field with high disease incidence. Specific gravity is similar to six units higher than Snowden. Chip color and sugar under long storage may be better than Snowden. **Incentives for production:** Good chipping ability. Chips processed from potatoes stored at 48-50°F of can retain light color for six to nine months. **Good tolerance to Verticillium wilt. Tubers:** Uniform mid to large size, round, full and very smooth shape. **High yield potential, similar to Snowden. Specific Gravity:** high, similar to Snowden, 1.080-1.095 average in most locations. **Foundation seed status**: E1 in 2013, SpudPro Foundation seed for on-farm tests in 2015.

W6609-3: Long Storage Chip Variety with Common Scab Resistance

Parentage: Pike x Dakota Pearl. Strengths: the main strength of this breeding clone is the **combination of scab tolerance, processing quality and tuber type**, which represent good variety potential. **Specific gravity**: is similar to Snowden. **Chip color and sugar levels**: consistently lower than Snowden under long storage. Yield is from moderate to good. It has been included in the National Chip Processing Trial in 2013 for a better assessment of yield potential and adaptation. **Foundation seed status**: E1 in 2013, SpudPro Foundation seed for on-farm tests in 2015.

W5015-5: Long Storage Chipper with Late Blight Resistance

Parentage: Brodick x White Pearl**. Strengths:** High yielding long storage chipper. Yield may be similar or better than Snowden under long storage and foliar late blight tolerance. **Incentives for production:** High yield, good chipping ability. Chips processed from potatoes stored at 48-

50°F of can retain light color for six to nine months. High gravity, similar to Snowden. **Tubers:** Round-oval, full uniform shape and size. **Vine Maturity:** Full season cultivar**. Foundation seed status**: Mini-tuber production in 2013, SpudPro Foundation seed for on-farm tests in 2016.

W6234-4rus: Early Russet Processing Potato with Reduced Acrylamide

Parentage: Umatilla Russet x A9014-2rus. **Strengths:** Attractive smooth and blocky tuber type which is suitable for processors and in addition has lighter fry color compared to Russet Burbank. W6234-4rus has also low acrylamide content compared to most russet varieties, including Russet Burbank. **Yield:** Similar or higher marketable yield compared to Russet Burbank. **Specific Gravity**: 2012 NCRT results showed average gravity of 1.082 over six locations, four points higher than Burbank. Similar results were observed in the SpudPro trial of 2012. Results from the National French Fry Processing Trial in 2013 indicate that W6234-4rus has a good potential for quick service restaurant French fry applications. Two fry processing companies are further evaluating this clone. **Foundation seed status**: E2 production in 2013, SpudPro Foundation seed for on-farm tests in 2014.

W8152-1rus: French fry Processing Russet with Very Low Acrylamide Level

Parentage: A93004-3RU x CO94035-15RU. **Strengths:** Early russet of processing potential. High yield potential, good size and grade; blocky shape, specific gravity higher than Burbank and better fry color through March. Lowest acrylamide values among 81 clones tested in ID, ND and WA in 2011. **Incentives for production:** Long storage French fry processing russet with three times less acrylamide content than the average russet varieties available. **Specific gravity:** higher than Russet Burbank. In 2012, W8152 was also evaluated in the SpudPro trial; yield of this clone and gravity were higher than Russet Burbank. **Foundation seed status**: Mini-tuber production in 2013, SpudPro Foundation seed for on-farm tests in 2016.

W6002-1R: Very Uniform and Attractive Medium Size Red Skin Clone

Parentage: B-1491-5R x W1100R. **Strengths:** Very uniform tuber size, shallow eyes, nice red color that is maintained in storage, stores well. **Incentives for production:** Attractive skin color that holds color in storage, very uniform tubers with good market appeal, good skin set, pronounced skin netting has not been observed. Recent trial data suggests that this clone may be more resistant to heat and drought stress than comparable red skin varieties. **Plant:** Intermediate growth type, medium vigorous vines. **Tubers:** It exhibits very uniform tuber size, shallow eyes, nice red color; excellent at harvest for fresh market and may be maintained in storage through

February. **Maturity:** Similar to Dark Red Norland. **Yield:** High, similar or higher than Dark Red Norland.

W8405-1R: An Attractive Red Clone

Parentage: Kankan x W2303-9R. **Strengths**: Attractive round oval red clone. Color can be maintained in storage much better than Dark Red Norland. Very high yield potential. **Incentives for production**: High yield, smooth red potato clone. **Plant:** Good initial and excellent late plant vigor. Vine row closing occur earlier than many red clones. **Tubers:** Uniform round-oval shape, shallow eyes. Good internal quality, lacking of internal defects. **Maturity**: Medium-late. **Yield Potential**: Higher than Dark Red Norland, up to 20% higher in some years. **Specific Gravity**: 1.052-1.069, similar to Dark Red Norland. **Diseases**: Tolerant to early blight and Verticillium wilt. **Utilization**: Fresh market red. **Storability**: Tubers harvested in September in WI and stored at 38°F (after two weeks at 55°F) normally store well and maintain color at through February. **Foundation seed status**: Mini-tuber production in 2013, SpudPro Foundation seed for on-farm tests in 2016.

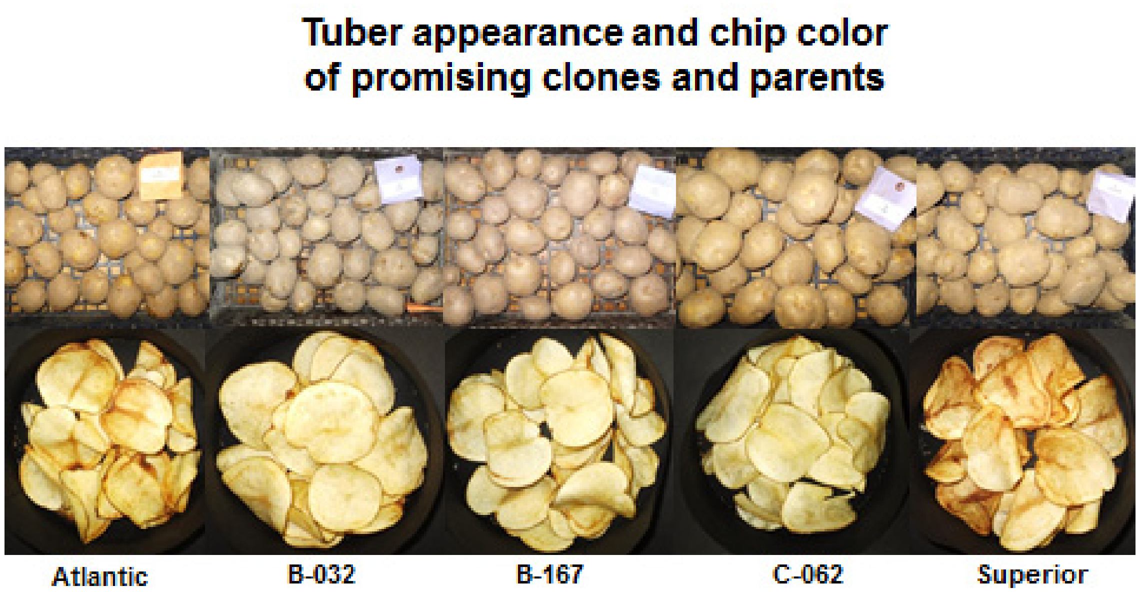
W6703-1Y: A Yellow Flesh Clone with Resistance to Common Scab

Parentage: Satina x W2275-2Y. **Strengths**: Yellow flesh variety with very smooth (shallow eyes) tubers. **Incentives for production**: Strong common scab resistance; good option for production of yellow flesh potatoes in areas where varieties such as Yukon Gold cannot be planted due to high incidence and severity of common scab. **Vine Maturity:** Full season cultivar. **Yield Potential:** Medium to high. **Specific Gravity:** 1.067-1.077. **Diseases**: Also tolerant to early blight and Verticillium wilt. **Foundation seed status**: E1 production in 2013, SpudPro Foundation seed for on-farm tests in 2015.

Ongoing Research Projects in the Breeding Program

1. **Understanding genetics of cold storage chip quality**: In this project we have created two segregating populations parents with contrasting cold induced sweetening resistance. One population was created from a cross between Bannock Russet and Tundra and the other between Liberator and W4013-1. These populations have been evaluated for cold storage chip quality for the last two seasons. The data will be used to map traits controlling cold storage chip quality.

2. **Understanding genetics of tuber internal quality:** In this project we have created populations from reciprocal crosses made between Atlantic and Superior. These populations are segregating for many commercially important traits including internal defects (hollow heart), scab, specific gravity, yield, tuber calcium and fry quality. One of these populations was genotyped by the SolCap project. The data are being analyzed for the detecting QTLs for these traits, In addition we are also attempting to select clones that combine the desired traits of yield and specific gravity of Atlantic with scab resistance and excellent tuber internal quality of Superior. Below is an example of some promising clones.



2014 UWEX WPVGA Poster Session Abstract Submissions

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Ecology and management of insect pests and diseases

1. Frost, K.E., Groves, R.L., Gevens, A.J. The development of a web-based tool for carrot disease forecasting
2. Frost, K.E., Seidl, A.C., Rouse, D.I., Gevens, A.J. Effect of temperature on growth and sporulation of the US-22, US-23, and US-24 clonal lineages of *Phytophthora infestans* and implications for late blight epidemiology

Crop fertility, irrigation, and weed management

3. Chawner, M., Ruark, M.D., Stute, J., Ballweg, M., Proost, R. Assessing the nitrogen credit of radish as a cover crop
4. Panuska, J., Wayne, R. Using the Wisconsin Irrigation Scheduling Program (WISP) and soil moisture monitoring to manage root zone water content

Plant breeding, variety evaluation, crop physiology

5. Arcibal, E., Jahn, M., Jiang, J., Rakotondrafara, A. Engineering resistance against PVY strains in various potato varieties
6. Fajardo, D., Jansky, S.H. Amylose content in tuber starch of potato cultivars
7. Fulladolsa, A.C., Groves, R.L., LaPlant, K.E., Charkowski, A.O. Effects of seed type and variety on the agronomic performance of potato minitubers and the incidence of *Potato virus Y*
8. Rasmussen, J. Innate™ technology from Simplot
9. Wang, Y., Bethke, P.C., Bussan, A.J. National Fry Processor Trial and SCRI-Acrylamide Project Update for 2013

Abstracts

Ecology and management of insect pests and diseases

1.

The development of a web-based tool for carrot disease forecasting

Kenneth E. Frost[1], Russell L. Groves[2], and Amanda J. Gevens[3]

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Alternaria leaf blight, caused by the fungus *Alternaria dauci*, and Cercospora leaf spot, caused by the fungus *Cercospora carotae*, infect leaves and petioles of carrot and are the most prevalent foliar diseases of carrot worldwide. These foliar blight pathogens reduce yield by limiting the plant's photosynthetic capacity and by weakening the petioles needed for mechanical harvest. Typically, carrots are harvested by implements that loosen the soil and simultaneously grasp the foliage while lifting the roots out of the soil; blighted petioles break when gripped by the mechanical harvester and carrots are left in the soil. Environmental conditions greatly influence the occurrence and progression of these foliar diseases of carrot and the anticipation of heightened disease risk through the identification and monitoring of critical environmental factors, such as, relative humidity and temperature, can enhance disease management by optimizing the timing of fungicide applications. However, implementation of the weather-based models is difficult because, typically, each field requires a customized forecast that is dependent on disease severity, weather conditions, and fungicide program, factors that are field-specific. A goal of this research is to provide a set of generalized recommendations for managing foliar diseases of carrot that can be used for the majority of WI fields without the need for grower investment in weather stations. In 2013, a modified TOM-CAST disease forecasting model for carrot foliar disease is being evaluated in field trials for the management of *A. dauci* and *C. carotae*, respectively. This model uses environmental variables, from in-field weather stations and gridded weather predictions from the North American Meso-scale (NAM) weather model, to calculate an action threshold for fungicide applications. Research plots are being established at the UW-Hancock Agricultural Research Station and on a commercial farm with four replicates. Plots will be scouted for disease weekly from mid-June to early September and all treatments will contain a standard fungicide program. Additional treatments will be established to examine when a fungicide program should be initiated for optimal control of carrot foliar diseases with treatment applications being initiated based on both disease symptoms and historical weather and disease incidence data. The development of an internet-based graphical user interface to automate the functionality of the database and make these disease forecasts available to vegetable growers in WI, currently underway, will be discussed.

2.

Effect of temperature on growth and sporulation of the US-22, US-23, and US-24 clonal lineages of *Phytophthora infestans* and implications for late blight epidemiology

Anna C. Seidl, Kenneth E. Frost, Douglas I. Rouse, Amanda J. Gevens, University of Wisconsin-Madison, Department of Plant Pathology

Epidemics of late blight, caused by *Phytophthora infestans* (Mont.) deBary have been studied by plant pathologists and regarded with great concern by potato and tomato growers since identified as a cause of the Irish potato famine of the 1840s. *Phytophthora infestans* populations have continued to evolve, with unique clonal lineages arising which differ in pathogen fitness and pathogenicity. Recently, the US-23 clonal lineage has predominated late blight epidemics in most U.S. production regions, including Wisconsin. For three recently identified clonal lineages of *P. infestans*, US-22, US-23, and US-24, sporulation rates were experimentally determined on potato and tomato foliage and the effect of temperature on lesion growth rate on tomato was investigated. The US-22 and US-23 lineages had greater lesion growth rates on tomato than US-

24. Sporulation rates for all lineages were greater on potato than tomato, and the US-23 lineage had greater sporulation rates on both tomato and potato than the other lineages. Experimentally determined pathogen parameters were input to the LATEBLIGHT model and epidemics simulated using archived Wisconsin weather data from four growing seasons (2009 to 2012) to investigate the effect of these new lineages on late blight epidemiology. The high lesion growth rates of US-22 and US-23 resulted in large epidemics in all years tested, particularly in 2011. The high potato sporulation rates caused potato epidemics to progress faster than tomato epidemics; however, the abnormally high sporulation rates of US-23 resulted in larger simulated epidemics than with US-22 or US-24, or with the EC-1 clonal lineage pathogen parameters included with the model when evaluated for both hosts. Additionally, US-23 consistently caused large simulated epidemics when the pathogen parameters of lesion growth rate and sporulation were input into the model singly or together. Sporangial size of the US-23 lineage was significantly smaller than that of US-22 and US-24, which may result in more efficient release of sporangia from the tomato or potato canopy and enhance long-distance spread of this lineage. Our experimentally determined pathogen parameters and resulting simulated epidemics suggest that the US-23 clonal lineage of *P. infestans* may have the greatest fitness among currently prevalent lineages and be the most likely lineage to persist in the *P. infestans* population.

Crop fertility and irrigation

3.

Assessing the nitrogen credit of radish as a cover crop

Megan Chawner, Matt Ruark, Jim Stute, Mike Ballweg, and Richard Proost
University of Wisconsin-Madison, Department of Soil Science

Oilseed radish (*Raphanus sativus L)* has become a popular cover crop option in the Midwest for the late summer, especially among no-till farmers. However, little, if any information is available on brassica cover crops, radish included. The objective of this project was to determine the effects of radish as a cover crop, specifically quantifying the uptake and release of nitrogen, as well as compaction and nematode suppression. Radish cover crops were planted in mid-August in three field sites located in Southern and Northeast Wisconsin. Each radish treatment was accompanied by a no cover crop treatment, and all treatments were split into increasing amounts of nitrogen fertilizer. Soil samples (0-1' and 1-2') were collected within each plot and analyzed for extractable nitrate using KCl extraction and colorimetric analysis using a microplate reader. Radish biomass (above ground and root) was collected from a 9 ft^2 area within each whole plot prior to winterkill and analyzed for total dry matter production and total nitrogen uptake. Soil samples (0-1') were collected for each plot and analyzed for nematodes. Nematodes were isolated from the soil by a series of washings through increasingly smaller sized sieves. The samples were then examined under a microscope to identify and quantify both root lesion nematodes and soybean cyst nematodes. Soil compaction was measured in each plot using a portable constant-rate cone penetrometer. Soil moisture was determined as gravimetric soil moisture with a soil moisture probe. Results from the 2012 growing season indicates that radish increased soil nitrate early in the growing season, but dry growing conditions limited corn yield and response to N. Radish decomposition in 2013 was quite different resulting in no detectable increase in early season nitrate. To date, a N credit has not been confirmed with yield response data.

4.

Using the Wisconsin Irrigation Scheduling Program (WISP) and soil moisture monitoring to manage root zone soil water content

J. Panuska [1] and R. Wayne [2], University of Wisconsin-Madison, Biological Systems Engineering Department [1] and Department of Science [2].

Water stress can adversely impact crop yield and quality making adequate root zone soil water availability essential to any crop production operation. Irrigation has become an important tool of choice by growers for drought risk management. The recommended approach to root zone soil water management includes the use of soil moisture tracking in combination with monitoring. Irrigation scheduling and rainfall forecasts can project soil moisture conditions into the near future (1-3 days) while monitoring can be used to ground truth scheduler predictions.

The Wisconsin Irrigation Scheduling Program (WISP) is an irrigation water management tool designed to help growers optimize crop water use efficiency by tracking the root zone water inputs and outputs. Using WISP's water balance predictions, along with soil moisture monitoring, a grower can plan irrigation timing and amount to take maximum advantage of natural rainfall while minimizing over-application of water. WISP uses the checkbook method to track water inputs (rainfall and irrigation) on a daily basis and losses through evapotranspiration (ET) and deep drainage.

Types of moisture monitoring systems include portable probes and sensors at fixed locations. Portable probes have the advantage that measurements can be taken at several locations, but require walking or driving to the desired location. Stationary probes are placed at several predetermined depths and can operate continuously. Stationary probes must be placed at locations considered to be representative of the management unit. Stationary probes need to be directly accessed in the field or they can continuously upload data for web access. Monitoring technologies range from relative inexpensive mechanical means to more costly electronic sensors. Common sensor technologies include: soil water tension, capacitance and time domain reflectively. The approximate cost, advantages and disadvantages of the various technologies will be presented and discussed.

5.

Engineering Resistance Against PVY Strains in Various Potato Varieties

Arcibal, E., Jahn, M., Jiang, J., and Rakotondrafara, A., University of Wisconsin-Madison, Department of Plant Pathology

Potato virus Y (PVY) remains a persistent problem in potato production. An important contributor is the popularity of several varieties, including *Russet Norkotah or Silverton,* that exhibit no or mild symptoms and thus hard to detect in the fields, while serving as reservoirs for PVY. PVY incidence has been exacerbated with the emergence of viral strains that cause tuber necrosis, as well as the presence of new invasive vectors. Major efforts have been provided in the development of effective strategies to reduce PVY incidence, including breeding for PVY resistance and the release of certified PVY free seed potato lots. Genetic engineering is a powerful tool for trait introgression that maintains the characteristics of original cultivars. We identified the potato gene closely related to the natural PVY resistance genes in tomato and pepper and modified it to confer resistance. The resistance gene encodes the Eukaryotic Initiation Factor 4E (eIF4E), an important susceptibility factor in the viral life cycle. We generated transgenic *Russet Norkotah*, *Atlantic* and *Silverton* potato lines by modifying the endogenous potato eIF4E with mutations similar to that of the pepper resistance homolog. Our goals are to:

1) Screen the transgenic lines for resistance against PVY:O, N:O, and NTN strains, 2) Test PVY spread in the developing tubers, and 3) Assess heritability of the eIF4E- resistance phenotype by crossing with wild type line. Our first screens revealed that our transgenic *Russet Norkotah* and *Atlantic* lines tested negative to PVY:O and PVY N:O accumulation both in local and systemic leaf tissues.

6.

Amylose content in tuber starch of potato cultivars

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Potato tuber is mostly water and starch. Approximately 20% of fresh tuber weight is the starch and the remainder is water. Most of the starch in the tuber, approximately 75%, is amylopectin and 25% amylose, but can vary depending on the cultivar. A total of 162 American (85) and foreign (77) potato cultivars were evaluated for amylose content in the tuber. A wider range of amylose content was found in the foreign varieties (27.2% - 39.1%) than in the American ones (28.2% - 36.6%). A higher amylose content mean was found in the foreign (34%) compared to the American cultivars (31.4%) was the lowest. Overall, a narrower genetic background based in the amylose content in the American cultivars could be inferred based on these results. The discovery of varieties with high and low amylose content in the tuber can be useful as potential parents in breeding programs.

7.

Effects of seed type and variety on the agronomic performance of potato minitubers and the incidence of *Potato virus Y*

Ana C. Fulladolsa P.[1], Russell L. Groves[2], Kyle E. LaPlant[1], and Amy O. Charkowski[1], Departments of [1]Plant Pathology and [2]Entomology, University of Wisconsin-Madison

Vegetative seed potatoes are produced under regulation by certification agencies that ensure low levels of varietal mixture and disease incidence. Production begins by propagating plants in tissue culture and then transplanting them into pots or a hydroponic system in a greenhouse to produce minitubers. Certification enforces a zero percent tolerance for virus and other diseases in tissue culture and greenhouse-grown plants. Minitubers are planted in the field to produce conventional seed potatoes, which are re-planted for multiplication. Seed lots must have low levels of diseases in order to be certified. The use of minitubers as the initial seed source minimizes the risk of infection by important seed potato pathogens, such as *Potato virus Y* (PVY). Expanding seed production from minitubers is potentially an effective strategy for minimizing initial PVY inoculum; however more research is needed to determine agronomic performance of minitubers. We evaluated the effects of seed type for three different varieties under overhead and drip irrigation on potato yield and PVY incidence. 4-row (20ft/row) plots were planted for each combination of seed type and variety in a randomized complete block design with 4 replications. Potato tuber weight and number of tubers was measured after harvest. A sample of tubers was grown out during the winter and PVY incidence was determined by serological assays performed on leaf tissue. Yield data analyses indicated that plants grown from minitubers had lower total tuber yield ($\alpha<0.001$; df=1). There was no significant effect of seed type on PVY incidence or of variety alone on potato tuber yield or PVY incidence. However, there was an effect of seed-variety interaction on weight of B-sized tubers (1.5 to 3 inches) and on weight of cull potatoes.

8.

Innate™ Technology from Simplot

Jolyn Rasmussen, Sr. Research Agronomist, Simplot Plant Sciences, Boise ID

As a pioneer in potato industry, Simplot has developed Innate™ Technology, an innovative biotechnology approach for improving potatoes. This technology allows us to incorporate desired genes from wild and cultivated potatoes without adding genes from foreign species. The Innate™ Technology consists of three components: transformation, gene silencing, and native trait transfer. Using this approach, we introduced two important traits in our Innate™ 1.0 lines; low bruise and low asparagine. In our subsequent 2.0 lines, we added another two essential traits: late blight resistance and cold-induced sweetening tolerance. These traits save money for the grower by reducing input cost and loss, and also improve human health by lowering acrylamide formation in processed potatoes. Varieties included in the program are Ranger Russet, Russet Burbank, Atlantic, and Snowden. Pending USDA deregulation, Innate™ potatoes could be commercially available in 2015.

9.

National Fry Processor Trial and SCRI-Acrylamide Project Update for 2013

Wang, Yi[1], Bethke, P.C.[1,2], and Bussan, A.J.[1]
[1]Department of Horticulture, University of Wisconsin-Madison, [2]USDA-ARS, Madison, WI

Acrylamide is present in many carbohydrate-rich foods, such as potato chips and French fries, processed during certain types of high-temperature cooking. These foods account for over half of US potato consumption. Acrylamide is a potential human carcinogen, and research on acrylamide is underway all over the world. In November 2013, the U.S. Food and Drug Administration (FDA) has issued draft guidance for the food industry to help growers, manufacturers and food service operators take steps to reduce levels of acrylamide in certain foods. A website about the SCRI-acrylamide project was set up in June 2013 (acrylamide.vegetables.wisc.edu). It includes all the available information about this ongoing USDA grant with the long-term goal of facilitating the rapid, efficient development and adoption of new potato varieties that have exceptional agronomic, processing and consumer acceptance traits with low acrylamide forming potential. The 2013 NFPT was conducted at 5 sites (ID, ME, ND, WA, WI) with 81 clones. Simplot and McCain Foods have been involved in performing consumer attribute testing for early and late season storage samples of selected advanced clones that demonstrated low acrylamide levels in previous tests. Some clones in the most recent testing showed lower acrylamide content and better consumer attributes compared to the Russet Burbank standard. The 2013 SCRI-acrylamide agronomic trials were done at 6 sites (ID, ME, MN, OR, WA, WI). Fourteen clones as well as the Burbank standard were planted, and trials included more than one replication for each clone at each site. The agronomic trials produced about 600 lbs of tubers per clone per site for expanded consumer attribute testing in the future. Many new traits that were not evaluated in NFPT were included, such as individual tuber specific gravity variation, sugar ends defect screening, internal defects, and fry color photovolt reading. Minituber production and tissue culture plantlet clean-up is also underway for clones that look promising to meet the objectives of the project.

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

MUCK POTATO HERBICIDE EFFICACY EVALUATION - Endeavor - 2013

Jed B. Colquhoun / Rich A. Rittmeyer / Daniel J. Heider

Location: Gumz Farms, Endeavor Wisconsin

Plot Information:

Soil Type: Muck
Potato Cultivar: Dark Red Norland
Date Planted: approx. 5/14/13
Row Spacing: 36 Inches, 2 rows/plot
Plant Spacing: 12 inches
Date Harvested: 8/24/11
Plot Size-Design: 6' x 15', 3 Reps
Rating Dates: 6/17, 7/2. 7/26

Application Equipment: Backpack CO2 pressurized sprayer. GPA 20, PSI 27, MPH 3.3, Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Herbicide Application Data:

Date	5/28/13	
Time	12:30 pm	
Treatment	HS	
Soil Moisture		
SF	moist	
1"	moist	
3"	moist	
Soil Temp (F^o)		
SF	67.5	
2"	59.6	
4"	58.5	
Air Temp (F^o)	59.5	
Wind (mph/dir.)	0-2 NE	
%RH	80%	
Clouds (%)	100%	
Crop Stage	pre	
Weed & Size	pre	

Weed Abbreviations:	Plot Weed Density:
COLQ = Common Lambsquarters	High
RRPW = Redroot Pigweed	High
GRASS = Mixed grass species	Moderate

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Muck Potato Herbicide Efficacy - Endeavor, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/17/13 % Injury	% Weed Control 6/17 RRPW	% Weed Control 6/17 COLQ	7/2/13 % Injury	% Weed Control7/2/13 RRPW	% Weed Control7/2/13 COLQ
1	Untreated Check				0 a	61.7 ab	98.3 a	3.3 a	46.7 b	96.7 a
2	Dual Magnum	2	PT/A	HS	0 a	95 a	98.3 a	6.7 a	91.7 a	98.3 a
	Metribuzin	0.67	LB/A	HS						
3	Dual Magnum	2	PT/A	HS	0 a	91.7 a	100 a	3.3 a	88.3 a	100 a
	Callisto	2	OZ/A	HS						
4	Dual Magnum	2	PT/A	HS	0 a	95 a	100 a	3.3 a	93.3 a	100 a
	Firstrate	0.8	OZ/A	HS						
5	Dual Magnum	2	PT/A	HS	0 a	91.7 a	98.3 a	3.3 a	86.7 a	100 a
	Sharpen	1.5	OZ/A	HS						
6	Outlook	18	OZ/A	HS	0 a	96.7 a	100 a	0 a	95 a	98.3 a
	Zidua	4	OZ/A	HS						
7	Bicyclopyrone	0.5	OZ/A	HS	0 a	23.3 bc	98.3 a	3.3 a	23.3 bc	95 a
8	Bicyclopyrone	0.75	OZ/A	HS	0 a	16.7 c	90 a	3.3 a	10 c	88.3 a
LSD (P=.05)					0	40.11	7.05	10.55	33.65	7.79

Means followed by same letter do not significantly differ (P=.05, LSD)

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	7/26/13 % Injury	% Weed Control 7/26/13 RRPW	% Weed Control 7/26/13 COLQ	% Weed Control 7/26/13 GRASS	8/28/13 Yld (cwt/a)
1	Untreated Check				0 a	63.3 a	100 a	88.3 a	194.73 a
2	Dual Magnum	2	PT/A	HS	0 a	76.7 a	90 a	88.3 a	298.14 a
	Metribuzin	0.67	LB/A	HS					
3	Dual Magnum	2	PT/A	HS	0 a	81.7 a	100 a	93.3 a	266.68 a
	Callisto	2	OZ/A	HS					
4	Dual Magnum	2	PT/A	HS	0 a	76.7 a	98.3 a	93.3 a	259.42 a
	Firstrate	0.8	OZ/A	HS					
5	Dual Magnum	2	PT/A	HS	0 a	80 a	98.3 a	88.3 a	335.25 a
	Sharpen	1.5	OZ/A	HS					
6	Outlook	18	OZ/A	HS	0 a	93.3 a	100 a	88.3 a	327.67 a
	Zidua	4	OZ/A	HS					
7	Bicyclopyrone	0.5	OZ/A	HS	0 a	56.7 a	81.7 a	66.7 a	244.10 a
8	Bicyclopyrone	0.75	OZ/A	HS	0 a	66.7 a	96.7 a	33.3 b	261.68 a
LSD (P=.05)					0	25.36	16.78	26.95	95.129

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

POTATO HERBICIDE EVALUATION - ARLINGTON - 2013

Daniel J. Heider / Jed B. Colquhoun

Location: Arlington Ag Research Station - Horticulture Farm Field 605

Plot Information:

Soil Type: Plano Silt Loam; pH 7.0; OM 2.8%.
Variety: 'Superior'
Date Planted: 5/8/13
Row Spacing: 36 Inches, 4 rows/plot
Plant Spacing: 12 inches
Date Harvested: 8/29/13
Plot Size-Design: 12' x 20', 3 Reps
Rating Dates: 6/7, 6/11, 6/17

Application Equipment: Backpack CO^2 pressure sprayer. GPA 20, PSI 27, MPH 3.3, Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Incorporation Equipment: N/A

Herbicide Application Data:

Date	5/22/13	6/11/13
Time	8:00 am	9:30 AM
Treatment	HS	PO1
Soil Moisture		
SF	moist	dry
1"	moist	moist
3"	moist	moist
Soil Temp (F°)		
SF	64.2	87.3
3"	62.4	71.9
Air Temp (F°)	65.1	77.3
Wind	3.5 NE	4.5 W
%RH	74.2%	58.7%
Sky (% clouds)	100%	60%
Crop Stage	PRE	10-12"
Weed & Size	PRE	COLQ 1"
	-----	RRPW 1"
	-----	VELE 1"
	-----	YEFT 1"

Summary: Excellent early season temperatures and moisture resulted in increased pre-emergence herbicide activity. Injury ratings are based soley on visual observations. Many of the treatments incorporated currently unregistered applications with many resulting in relatively little to no injury. Results of this trial and the Hancock, WI location will be utilized to develop plans for further evaluation of potential herbicide applications in potato.

Fertilization and other pesticides: Fall 2012 - dairy replacement pack manure, 160 lb N/A.

Irrigation: none

Weed Abbreviations:	Plot Weed Density:	Weed Abbreviations:	Plot Weed Density:
COLQ = Common Lambsquarters	High	VELE = Velvetleaf	Moderate
RRPW = Redroot Pigweed	High	YEFT = Yellow Foxtail	Moderate
HANS = Hairy Nightshade	Low		

Potato Herbicide Efficacy - Arlington, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/7/13 % Injury	% Weed Control 6/7/13 COLQ	RRPW	HANS	YEFT
1	Untreated Check				0 e	0 e	0 c	0 c	0 c
2	Lorox	1	LB/A	HS	0 e	100 a	100 a	98.3 a	100 a
	Dual Magnum	1	PT/A	HS					
3	Lorox	1	LB/A	HS	0 e	100 a	100 a	96.7 a	100 a
	Prowl H2O	1.5	PT/A	HS					
4	Lorox	1	LB/A	HS	0 e	98.3 ab	80 b	93.3 a	100 a
	Sonalan HFP	2	PT/A	HS					
5	Lorox	1	LB/A	HS	0 e	100 a	98.3 a	99.3 a	100 a
	Sonalan HFP	4	PT/A	HS					
6	Zidua	2	OZ/A	HS	0 e	95 bc	100 a	98.3 a	100 a
7	Zidua	2	OZ/A	HS	5 cd	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS					
8	Zidua	4	OZ/A	HS	0 e	100 a	100 a	98.3 a	100 a
9	Zidua	4	OZ/A	HS	10 b	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS					
10	Bicyclopyrone	0.5	OZ/A	HS	0 e	90 d	96.7 a	36.7 b	98.3 a
11	Bicyclopyrone	0.75	OZ/A	HS	0 e	95 bc	97.7 a	36.7 b	94.3 b
12	Bicyclopyrone	0.5	OZ/A	PO1	0 e	0 e	0 c	0 c	0 c
	NIS	0.25	% V/V	PO1					
13	Bicyclopyrone	0.75	OZ/A	PO1	0 e	0 e	0 c	0 c	0 c
	NIS	0.25	% V/V	PO1					
14	Firstrate	0.25	OZ/A	HS	0 e	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1					
	NIS	0.25	% V/V	PO1					
15	Firstrate	0.5	OZ/A	HS	1.7 de	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1					
	NIS	0.25	% V/V	PO1					
16	Firstrate	0.75	OZ/A	HS	6.7 bc	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1					
	NIS	0.25	% V/V	PO1					
17	Sharpen	1.5	OZ/A	HS	1.7 de	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS					
18	Sharpen	2.5	OZ/A	HS	3.3 cde	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS					
19	Verdict	13	OZ/A	HS	5 cd	93.3 cd	95 a	98.3 a	100 a
20	Callisto	1	OZ/A	HS	6.7 bc	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS					
21	Callisto	2	OZ/A	HS	16.7 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS					
22	Imazosulfuron	0.4	LB A/A	HS	0 e	100 a	100 a	66.7 ab	100 a
23	Dual Magnum	1	PT/A	HS	1.7 de	100 a	100 a	73.3 a	100 a
	Python	0.5	OZ/A	HS					
24	Dual Magnum	1	PT/A	HS	10 b	100 a	100 a	100 a	100 a
	Python	1	OZ/A	HS					
LSD (P=.05)					4.85	4.99	12.35	34.17	2.93

Means followed by same letter do not significantly differ (P=.05, LSD)

Potato Herbicide Efficacy - Arlington, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/11/13 % Injury	% Weed Control 6/11/13 COLQ	RRPW	VELE	HANS	YEFT
1	Untreated Check				0 c	0 c	0 c	0 c	0 c	0 c
2	Lorox	1	LB/A	HS	0 c	96 a	100 a	98.3 a	91.7 a	100 a
	Dual Magnum	1	PT/A	HS						
3	Lorox	1	LB/A	HS	0 c	100 a	100 a	91.7 a	90 a	100 a
	Prowl H2O	1.5	PT/A	HS						
4	Lorox	1	LB/A	HS	0 c	96.7 a	100 a	98.3 a	83.3 a	98.3 a
	Sonalan HFP	2	PT/A	HS						
5	Lorox	1	LB/A	HS	0 c	100 a	100 a	93.3 a	91.7 a	98.3 a
	Sonalan HFP	4	PT/A	HS						
6	Zidua	2	OZ/A	HS	0 c	95 a	100 a	100 a	100 a	100 a
7	Zidua	2	OZ/A	HS	0 c	100 a	100 a	100 a	95 a	100 a
	Outlook	1	PT/A	HS						
8	Zidua	4	OZ/A	HS	0 c	100 a	100 a	100 a	100 a	100 a
9	Zidua	4	OZ/A	HS	0 c	100 a	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS						
10	Bicyclopyrone	0.5	OZ/A	HS	0 c	83.3 ak	88.3 a	92.7 a	30 c	95 a
11	Bicyclopyrone	0.75	OZ/A	HS	0 c	85 ak	90 a	96 a	33.3 bc	86.7 ak
12	Bicyclopyrone	0.5	OZ/A	PO1	0 c	0 c	0 c	0 c	0 c	0 c
	NIS	0.25	% V/V	PO1						
13	Bicyclopyrone	0.75	OZ/A	PO1	0 c	0 c	0 c	0 c	0 c	0 c
	NIS	0.25	% V/V	PO1						
14	Firstrate	0.25	OZ/A	HS	0 c	100 a	100 a	100 a	100 a	99.333 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
15	Firstrate	0.5	OZ/A	HS	0 c	100 a	100 a	100 a	96.667 a	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
16	Firstrate	0.75	OZ/A	HS	1.7 c	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
17	Sharpen	1.5	OZ/A	HS	0 c	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
18	Sharpen	2.5	OZ/A	HS	0 c	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
19	Verdict	13	OZ/A	HS	0 c	66.7 b	66.7 b	66.7 b	66.7 ab	66.7 b
20	Callisto	1	OZ/A	HS	5 b	100 a	100 a	100 a	98.3 a	100 a
	Dual Magnum	1	PT/A	HS						
21	Callisto	2	OZ/A	HS	8.3 a	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
22	Imazosulfuron	0.4	LB A/A	HS	0 c	100 a	100 a	100 a	66.7 ab	100 a
23	Dual Magnum	1	PT/A	HS	1.7 c	100 a	100 a	98.3 a	91.7 a	100 a
	Python	0.5	OZ/A	HS						
24	Dual Magnum	1	PT/A	HS	6.7 ab	100 a	100 a	100 a	100 a	100 a
	Python	1	OZ/A	HS						
LSD (P=.05)					1.98	20.80	20.96	20.50	35.85	21.41

Means followed by same letter do not significantly differ (P=.05, LSD)

Potato Herbicide Efficacy - Arlington, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/17/13 % Injury	% Weed Control 6/17/13 COLQ	RRPW	VELE	HANS	YEFT
1	Untreated Check				0 d	0 f	0 d	0 c	0 e	0 c
2	Lorox	1	LB/A	HS	0 d	94.3 ab	99.3 a	98.3 a	98.3 a	100 a
	Dual Magnum	1	PT/A	HS						
3	Lorox	1	LB/A	HS	0 d	99.3 a	99.3 a	95 a	91 ab	96.7 a
	Prowl H2O	1.5	PT/A	HS						
4	Lorox	1	LB/A	HS	0 d	91.7 abc	93.3 ab	93.3 a	53.3 bcd	97.7 a
	Sonalan HFP	2	PT/A	HS						
5	Lorox	1	LB/A	HS	0 d	90 abc	93.3 ab	95 a	78.3 ab	97 a
	Sonalan HFP	4	PT/A	HS						
6	Zidua	2	OZ/A	HS	1.7 cd	96.7 a	99.3 a	100 a	98.3 a	99.3 a
7	Zidua	2	OZ/A	HS	0 d	100 a	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS						
8	Zidua	4	OZ/A	HS	0 d	100 a	100 a	100 a	98.3 a	100 a
9	Zidua	4	OZ/A	HS	0 d	98.3 a	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS						
10	Bicyclopyrone	0.5	OZ/A	HS	0 d	36.7 e	55 c	95 a	20 de	88.3 a
11	Bicyclopyrone	0.75	OZ/A	HS	0 d	55 de	66.7 bc	96.7 a	31.7 cde	88.3 a
12	Bicyclopyrone	0.5	OZ/A	PO1	20 b	46.7 de	63.3 c	95 a	56.7 bcd	93.3 a
	NIS	0.25	% V/V	PO1						
13	Bicyclopyrone	0.75	OZ/A	PO1	33.3 a	70 bcd	75 abc	98.3 a	70 abc	88.3 a
	NIS	0.25	% V/V	PO1						
14	Firstrate	0.25	OZ/A	HS	0 d	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
15	Firstrate	0.5	OZ/A	HS	1.7 cd	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
16	Firstrate	0.75	OZ/A	HS	5 c	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
17	Sharpen	1.5	OZ/A	HS	1.7 cd	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
18	Sharpen	2.5	OZ/A	HS	1.7 cd	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
19	Verdict	13	OZ/A	HS	1.7 cd	66.7 cd	66.7 bc	66.7 b	66.7 abc	66.7 b
20	Callisto	1	OZ/A	HS	0 d	99.3 a	100 a	97.7 a	98.3 a	100 a
	Dual Magnum	1	PT/A	HS						
21	Callisto	2	OZ/A	HS	0 d	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
22	Imazosulfuron	0.4	LB A/A	HS	0 d	100 a	100 a	98.3 a	63.3 abc	98.3 a
23	Dual Magnum	1	PT/A	HS	0 d	100 a	100 a	98.3 a	91.7 ab	100 a
	Python	0.5	OZ/A	HS						
24	Dual Magnum	1	PT/A	HS	0 d	100 a	100 a	98.3 a	100 a	100 a
	Python	1	OZ/A	HS						
LSD (P=.05)					3.69	25.53	28.71	20.06	39.57	20.51

Means followed by same letter do not significantly differ (P=.05, LSD)

Potato Herbicide Efficacy - Arlington, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Potato Tuber Yield (cwt/a) 8/29/13 B's	Culls	A's	Total Yield
1	Untreated Check				47.19 a	8.59 de	214.90 cde	270.68 a
2	Lorox	1	LB/A	HS	56.87 a	12.95 cde	248.66 a-d	318.47 a
	Dual Magnum	1	PT/A	HS				
3	Lorox	1	LB/A	HS	73.08 a	13.79 cde	300.08 ab	386.96 a
	Prowl H2O	1.5	PT/A	HS				
4	Lorox	1	LB/A	HS	52.88 a	12.22 cde	308.31 a	373.41 a
	Sonalan HFP	2	PT/A	HS				
5	Lorox	1	LB/A	HS	45.98 a	7.99 de	245.99 a-d	299.96 a
	Sonalan HFP	4	PT/A	HS				
6	Zidua	2	OZ/A	HS	50.94 a	13.67 cde	215.74 cde	280.36 a
7	Zidua	2	OZ/A	HS	57.60 a	8.35 de	225.54 b-e	291.49 a
	Outlook	1	PT/A	HS				
8	Zidua	4	OZ/A	HS	49.97 a	7.74 de	219.13 cde	276.85 a
9	Zidua	4	OZ/A	HS	44.53 a	10.29 cde	254.95 a-d	309.76 a
	Outlook	1	PT/A	HS				
10	Bicyclopyrone	0.5	OZ/A	HS	80.59 a	6.78 e	244.90 a-e	332.27 a
11	Bicyclopyrone	0.75	OZ/A	HS	53.24 a	9.80 de	242.48 a-e	305.53 a
12	Bicyclopyrone	0.5	OZ/A	PO1	53.12 a	10.16 cde	185.86 de	249.14 a
	NIS	0.25	% V/V	PO1				
13	Bicyclopyrone	0.75	OZ/A	PO1	43.08 a	14.88 b-e	187.55 de	245.51 a
	NIS	0.25	% V/V	PO1				
14	Firstrate	0.25	OZ/A	HS	51.91 a	10.65 cde	201.34 cde	263.90 a
	Select Max	1	PT/A	PO1				
	NIS	0.25	% V/V	PO1				
15	Firstrate	0.5	OZ/A	HS	51.43 a	19.60 a-d	183.92 de	254.95 a
	Select Max	1	PT/A	PO1				
	NIS	0.25	% V/V	PO1				
16	Firstrate	0.75	OZ/A	HS	55.30 a	30.98 a	165.04 e	251.32 a
	Select Max	1	PT/A	PO1				
	NIS	0.25	% V/V	PO1				
17	Sharpen	1.5	OZ/A	HS	60.86 a	17.30 b-e	226.15 b-e	304.32 a
	Dual Magnum	1	PT/A	HS				
18	Sharpen	2.5	OZ/A	HS	51.91 a	9.32 de	205.58 cde	266.81 a
	Dual Magnum	1	PT/A	HS				
19	Verdict	13	OZ/A	HS	56.99 a	17.06 b-e	196.50 cde	270.56 a
20	Callisto	1	OZ/A	HS	65.95 a	11.37 cde	322.10 a	399.42 a
	Dual Magnum	1	PT/A	HS				
21	Callisto	2	OZ/A	HS	38.96 a	6.66 e	250.35 a-d	295.97 a
	Dual Magnum	1	PT/A	HS				
22	Imazosulfuron	0.4	LB A/A	HS	68.49 a	22.75 abc	268.86 abc	360.10 a
23	Dual Magnum	1	PT/A	HS	62.56 a	18.39 a-e	243.09 a-e	324.04 a
	Python	0.5	OZ/A	HS				
24	Dual Magnum	1	PT/A	HS	56.63 a	26.74 ab	223.97 b-e	307.34 a
	Python	1	OZ/A	HS				
LSD (P=.05)					32.576	12.620	80.236	96.288

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Herbicide Efficacy Evaluation - Hancock - 2013

Daniel J. Heider / Jed B. Colquhoun

Location: Hancock Ag Research Station: R-2 Pivot

Plot Information:

Soil Type: Plainfield Loamy Sand; pH 7.0; OM 0.7%.
Potato Cultivar: Russet Burbank
Date Planted: 4/30/13
Row Spacing: 36 Inches, 4 rows/plot
Plant Spacing: 12 inches
Date Harvested: 9/11/13
Plot Size-Design: 12' x 20', 3 Reps
Rating Dates: 5/29, 6/7, 6/18

Application Equipment: Backpack CO^2 pressure sprayer. GPA 20, PSI 27, MPH 3.3,
Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Herbicide Application Data:

Date	5/18/13	6/10/13
Time	10:45 am	2:30 pm
Treatment	HS	PO1
Soil Moisture		
SF	moist	moist
1"	moist	moist
3"	moist	moist
Soil Temp (F^o)		
SF	68.9	88.5
3"	60.7	81.3
Air Temp (F^o)	65.6	79.0
Wind	3.5 E	1.3 S
%RH	71.5%	41.7%
Sky Condition	100% clouds	95% clouds
Crop Stage	pre	12" (hook)
Weed & Size	pre	COLQ 1"
	-----	RRPW 1"
	-----	CORW 1-2"
	-----	WIBU 1-2"
	-----	HANS 1"
		YEFT 1"

Summary: This trial is designed to primarily evaluate herbicides currently unregistered in potato for potential new uses. Many of the treatments resulted in minimal or no injury and acceptable weed control; including combinations of Zidua, Firstrate, Sharpen, Verdict and Imazosulfuron herbicides. Additonal trials will be perfomed with these herbicides to further test their potential in potato.

Weed Abbreviations:	Plot Weed Density:
COLQ = Common Lambsquarters	moderate
RRPW = Redroot Pigweed	moderate
HANS = Hairy Nightshade	low
CORW = Common Ragweed	high
WIBU = Wild Buckwheat	high
YEFT = Yellow Foxtail	moderate

Potato Herbicide Efficacy - Hancock, WI - 2013

2013 Field Season Precipitation/Irrigation (R-2 Pivot)

Date	Type	Amount (inches)	Date	Type	Amount (inches)
30-Apr	Precipitation	0.06	8-Jul	Precipitation	0.43
3-May	Precipitation	0.33	10-Jul	Precipitation	0.5
4-May	Precipitation	0.43	11-Jul	Irrigation	0.5
10-May	Precipitation	0.84	12-Jul	Irrigation	0.3
14-May	Precipitation	0.04	13-Jul	Irrigation	0.5
17-May	Precipitation	0.04	15-Jul	Irrigation	0.6
18-May	Precipitation	0.4	17-Jul	Irrigation	0.6
20-May	Precipitation	0.26	19-Jul	Irrigation	0.6
21-May	Precipitation	0.02	19-Jul	Precipitation	0.02
22-May	Precipitation	0.13	21-Jul	Irrigation	0.6
23-May	Precipitation	0.59	22-Jul	Precipitation	0.38
28-May	Precipitation	0.45	23-Jul	Irrigation	0.5
29-May	Precipitation	0.06	24-Jul	Precipitation	0.2
30-May	Precipitation	0.71	25-Jul	Irrigation	0.5
1-Jun	Precipitation	0.02	26-Jul	Precipitation	0.13
2-Jun	Irrigation	0.5	27-Jul	Irrigation	0.35
5-Jun	Precipitation	0.45	29-Jul	Precipitation	0.44
6-Jun	Precipitation	0.52	30-Jul	Irrigation	0.35
7-Jun	Precipitation	0.01	1-Aug	Irrigation	0.35
8-Jun	Precipitation	0.01	1-Aug	Precipitation	0.09
10-Jun	Irrigation	0.4	3-Aug	Irrigation	0.4
12-Jun	Precipitation	0.03	5-Aug	Irrigation	0.35
13-Jun	Precipitation	0.22	6-Aug	Precipitation	0.01
14-Jun	Irrigation	0.5	7-Aug	Precipitation	0.45
15-Jun	Precipitation	0.6	8-Aug	Irrigation	0.35
17-Jun	Irrigation	0.25	10-Aug	Irrigation	0.4
17-Jun	Precipitation	0.02	12-Aug	Precipitation	0.22
18-Jun	Irrigation	0.35	13-Aug	Irrigation	0.35
18-Jun	Precipitation	0.04	13-Aug	Precipitation	0.01
20-Jun	Irrigation	0.5	15-Aug	Irrigation	0.4
21-Jun	Precipitation	0.92	17-Aug	Irrigation	0.5
22-Jun	Precipitation	1.01	19-Aug	Irrigation	0.5
23-Jun	Precipitation	0.46	21-Aug	Irrigation	0.4
25-Jun	Precipitation	0.22	21-Aug	Precipitation	0.08
26-Jun	Irrigation	0.4	22-Aug	Precipitation	0.1
27-Jun	Precipitation	0.01	23-Aug	Irrigation	0.4
28-Jun	Irrigation	0.5	25-Aug	Irrigation	0.5
28-Jun	Precipitation	0.12	27-Aug	Irrigation	0.5
1-Jul	Irrigation	0.4	28-Aug	Precipitation	0.97
3-Jul	Irrigation	0.4	30-Aug	Irrigation	0.5
5-Jul	Irrigation	0.4	1-Sep	Irrigation	0.5
7-Jul	Irrigation	0.5	3-Sep	Irrigation	0.4
7-Jul	Precipitation	0.43	5-Sep	Irrigation	0.5
			7-Sep	Irrigation	0.5
			9-Sep	Irrigation	0.4
			9-Sep	Precipitation	0.04

Potato Herbicide Efficacy - Hancock, WI - 2013

2013 Maintenance Fertilizer & Pesticides (R-2 Pivot)

Date	Product	Rate	Unit
23-Apr	0-0-60	350	lb/A
23-Apr	0-0-0-17S-21Ca	500	lb/A
30-Apr	6-30-22-4S, Platinum impreg.	550	lb/A
18-May	21-0-0-24S	360	lb/A
10-Jun	34-0-0	350	lb/A
11-Jun	Revus	8	oz/A
24-Jun	Asana XL	3	oz/A
24-Jun	Blackhawk	3.3	oz/A
27-Jun	Bravo ZN	2.25	pt/A
1-Jul	34-0-0	100	lb/A
2-Jul	Blackhawk	3	oz/A
2-Jul	Tanos	8	oz/A
2-Jul	Bravo ZN	2.25	pt/A
8-Jul	Headline	12	oz/A
8-Jul	Bravo ZN	2.25	pt/A
12-Jul	Bravo ZN	2.25	pt/A
12-Jul	Tanos	8	oz/A
15-Jul	34-0-0	100	lb/A
19-Jul	Bravo ZN	2.25	pt/A
19-Jul	Revus Top	7	oz/A
26-Jul	Asana XL	4	oz/A
26-Jul	Bravo ZN	2.25	pt/A
26-Jul	Coragen	5	oz/A
26-Jul	Headline	12	oz/A
2-Aug	Bravo ZN	2.25	pt/A
2-Aug	Revus Top	7	oz/A
9-Aug	Bravo ZN	2.25	pt/A
9-Aug	Coragen	4	oz/A
9-Aug	Tanos	6.5	oz/A
9-Aug	Asana XL	3	oz/A
16-Aug	Manzate FL	2.125	pt/A
16-Aug	Revus Top	7	oz/A
23-Aug	Manzate FL	2.125	pt/A
23-Aug	Tanos	8	oz/A
28-Aug	Diquat E	1.5	pt/A
30-Aug	Manzate FL	2.125	pt/A
30-Aug	Forum	6	oz/A
3-Sep	Diquat E	1.5	pt/A

Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	5/29/13 % Injury	6/7/13 % Injury	% Weed Control 6/7/13 COLQ	RRPW	CORW	WIBU	HANS
1	Untreated Check				0 b	0 e	0 c	0 c	0 d	0 d	0 c
2	Lorox	1	LB/A	HS	0 b	0 e	100 a	100 a	96.7 ab	100 a	100 a
	Dual Magnum	1	PT/A	HS							
3	Lorox	1	LB/A	HS	0 b	0 e	100 a	98.3 a	100 a	99.3 a	98.3 a
	Prowl H2O	1.5	PT/A	HS							
4	Lorox	1	LB/A	HS	0 b	0 e	100 a	95 a	98.3 ab	98.3 a	100 a
	Sonalan HFP	2	PT/A	HS							
5	Lorox	1	LB/A	HS	0 b	0 e	100 a	100 a	100 a	100 a	100 a
	Sonalan HFP	4	PT/A	HS							
6	Zidua	2	OZ/A	HS	0 b	0 e	100 a	100 a	93.3 abc	86.7 ab	100 a
7	Zidua	2	OZ/A	HS	0 b	0 e	100 a	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS							
8	Zidua	4	OZ/A	HS	0 b	0 e	100 a	100 a	95 abc	100 a	100 a
9	Zidua	4	OZ/A	HS	0 b	0 e	100 a	100 a	100 a	100 a	100 a
	Outlook	1	PT/A	HS							
10	Bicyclopyrone	0.5	OZ/A	HS	0 b	0 e	90 b	96 a	86.7 bc	78.3 b	80 b
11	Bicyclopyrone	0.75	OZ/A	HS	0 b	0 e	98.3 a	93.3 a	83.3 c	55 c	76.7 b
12	Bicyclopyrone	0.5	OZ/A	PO1	0 b	0 e	0 c	0 c	0 d	0 d	0 c
	NIS	0.25	% V/V	PO1							
13	Bicyclopyrone	0.75	OZ/A	PO1	0 b	0 e	0 c	0 c	0 d	0 d	0 c
	NIS	0.25	% V/V	PO1							
14	Firstrate	0.25	OZ/A	HS	0 b	0 e	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1							
	NIS	0.25	% V/V	PO1							
15	Firstrate	0.5	OZ/A	HS	0 b	1.7 de	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1							
	NIS	0.25	% V/V	PO1							
16	Firstrate	0.75	OZ/A	HS	0 b	11.7 c	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1							
	NIS	0.25	% V/V	PO1							
17	Sharpen	1.5	OZ/A	HS	0 b	1.7 de	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS							
18	Sharpen	2.5	OZ/A	HS	0 b	0 e	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS							
19	Verdict	13	OZ/A	HS	0 b	5 d	100 a	100 a	100 a	100 a	100 a
20	Callisto	1	OZ/A	HS	1.7 b	18.3 b	100 a	70 b	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS							
21	Callisto	2	OZ/A	HS	11.7 a	46.7 a	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS							
22	Imazosulfuron	0.4	LB A/A	HS	0 b	0 e	100 a	100 a	99.3 a	100 a	98.3 a
23	Dual Magnum	1	PT/A	HS	0 b	1.7 de	100 a	100 a	100 a	100 a	100 a
	Python	0.5	OZ/A	HS							
24	Dual Magnum	1	PT/A	HS	0 b	5 d	100 a	100 a	100 a	100 a	100 a
	Python	1	OZ/A	HS							
LSD (P=.05)					3.68	3.40	1.98	18.39	11.93	15.73	10.18

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/18/13 % Injury	% Weed Control 6/18/13 COLQ	RRPW	CORW	WIBU	HANS
1	Untreated Check				0 f	0 c	0 d	0 c	0 d	0 c
2	Lorox	1	LB/A	HS	0 f	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
3	Lorox	1	LB/A	HS	0 f	100 a	100 a	98.3 a	96.7 ab	100 a
	Prowl H2O	1.5	PT/A	HS						
4	Lorox	1	LB/A	HS	0 f	100 a	100 a	96.7 a	93.3 ab	100 a
	Sonalan HFP	2	PT/A	HS						
5	Lorox	1	LB/A	HS	0 f	100 a	100 a	100 a	100 a	100 a
	Sonalan HFP	4	PT/A	HS						
6	Zidua	2	OZ/A	HS	0 f	100 a	100 a	93.3 a	93.3 ab	100 a
7	Zidua	2	OZ/A	HS	0 f	100 a	100 a	100 a	98.3 ab	100 a
	Outlook	1	PT/A	HS						
8	Zidua	4	OZ/A	HS	0 f	98.3 a	100 a	100 a	95 ab	100 a
9	Zidua	4	OZ/A	HS	0 f	100 a	100 a	98.3 a	96.7 ab	100 a
	Outlook	1	PT/A	HS						
10	Bicyclopyrone	0.5	OZ/A	HS	0 f	96.7 a	100 a	98.3 a	83.3 b	86.7 a
11	Bicyclopyrone	0.75	OZ/A	HS	0 f	63.3 b	93.3 c	53.3 b	26.7 c	46.7 b
12	Bicyclopyrone	0.5	OZ/A	PO1	18.3 b	60 b	93.3 c	61.7 b	23.3 c	91.7 a
	NIS	0.25	% V/V	PO1						
13	Bicyclopyrone	0.75	OZ/A	PO1	28.3 a	85 a	96.7 b	88.3 a	23.3 c	91.7 a
	NIS	0.25	% V/V	PO1						
14	Firstrate	0.25	OZ/A	HS	0 f	99.3 a	100 a	93.3 a	88.3 ab	96.7 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
15	Firstrate	0.5	OZ/A	HS	3.3 de	100 a	100 a	100 a	98.3 ab	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
16	Firstrate	0.75	OZ/A	HS	5 d	100 a	100 a	100 a	100 a	100 a
	Select Max	1	PT/A	PO1						
	NIS	0.25	% V/V	PO1						
17	Sharpen	1.5	OZ/A	HS	1.7 ef	98.3 a	100 a	96.7 a	91.7 ab	95 a
	Dual Magnum	1	PT/A	HS						
18	Sharpen	2.5	OZ/A	HS	1.7 ef	98.3 a	100 a	90 a	93.3 ab	96.7 a
	Dual Magnum	1	PT/A	HS						
19	Verdict	13	OZ/A	HS	5 d	97.7 a	100 a	93.3 a	86.7 ab	100 a
20	Callisto	1	OZ/A	HS	0 f	100 a	100 a	96.7 a	95 ab	100 a
	Dual Magnum	1	PT/A	HS						
21	Callisto	2	OZ/A	HS	11.7 c	100 a	100 a	95 a	91.7 ab	100 a
	Dual Magnum	1	PT/A	HS						
22	Imazosulfuron	0.4	LB A/A	HS	0 f	98.3 a	100 a	100 a	95 ab	100 a
23	Dual Magnum	1	PT/A	HS	1.7 ef	100 a	100 a	98.3 a	93.3 ab	100 a
	Python	0.5	OZ/A	HS						
24	Dual Magnum	1	PT/A	HS	5 d	100 a	100 a	91.7 a	95 ab	100 a
	Python	1	OZ/A	HS						
LSD (P=.05)					2.50	15.24	2.40	20.89	16.48	18.01

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Potato Tuber Yield (cwt/a) 9/11/13 B's	Culls	2-4 oz	4-6 oz	6-10 oz
1	Untreated Check				1.44 a	2.53 b	72.22 a	165.81 a-d	302.21 ab
2	Lorox	1	LB/A	HS	3.11 a	3.95 b	78.32 a	150.08 b-g	250.71 bcd
	Dual Magnum	1	PT/A	HS					
3	Lorox	1	LB/A	HS	5.16 a	2.86 b	75.21 a	149.62 b-g	322.78 a
	Prowl H2O	1.5	PT/A	HS					
4	Lorox	1	LB/A	HS	5.50 a	4.63 b	75.82 a	143.52 b-g	254.72 bcd
	Sonalan HFP	2	PT/A	HS					
5	Lorox	1	LB/A	HS	3.81 a	4.36 b	87.90 a	173.38 ab	239.14 cd
	Sonalan HFP	4	PT/A	HS					
6	Zidua	2	OZ/A	HS	4.69 a	2.44 b	75.89 a	172.60 ab	258.05 bcd
7	Zidua	2	OZ/A	HS	4.16 a	3.46 b	85.31 a	159.10 b-f	263.29 a-d
	Outlook	1	PT/A	HS					
8	Zidua	4	OZ/A	HS	2.57 a	3.96 b	81.46 a	199.84 a	272.63 a-d
9	Zidua	4	OZ/A	HS	2.17 a	4.11 b	91.69 a	164.41 a-e	215.57 de
	Outlook	1	PT/A	HS					
10	Bicyclopyrone	0.5	OZ/A	HS	3.29 a	3.96 b	81.28 a	168.50 abc	256.99 bcd
11	Bicyclopyrone	0.75	OZ/A	HS	4.35 a	3.60 b	65.58 a	173.94 ab	271.11 a-d
12	Bicyclopyrone	0.5	OZ/A	PO1	2.43 a	2.19 b	63.58 a	118.50 gh	271.28 a-d
	NIS	0.25	% V/V	PO1					
13	Bicyclopyrone	0.75	OZ/A	PO1	1.37 a	3.60 b	54.90 a	128.31 efg	246.47 bcd
	NIS	0.25	% V/V	PO1					
14	Firstrate	0.25	OZ/A	HS	3.63 a	4.01 b	81.37 a	139.30 b-g	270.11 a-d
	Select Max	1	PT/A	PO1					
	NIS	0.25	% V/V	PO1					
15	Firstrate	0.5	OZ/A	HS	2.94 a	4.16 b	60.36 a	144.00 b-g	260.38 bcd
	Select Max	1	PT/A	PO1					
	NIS	0.25	% V/V	PO1					
16	Firstrate	0.75	OZ/A	HS	1.98 a	3.59 b	64.28 a	119.79 g	243.14 bcd
	Select Max	1	PT/A	PO1					
	NIS	0.25	% V/V	PO1					
17	Sharpen	1.5	OZ/A	HS	2.77 a	3.81 b	57.87 a	142.45 b-g	261.20 a-d
	Dual Magnum	1	PT/A	HS					
18	Sharpen	2.5	OZ/A	HS	2.46 a	4.02 b	73.22 a	135.51 c-g	260.91 a-d
	Dual Magnum	1	PT/A	HS					
19	Verdict	13	OZ/A	HS	1.68 a	4.21 b	60.24 a	128.10 fg	285.12 abc
20	Callisto	1	OZ/A	HS	1.54 a	3.07 b	54.78 a	147.35 b-g	248.47 bcd
	Dual Magnum	1	PT/A	HS					
21	Callisto	2	OZ/A	HS	2.15 a	2.69 b	64.36 a	144.84 b-g	221.57 de
	Dual Magnum	1	PT/A	HS					
22	Imazosulfuron	0.4	LB A/A	HS	3.71 a	2.66 b	87.80 a	157.42 b-f	257.49 bcd
23	Dual Magnum	1	PT/A	HS	2.38 a	4.28 b	58.49 a	132.17 d-g	252.21 bcd
	Python	0.5	OZ/A	HS					
24	Dual Magnum	1	PT/A	HS	1.93 a	10.94 a	60.19 a	83.10 h	161.12 e
	Python	1	OZ/A	HS					
LSD (P=.05)					3.190	2.451	27.973	36.173	62.061

Means followed by same letter do not significantly differ (P=.05, LSD)

Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Potato Tuber Yield (cwt/a) 9/11/13 10-13 oz	13-16 oz	>16 oz	Total Yield
1	Untreated Check				101.39 a	19.52 a	8.71 a	673.83 abc
2	Lorox	1	LB/A	HS	92.04 a	38.01 a	22.68 a	638.91 a-d
	Dual Magnum	1	PT/A	HS				
3	Lorox	1	LB/A	HS	79.06 a	38.77 a	13.87 a	687.33 abc
	Prowl H2O	1.5	PT/A	HS				
4	Lorox	1	LB/A	HS	65.80 a	47.92 a	31.25 a	629.16 a-d
	Sonalan HFP	2	PT/A	HS				
5	Lorox	1	LB/A	HS	79.27 a	40.56 a	30.32 a	658.73 abc
	Sonalan HFP	4	PT/A	HS				
6	Zidua	2	OZ/A	HS	106.20 a	36.96 a	24.86 a	681.69 abc
7	Zidua	2	OZ/A	HS	95.28 a	27.80 a	3.52 a	641.92 a-d
	Outlook	1	PT/A	HS				
8	Zidua	4	OZ/A	HS	94.82 a	36.78 a	23.30 a	715.35 a
9	Zidua	4	OZ/A	HS	85.87 a	38.21 a	8.75 a	610.80 bcd
	Outlook	1	PT/A	HS				
10	Bicyclopyrone	0.5	OZ/A	HS	76.90 a	34.53 a	10.60 a	636.05 a-d
11	Bicyclopyrone	0.75	OZ/A	HS	75.03 a	41.60 a	23.00 a	658.23 abc
12	Bicyclopyrone	0.5	OZ/A	PO1	88.98 a	43.33 a	43.72 a	634.01 a-d
	NIS	0.25	% V/V	PO1				
13	Bicyclopyrone	0.75	OZ/A	PO1	96.16 a	43.37 a	18.64 a	592.82 cd
	NIS	0.25	% V/V	PO1				
14	Firstrate	0.25	OZ/A	HS	77.73 a	36.08 a	30.57 a	642.80 a-d
	Select Max	1	PT/A	PO1				
	NIS	0.25	% V/V	PO1				
15	Firstrate	0.5	OZ/A	HS	93.05 a	42.99 a	12.12 a	620.01 a-d
	Select Max	1	PT/A	PO1				
	NIS	0.25	% V/V	PO1				
16	Firstrate	0.75	OZ/A	HS	79.10 a	45.04 a	35.00 a	591.91 cd
	Select Max	1	PT/A	PO1				
	NIS	0.25	% V/V	PO1				
17	Sharpen	1.5	OZ/A	HS	94.71 a	58.67 a	17.64 a	639.13 a-d
	Dual Magnum	1	PT/A	HS				
18	Sharpen	2.5	OZ/A	HS	76.79 a	36.28 a	30.34 a	619.53 bcd
	Dual Magnum	1	PT/A	HS				
19	Verdict	13	OZ/A	HS	83.99 a	37.03 a	23.67 a	624.03 a-d
20	Callisto	1	OZ/A	HS	92.93 a	59.72 a	24.77 a	632.63 a-d
	Dual Magnum	1	PT/A	HS				
21	Callisto	2	OZ/A	HS	72.26 a	33.21 a	17.83 a	558.90 d
	Dual Magnum	1	PT/A	HS				
22	Imazosulfuron	0.4	LB A/A	HS	119.01 a	56.35 a	18.42 a	702.86 ab
23	Dual Magnum	1	PT/A	HS	77.63 a	52.20 a	28.87 a	608.22 bcd
	Python	0.5	OZ/A	HS				
24	Dual Magnum	1	PT/A	HS	52.25 a	36.78 a	10.36 a	416.65 e
	Python	1	OZ/A	HS				
LSD (P=.05)					47.258	30.781	22.366	95.659

Means followed by same letter do not significantly differ (P=.05, LSD)

Potato Herbicides for Extended Control Evaluation - Hancock - 2013

Daniel J. Heider / Jed B. Colquhoun

Location: Hancock Ag Research Station: R-2 Pivot

Plot Information:

Soil Type: Plainfield Loamy Sand; pH 7.0; OM 0.7%.
Potato Cultivar: Russet Burbank
Date Planted: 4/30/13
Row Spacing: 36 Inches, 4 rows/plot
Plant Spacing: 12 inches
Date Harvested: 9/11/13
Plot Size-Design: 12' x 20', 3 Reps
Rating Dates: 5/9, 6/7, 6/18, 7/2

Application Equipment: Backpack CO^2 pressure sprayer. GPA 20, PSI 27, MPH 3.3,
Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Herbicide Application Data:

Date	5/18/12	6/10/13	6/24/13
Time	2:00 pm	2:00 pm	2:00 pm
Treatment	HS	PO1	PO2
Soil Moisture			
SF	moist	moist	moist
1"	moist	moist	moist
3"	moist	moist	moist
Soil Temp (F°)			
SF	81.1	88.5	101.2
3"	72.6	81.2	85.1
Air Temp (F°)	79.2	80.5	84.2
Wind	1.8 S	1.2 S	3-4.2 SW
%RH	49%	42.5%	61.1%
Sky Condition	100% clouds	95% clouds	20% clouds
Crop Stage	pre	12" (hook)	tuber init.
Weed & Size	pre	COLQ 1"	-----
	-----	RRPW 1"	-----
	-----	CORW 1-2"	
	-----	WIBU 1-2"	
	-----	HANS - 1"	

Summary: This trial focused on evaluation of potential season long weed control strategies in potato. Many of the herbicides were applied in a manner that is currently unregistered in potato. No injury was observed from any of the post-emergence treatments and weed control was excellent until harvest in all treatments. Yield parameters such as total B's, culls or total yield were not statistically different across treatments.

Weed Abbreviations:	Plot Weed Density:
COLQ = Common Lambsquarters	moderate
RRPW = Redroot Pigweed	moderate
CORW = Common Ragweed	high
WIBU = Wild Buckwheat	high
HANS = Hairy Nightshade	low

Potato Herbicides for Extended Control - Hancock, WI - 2013

2013 Field Season Precipitation/Irrigation (R-2 Pivot)

Date	Type	Amount (inches)	Date	Type	Amount (inches)
30-Apr	Precipitation	0.06	8-Jul	Precipitation	0.43
3-May	Precipitation	0.33	10-Jul	Precipitation	0.5
4-May	Precipitation	0.43	11-Jul	Irrigation	0.5
10-May	Precipitation	0.84	12-Jul	Irrigation	0.3
14-May	Precipitation	0.04	13-Jul	Irrigation	0.5
17-May	Precipitation	0.04	15-Jul	Irrigation	0.6
18-May	Precipitation	0.4	17-Jul	Irrigation	0.6
20-May	Precipitation	0.26	19-Jul	Irrigation	0.6
21-May	Precipitation	0.02	19-Jul	Precipitation	0.02
22-May	Precipitation	0.13	21-Jul	Irrigation	0.6
23-May	Precipitation	0.59	22-Jul	Precipitation	0.38
28-May	Precipitation	0.45	23-Jul	Irrigation	0.5
29-May	Precipitation	0.06	24-Jul	Precipitation	0.2
30-May	Precipitation	0.71	25-Jul	Irrigation	0.5
1-Jun	Precipitation	0.02	26-Jul	Precipitation	0.13
2-Jun	Irrigation	0.5	27-Jul	Irrigation	0.35
5-Jun	Precipitation	0.45	29-Jul	Precipitation	0.44
6-Jun	Precipitation	0.52	30-Jul	Irrigation	0.35
7-Jun	Precipitation	0.01	1-Aug	Irrigation	0.35
8-Jun	Precipitation	0.01	1-Aug	Precipitation	0.09
10-Jun	Irrigation	0.4	3-Aug	Irrigation	0.4
12-Jun	Precipitation	0.03	5-Aug	Irrigation	0.35
13-Jun	Precipitation	0.22	6-Aug	Precipitation	0.01
14-Jun	Irrigation	0.5	7-Aug	Precipitation	0.45
15-Jun	Precipitation	0.6	8-Aug	Irrigation	0.35
17-Jun	Irrigation	0.25	10-Aug	Irrigation	0.4
17-Jun	Precipitation	0.02	12-Aug	Precipitation	0.22
18-Jun	Irrigation	0.35	13-Aug	Irrigation	0.35
18-Jun	Precipitation	0.04	13-Aug	Precipitation	0.01
20-Jun	Irrigation	0.5	15-Aug	Irrigation	0.4
21-Jun	Precipitation	0.92	17-Aug	Irrigation	0.5
22-Jun	Precipitation	1.01	19-Aug	Irrigation	0.5
23-Jun	Precipitation	0.46	21-Aug	Irrigation	0.4
25-Jun	Precipitation	0.22	21-Aug	Precipitation	0.08
26-Jun	Irrigation	0.4	22-Aug	Precipitation	0.1
27-Jun	Precipitation	0.01	23-Aug	Irrigation	0.4
28-Jun	Irrigation	0.5	25-Aug	Irrigation	0.5
28-Jun	Precipitation	0.12	27-Aug	Irrigation	0.5
1-Jul	Irrigation	0.4	28-Aug	Precipitation	0.97
3-Jul	Irrigation	0.4	30-Aug	Irrigation	0.5
5-Jul	Irrigation	0.4	1-Sep	Irrigation	0.5
7-Jul	Irrigation	0.5	3-Sep	Irrigation	0.4
7-Jul	Precipitation	0.43	5-Sep	Irrigation	0.5
			7-Sep	Irrigation	0.5
			9-Sep	Irrigation	0.4
			9-Sep	Precipitation	0.04

Potato Herbicides for Extended Control - Hancock, WI - 2013

2013 Maintenance Fertilizer & Pesticides (R-2 Pivot)

Date	Product	Rate	Unit
23-Apr	0-0-60	350	lb/A
23-Apr	0-0-0-17S-21Ca	500	lb/A
30-Apr	6-30-22-4S, Platinum impreg.	550	lb/A
18-May	21-0-0-24S	360	lb/A
10-Jun	34-0-0	350	lb/A
11-Jun	Revus	8	oz/A
24-Jun	Asana XL	3	oz/A
24-Jun	Blackhawk	3.3	oz/A
27-Jun	Bravo ZN	2.25	pt/A
1-Jul	34-0-0	100	lb/A
2-Jul	Blackhawk	3	oz/A
2-Jul	Tanos	8	oz/A
2-Jul	Bravo ZN	2.25	pt/A
8-Jul	Headline	12	oz/A
8-Jul	Bravo ZN	2.25	pt/A
12-Jul	Bravo ZN	2.25	pt/A
12-Jul	Tanos	8	oz/A
15-Jul	34-0-0	100	lb/A
19-Jul	Bravo ZN	2.25	pt/A
19-Jul	Revus Top	7	oz/A
26-Jul	Asana XL	4	oz/A
26-Jul	Bravo ZN	2.25	pt/A
26-Jul	Coragen	5	oz/A
26-Jul	Headline	12	oz/A
2-Aug	Bravo ZN	2.25	pt/A
2-Aug	Revus Top	7	oz/A
9-Aug	Bravo ZN	2.25	pt/A
9-Aug	Coragen	4	oz/A
9-Aug	Tanos	6.5	oz/A
9-Aug	Asana XL	3	oz/A
16-Aug	Manzate FL	2.125	pt/A
16-Aug	Revus Top	7	oz/A
23-Aug	Manzate FL	2.125	pt/A
23-Aug	Tanos	8	oz/A
28-Aug	Diquat E	1.5	pt/A
30-Aug	Manzate FL	2.125	pt/A
30-Aug	Forum	6	oz/A
3-Sep	Diquat E	1.5	pt/A

Potato Herbicides for Extended Control - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/7/13 % Injury	% Weed Control 6/7/13 COLQ	RRPW	CORW	WIBU	HANS
1	Metribuzin	0.67	LB/A	HS	0 a	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
	Eptam	3	PT/A	PO2						
2	Metribuzin	0.67	LB/A	HS	0 a	100 a	100 a	100 a	100 a	63.3 c
	Matrix	1	OZ/A	PO1						
	NIS	0.25	% V/V	PO1						
	2,4-D Amine 4	3	OZ/A	PO2						
3	Metribuzin	0.67	LB/A	HS	1.7 a	100 a	100 a	100 a	100 a	100 a
	Dual Magnum	1	PT/A	HS						
	Prowl H2O	1	PT/A	PO2						
4	Metribuzin	0.67	LB/A	HS	1.7 a	100 a	100 a	100 a	100 a	100 a
	Matrix	1	OZ/A	PO1						
	NIS	0.25	% V/V	PO1						
	Eptam	3	PT/A	PO2						
5	Metribuzin	0.67	LB/A	HS	0 a	100 a	100 a	100 a	95 b	70 bc
	Prowl H2O	1	PT/A	HS						
	Dual Magnum	1	PT/A	PO2						
6	Metribuzin	0.67	LB/A	HS	0 a	100 a	100 a	100 a	100 a	90 abc
	Prowl H2O	1	PT/A	HS						
	Outlook	14	OZ/A	PO2						
7	Metribuzin	0.67	LB/A	HS	0 a	100 a	100 a	99.3 ab	100 a	100 a
	Dual Magnum	1	PT/A	HS						
	Curbit	2	PT/A	PO2						
8	Metribuzin	0.67	LB/A	HS	0 a	100 a	100 a	96.7 b	100 a	96.7 ab
	Prowl H2O	1	PT/A	HS						
	Matrix	1	OZ/A	PO2						
	Eptam	1	PT/A	PO2						
	MSO	1	% V/V	PO2						
	AMS	2	LB/A	PO2						
9	Prowl H2O	1	PT/A	PO1	0 a	0 b	0 b	0 c	0 c	0 d
	Matrix	1	OZ/A	PO1						
	NIS	0.25	% V/V	PO1						
10	Matrix	1	OZ/A	PO1	0 a	0 b	0 b	0 c	0 c	0 d
	NIS	0.25	% V/V	PO1						
	Select Max	16	OZ/A	PO1						
11	Eptam	3	PT/A	PO1	0 a	0 b	0 b	0 c	0 c	0 d
	Matrix	1	OZ/A	PO1						
	NIS	0.25	% V/V	PO1						
12	Matrix	1	OZ/A	PO1	0 a	0 b	0 b	0 c	0 c	0 d
	NIS	0.25	% V/V	PO1						
	Select Max	16	OZ/A	PO1						
	Metribuzin	0.67	LB/A	PO1						
LSD (P=.05)					1.90	0.00	0.00	2.83	2.44	28.76

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may contain both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Herbicides for Extended Control - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	% Weed Control 6/19/13 COLQ	RRPW	CORW	WIBU	HANS
1	Metribuzin	0.67	LB/A	HS	100 a	100 a	100 a	98.3 a	100 a
	Dual Magnum	1	PT/A	HS					
	Eptam	3	PT/A	PO2					
2	Metribuzin	0.67	LB/A	HS	100 a	100 a	100 a	100 a	100 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
	2,4-D Amine 4	3	OZ/A	PO2					
3	Metribuzin	0.67	LB/A	HS	100 a	100 a	95 a	95 b	100 a
	Dual Magnum	1	PT/A	HS					
	Prowl H2O	1	PT/A	PO2					
4	Metribuzin	0.67	LB/A	HS	100 a	100 a	100 a	100 a	100 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
	Eptam	3	PT/A	PO2					
5	Metribuzin	0.67	LB/A	HS	100 a	100 a	98.3 a	100 a	90 a
	Prowl H2O	1	PT/A	HS					
	Dual Magnum	1	PT/A	PO2					
6	Metribuzin	0.67	LB/A	HS	100 a	100 a	100 a	100 a	98.3 a
	Prowl H2O	1	PT/A	HS					
	Outlook	14	OZ/A	PO2					
7	Metribuzin	0.67	LB/A	HS	100 a	100 a	97.7 a	100 a	100 a
	Dual Magnum	1	PT/A	HS					
	Curbit	2	PT/A	PO2					
8	Metribuzin	0.67	LB/A	HS	100 a	100 a	96.7 a	100 a	100 a
	Prowl H2O	1	PT/A	HS					
	Matrix	1	OZ/A	PO2					
	Eptam	1	PT/A	PO2					
	MSO	1	% V/V	PO2					
	AMS	2	LB/A	PO2					
9	Prowl H2O	1	PT/A	PO1	100 a	100 a	98.3 a	100 a	100 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
10	Matrix	1	OZ/A	PO1	100 a	100 a	100 a	100 a	100 a
	NIS	0.25	% V/V	PO1					
	Select Max	16	OZ/A	PO1					
11	Eptam	3	PT/A	PO1	100 a	100 a	100 a	99.3 a	99.3 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
12	Matrix	1	OZ/A	PO1	100 a	100 a	100 a	100 a	100 a
	NIS	0.25	% V/V	PO1					
	Select Max	16	OZ/A	PO1					
	Metribuzin	0.67	LB/A	PO1					
LSD (P=.05)					0.00	0.00	3.56	2.83	6.46

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may contain both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Herbicides for Extended Control - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Tuber Yield (cwt/a) 9/11/13 B's	Culls	2-4 oz	4-6 oz	6-10 oz
1	Metribuzin	0.67	LB/A	HS	3.04 a	6.79 a	76.27 a	182.93 ab	263.22 a
	Dual Magnum	1	PT/A	HS					
	Eptam	3	PT/A	PO2					
2	Metribuzin	0.67	LB/A	HS	3.22 a	5.39 a	94.10 a	197.82 a	257.56 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
	2,4-D Amine 4	3	OZ/A	PO2					
3	Metribuzin	0.67	LB/A	HS	1.62 a	5.88 a	74.51 a	145.79 b-e	284.82 a
	Dual Magnum	1	PT/A	HS					
	Prowl H2O	1	PT/A	PO2					
4	Metribuzin	0.67	LB/A	HS	2.05 a	6.53 a	44.38 a	112.12 de	257.09 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
	Eptam	3	PT/A	PO2					
5	Metribuzin	0.67	LB/A	HS	1.72 a	5.64 a	71.19 a	128.35 cde	237.33 a
	Prowl H2O	1	PT/A	HS					
	Dual Magnum	1	PT/A	PO2					
6	Metribuzin	0.67	LB/A	HS	4.44 a	5.45 a	59.46 a	107.80 e	283.65 a
	Prowl H2O	1	PT/A	HS					
	Outlook	14	OZ/A	PO2					
7	Metribuzin	0.67	LB/A	HS	2.55 a	3.71 a	60.52 a	157.72 a-d	231.18 a
	Dual Magnum	1	PT/A	HS					
	Curbit	2	PT/A	PO2					
8	Metribuzin	0.67	LB/A	HS	1.68 a	7.12 a	61.63 a	128.70 cde	242.33 a
	Prowl H2O	1	PT/A	HS					
	Matrix	1	OZ/A	PO2					
	Eptam	1	PT/A	PO2					
	MSO	1	% V/V	PO2					
	AMS	2	LB/A	PO2					
9	Prowl H2O	1	PT/A	PO1	2.13 a	6.88 a	75.19 a	148.21 b-e	252.07 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
10	Matrix	1	OZ/A	PO1	1.85 a	4.37 a	64.91 a	129.89 cde	292.44 a
	NIS	0.25	% V/V	PO1					
	Select Max	16	OZ/A	PO1					
11	Eptam	3	PT/A	PO1	2.76 a	5.84 a	73.44 a	151.28 a-e	251.83 a
	Matrix	1	OZ/A	PO1					
	NIS	0.25	% V/V	PO1					
12	Matrix	1	OZ/A	PO1	2.18 a	4.04 a	63.45 a	163.01 abc	205.80 a
	NIS	0.25	% V/V	PO1					
	Select Max	16	OZ/A	PO1					
	Metribuzin	0.67	LB/A	PO1					
LSD (P=.05)					2.526	3.004	28.464	49.106	78.680

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may contain both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Herbicides for Extended Control - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Tuber Yield (cwt/a) 9/11/13 10-13 oz	13-16 oz	>16 oz	Total Yield
1	Metribuzin	0.67	LB/A	HS	116.31 a	32.61 a	5.81 e	686.98 a
	Dual Magnum	1	PT/A	HS				
	Eptam	3	PT/A	PO2				
2	Metribuzin	0.67	LB/A	HS	65.36 a	35.88 a	15.34 cde	674.66 a
	Matrix	1	OZ/A	PO1				
	NIS	0.25	% V/V	PO1				
	2,4-D Amine 4	3	OZ/A	PO2				
3	Metribuzin	0.67	LB/A	HS	82.76 a	12.56 a	42.98 ab	650.91 a
	Dual Magnum	1	PT/A	HS				
	Prowl H2O	1	PT/A	PO2				
4	Metribuzin	0.67	LB/A	HS	98.99 a	72.84 a	59.95 a	653.95 a
	Matrix	1	OZ/A	PO1				
	NIS	0.25	% V/V	PO1				
	Eptam	3	PT/A	PO2				
5	Metribuzin	0.67	LB/A	HS	96.79 a	59.36 a	37.92 abc	638.30 a
	Prowl H2O	1	PT/A	HS				
	Dual Magnum	1	PT/A	PO2				
6	Metribuzin	0.67	LB/A	HS	112.10 a	46.05 a	41.50 ab	660.44 a
	Prowl H2O	1	PT/A	HS				
	Outlook	14	OZ/A	PO2				
7	Metribuzin	0.67	LB/A	HS	99.86 a	26.63 a	13.81 cde	595.98 a
	Dual Magnum	1	PT/A	HS				
	Curbit	2	PT/A	PO2				
8	Metribuzin	0.67	LB/A	HS	81.81 a	45.09 a	15.84 cde	584.20 a
	Prowl H2O	1	PT/A	HS				
	Matrix	1	OZ/A	PO2				
	Eptam	1	PT/A	PO2				
	MSO	1	% V/V	PO2				
	AMS	2	LB/A	PO2				
9	Prowl H2O	1	PT/A	PO1	106.25 a	41.14 a	13.38 cde	645.25 a
	Matrix	1	OZ/A	PO1				
	NIS	0.25	% V/V	PO1				
10	Matrix	1	OZ/A	PO1	127.17 a	43.17 a	41.46 ab	705.26 a
	NIS	0.25	% V/V	PO1				
	Select Max	16	OZ/A	PO1				
11	Eptam	3	PT/A	PO1	77.37 a	43.56 a	32.78 bcd	638.86 a
	Matrix	1	OZ/A	PO1				
	NIS	0.25	% V/V	PO1				
12	Matrix	1	OZ/A	PO1	89.00 a	31.65 a	11.00 de	570.13 a
	NIS	0.25	% V/V	PO1				
	Select Max	16	OZ/A	PO1				
	Metribuzin	0.67	LB/A	PO1				
LSD (P=.05)					39.143	32.948	24.686	113.582

Means followed by same letter do not significantly differ (P=.05, LSD)

POTATO VINE DESICCATION EVALUATION - ANTIGO - 2013

Daniel J. Heider / Jed B. Colquhoun / Richard A. Rittmeyer

Location: Langlade County Airport
Antigo, WI

Plot Information:

Soil Type: Antigo Silt Loam
Variety: 'Snowden'
Date Planted: 5/17
Row Spacing: 36 Inches
Plot Size-Design: 12' x 20', 4 Reps
Rating Date: 9/9, 9/17
Harvest Date: 9/24

Summary: This vine desiccation trial treated potatoes with minimal senescence to evaluate the vine desiccants in a worse case scenario. Although most treatments provided satisfactory results by harvest, slightly different rates of desiccation were evident resulting in in increased yields in the UTC and treatments which were slower acting.

Application Equipment: Tractor mounted air pressure sprayer. GPA 20, PSI 25, MPH 3.3, Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Herbicide Application Data:

Date	9/3/13	9/9/13
Time	2:30 pm	7:30 am
Treatment	VK1	VK2
Soil Moisture		
SF	moist	dry
1"	moist	moist
3"	moist	moist
Soil Temp (F^o)		
SF	78.8	67.6
3"	74.2	65.4
Air Temp (F^o)	72.5	64.1
Wind	4.2 SW	3.3 SE
%RH	42.6%	74.6%
Sky Condition	0% clouds	100% clouds
Crop Stage	Lvs:1-3% Senescence	Lvs: 4% Senescence
	Stems: 0% Senescence	Stems: 0% Senescence

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Vine Desiccation Evaluation - Antigo, WI - 2013

Trt	Treatment		Rate	Grow	9/9/13 % Desiccation		9/17/13 % Desiccation		Tuber Yield (cwt/a) 9/24/13			
No.	Name	Rate	Unit	Stg	Leaves	Stems	Leaves	Stems	B's	Culls	A's	Total Yld.
1	Untreated Check				3.8 g	1 j	14.5 c	6.5 e	22.23 a	37.21 a	567.64 a	627.08 a
2	Vida	5.5	OZ/A	VK1	70 f	25 ghi	87.5 b	80 d	21.60 a	31.76 ab	541.96 a	595.32 ab
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
3	Vida	5.5	OZ/A	VK1	71.3 f	25 ghi	96.3 a	92.5 c	24.41 a	21.42 c-h	475.98 a	521.81 cd
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
	Vida	5.5	OZ/A	VK2								
	MSO	1	% V/V	VK2								
	AMS	2.5	LB/A	VK2								
4	Vida	5.5	OZ/A	VK1	78.8 ef	32.5 e-i	100 a	97.5 abc	20.42 a	15.34 fgh	518.00 a	553.76 bc
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
	Reglone	1	PT/A	VK2								
	NIS	0.25	% V/V	VK2								
5	Reglone	1	PT/A	VK1	95.3 abc	56.3 bc	97.5 a	96.3 abc	21.87 a	24.50 b-g	503.21 a	549.58 bc
	NIS	0.25	% V/V	VK1								
6	Reglone	1.5	PT/A	VK1	90.8 a-d	41.3 c-g	98.3 a	97 abc	21.15 a	15.16 gh	507.47 a	543.77 bcd
	NIS	0.25	% V/V	VK1								
7	Reglone	1	PT/A	VK1	93.8 abc	51.3 bcd	98.8 a	98.8 ab	22.05 a	25.68 b-e	507.57 a	555.30 bc
	NIS	0.25	% V/V	VK1								
	Reglone	1	PT/A	VK2								
	NIS	0.25	% V/V	VK2								
8	Reglone	2	PT/A	VK1	99.5 a	62.5 b	100 a	97.5 abc	24.68 a	25.59 b-f	510.20 a	560.47 bc
	NIS	0.25	% V/V	VK1								
9	Rely 280	21	OZ/A	VK1	98.3 ab	23.8 hi	100 a	97.5 abc	18.60 a	30.67 abc	499.22 a	548.49 bc
10	Rely 280	21	OZ/A	VK1	99.5 a	22.5 i	100 a	96.3 abc	21.60 a	25.59 b-f	520.09 a	567.28 bc
	AMS	2.5	LB/A	VK1								
11	AIM EC	5.8	OZ/A	VK1	80 def	32.5 e-i	96.3 a	93.8 bc	20.15 a	24.59 b-g	520.91 a	565.65 bc
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
12	AIM EC	3.2	OZ/A	VK1	85 cde	37.5 d-i	100 a	100 a	22.23 a	19.06 e-h	516.64 a	557.93 bc
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
	AIM EC	3.2	OZ/A	VK2								
	MSO	1	% V/V	VK2								
	AMS	2.5	LB/A	VK2								

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Potato Vine Desiccation Evaluation - Antigo, WI - 2013

Trt	Treatment		Rate	Grow	9/9/13 % Desiccation		9/17/13 % Desiccation		Tuber Yield (cwt/a) 9/24/13			
No.	Name	Rate	Unit	Stg	Leaves	Stems	Leaves	Stems	B's	Culls	A's	Total Yld.
13	AIM EC	5.8	OZ/A	VK1	94.8 abc	50 bcd	100 a	100 a	22.42 a	29.77 a-d	514.46 a	566.64 bc
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
	AIM EC	5.8	OZ/A	VK2								
	MSO	1	% V/V	VK2								
	AMS	2.5	LB/A	VK2								
14	Sharpen	2	OZ/A	VK1	91.3 abc	47.5 b-e	98.8 a	97.5 abc	21.96 a	16.70 e-h	516.46 a	555.12 bc
	MSO	1	% V/V	VK1								
	AMS	8.5	LB/100 GA	VK1								
15	Sharpen	4	OZ/A	VK1	94.5 abc	42.5 c-f	98.8 a	98.8 ab	19.69 a	18.60 e-h	451.84 a	490.14 d
	MSO	1	% V/V	VK1								
	AMS	8.5	LB/100 GA	VK1								
16	Sharpen	2	OZ/A	VK1	85 cde	40 c-h	100 a	100 a	21.69 a	21.33 c-h	494.04 a	537.06 cd
	MSO	1	% V/V	VK1								
	AMS	8.5	LB/100 GA	VK1								
	Sharpen	2	OZ/A	VK2								
	MSO	1	% V/V	VK2								
	AMS	8.5	LB/100 GA	VK2								
17	Sharpen	2	OZ/A	VK1	92 abc	42.5 c-f	100 a	100 a	22.42 a	21.42 c-h	520.09 a	563.92 bc
	MSO	1	PT/A	VK1								
	AMS	8.5	LB/100 GA	VK1								
	Sharpen	2	OZ/A	VK2								
	MSO	1	PT/A	VK2								
	AMS	8.5	LB/100 GA	VK2								
18	Sharpen	2	OZ/A	VK1	84.5 cde	30 f-i	100 a	100 a	18.97 a	20.06 d-h	520.18 a	559.20 bc
	MSO	2	PT/A	VK1								
	AMS	8.5	LB/100 GA	VK1								
	Sharpen	2	OZ/A	VK2								
	MSO	2	PT/A	VK2								
	AMS	8.5	LB/100 GA	VK2								
19	Green Chopped			VK1	98 ab	86.3 a	100 a	100 a	21.05 a	13.98 h	486.78 a	521.81 cd
20	AIM EC	5.8	OZ/A	VK1	88.3 b-e	37.5 d-i	95 a	92.5 c	24.50 a	23.60 b-h	491.87 a	539.96 cd
	MSO	1	% V/V	VK1								
	AMS	2.5	LB/A	VK1								
LSD (P=.05)					10.80	16.60	7.01	6.21	7.103	10.297	56.452	53.749

Means followed by same letter do not significantly differ (P=.05, LSD)

Seed Potato Herbicide Injury Evaluation - Hancock - 2013

Jed B. Colquhoun / Daniel J. Heider

Location: Hancock Ag Research Station: R-2 Pivot

Plot Information:

Soil Type: Plainfield Loamy Sand; pH 7.0; OM 0.7%.
Potato Cultivar: Russet Burbank
Date Planted: 4/30/13
Row Spacing: 36 Inches, 4 rows/plot
Plant Spacing: 12 inches
Date Harvested: 9/11/13
Plot Size-Design: 12' x 20', 3 Reps
Rating Dates: 5/9, 6/7, 6/18

Application Equipment: Tractor mounted air pressure sprayer. GPA 20, PSI 27, MPH 3.3, Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Herbicide Application Data:

Date	5/18/13	6/19/13
Time	3:00 pm	2:30 pm
Treatment	HS	PO1
Soil Moisture		
SF	moist	moist
1"	moist	moist
3"	moist	moist
Soil Temp (F^o)		
SF	79.7	93.7
3"	71.5	86.1
Air Temp (F^o)	79.9	78.2
Wind	1.4 S	1.4 SW
%RH	46%	41%
Sky Condition	100% clouds	25% clouds
Crop Stage	pre	tuber initi.
Weed & Size	pre	

Summary: This trial was designed to simulate the effects of possible drift or tank contamination rates of herbicides on potato. Summarized here are the visual injury ratings and subsequent yield of the potato crop. Injury to the crop was highly variable depending upon the treatment, however no yield effects were observed. Seed was collected at harvest and will be grown out during both the winter trials and the 2014 growing season in Wisconsin to determine if there were any detrimental effects on seed-piece viability or the subsequent crop.

5/18/13 - HS application of 1 pt/a Dual Magnum + 0.67 lb/a Metribuzin DF over entire trial (including untreated check)

6/19/13 - marble sized tubers present, plants exhibiting flower buds and a few open flowers

Seed Potato Herbicide Injury - Hancock, WI - 2013

2013 Field Season Precipitation/Irrigation (R-2 Pivot)

Date	Type	Amount (inches)	Date	Type	Amount (inches)
30-Apr	Precipitation	0.06	8-Jul	Precipitation	0.43
3-May	Precipitation	0.33	10-Jul	Precipitation	0.5
4-May	Precipitation	0.43	11-Jul	Irrigation	0.5
10-May	Precipitation	0.84	12-Jul	Irrigation	0.3
14-May	Precipitation	0.04	13-Jul	Irrigation	0.5
17-May	Precipitation	0.04	15-Jul	Irrigation	0.6
18-May	Precipitation	0.4	17-Jul	Irrigation	0.6
20-May	Precipitation	0.26	19-Jul	Irrigation	0.6
21-May	Precipitation	0.02	19-Jul	Precipitation	0.02
22-May	Precipitation	0.13	21-Jul	Irrigation	0.6
23-May	Precipitation	0.59	22-Jul	Precipitation	0.38
28-May	Precipitation	0.45	23-Jul	Irrigation	0.5
29-May	Precipitation	0.06	24-Jul	Precipitation	0.2
30-May	Precipitation	0.71	25-Jul	Irrigation	0.5
1-Jun	Precipitation	0.02	26-Jul	Precipitation	0.13
2-Jun	Irrigation	0.5	27-Jul	Irrigation	0.35
5-Jun	Precipitation	0.45	29-Jul	Precipitation	0.44
6-Jun	Precipitation	0.52	30-Jul	Irrigation	0.35
7-Jun	Precipitation	0.01	1-Aug	Irrigation	0.35
8-Jun	Precipitation	0.01	1-Aug	Precipitation	0.09
10-Jun	Irrigation	0.4	3-Aug	Irrigation	0.4
12-Jun	Precipitation	0.03	5-Aug	Irrigation	0.35
13-Jun	Precipitation	0.22	6-Aug	Precipitation	0.01
14-Jun	Irrigation	0.5	7-Aug	Precipitation	0.45
15-Jun	Precipitation	0.6	8-Aug	Irrigation	0.35
17-Jun	Irrigation	0.25	10-Aug	Irrigation	0.4
17-Jun	Precipitation	0.02	12-Aug	Precipitation	0.22
18-Jun	Irrigation	0.35	13-Aug	Irrigation	0.35
18-Jun	Precipitation	0.04	13-Aug	Precipitation	0.01
20-Jun	Irrigation	0.5	15-Aug	Irrigation	0.4
21-Jun	Precipitation	0.92	17-Aug	Irrigation	0.5
22-Jun	Precipitation	1.01	19-Aug	Irrigation	0.5
23-Jun	Precipitation	0.46	21-Aug	Irrigation	0.4
25-Jun	Precipitation	0.22	21-Aug	Precipitation	0.08
26-Jun	Irrigation	0.4	22-Aug	Precipitation	0.1
27-Jun	Precipitation	0.01	23-Aug	Irrigation	0.4
28-Jun	Irrigation	0.5	25-Aug	Irrigation	0.5
28-Jun	Precipitation	0.12	27-Aug	Irrigation	0.5
1-Jul	Irrigation	0.4	28-Aug	Precipitation	0.97
3-Jul	Irrigation	0.4	30-Aug	Irrigation	0.5
5-Jul	Irrigation	0.4	1-Sep	Irrigation	0.5
7-Jul	Irrigation	0.5	3-Sep	Irrigation	0.4
7-Jul	Precipitation	0.43	5-Sep	Irrigation	0.5
			7-Sep	Irrigation	0.5
			9-Sep	Irrigation	0.4
			9-Sep	Precipitation	0.04

Seed Potato Herbicide Injury - Hancock, WI - 2013

2013 Maintenance Fertilizer & Pesticides (R-2 Pivot)

Date	Product	Rate	Unit
23-Apr	0-0-60	350	lb/A
23-Apr	0-0-0-17S-21Ca	500	lb/A
30-Apr	6-30-22-4S, Platinum impreg.	550	lb/A
18-May	21-0-0-24S	360	lb/A
10-Jun	34-0-0	350	lb/A
11-Jun	Revus	8	oz/A
24-Jun	Asana XL	3	oz/A
24-Jun	Blackhawk	3.3	oz/A
27-Jun	Bravo ZN	2.25	pt/A
1-Jul	34-0-0	100	lb/A
2-Jul	Blackhawk	3	oz/A
2-Jul	Tanos	8	oz/A
2-Jul	Bravo ZN	2.25	pt/A
8-Jul	Headline	12	oz/A
8-Jul	Bravo ZN	2.25	pt/A
12-Jul	Bravo ZN	2.25	pt/A
12-Jul	Tanos	8	oz/A
15-Jul	34-0-0	100	lb/A
19-Jul	Bravo ZN	2.25	pt/A
19-Jul	Revus Top	7	oz/A
26-Jul	Asana XL	4	oz/A
26-Jul	Bravo ZN	2.25	pt/A
26-Jul	Coragen	5	oz/A
26-Jul	Headline	12	oz/A
2-Aug	Bravo ZN	2.25	pt/A
2-Aug	Revus Top	7	oz/A
9-Aug	Bravo ZN	2.25	pt/A
9-Aug	Coragen	4	oz/A
9-Aug	Tanos	6.5	oz/A
9-Aug	Asana XL	3	oz/A
16-Aug	Manzate FL	2.125	pt/A
16-Aug	Revus Top	7	oz/A
23-Aug	Manzate FL	2.125	pt/A
23-Aug	Tanos	8	oz/A
28-Aug	Diquat E	1.5	pt/A
30-Aug	Manzate FL	2.125	pt/A
30-Aug	Forum	6	oz/A
3-Sep	Diquat E	1.5	pt/A

Seed Potato Herbicide Injury - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/24/13 % Injury	7/1/13 % Injury	7/8/13 % Injury	7/17/13 % Injury
1	Untreated Check				0 f	0 c	0 d	0 b
2	2,4-D Amine	0.16	OZ/A	PO1	0 f	0.5 c	0 d	0 b
3	Clarity	0.16	OZ/A	PO1	0.5 ef	17.5 a	25 a	16.3 a
	AMS	0.025	LB/A	PO1				
4	Roundup Weathermax	0.24	OZ/A	PO1	0 f	0.3 c	0 d	0 b
	AMS	0.085	LB/100 GAL	PO1				
5	Roundup Weathermax	0.48	OZ/A	PO1	0.5 ef	1 c	0.3 d	0 b
	AMS	0.17	LB/100 GAL	PO1				
6	Roundup Weathermax	0.96	OZ/A	PO1	3 c	1.5 c	0.8 d	0 b
	AMS	0.34	LB/100 GAL	PO1				
7	Callisto	0.03	OZ/A	PO1	10 a	12.5 b	11.3 c	0.5 b
	COC	0.01	% V/V	PO1				
	AMS	0.085	LB/100 GAL	PO1				
8	Impact	0.0075	OZ/A	PO1	1 de	2 c	0 d	0 b
	MSO	0.01	% V/V	PO1				
	AMS	0.085	LB/100 GAL	PO1				
9	Laudis	0.03	OZ/A	PO1	5 b	1.8 c	1.5 d	0 b
	MSO	0.01	% V/V	PO1				
	AMS	0.085	LB/100 GAL	PO1				
10	Cadet	0.0075	OZ/A	PO1	0 f	0 c	0 d	0 b
	NIS	0.01	% V/V	PO1				
	AMS	0.015	LB/A	PO1				
11	Firstrate	0.006	OZ/A	PO1	1.3 d	1.3 c	1.5 d	0 b
	NIS	0.0025	% V/V	PO1				
	AMS	0.02	LB/A	PO1				
12	Resource	0.08	OZ/A	PO1	0 f	0 c	0.3 d	0 b
	COC	0.32	OZ/A	PO1				
13	Harmony SG	0.00125	OZ/A	PO1	0 f	1.5 c	0.3 d	0 b
	NIS	0.0025	% V/V	PO1				
	AMS	0.02	LB/A	PO1				
14	Express	0.005	OZ/A	PO1	1.5 d	1.8 c	0.8 d	0 b
	NIS	0.0025	% V/V	PO1				
	AMS	0.02	LB/A	PO1				
15	Milestone	0.05	OZ/A	PO1	0 f	13.8 b	21.3 b	17.5 a
	NIS	0.0025	% V/V	PO1				
16	Escort	0.003	OZ/A	PO1	0.5 ef	0 c	0.3 d	0 b
	NIS	0.0025	% V/V	PO1				
LSD (P=.05)					0.70	2.60	2.12	1.43

Means followed by same letter do not significantly differ (P=.05, LSD)

Seed Potato Herbicide Injury - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Tuber Yield (cwt/a) 9/11/13 B's	Culls	2-4 oz	4-6 oz	6-10 oz
1	Untreated Check				2.36 a	63.53 a	66.90 a	144.22 a	247.97 a
2	2,4-D Amine	0.16	OZ/A	PO1	2.43 a	66.79 a	63.13 a	150.61 a	276.73 a
3	Clarity	0.16	OZ/A	PO1	1.14 a	54.81 a	74.38 a	130.75 a	275.86 a
	AMS	0.025	LB/A	PO1					
4	Roundup Weathermax	0.24	OZ/A	PO1	2.85 a	61.89 a	65.25 a	129.46 a	273.54 a
	AMS	0.085	LB/100 GAL	PO1					
5	Roundup Weathermax	0.48	OZ/A	PO1	1.14 a	67.34 a	56.88 a	130.84 a	229.71 a
	AMS	0.17	LB/100 GAL	PO1					
6	Roundup Weathermax	0.96	OZ/A	PO1	2.90 a	40.11 a	79.24 a	169.21 a	285.30 a
	AMS	0.34	LB/100 GAL	PO1					
7	Callisto	0.03	OZ/A	PO1	2.31 a	52.45 a	70.13 a	138.12 a	249.44 a
	COC	0.01	% V/V	PO1					
	AMS	0.085	LB/100 GAL	PO1					
8	Impact	0.0075	OZ/A	PO1	1.63 a	49.37 a	61.38 a	127.72 a	263.59 a
	MSO	0.01	% V/V	PO1					
	AMS	0.085	LB/100 GAL	PO1					
9	Laudis	0.03	OZ/A	PO1	1.80 a	60.98 a	61.11 a	140.86 a	282.09 a
	MSO	0.01	% V/V	PO1					
	AMS	0.085	LB/100 GAL	PO1					
10	Cadet	0.0075	OZ/A	PO1	1.58 a	60.44 a	61.06 a	131.99 a	295.85 a
	NIS	0.01	% V/V	PO1					
	AMS	0.015	LB/A	PO1					
11	Firstrate	0.006	OZ/A	PO1	2.52 a	83.67 a	78.59 a	147.29 a	240.74 a
	NIS	0.0025	% V/V	PO1					
	AMS	0.02	LB/A	PO1					
12	Resource	0.08	OZ/A	PO1	4.14 a	62.80 a	68.21 a	140.32 a	277.62 a
	COC	0.32	OZ/A	PO1					
13	Harmony SG	0.00125	OZ/A	PO1	2.58 a	43.92 a	63.74 a	159.38 a	306.39 a
	NIS	0.0025	% V/V	PO1					
	AMS	0.02	LB/A	PO1					
14	Express	0.005	OZ/A	PO1	2.61 a	77.86 a	71.42 a	144.64 a	286.32 a
	NIS	0.0025	% V/V	PO1					
	AMS	0.02	LB/A	PO1					
15	Milestone	0.05	OZ/A	PO1	1.65 a	49.55 a	95.58 a	166.40 a	260.45 a
	NIS	0.0025	% V/V	PO1					
16	Escort	0.003	OZ/A	PO1	2.07 a	61.53 a	73.02 a	141.66 a	261.36 a
	NIS	0.0025	% V/V	PO1					
LSD (P=.05)					1.971	29.621	22.141	45.714	61.815

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may contain both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Seed Potato Herbicide Injury - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	Tuber Yield (cwt/a) 9/11/13 10-13 oz	13-16 oz	>16 oz	Total Yield
1	Untreated Check				78.93 a	47.92 a	43.29 a	695.11 a
2	2,4-D Amine	0.16	OZ/A	PO1	95.51 a	33.83 a	35.83 a	724.86 a
3	Clarity	0.16	OZ/A	PO1	119.41 a	33.87 a	49.91 a	740.14 a
	AMS	0.025	LB/A	PO1				
4	Roundup Weathermax	0.24	OZ/A	PO1	84.72 a	60.49 a	32.96 a	711.17 a
	AMS	0.085	LB/100 GAL	PO1				
5	Roundup Weathermax	0.48	OZ/A	PO1	113.13 a	46.70 a	54.70 a	700.45 a
	AMS	0.17	LB/100 GAL	PO1				
6	Roundup Weathermax	0.96	OZ/A	PO1	112.75 a	41.82 a	25.88 a	757.22 a
	AMS	0.34	LB/100 GAL	PO1				
7	Callisto	0.03	OZ/A	PO1	103.95 a	40.97 a	31.24 a	688.59 a
	COC	0.01	% V/V	PO1				
	AMS	0.085	LB/100 GAL	PO1				
8	Impact	0.0075	OZ/A	PO1	110.73 a	54.83 a	40.06 a	709.32 a
	MSO	0.01	% V/V	PO1				
	AMS	0.085	LB/100 GAL	PO1				
9	Laudis	0.03	OZ/A	PO1	116.07 a	40.55 a	42.22 a	745.68 a
	MSO	0.01	% V/V	PO1				
	AMS	0.085	LB/100 GAL	PO1				
10	Cadet	0.0075	OZ/A	PO1	94.02 a	68.73 a	27.90 a	741.56 a
	NIS	0.01	% V/V	PO1				
	AMS	0.015	LB/A	PO1				
11	Firstrate	0.006	OZ/A	PO1	97.16 a	52.67 a	52.33 a	754.97 a
	NIS	0.0025	% V/V	PO1				
	AMS	0.02	LB/A	PO1				
12	Resource	0.08	OZ/A	PO1	100.86 a	54.76 a	31.24 a	739.94 a
	COC	0.32	OZ/A	PO1				
13	Harmony SG	0.00125	OZ/A	PO1	96.10 a	49.04 a	34.27 a	755.42 a
	NIS	0.0025	% V/V	PO1				
	AMS	0.02	LB/A	PO1				
14	Express	0.005	OZ/A	PO1	106.32 a	30.76 a	24.68 a	744.62 a
	NIS	0.0025	% V/V	PO1				
	AMS	0.02	LB/A	PO1				
15	Milestone	0.05	OZ/A	PO1	76.23 a	36.83 a	16.19 a	702.88 a
	NIS	0.0025	% V/V	PO1				
16	Escort	0.003	OZ/A	PO1	94.78 a	55.01 a	22.29 a	711.72 a
	NIS	0.0025	% V/V	PO1				
LSD (P=.05)					37.156	28.828	26.572	88.945

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Sweet Potato Herbicide Efficacy Evaluation - Hancock - 2013

Daniel J. Heider

Location: Hancock Ag Research Station: R-2 Pivot

Plot Information:

Soil Type: Plainfield Sand; pH 7.0; OM 0.7%.
Potato Cultivar: 'Beuregard'
Date Planted: 5/29/13
Row Spacing: 36 Inches, 2 rows/plot
Plant Spacing: 12 inches
Date Harvested: 10/2/13
Plot Size-Design: 12' x 20', 3 Reps
Rating Dates: 6/18, 7/1, 7/8, 7/17

Application Equipment: Backpack CO^2 pressure sprayer. GPA 20, PSI 27, MPH 3.3,
Nozzle - XR8003VS, Nozzle spacing 18", Height 18".

Herbicide Application Data:

Date	5/29/13	5/29/13	7/1/13
Time	11:00 am	3:00 pm	11:00 am
Treatment	PRETRA	POSTRA	POST
Soil Moisture			
SF	moist	moist	dry
1"	moist	moist	moist
3"	moist	moist	moist
Soil Temp (F^o)			
SF	80.4	89.4	97.4
3"	66.9	78.3	77.1
Air Temp (F^o)	76.4	83.9	79.1
Wind (speed/dir.)	3 SW	3.9 S	3.4 E
%RH	78.2%	50.2%	41.8%
Clouds	35%	10%	0%
Crop Stage	pre	slips	6-8"
Weed & Size	pre	-----	COLQ 2-4"
	-----	-----	CORW 2-6"
	-----	-----	WIBU 2-4"
	-----	-----	HANS 2-6"
	-----	-----	YEFT 3"

Summary: Few herbicides are currently registered for use in sweet potato. Although the treatments containing registered applications of Valor SX, Command and Devrinol performed well, several unregistered herbicides including Zidua, Dual Magnum and Lorox appear promising. A lack of heat units resulted in less bulking than in past years, however several treatments still managed to yield in the 200-400 cwt/a range.

Weed Abbreviations:	Plot Weed Density:
COLQ = Common Lambsquarters	moderate
CORW = Common Ragweed	high
WIBU = Wild Buckwheat	high
HANS = Hairy Nightshade	low
YEFT = Yellow Foxtail	moderate

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Sweet Potato Herbicide Efficacy - Hancock, WI - 2013

2013 Field Season Precipitation/Irrigation (R-2 Pivot)

Date	Type	Amount (inches)	Date	Type	Amount (inches)
30-Apr	Precipitation	0.06	8-Jul	Precipitation	0.43
3-May	Precipitation	0.33	10-Jul	Precipitation	0.5
4-May	Precipitation	0.43	11-Jul	Irrigation	0.5
10-May	Precipitation	0.84	12-Jul	Irrigation	0.3
14-May	Precipitation	0.04	13-Jul	Irrigation	0.5
17-May	Precipitation	0.04	15-Jul	Irrigation	0.6
18-May	Precipitation	0.4	17-Jul	Irrigation	0.6
20-May	Precipitation	0.26	19-Jul	Irrigation	0.6
21-May	Precipitation	0.02	19-Jul	Precipitation	0.02
22-May	Precipitation	0.13	21-Jul	Irrigation	0.6
23-May	Precipitation	0.59	22-Jul	Precipitation	0.38
28-May	Precipitation	0.45	23-Jul	Irrigation	0.5
29-May	Precipitation	0.06	24-Jul	Precipitation	0.2
30-May	Precipitation	0.71	25-Jul	Irrigation	0.5
1-Jun	Precipitation	0.02	26-Jul	Precipitation	0.13
2-Jun	Irrigation	0.5	27-Jul	Irrigation	0.35
5-Jun	Precipitation	0.45	29-Jul	Precipitation	0.44
6-Jun	Precipitation	0.52	30-Jul	Irrigation	0.35
7-Jun	Precipitation	0.01	1-Aug	Irrigation	0.35
8-Jun	Precipitation	0.01	1-Aug	Precipitation	0.09
10-Jun	Irrigation	0.4	3-Aug	Irrigation	0.4
12-Jun	Precipitation	0.03	5-Aug	Irrigation	0.35
13-Jun	Precipitation	0.22	6-Aug	Precipitation	0.01
14-Jun	Irrigation	0.5	7-Aug	Precipitation	0.45
15-Jun	Precipitation	0.6	8-Aug	Irrigation	0.35
17-Jun	Irrigation	0.25	10-Aug	Irrigation	0.4
17-Jun	Precipitation	0.02	12-Aug	Precipitation	0.22
18-Jun	Irrigation	0.35	13-Aug	Irrigation	0.35
18-Jun	Precipitation	0.04	13-Aug	Precipitation	0.01
20-Jun	Irrigation	0.5	15-Aug	Irrigation	0.4
21-Jun	Precipitation	0.92	17-Aug	Irrigation	0.5
22-Jun	Precipitation	1.01	19-Aug	Irrigation	0.5
23-Jun	Precipitation	0.46	21-Aug	Irrigation	0.4
25-Jun	Precipitation	0.22	21-Aug	Precipitation	0.08
26-Jun	Irrigation	0.4	22-Aug	Precipitation	0.1
27-Jun	Precipitation	0.01	23-Aug	Irrigation	0.4
28-Jun	Irrigation	0.5	25-Aug	Irrigation	0.5
28-Jun	Precipitation	0.12	27-Aug	Irrigation	0.5
1-Jul	Irrigation	0.4	28-Aug	Precipitation	0.97
3-Jul	Irrigation	0.4	30-Aug	Irrigation	0.5
5-Jul	Irrigation	0.4	1-Sep	Irrigation	0.5
7-Jul	Irrigation	0.5	3-Sep	Irrigation	0.4
7-Jul	Precipitation	0.43	5-Sep	Irrigation	0.5
			7-Sep	Irrigation	0.5
			9-Sep	Irrigation	0.4
			9-Sep	Precipitation	0.04

2013 Maintenance Fertilizer & Pesticides (R-2 Pivot)

Date	Product	Rate	Unit
23-Apr	0-0-60	350	lb/A
23-Apr	0-0-0-17S-21Ca	500	lb/A

Sweet Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	6/19/13 % Injury	% Weed Control 6/19/13 COLQ	RRPW	CORW	WIBU	HANS
1	Handweeded Check				0 c	100 a	100 a	100 a	100 a	100 a
2	Valor SX	2.5	OZ/A	PRETRA	15 b	100 a	100 a	100 a	100 a	100 a
	Command	2.5	PT/A	POSTRA						
3	Valor SX	2.5	OZ/A	PRETRA	38.3 a	100 a	100 a	100 a	100 a	100 a
	Zidua	0.21	LB A/A	PRETRA						
4	Devrinol	2	LB/A	POSTRA	3.3 c	100 a	100 a	100 a	100 a	100 a
	Command	2.5	PT/A	POSTRA						
5	Bicyclopyrone	0.5	OZ/A	PRETRA	3.3 c	65 b	65 b	33.3 b	30 b	33.3 b
6	Bicyclopyrone	0.75	OZ/A	PRETRA	0 c	96.7 a	96.7 a	33.3 b	26.7 b	23.3 b
7	Bicyclopyrone	0.5	OZ/A	POST	0 c	0 c	0 c	0 b	0 b	0 b
	NIS	0.25	% V/V	POST						
8	Bicyclopyrone	0.75	OZ/A	POST	0 c	0 c	0 c	0 b	0 b	0 b
	NIS	0.25	% V/V	POST						
9	Dual Magnum	1	PT/A	POSTRA	1.7 c	100 a	100 a	99.3 a	99.3 a	100 a
	Lorox	0.5	LB A/A	POSTRA						
10	Dual Magnum	1	PT/A	POSTRA	10 bc	100 a	100 a	96.7 a	100 a	100 a
	Python	1	OZ/A	POSTRA						
LSD (P=.05)					11.18	30.51	30.51	38.84	35.68	36.18

Means followed by same letter do not significantly differ (P=.05, LSD)

Sweet Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	7/1/13 % Injury	% Weed Control 7/1/13 COLQ	CORW	WIBU	HANS	YEFT
1	Handweeded Check				0 c	91 a	94.3 a	95 a	88.3 a	100 a
2	Valor SX	2.5	OZ/A	PRETRA	8.3 b	100 a	100 a	100 a	100 a	100 a
	Command	2.5	PT/A	POSTRA						
3	Valor SX	2.5	OZ/A	PRETRA	16.7 a	100 a	100 a	100 a	100 a	100 a
	Zidua	0.21	LB A/A	PRETRA						
4	Devrinol	2	LB/A	POSTRA	1.7 c	100 a	99.33 a	100 a	100 a	100 a
	Command	2.5	PT/A	POSTRA						
5	Bicyclopyrone	0.5	OZ/A	PRETRA	0 c	26.7 bc	30 b	30 bc	33.3 bc	33.3 b
6	Bicyclopyrone	0.75	OZ/A	PRETRA	0 c	63.3 ab	26.7 b	43.3 b	43.3 b	33.3 b
7	Bicyclopyrone	0.5	OZ/A	POST	0 c	0 c	0 b	0 c	0 c	0 b
	NIS	0.25	% V/V	POST						
8	Bicyclopyrone	0.75	OZ/A	POST	0 c	0 c	0 b	0 c	0 c	0 b
	NIS	0.25	% V/V	POST						
9	Dual Magnum	1	PT/A	POSTRA	0 c	96.7 a	93.3 a	91.7 a	100 a	100 a
	Lorox	0.5	LB A/A	POSTRA						
10	Dual Magnum	1	PT/A	POSTRA	10 b	100 a	91.7 a	92.7 a	100 a	100 a
	Python	1	OZ/A	POSTRA						
LSD (P=.05)					2.50	38.02	35.50	35.37	37.42	41.76

Means followed by same letter do not significantly differ (P=.05, LSD)

Treatments may include both registered and currently unregistered applications.
Always consult a current label prior to making any pesticide application.

Sweet Potato Herbicide Efficacy - Hancock, WI - 2013

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	7/8/13 % Injury	% Weed Control 7/8/13 COLQ	CORW	WIBU	HANS	YEFT
1	Handweeded Check				0 b	100 a	100 a	100 a	100 a	100 a
2	Valor SX	2.5	OZ/A	PRETRA	1.7 b	100 a	100 a	100 a	100 a	100 a
	Command	2.5	PT/A	POSTRA						
3	Valor SX	2.5	OZ/A	PRETRA	20 a	100 a	100 a	100 a	100 a	100 a
	Zidua	0.21	LB A/A	PRETRA						
4	Devrinol	2	LB/A	POSTRA	0 b	100 a	99.3 a	100 a	100 a	100 a
	Command	2.5	PT/A	POSTRA						
5	Bicyclopyrone	0.5	OZ/A	PRETRA	0 b	10 c	6.7 c	3.3 c	6.7 cd	0 b
6	Bicyclopyrone	0.75	OZ/A	PRETRA	0 b	20 c	6.7 c	6.7 c	0 d	0 b
7	Bicyclopyrone	0.5	OZ/A	POST	0 b	43.3 b	40 b	0 c	10 c	0 b
	NIS	0.25	% V/V	POST						
8	Bicyclopyrone	0.75	OZ/A	POST	1.7 b	40 b	43.3 b	0 c	18.3 b	0 b
	NIS	0.25	% V/V	POST						
9	Dual Magnum	1	PT/A	POSTRA	0 b	99.3 a	92.7 a	88.3 b	98.3 a	100 a
	Lorox	0.5	LB A/A	POSTRA						
10	Dual Magnum	1	PT/A	POSTRA	1.7 b	97 a	86.7 a	90 b	93.3 a	100 a
	Python	1	OZ/A	POSTRA						
LSD (P=.05)					2.71	13.68	13.42	8.75	8.24	0.00

Means followed by same letter do not significantly differ (P=.05, LSD)

Trt No.	Treatment Name	Rate	Rate Unit	Grow Stg	% Weed Control 7/17/13 COLQ	CORW	WIBU	HANS	YEFT	10/2/13 Yield cwt/a
1	Handweeded Check				100 a	100 a	100 a	100 a	100 a	415.27 a
2	Valor SX	2.5	OZ/A	PRETRA	100 a	100 a	100 a	100 a	100 a	360.58 ab
	Command	2.5	PT/A	POSTRA						
3	Valor SX	2.5	OZ/A	PRETRA	100 a	98.7 a	97 a	100 a	100 a	186.82 cd
	Zidua	0.21	LB A/A	PRETRA						
4	Devrinol	2	LB/A	POSTRA	98.3 a	97.7 a	99.3 a	100 a	99.3 a	402.45 a
	Command	2.5	PT/A	POSTRA						
5	Bicyclopyrone	0.5	OZ/A	PRETRA	20 b	20 c	3.3 d	6.7 c	23.3 b	55.90 e
6	Bicyclopyrone	0.75	OZ/A	PRETRA	13.3 b	0 c	6.7 d	0 c	16.7 b	45.25 e
7	Bicyclopyrone	0.5	OZ/A	POST	3.3 b	20 c	10 d	0 c	6.7 b	80.10 e
	NIS	0.25	% V/V	POST						
8	Bicyclopyrone	0.75	OZ/A	POST	0 b	26.7 c	0 d	0 c	6.7 b	85.91 e
	NIS	0.25	% V/V	POST						
9	Dual Magnum	1	PT/A	POSTRA	88.3 a	86.7 ab	73.3 b	95 a	100 a	278.06 bc
	Lorox	0.5	LB A/A	POSTRA						
10	Dual Magnum	1	PT/A	POSTRA	90 a	61.7 b	46.7 c	60 b	100 a	134.31 de
	Python	1	OZ/A	POSTRA						
LSD (P=.05)					22.46	27.29	23.05	11.68	27.38	94.980

Means followed by same letter do not significantly differ (P=.05, LSD)

POTATO (*Solanum tuberosum* 'Yukon Gold')
Common Scab; *Streptomyces scabies*

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Evaluating seed treatment and in-furrow treatments for control of potato common scab in Wisconsin, 2013.

A trial was established 29 May at the Langlade County Research Area, Antigo, WI, to evaluate fungicide efficacy for control of potato common scab. Approximately 2 oz seedpieces were cut mechanically on 15 May from US#1 Yukon Gold tubers. Seedpieces healed for 7 days before planting. A randomized complete block design with four replications was used for the trial and treatment plots consisted of four 24-ft-long rows spaced 36 in. apart with 12 in. spacing in the row. In-furrow treatments were applied the day of planting using a CO^2 backpack sprayer equipped with a single TeeJet 8002VS flat fan nozzle calibrated to deliver 12 gal/A at a boom pressure of 40 psi. Seed treatments were applied to cut seed prior to planting using same sprayer equipment as previously described. Treated seedpieces were allowed to dry thoroughly before planting. After planting and in-furrow treatments, furrows were mechanically covered using hilling disks. The soil type was Antigo silt loam and fertility, insects, weeds, and foliar diseases were maintained during the growing season according to standard grower practices for the region. To minimize soil compaction and damage to plants in rows used for foliar and yield evaluation, drive rows for pesticide application equipment were placed adjacent to plots. Seed emergence data were collected 21 June from 10 linear feet of each of the center 2 rows of each plot. Vines were chemically killed with Reglone 1.0 pt/acre on 16 and 23 Sep 2013. The center two rows of each plot were harvested 30 Sep 2013. Tubers were graded into marketable (US#1), undersize, and cull categories on the day of harvest. After undersize tubers were graded out and tubers washed, but before scabbed tubers are removed, 20 tubers from each plot were chosen arbitrarily and assessed for scab incidence and severity. Disease severity was rated on a scale of 0-3 with 0=no disease, 1=<10% surface area symptomatic, 2=10-25%, 3=>25%, and an average tuber severity was calculated. Data were analyzed using ANOVA (α=0.05) and Fisher's LSD at alpha=0.05.

There were no significant differences in seed emergence among treatments. There were no significant differences in total yield or in US#1 yield, undersize yield, and cull weight (only US#1data shown). Disease pressure was low in this field trial. This is a field with no recent history of potato production, in its first year of use as a common scab disease nursery. While common scab tuber incidence was high among all treatments, the average severity of symptoms was low. There were no significant differences in common scab disease incidence and severity.

Treatment and rate[z]	Application Type	Seed Emergence	US#1 Yield (cwt/A)	Incidence (%)	Average Severity
Untreated Control………………….		13.3	403.5	80.0	1.03
Blocker 4F 11.0 fl oz………………	In Furrow	9.5	351.4	80.0	0.96
Blocker 4F 5.5 fl oz +					
Serenade Soil 4.4 fl oz…………..	In-Furrow	10.8	363.5	86.3	1.01
Quadris 2.08SC 0.6 fl oz…………...	In-Furrow	11.5	350.4	80.0	1.11
Blocker 4F 11.0 fl oz	In-Furrow				
Rejuvenate 6.25SL 0.005 fl oz…..	Seed Treatment	9.3	348.0	67.5	0.83
Rejuvenate 6.25SL 0.005 fl oz……..	Seed Treatment	13.5	400.8	90.0	1.10
Tiger Sul 90CR 114.0 oz…………..	In-Furrow	12.5	396.6	86.3	1.03
Regalia 5SC 0.5 fl oz………………	In-Furrow	11.5	355.0	86.3	1.06
Regalia 5SC 4.0 fl oz………………	In-Furrow	14.0	432.1	91.3	1.01
Serenade Soil 8.8 fl oz……………..	In-Furrow	12.5	424.6	85.0	1.11
Serenade Soil 4.4 fl oz……………..	In-Furrow	12.8	387.2	83.8	0.96

[z]Treatment rates applied in-furrow are given per 1000 linear row ft. Seed treatment rates are given per 100 lb seed.

POTATO (*Solanum tuberosum* 'Russet Burbank')
Early Blight; *Alternaria solani*
Late Blight; *Phytophthora infestans*

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Evaluation of foliar fungicides for control of potato early blight in Wisconsin, 2013.

Potato seedpieces were planted 5 May to initiate a field trial at the University of Wisconsin Agriculture Research Station in Hancock, WI to evaluate fungicide programs for control of foliar potato blights. Treatments were included for early blight (*Alternaria solani*) and late blight (*Phytophthora infestans)* control, but no late blight symptoms were observed during the course of the trial. Approximately 2 oz seedpieces were cut mechanically on 22 Apr from US#1 'Russet Burbank' tubers. Seedpieces were allowed to heal prior to planting. A randomized complete block design with four replications was used for the trial, and treatment plots consisted of four 24-ft-long rows spaced 36 in. apart with 12 in. spacing in the row. To minimize soil compaction and damage to plants in rows used for foliar and yield evaluations, drive rows for pesticide application equipment were placed adjacent to plots. Fungicide treatments were initiated on 3 Jul after the P-day value reached 300. Subsequent applications were applied on a weekly basis to all four rows of each plot on the following dates: 10 Jul, 17 Jul, 24 Jul, 31 Jul, 7 Aug, 14 Aug, 21 Aug, 28 Aug, 4 Sep, (9 Sep and 16 Sep vine kill with Diquat E 1.5 pt/acre), for a total of ten fungicide applications. Treatments were applied with a plot sprayer consisting of a tractor-mounted boom, pressurized with an air compressor, using TeeJet Hollow Disc Cone D3-23 nozzles (16 nozzles at 8-in. spacing). Fungicides were applied at a rate equivalent to 35 gal water/A at 40 psi. Plots were not inoculated but relied on natural dispersal of inocula for disease establishment. Early blight severity for 20 ft. of the two center rows was rated on 1 Aug, 20 Auf, 29 Aug, and 9 Sep using the Horsfall-Barratt rating scale (0-11 rating with 0=no disease, 11=100% disease severity). Plots were harvested and graded on 23 Sep. A subset of 12 tubers from each plot was tested for specific gravity at time of grading. Precipitation in Hancock during the potato production season was 15.0 in. Supplemental irrigation was applied 44 times during the potato production season for an additional 19.5 in.

Early blight pressure was moderate and progressed later than typical for the production region. Late blight, while present in the growing region, was not observed in the trial. The average tuber specific gravity across treatments was 1.082 with no significant differences between treatments. There were no significant differences in weight of B grade potatoes among all treatments. More than half (n=21) of the fungicide programs tested resulted in total yields that were significantly greater than the untreated control. Treatments performing statistically similar to the untreated control included programs with just one active ingredient applied season-long. The four top-yielding programs (>770 cwt/acre) included Bravo Zn 4.17F 2.0 pt (spray weeks 1,2,4,8,10) alternated with Reason 500SC 4.0 fl oz + Bravo Zn 4.17F 1.5 pt (3,6) alternated with Luna Tranquility 500SC 11.0 fl oz + Manzate 75WG 24.0 oz (5,7) alternated with Previcur Flex 6F 1.2 pt (8) alternated with Scala 60SC 7.0 fl oz + Manzate 75WG 24.0 oz (9); Tanos 50WG 3 oz + Manzate 75WG 18 oz (1,3,5,7,9) alternated with Fontelis 1.67SC 3.34 fl oz (2,4,6,8,10); Bravo Zn 4.17F 2.0 pt (1,3,5,9) alternated with Priaxor 4.17SC 4.5 fl oz + Bravo Zn 4.17F 2.0 pt (2,6) alternated with Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt (4) alternated with Quash 50WDG 2.5 oz + Dithane 75DF 2.0 lb (7) alternated with Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz (8) alternated with Forum 4.17SC 6.0 fl oz + Dithane DF 75DF 2.0 lb (10); and the season-long (1-10) program of Bravo WS 720SC 1.5 pt + Dithane DF 75DF 2.0 lb. All treatments, with the exception of EF400 12.0 fl oz (1-10), had significantly less early blight disease when compared to the untreated control. No phytotoxicity was noted with any of the treatment programs tested. The efficacy of newer fungicides provides a toolbox of additional fungicides for use in resistance management programming in Wisconsin potato systems.

Treatment and rate/acre	Application Timing[x]	Yield (cwt/acre)				RAUDPC[z]
		Culls	Bs	US #1	Total	
Untreated Control………………………………………………..	NA	12.1abc[y]	38.5	571.0a	621.5a	0.364o
Bravo Zn 4.17F 2.0 pt………………………………………………	1-10	12.5abc	24.9	667.4cdef	704.8abcd	0.227hijk
Quadris 2.08SC 6.0 fl oz	1,3,5					
Bravo Zn 4.17F 2.0 pt……………………………………………	2,4,6,7-10	12.5abc	30.6	725.8defg	768.9de	0.232hijk
Moncoat MZ 7.5DP 1.0 lb/100 lb cut seed						
Bravo Zn 4.17F 2.0 pt	1,2,4,					
Headline 2.09SC 10.0 fl oz + Bravo Zn 4.17F 2.0 pt	3,6					
Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt	5,7					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz…………	8,9,10	32.3d	22.4	5773ab	631.8ab	0.201cdefghi
EF400 12.0 fl oz……………………………………………………	1-10	8.0ab	33.4	649.7abcd	690.9abcd	0.327no
Champ Formula II 37.5DF 2.0 pt………………………………….	1-10	11.4abc	27.4	649.4abcd	688.1abcd	0.255jklm
Bravo Zn 4.17F 2.0 pt	1,3,7,9					
Reason 500SC 4.0 fl oz + Bravo Zn 4.17F 1.5 pt	2,5					
Luna Tranquility 500SC 8.0 fl oz + Manzate 75WG 24.0 oz	4,6					
Scala 60SC 7.0 fl oz + Manzate 75WG 24.0 oz	8,10					
Previcur Flex 6F 1.2 pt……………………………………….	7	15.5abc	28.3	713.8cdefg	757.6cde	0.122a
Bravo Zn 4.17F 2.0 pt	1,2,4,8,10					
Reason 500SC 4.0 fl oz + Bravo Zn 4.17F 1.5 pt	3,6					
Luna Tranquility 500SC 11.0 fl oz + Manzate 75WG 24.0 oz	5,7					
Previcur Flex 6F 1.2 pt	8					
Scala 60SC 7.0 fl oz + Manzate 75WG 24.0 oz……………..	9	11.4abc	32.1	755.5g	798.9e	0.163abcdef
Bravo Zn 4.17F 2.0 pt	1,2,4					
Headline 2.09SC 6.0 fl oz + Bravo Zn 4.17F 2.0 pt	3,6					
Luna Tranquility 500SC 11.0 fl oz + Bravo Zn 4.17F 2.0 pt	5,7					
Manzate 75WG 24.0 oz	8					
Scala 60SC 7.0 fl oz + Manzate 75WG 24.0 oz	9					
Super Tin 80WP 2.5 fl oz……………………………………..	10	18.2abc	28.1	660.5bcde	706.7abcd	0.153abcd
DPX-RON94 10SE 19.62 fl oz…………………………………….	1-10	16.7abc	27.0	691.8cdefg	735.4cde	0.230hijk

DPX-RON94 10SE 57.7 fl oz……………………………………..	1-10	17.8abc	31.1	675.8cdefg	724.7cde	0.201cdefghi
Tanos 50WG 3 oz + Manzate 75WG 18 oz	1,3,5,7,9					
Fontelis 1.67SC 3.34 fl oz………………………………………	2,4,6,8,10	8.3ab	25.1	737.3efg	770.8de	0.207efghij
Fontelis 1.67SC 3.34 fl oz…………………………………………	1-10	17.4abc	26.5	628.5abc	672.4abc	0.272klm
Bravo Zn 4.17F 2.0 pt	1,3,5,9					
Priaxor 4.17SC 4.5 fl oz + Bravo Zn 4.17F 2.0 pt	2,4,6					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz	7,8					
Forum 4.17SC 6.0 fl oz + Dithane DF 75DF 2.0 lb……………	10	22.4cd	25.2	661.5bcde	709.1bcd	0.152abcd
Bravo Zn 4.17F 2.0 pt	1,3,5,9					
Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt	2,6					
Priaxor 4.17SC 4.5 fl oz + Bravo Zn 4.17F 2.0 pt	4					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz	7,8					
Forum 4.17SC 6.0 fl oz + Dithane DF 75DF 2.0 lb……………..	10	13.6abc	27.7	713.7cdefg	755.1cde	0.160abcdef
Bravo Zn 4.17F 2.0 pt	1,3,5,9					
Priaxor 4.17SC 4.5 fl oz + Bravo Zn 4.17F 2.0 pt	2,6					
Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt	4					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz	7,8					
Forum 4.17SC 6.0 fl oz + Dithane DF 75DF 2.0 lb……………..	10	15.2abc	28.4	718.9defg	762.4de	0.157abcde
Bravo Zn 4.17F 2.0 pt	1,3,5,9					
Priaxor 4.17SC 4.5 fl oz + Bravo Zn 4.17F 2.0 pt	2,6					
Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt	4,8					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz	7					
Forum 4.17SC 6.0 fl oz + Dithane DF 75DF 2.0 lb……………..	10	14.4abc	26.6	704.7cdefg	745.7cde	0.132ab
Bravo Zn 4.17F 2.0 pt	1,3,5,9					
Priaxor 4.17SC 4.5 fl oz + Bravo Zn 4.17F 2.0 pt	2,6					
Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt	4					
Quash 50WDG 2.5 oz + Dithane 75DF 2.0 lb	7					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz	8					
Forum 4.17SC 6.0 fl oz + Dithane DF 75DF 2.0 lb……………	10	18.2abc	29.2	751.8fg	799.2e	0.142ab
Bravo WS 720SC 1.5 pt……………………………………………	1-10	8.7ab	33.6	673.8cdefg	716.1bcde	0.203defghi
Bravo WS 720SC 1.5 pt	1-4,7,10					

Vangard 75SC 7.0 oz…………………………………………	5,6,8,9	13.7abc	28.6	721.8defg	764.0de	0.175bcdefg
Bravo WS 720SC 1.5 pt	1-4,7,10					
Inspire Super 2.82EW 20.0 fl oz……………………………...	5,6,8,9	21.2cd	30.8	704.6cdefg	756.6cde	0.144ab
Bravo WS 720SC 1.5 pt	1-4,7,10					
Switch 62.5 WG 11.0 oz………………………………………	5,6,8,9	11.4abc	27.5	688.3cdefg	727.1cde	0.150abc
Bravo WS 720SC 1.5 pt	1-4,7,10					
Switch 62.5 WG 14.0 oz………………………………………	5,6,8,9	20.9c	28.0	709.6cdefg	758.4de	0.131ab
A18126 45WG 5.0 fl oz + NIS 0.25%...	1,3,5,7,9	14.8abc	26.9	708.3cdefg	749.9cde	0.275klm
A18126 45WG 9.0 fl oz + NIS 0.25%...	1,3,5,7,9	16.7abc	29.3	656.0abcde	702.0abcd	0.241ijkl
Champ Formula II 37.5DF 2.0 pt………………………………..	1,3,5,7,9	17.1abc	31.9	652.5abcde	701.3abcd	0.297mn
Kocide 3000 46.1DF 1.5 lb……………………………………....	1-10	13.7abc	32.7	640.5abcd	686.8abcd	0.284lmn
Dithane DF 75DF 2.0 lb…………………………………………	1-10	21.2cd	24.9	690.2cdefg	736.3cde	0.181bcdefgh
Bravo WS 720SC 1.5 pt	1,3,5,7,9					
Dithane DF 75DF 2.0 lb……………………………………	2,4,6,8,10	14.0abc	30.0	687.0cdefg	731.1cde	0.209fghij
Bravo WS 720SC 1.5 pt + Dithane DF 75DF 2.0 lb………………	1-10	19.0bc	28.4	724.7defg	772.0de	0.152abcd
Bravo Zn 4.17F 2.0 pt	1					
Headline 2.09SC 10.0 fl oz + Bravo Zn 4.17F 2.0 pt	3					
Endura 70WG 3.5 oz + Bravo Zn 4.17F 2.0 pt	5					
Revus Top 4.17SC 7.0 fl oz + Bravo Zn 4.17F 2.0 pt	7					
Dithane DF 75DF 2.0 lb + Super Tin 80WP 2.5 fl oz…………..	9	12.5abc	21.8	700.5cdefg	734.8cde	0.214ghij

[z]RAUDPC= Relative Area Under the Disease Progress Curve.
[y]Column numbers followed by the same letter are not significantly different at *P*=0.05 as determined by Fisher's Least Significant Difference (LSD) test.
[x]Fungicide applications were made on 10 dates: 1=3 Jul, 2 = 10 Jul, 3= 17 Jul, 4 = 24 Jul, 5 = 31 Jul, 6 = 7 Aug, 7 = 14 Aug, 8 = 21 Aug, 9 = 28 Aug, 10 = 4 Sep.

POTATO (*Solanum tuberosum* 'Russet Burbank')
Rhizoctonia: *Rhizoctonia solani*

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Evaluation of seed, in-furrow, and foliar treatments for control of Rhizoctonia diseases of potato in Wisconsin, 2013.

Potatoes were planted on 6 May to initiate a field trial at the Hancock Research Station in central WI to evaluate seed treatment, in-furrow, and foliar-applied fungicides for the control of Rhizoctonia diseases of potato, including seedling decline and tuber black scurf. Fertilization, insect, weed, and foliar disease control was accomplished using standard commercial practices for the production region. Approximately 2 oz seedpieces were cut mechanically on 25 April from US#1 'Russet Burbank' tubers. Seedpieces were allowed to heal for 2 days at 55°F with 95% relative humidity and good airflow prior to treatment and/or planting. A randomized complete block design with four replications were used for the trial, and treatment plots consisted of four 24-ft-long rows spaced 36 in. apart with 12 in. spacing in the row. To minimize soil compaction and damage to plants in rows used for foliar and yield evaluations, drive rows for pesticide application equipment were placed adjacent to plots. In-furrow treatments were applied using a CO_2 backpack sprayer equipped with a single TeeJet 8002VS flat fan nozzle calibrated to deliver 12 gal/A at a boom pressure of 40 psi. Seed treatments were applied to cut seed prior to planting using same sprayer equipment as previously described. Foliar treatments were applied using the same sprayer equipment as previously described yet calibrated to deliver 35 gal/A at a boom pressure of 40 psi and were applied in addition to aforementioned standard fungicide program. Plots were not inoculated but relied on natural inocula for disease establishment. Seed emergence data were collected 4 June as the number of emerged hills in 10 linear feet of each of the center 2 rows of each plot. Vines were killed with herbicide (Diquat E 1.5 pt/acre +non-ionic surfactant) applied on 9 and 16 September. Plots were harvested, graded, and evaluated for black scurf disease incidence on 24 September. Twenty tubers were randomly selected from each plot and visually evaluated for symptoms of black scurf (% incidence= number of symptomatic tubers/20*100). Precipitation in Hancock during the potato production season was 15.0 in. Supplemental irrigation was applied 44 times during the potato production season for an additional 19.5 in.

Cool and wet soil conditions favoring Rhizoctonia disease prevailed during mid-May of trial year. Overall, marketable yields were high in this trial with all treatments resulting in ≥582 cwt/acre. There were no significant differences among treatments for marketable yield. Most (20/31) of the treatments significantly reduced black scurf incidence when compared to the untreated control; of these treatments, 9 included in-furrow applications and 11 were seed treatments. Treatments providing the lowest incidence of black scurf included two experimental seed treatments, A16148 500FS 0.077 fl oz + A9765 600FS 0.128 fl oz seed and A18232 435.7FS 0.308 fl oz + A16148 500FS 0.046 fl oz; and recently registered seed treatment Emesto Silver 118FS 0.31 fl oz + Admire Pro 4.6SC 0.35 oz. All but 3 treatments resulted in lower emergence than the untreated control. Notably, some of the best treatments for black scurf control, significantly reduced seed emergence including A18232 435.7FS 0.308 fl oz + A16148 500FS 0.077 fl oz + A12946 250SC 0.614 fl oz. No phytotoxicity was noted with any of the treatments.

Product and Rate[x]	Application Type[z]	Seed Emergence	Black Scurf Incidence (%)	Marketable Yield (cwt/A)
Untreated Control……………………….	NA	18.3fgh[y]	67.5fg	648.8
Tiger Sul 90CR 50.0 oz…………………	In-Furrow	18.5fgh	82.5g	625.5
DPX-RON94 10SE 4.0 fl oz………….….	In-Furrow	19.3gh	45.0def	620.8
DPX-RON94 10SE 1.35 fl oz………….	In-Furrow	17.5defgh	45.0def	636.4
Quadris SC250GL 0.8 fl oz……………..	In-Furrow	15.5bcdef	17.5abc	631.2
Vertisan EC 1.67 LG 1.1 fl oz…………..	In-Furrow	17.3defgh	27.5abcd	592.6
A18126 FS435.7 0.34 fl oz……….…….	In-Furrow	15.3bcdef	27.5abcd	653.6
Quadris 2.08SC 0.6 fl oz……….……….	In-Furrow	16.3cdefg	27.5abcd	669.4
A15457 100EC 0.47 fl oz……….……….	In-Furrow	15.8bcdefg	37.5bcde	643.2
Priaxor 4.17SC 0.55 fl oz……….……….	In-Furrow	15.5bcdef	42.5cdef	660.7
Serenade Soil 7.7 fl oz………..................	In-Furrow	16.75cdefg	80.0g	671.3
Moncut 70DF 1.18 oz…………………..	In-Furrow	17.5defgh	67.5fg	633.1
Moncut 70DF 0.76 oz…………………..	In-Furrow	14.0abcd	65.0fg	636.3
Gowan 9935 70DF 1.2 oz………………	In-Furrow	16.8cdefg	60.0efg	636.1
Gowan 9935 70DF 0.8 oz……..………..	In-Furrow	15.3bcdef	57.5efg	653.2
Regalia 5SC 2.0 fl oz +				
Quadris SC250GL 0.6 fl oz…………..	In-Furrow	17.8efgh	10.0a	687.6
Regalia 5SC 2.2 fl oz +				
Quadris SC250GL 0.6 fl oz…………....	In-Furrow			
Regalia 5SC 1.0 qt +				
Quadris SC250GL 6.0 fl oz…………..	Spray 1 + 2	20.8h	15.0ab	671.4
Emesto Silver 118FS 0.31 fl oz +				
Manzate 75DF 1.0 lb………………....	Seed Treatment	17.8efgh	20.0abcd	618.9
Emesto Silver 118FS 0.31 fl oz +				
Manzate 75DF 1.0 lb	Seed Treatment			
Serenade Soil 7.7 fl oz………..………	In-Furrow	15.3bcdef	12.5ab	606.8
Regalia 5SC 2.0 fl oz	Seed Treatment			
Quadris SC250GL 0.6 fl oz………..…	In-Furrow	17.3defgh	30.0abcd	640.9
Maxim MZ 6.2 0.5 lb……………………	Seed Treatment	17.5defgh	10.0a	656.8
Tops MZ 8.5D 1.0 lb……………………	Seed Treatment	15.8bcdefgh	37.5bcde	661.8
A18232 435.7FS 0.308 fl oz……………	Seed Treatment	15.8bcdefgh	15.0ab	643.9
A16148 500FS0.046 fl oz +				
A9765 600FS 0.128 fl oz…………….	Seed Treatment	16.8cdefg	7.5a	693.7
A16148 500FS 0.077 fl oz +				
A9765 600FS 0.128 fl oz…..………..	Seed Treatment	14.5abcde	5.0a	644.9
A18232 435.7FS 0.308 fl oz +				
A16148 500FS 0.046 fl oz…..……….	Seed Treatment	15.3bcdef	6.7a	649.1
A18232 435.7FS 0.308 fl oz +				
A16148 500FS 0.077 fl oz…..………	Seed Treatment	18.0efgh	15.0ab	701.2
A18232 435.7FS 0.308 fl oz +				
A16148 500FS 0.077 fl oz +				
A12946 250SC 0.614 fl oz…..……...	Seed Treatment	11.3a	7.5a	582.2
Emesto Silver 118FS 0.31 fl oz +				
Admire Pro 4.6SC 0.35 oz…..………	Seed Treatment	17.5defgh	15.0ab	663.2
Regalia 5SC 2.0 fl oz…..……………...	Seed Treatment	12.5ab	30.0abcd	626.9
Regalia 5SC 2.0 fl oz	Seed Treatment			
Regalia 5SC 2.0 qt…..……………….	Spray 1	13.5abc	45.0def	649.5

[z] Foliar applications were applied at either the 4-6 leaf rosette stage on 29 May (Spray 1) and/or at the hooking stage 12 June (Spray 2).
[y]Column numbers followed by the same letter are not significantly different at P=0.05 as determined by Fisher's Least Significant Difference (LSD) test.
[x]Treatment rates applied in-furrow are given per linear 1000 row ft. Seed treatment rates are given per 100 lb seed. Foliar treatment rates are given per acre.

POTATO (*Solanum tuberosum* 'Dark Red Norland)
Silver Scurf; *Helminthosporium solani*

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Evaluation of seed treatment and in-furrow treatments for control of silver scurf of potato in Wisconsin, 2013.

Potatoes were planted on 6 May to initiate a field trial at the Hancock Research Station in central WI to evaluate seed treatment and in-furrow applied fungicides for the control of silver scurf of potato. Fertilization, insect, weed, and foliar disease control was accomplished using standard industry practices for the production region. Approximately 2 oz seedpieces were cut mechanically on 22 April from US#1 'Dark Red Norland' tubers. Seedpieces were allowed to heal prior to treatment and/or planting. A randomized complete block design with four replications were used for the trial, and treatment plots consisted of four 24-ft-long rows spaced 36 in. apart with 12 in. spacing in the row. To minimize soil compaction and damage to plants in rows used for foliar and yield evaluations, drive rows for pesticide application equipment were placed adjacent to plots. In-furrow and foliar treatments were applied using a CO_2 backpack sprayer equipped with a single Tee Jet 8002VS nozzle and calibrated to deliver 12 gal/A at a boom pressure of 40 psi. Seed treatments were applied to cut seed prior to planting using same sprayer equipment as previously described. Plots were not inoculated but relied on natural inocula for disease establishment. Seed emergence data were collected on 4 June as the number of emerged hills in 10 linear feet of each of the center 2 rows of each plot. Vines were killed with herbicide (Diquat E 1.5 pt/acre + non-ionic surfactant) applied on 9 and 16 September. Plots were harvested, graded, and evaluated for silver scurf on 25 September. Twenty tubers were randomly selected from each plot and evaluated for silver scurf incidence (# symptomatic tubers/20*100). Precipitation in Hancock during the potato production season was 15.0 in. Supplemental irrigation was applied 44 times during the potato production season for an additional 19.5 in.

Four treatments: A18232 435.7FS 0.308 fl oz, A16148 500FS 0.077 fl oz + A9765 600FS 0.128 fl oz, A18232 435.7FS 0.308 fl oz + A16148 500FS0.046 fl oz, and A18232 435.7FS 0.308 fl oz + A16148 500FS 0.077 fl oz resulted in significantly reduced seed emergence when compared to the untreated control. There were no significant differences among treatments in controlling the incidence of silver scurf on tubers. There were no significant differences among treatments on marketable yield. No treatments resulted in phytotoxicity.

Treatment and rate[z]	Application Type	Seed Emergence	Silver Scurf Incidence (%)	Marketable Yield (cwt/acre)
Untreated Control…………………....	NA	17.5c[y]	57.5	665.7
A18232 435.7FS 0.308 fl oz………..	Seed Treatment	14.3ab	60.0	559.5
A16148 500FS0.046 fl oz + A9765 600FS 0.128 fl oz…………	Seed Treatment	15.8abc	65.0	627.2
A16148 500FS 0.077 fl oz + A9765 600FS 0.128 fl oz…………	Seed Treatment	13.8a	65.0	622.1
A18232 435.7FS 0.308 fl oz + A16148 500FS0.046 fl oz………....	Seed Treatment	14.5ab	45.0	612.8
A18232 435.7FS 0.308 fl oz + A16148 500FS 0.077 fl oz………..	Seed Treatment	13.8a	62.5	584.9
A18232 435.7FS 0.308 fl oz + A16148 500FS 0.077 fl oz + A12946 250SC 0.614 fl oz……….	Seed Treatment	18.0c	55.0	599.6
Emesto Silver 118FS 0.31 oz + Admire Pro 4.6SC 0.35 oz…….....	Seed Treatment	17.0bc	62.5	576.5
Quadris 2.08SC 0.8 fl oz……………	In-Furrow	17.0bc	62.5	716.6
Maxim MZ 6.2 0.5 lb………………..	Seed Treatment	16.8bc	52.5	684.4

[z]Treatment rates applied in-furrow are given per 1000 row ft. Seed treatment rates are given per 100 lb seed.
[y]Column numbers followed by the same letter are not significantly different at P=0.05 as determined by Fisher's Least Significant Difference (LSD) test.

SNAP BEAN (*Phaseolus vulgaris* 'Delmonte 04-88')
White Mold; *Sclerotinia sclerotiorum*

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Evaluation of fungicides to control white mold in snap beans, Hancock, WI, 2013.

A trial to evaluate the efficacy of fungicides to control white mold on snap bean was established 15 May using cultivar DM88-04 (Del Monte) seeded at approximately 10 per foot. Plots were 24 ft long with 4 rows spaced 15 in apart. Seed was commercially treated with thiram for root rot protection. There were 4 replications and plots were arranged in a randomized complete block design. Sunflowers were planted in this plot in 2012 and the flowers were inoculated with *Sclerotinia sclerotiorum*. Infected debris and sclerotia were tilled into the soil in the fall of 2012 and served as a natural source of ascospore inoculum for this experiment in spring/summer 2013. Fungicide applications for control of white mold were applied twice (depending on fungicide treatment) at 30% bloom (26 June) and 7 days later at 100% bloom (3 July). Fungicides were applied using a backpack CO_2 sprayer with a 4 nozzle spray boom with 19" spacing between standard flat tip spray nozzles (Tee Jet 8002VS) at a rate of 35 gallons per acre at 40 psi. On day of harvest, 19 July, the center 2 rows of each 4-row 24 ft plot was evaluated for white mold. The total number of symptomatic plants for each plot was recorded. The 2 center rows from each plot (48 ft total) were mechanically harvested and bean pods were graded to determine yield and proportion of yield in different size classes based on pod diameter: 1-3 (<0.35 in. diam.), 4 (>0.35 in. but <0.43 in.) and 5 (> 0.43 in.). Precipitation in Hancock during the snap bean trial was 9.35 in. Supplemental irrigation was applied 17 times during the trial for an additional 8.85 in.

Weather conditions during bloom were moderately conducive to infection of flowers and subsequent disease spread. Thus, the occurrence of infections was very low. There were no significant differences between treatments among the three bean pod grade categories (data not shown) and no significant differences in total yield across treatments. There were significant differences in number of white mold symptomatic plants on day of harvest. Only the EF400 12.0 fl oz + 0.25% NIS treatment resulted in a number of symptomatic plants that was not significantly different than the untreated control. No phytotoxicity was noted for any of the treatments included in this trial.

Product and rate/acre	Application Timing[z]	Number of Symptomatic Plants[y]	Marketable Yield (ton/A)
Untreated Control……………………………..	NA	10.8 d	3.96
DPX-RON94 10SE 57.5 fl oz………………..	1, 2	3.8 abc	3.86
DPX-RON94 10SE 19.2 fl oz………..........	1, 2	3.3 abc	3.38
Endura 70WDG 8.0 oz + 0.25% NIS....……..	1, 2	3.0 abc	3.35
Topsin M 70WSB 1.0 lb……………………..	1, 2	2.5 abc	3.58
Topsin M 70WSB 1.0 lb……………………..	1	1.3 abc	3.31
Topsin M 70WSB 1.0 lb……………………..	2	2.5 abc	3.13
Regalia 5SC 2.0 pt	1		
Topsin M 70WSB 1.0 lb………………….	2	0.3 a	3.45
Fontelis 1.67SC 1.5 pt……………………….	1, 2	2.0 abc	3.20
Aproach 2.08SC 12.0 fl oz…………………..	1, 2	1.5 abc	4.28
Quadris 2.08SC 9.0 fl oz…………………….	1, 2	1.3 abc	4.21
Priaxor 4.17SC 10.3 fl oz……………………	1, 2	1.3 abc	3.05
EF400 12.0 fl oz + 0.25% NIS………………	1, 2	5.8 cd	3.98
Endura 70WDG 8.0 oz + 0.25% NIS………..	1	0.5 ab	3.77
Endura 70WDG 8.0 oz + 0.25% NIS………..	2	5.5 bc	3.64

[z] Foliar applications were applied at either the 30% bloom stage on 26 June (1) and/or at 100% flowering (7 days after 30% bloom) on 3 July (2).

[y] Column numbers followed by the same letter are not significantly different at P=0.05 as determined by Fisher's Least Significant Difference (LSD) test.

SPUDPRO CANDIDATE TRIAL 2013

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Introduction

The SpudPro trial has been a part of Wisconsin's potato research program since 2003. During that period more than 80 unique clones that have with potential for variety. The data from this trial is used to provide data to the breeders and the SpudPro committee to complement previous knowledge and decide on the promotion of Wisconsin varieties. Every year, these varieties are compared to one another and to standard varieties for the different market categories. In 2013, sixteen clones, including five chippers, four reds and seven russets were studied and contrasted against their corresponding standards (Table 1). Of these, four clones, W8603-1, NYWJ11-5, AW071022-4rus and AW07966-1rus were introduced for the first year and the rest have been evaluated for at least two years.

Experimental Procedures: The trial was planted at the Hancock Agricultural Research Station on April 25 using three replications. Plots were planted in 20' single-rows 36" apart at 12" in-row spacing. Plots were maintained according to recommended production practices for each respective area (Detailed summaries of production practices are available from the main author). Plants were evaluated for early vigor in June 22 and late vigor on August 16. Vine kill occurred on September 13, 141 days after planting. Harvest and grading evaluation were conducted as shown in Table 1. Processing samples were obtained and stored in coolers that were ramped to a final holding temperature of 48˚F for frying and sugar evaluation.

Results: Comments on Spudpro candidate clones in Table 1

Chipping Clones:

Standard chipping varieties Atlantic and Snowden yielded at 683 and 641 cwt/a respectively and had specific gravity consistent with expected values (1.085 for Atlantic and 1.081 for Snowden).

W5955-1: this was the most outstanding chipping clone in 2013 with respect to field performance. Yield and gravity were statistically similar to Snowden. It had the best tuber preference type for a chipper (better size, rounder and smoother tubers compared to Atlantic or Snowden). Plant vigor was similar to Snowden early in the season and as strong as Atlantic for late vigor (August 16). W5955-1 is recommended for on-farm trialing as potential substitute for Snowden and Pike, because of its consistent tuber yield and quality and agronomic performance. Tuber size and weight were higher than the rest of chipping clones tested. In a separate study comparing W5955-1 and Pike over nine environments under common scab pressure, W5955-1 was similar to Pike in all nine environments and was consistently better than Snowden.

NYWJ11-5: This clone had the highest yield potential of all clones evaluated. In tests prior to 2013, this clone yields higher than Atlantic and Snowden, and has specific gravity similar to the standards Snowden and Atlantic. There was a high occurrence of hollow heart in this trial (30.4%); this potential weakness must be more thoroughly investigated since it may prevent this clone from becoming an important chip clone in the future.

W5015-5: Yield and gravity statistically similar to Snowden, but high internal brown spot and high hollow heart. These tuber internal defects may become a hindrance for this variety to develop into a preferred variety in the future.

W6609-3 and **W8603-1** had the lowest yield in this trial which may be their biggest weakness. W6609 has shown the best common scab resistance, frequently outperforming Pike in separate high severity scab trials but is likely not a potential chip variety due to its low yield.

Red Clones

Four clones were compared with the standard red variety Dark Red Norland. All of the clones had yield close to Dark Red Norland. Best tuber preference for color, skin finish and shape was observed for **W8890-1R** and **W8893-1R**.

Russet Clones:

W9433-1rus, a processing clone had the best overall performance, potentially recording larger yield and higher gravity and much better tuber type than Russet Burbank. For the fresh market category, **W8516-1rus** was rated best for combined yield and tuber appearance. **W9133-1rus** may be the strongest clones compared to the fresh market standard variety Russet Norkotah Sel. 8. W8722-1rus and W8772-1rus had better tuber preference compared to Russet Norkotah Sel. 8 but had very low yield compared to this.

Clones AW071022-4rus and A07966-1rus had a very high tuber yield in this trial, however, their tubers were too short, and they also had deeper eyes than the rest of the clones which resulted in poorer preference score.

Table 1. Tuber yield (cwt/A), tuber yield characterizationspecific gravity, tuber preference and % row cover, tuber external and internal traits, SpudPro trial 2013, Hancock Agricultural Research Station

		Tuber Yield					SG and Pref		% Row Cover		Tuber External Traits							Internal Defects		
Clone	Type	Yield (cwt/A)	Culls (cwt/A)	B Size (cwt/A)	Wt per tuber	Tubers/ hills	Spec Grav	Pref 1-9	22-Jun	16-Aug	Tuber width	Tuber length	Tuber heigth	Length: width	Tuber Eyes	Texture Scale 3-9	Common Scab	HH%	IBS%	VD%
Atlantic	chip	683	16.7	11.9	8.0	11.3	1.085	5.4	***63.6***	92.3	2.6	3.2	2.39	1.24	4.6	4.5	6.0	8.2	3.9	2.8
NYWJ11-5	chip	***827***	16.3	4.3	7.7	11.9	1.083	5.9	44.0	98.2	2.6	3.0	***2.47***	1.13	4.9	5.1	8.6	30.4	0.2	2.8
Snowden	chip	641	14.5	5.4	7.6	11.1	1.081	6.2	54.6	84.9	***2.7***	3.0	2.42	1.13	4.9	5.7	7.4	3.6	1.2	6.6
W5015-5	chip	575	15.5	8.6	6.4	11.8	1.078	6.9	41.0	92.3	2.5	2.8	2.36	1.14	5.7	5.1	8.9	28.5	59.6	2.8
W5955-1	chip	637	16.7	5.6	***9.6***	8.4	1.079	***7.2***	53.1	93.8	***2.7***	3.4	***2.49***	1.22	5.4	5.2	8.9	6.3	2.3	5.1
W6609-3	chip	491	16.1	15.5	5.7	12.7	1.080	6.8	60.6	73.1	2.3	2.9	2.23	1.23	***7.2***	5.7	8.9	3.5	5.0	1.2
W8603-1	chip	488	17.2	8.6	6.3	9.8	1.080	5.7	57.6	83.4	2.5	2.9	2.30	1.16	***6.9***	5.6	7.3	2.6	0.2	3.5
Dark Red Norland	red	579	17.1	18.0	5.3	***14.3***	1.055	4.8	***66.2***	11.6	2.3	2.7	2.26	1.16	5.8	5.9	8.6	2.8	3.4	2.0
W8886-3R	red	508	17.1	***9.8***	5.8	9.2	1.061	6.3	33.0	60.5	2.4	2.7	2.29	1.12	7.9	6.6	8.6	2.8	3.4	2.0
W8890-1R	red	571	15.9	22.9	5.0	13.7	1.063	***7.2***	***58.6***	26.4	2.3	2.6	2.25	1.13	7.8	6.7	8.3	0.9	8.8	15.1
W8893-1R	red	505	16.2	11.9	5.3	9.7	1.056	***7.4***	39.0	36.8	2.3	2.7	2.22	1.15	8.1	7.1	8.9	0.9	2.3	4.3
W9746-4R	red	548	17.3	20.8	4.9	***14.1***	1.063	6.8	33.0	***88.6***	2.2	2.6	2.21	1.18	7.9	6.5	8.0	0.9	5.6	5.1
AW071022-4rus	rus	***812***	35.9	3.7	6.7	9.9	1.071	3.3	***56.7***	***93.6***	2.4	3.3	2.28	1.38	5.1	5.5	8.0	8.1	0.2	4.3
AW07966-1rus	rus	***804***	32.1	4.4	7.2	***12.3***	***1.081***	3.0	46.0	***96.6***	2.5	3.3	***2.33***	1.32	5.7	***5.8***	4.8	3.4	0.2	3.5
Russet Burbank	rus	643	33.9	5.1	6.4	***11.5***	1.068	4.5	***61.1***	87.7	2.3	3.6	2.12	1.57	6.4	4.2	8.9	15.5	14.2	3.5
Norkotah Sel 8	rus	583	31.0	4.2	7.4	8.8	1.063	6.8	38.2	52.8	2.4	3.8	2.14	1.57	6.1	4.2	5.7	21.9	6.7	6.6
W8516-1rus	rus	623	32.6	1.3	***9.4***	7.3	1.065	***8.0***	27.9	86.2	***2.6***	3.9	***2.41***	1.48	***7.6***	4.0	8.6	21.9	1.2	5.1
W8722-1rus	rus	429	35.2	4.1	7.4	6.2	1.065	6.9	23.4	37.5	2.4	3.7	2.12	1.55	***7.9***	4.1	8.3	1.6	0.2	1.2
W8772-1rus	rus	467	31.3	3.9	6.6	7.3	1.063	6.9	27.2	32.9	2.3	3.7	2.05	1.62	***7.9***	4.1	8.9	9.9	1.2	2.0
W9133-1rus	rus	479	32.8	1.3	8.3	5.9	1.060	6.0	24.9	43.3	2.5	3.8	***2.33***	1.53	6.8	5.2	8.9	4.3	3.4	2.0
W9433-1rus	rus	***720***	32.5	1.1	***10.2***	7.3	***1.076***	***7.7***	32.5	***95.1***	***2.7***	***4.3***	2.27	1.59	7.1	5.4	8.6	6.2	6.6	2.8

Procedures:

Tuber Yield: Total Yield: Total tuber harvest include U.S. # 1 grade, <1 7/8 in. diameter (B size) and cull tubers; expressed as cwt/acre.
Tuber size (length, width and height): estimated by using an AgRay (X-ray) potato sorter
Weight per tuber: estimated also by an Agray potato sorter. .
Specific Gravity: Measure of potato solids at or shortly after harvest; measurements determined by weight in air/weight in water method (specific gravity = weight in air/weight in air-weight in water).
Tuber Preference Rating of general tuber appearance; 1 = extremely bad, 9=excellent tuber appearance.
Tuber Eyes: or eye depth, 1 = extremely deep, 9=very smooth
Skin Texture and blemishes; 3 = skin extremely rough, cracked, (>50%), 5 = tendency to netting or skin cracking (>20%), 7 = minimal netting or blemishes (<10%), 9 = free of blemishes, polished, attractive smooth surface.
Common Scab: 1 very deep pits covering 100% of the tuber surface, 9 = no lesions or signs of common scab.
Internal Defects: 30 tubers were cut and evaluated for hollow heart (HH), internal brown spot (IBS) and vascular discoloration (VD)and converted to percentage.

2013
Potato Variety and Advanced Selection Evaluation Trial

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Acknowledgements
We express grateful appreciation to the following individuals, groups and organizations for their contributions to the establishment, maintenance and completion of this project:

Financial Support
Wisconsin Potato Industry Board
Wisconsin Potato and Vegetable Growers Association
Wisconsin Potato and Vegetable Growers Association Research Committee

Research Site Support
Stephanie Plaster and Staff, Langlade County Extension and Research Facility

Technical Support
Amber Gotch
Samuel Perez
Nancy Gilberts-Keegan & Sue Reinert
Kim Goodin
Edith Parker
Scott Woodford

Introduction
Variety and advanced selection testing has been a part of Wisconsin's potato research program from 1951 to the present. During that period more than 1000 unique entries have been tested for adaptability to Wisconsin's soils and climate. *This trial has helped identify a number of varieties from Wisconsin and out of state that are currently being adopted.*

The approach taken in 2013 was to work primarily with public programs in the US that had history with the WI effort. The trial was focused, as in the past, on the main categories of Russet, Chip and Red skin with a minor effort in Yellow flesh. Five public and two private programs submitted 35 entries (Table 1). Entries were: two short storage chips, seven long storage chippers, two dual purpose russets and nine processing russets and five fresh market yellow flesh,

Procedures
The traditional trial locations are listed below with details related to each:

Hancock -- Hancock Agricultural Research Station, Hancock, WI
- Represents the irrigated sands of central Wisconsin
- Production is primarily for fresh packing and processing
- *Russet, white, yellow and red skin*
- Replicated (3x)

Antigo -- Langlade County Potato Research Facility, Antigo, WI
- Represents the irrigated silt loam soil of northeastern Wisconsin
- Production is primarily for certified seed, fresh packing and processing (chips)
- *Russet, white, yellow and red skin*

All entries were planted at Hancock and Antigo as three replications. Based on performance, first year entries will be either dropped or continued as replicated plots in future years based on merit.. All plots were planted in 20' single-rows 36" apart at 12" in-row spacing. Plots were maintained according to recommended production practices for each respective area (Detailed summaries of production practices are available from the author). Each site was visited several times during the growing season to observe plant development, and score vegetative characters. Days after planting (DAP) to vine kill for the respective site are as follows: around 140. Yield, U.S. No. 1 grade, size range, tuber appearance, specific gravity and internal qualities were measured at harvest. Table 2 provides a complete description of scales used for evaluation purposes and applies to all subsequent tables in this report.

Processing Studies
Sample Collection: Samples of all white and russet potato varieties included in the trial were collected for processing studies. The samples were drawn from plots grown at the Hancock trial site following grading. Up to 30 lbs. of 4-13 oz. tubers was saved from each replicate for each variety. Following specific gravity measurement and evaluation of internal qualities for each replication, all replicates were combined and the total amount of tubers was divided equally into three samples with care taken to select the tubers as randomly as possible to ensure blending of replicates.
Storage: Samples of each variety were stored at 55˚F and 95% relative humidity for several weeks to allow for wound healing. The lockers were set to ramp to 48˚F for long-term storage at the rate of 0.1˚F every twelve hours.

Chip Processing: Tubers of round, white varieties were selected randomly from each sample held at each storage temperature (45˚F and 48˚F) for each processing interval.
Tubers were cut in half lengthwise (along stem end to bud end axis) using a potato splitter designed and built by the author. One half of the tuber was discarded. Three slices were taken from the remaining half of each tuber. Slices were approximately one millimeter thick. The first slice from each tuber half was discarded and the second was used for the processing evaluation. Each slice was rinsed twice in cold water to remove free starch granules and then drained on a terry-cloth towel. The slices were placed in a specially designed wire basket to hold them in a vertical position while frying. The slices were fried in cottonseed oil at 360˚F for two minutes and ten seconds. Slices were drained in the frying basket for a short period of time and then placed on paper towels for further draining. Processed chip samples were evaluated using a Hunter Lab D25LT and presented as an average of 18 chips. Hunter Lab L values of 55 or greater are generally considered acceptable color.

French Fry Processing: Tubers of long, russet varieties were selected randomly from each sample held at each storage temperature (42˚F, 45˚F and 48˚F) for each processing interval. Slabs 1¼" wide x 3/8" thick were cut longitudinally from the center of each tuber using a Nemco Model N55450 restaurant-style hand-operated French fry cutter with a modified cutting head. Slabs were placed in a specially designed wire basket to hold them flat while frying. Slabs were oriented stem end down and maintained in this orientation throughout the processing and scoring process. Slabs were fried in cottonseed oil at 375˚F for three minutes and thirty seconds. Slabs were drained in the frying basket for a short period of time and then placed on paper towels for further draining. Processed slabs were scored using a Photovolt Model 577 Digital Reflectance

Meter within five minutes after frying. Photovolt readings were taken on the stem end and center of each slab. Lighter and more uniform fry colors are most desired.

Clones Tested:

Table 1. Clones tested in the 2013 Wisconsin Variety Trial at Hancock ARS and Antigo Airport location

Chippers	Russets	Russets	Yellow Flesh
Short Storage	**Dual Purpose**		**Fresh Market**
Accumulator	Teton Russet		Alegria
Atlantic	Mesa Russet		MN04844-07Y
			Soraya
Long Storage	**Fresh Market**	**Processing**	W6703-1Y
CO95051-7W	A03158-2TE	A03158-2TE	***YukonGold***
Nicolet	AF3362-1	AF3001-6	
Lamoka	AOTX02136-1RU	AF4281-3	
Lelah	Canela	Innovator	**Fresh Market Reds**
Tundra	CO03276-5RU	Pallisade	ATTX98453-6R
W5015-12	CO99045-1W/Y	Umatilla	W6002-1R
Snowden	MN0246rus/Y	W6234-4rus	W8405-1R
	Silverton Russet	W8152-1rus	W8890-1R
	W9133-1rus	***Russet Burbank***	***Dark Red Norland***
	NorkotahSel-8		***Red Norland***

Results: Comments on Wisconsin Variety Trials clones in Table 2a and 2b.

This report includes the field performance of the clones tested. The storage report will be made available as it gets developed in the storage season.

Short Storage Chippers

Accumulator (W2324-1): this clone continues to exhibit a very high yield, consistently above Atlantic. Similarly, its specific gravity is consistently similar to Atlantic. Accumulator is also a variety that has excellent early and late vigor which is very important to compete with weeds. Accumulator has deep eyes; this makes it unattractive, but it is currently likely the highest yielding chipping variety which cannot be ignored. In 2013 neither the Hancock nor the Antigo location was affected by common scab. High susceptibility to common scab is the biggest risk growers face with this variety.

Long Storage Chippers:
The real value of long storage chipping varieties can only be realized after April, when typically varieties such as Snowden are not storing well.

Nicolet (W2133-1): was the best field performing long storage chipper. In Hancock and Antigo, Nicolet had similar yield compared to Snowden. Specific gravity is also consistent with previous research (>1.080). Good early and late plant vigor. Tuber profile was also very good tuber size.
Lamoka: is the second best field performing variety. At Hancock, Lamoka had a tuber yield 100 cwt less than Nicolet and Snowden. In Hancock and Antigo, Lamoka tubers had excellent appearance. Plants are vigorous early and late in the growing season.

W5015-12 (Pinnacle): High yield in Hancock and Antigo and consistently high specific gravity. Plants are vigorous early and late in the growing season. In these trials the size profile of this clone was good. In some years and locations W5015-12 has a sizable proportion of small tubers.

Lelah (W2717-5): this clone has a great potential for long storage through May-June according to previous research. There is a general concern about this clone having low yield in some locations and year. Interestingly, yield in Antigo was again high, similar to Snowden. This clone also has very smooth tubers. It has early vigor but plants tend to die early as it happened in Hancock. Tuber size was small in Hancock and Antigo.

Tundra (W2310-3): moderate yield in Hancock and Antigo. One of the limitations of Tundra may be small tuber size.

Fresh Market Reds:

The best tuber appearance for this group was for W6002-1R and W8890-1R. W8405-1R exhibits an oval tuber shape. ATTX98453-6R had low yield.

Fresh Market Russets

A03158-2TE: This was the most attractive clone among the fresh market russets tested. This clone had high yield in Hancock and Antigo. Tubers may develop eyes of intermediate depth.

Silverton Russet had an excellent tuber aspect in Hancock but average aspect in Antigo

Canela Russet had a very good tuber aspect in Antigo, but it showed some susceptibility to hollow heart.

MN0246ru/Y had good yield in Hancock but showed significant hollow heart around 15% in both locations.

CO03276-5RU had moderate yields and significant hollow heart in Hancock.

AOTX02136-1RU had low yield, low early and late vigor, and smooth tubers.

W9133-1rus had low yield at Hancock. Smooth tubers and full shape.

AF3362-1 likely high yield, but tuber appearance may not be very appealing, large tubers due to moderately deep eyes.

MN0246ru/Y: good yield; tends to have small size, smooth.

Processing Russets:

W6234-4rus was among the best field performing clones. Yield was good at Hancock and Antigo; good tuber appearance, tuber size and shallow eyes. This clone had a specific gravity lower than Russet Burbank in Antigo.

Umatilla and **Pallisade** had the highest specific gravity. Umatilla had better tuber aspect than Pallisade. Pallisade had significantly higher culls than the rest of the varieties.

Innovator had good overall performance; however, the specific gravity is lower than Russet Burbank.

AF4281-3 High yield, but ugly appearance in both locations.

AF3001-6: high yield and nice tubers overall.

W8152-1rus: good yield, tuber shorter than required; a

Dual Purpose

Mesa Russet and **Teton Russets**, both had high yield, had low gravity, and Mesa Russet, hand had significantly high hollow heart.

Fresh Market Yellow Flesh

Soraya: Probaly the most exciting clone tested due to its good performance in both locations.

W6703-1Y : average yield, good tuber size.

Alegría: Good yield and **MN04844-07Y** low yield**.**

MN04844-07Y :low yield may be a future limitation in this case.

Table 2a.Yield, specific gravity, tuber preference, early and late vigor

		Total Yield (cwt/A)		A Size (cwt/A)		B Size (cwt/A)	Culls (cwt/A)		Specific Gravity		Tuber Preference		Early Vigor Jun		Late Vigor
		Han	**Ant**	**Han**	**Ant**	**Ant**	**Han**	**Ant**	**Han**	**Ant**	**Han**	**Ant**	**Han**	**Ant**	**Han**
Short	Atlantic	503	490	476	439	10.8	13.7	34.4	1.087	1.082	6.6	6.3	55.1	83.0	54.5
	Accumulator	574	***625***	542	***602***	12.7	17.4	29.8	1.084	1.078	4.2	4.7	62.5	***91.9***	60.7
Long Storage Chippers	CO95051-7W	408	470	385	408	18.3	11.5	35.3	1.082	1.079	6.0	6.6	44.9	81.6	56.1
	Lamoka	479	481	448	433	16.8	16.2	24.7	1.086	1.079	***7.5***	***7.4***	***71.2***	***91.9***	51.4
	Lelah	446	506	417	451	25.1	14.2	29.4	1.086	1.083	6.9	7.0	***66.8***	***97.8***	32.7
	Nicolet	579	492	552	425	16.3	15.6	45.6	1.083	1.080	***7.7***	6.3	62.5	86.0	56.1
	Tundra	463	459	433	409	14.4	15.8	25.0	1.086	1.084	5.4	5.8	53.7	86.0	51.4
	W5015-12	564	480	524	431	21.0	7.4	22.2	1.087	1.081	6.2	6.0	65.4	***93.3***	56.1
	Snowden	587	495	520	450	13.7	7.4	27.5	***1.095***	1.082	5.9	6.0	53.7	52.1	54.5
Fresh Market Reds	ATTX98453-6R	289	425	257	329	25.2	15.3	57.1	1.062	1.064	5.7	6.1	25.9	50.6	70.0
	W6002-1R	451	***585***	415	***542***	23.0	12.1	35.8	1.061	1.066	7.1	***7.2***	43.5	83.0	93.2
	W8405-1R	***592***	469	***548***	392	37.1	12.1	36.0	1.063	1.069	6.6	6.6	52.2	86.0	***100.0***
	W8890-1R	527	509	477	455	35.4	10.5	23.2	1.065	1.072	***7.4***	7.6	***66.8***	86.0	79.2
	Dark Red Norland	499	478	451	419	26.1	10.3	30.2	1.058	1.064	4.8	6.6	***74.2***	***91.9***	43.4
	Red Norland	476	540	434	472	18.8	18.4	56.1	1.056	1.062	4.4	5.3	***74.2***	***96.3***	40.3
Fresh Market Russets	A03158-2TE	581	511	562	439	23.0	22.4	55.0	1.074	1.075	***8.0***	***6.9***	56.6	80.1	77.6
	AF3362-1	556	520	533	457	***11.1***	22.2	58.2	1.074	1.074	5.3	6.4	52.2	71.2	76.9
	AOTX02136-1RU	370	480	359	399	22.3	19.0	58.0	1.069	1.073	6.6	6.0	37.6	74.2	18.4
	Canela	473	439	444	373	13.8	30.3	45.4	1.078	***1.087***	6.5	***7.2***	30.3	65.4	***80.7***
	CO03276-5RU	462	490	442	417	21.1	23.5	53.8	1.071	1.072	5.7	5.7	46.4	80.1	55.8
	CO99045-1W/Y	581	494	553	424	28.8	25.3	44.5	1.079	1.078	6.3	6.1	***69.8***	***96.3***	69.8
	MN0246ru/Y	529	476	506	386	40.0	23.5	50.4	1.072	1.078	6.0	4.9	56.6	87.4	74.5
	Silverton	478	458	463	382	23.2	18.8	50.4	1.078	1.068	***7.4***	6.3	58.1	78.6	74.5
	W9133-1rus	364	486	357	413	20.6	19.7	54.0	1.065	1.069	6.5	4.8	36.1	69.8	27.8
	Norkotah Sel 8	505	554	486	478	25.9	21.3	63.0	1.072	1.073	6.9	6.3	52.2	80.1	23.1
Processing Russets	AF3001-6	***593***	556	***581***	***524***	11.6	12.0	35.7	1.074	1.077	6.0	6.8	43.5	72.7	***80.1***
	AF4281-3	***598***	498	559	432	14.3	34.6	54.2	1.076	1.079	3.9	4.9	65.4	***90.4***	69.8
	Innovator	524	527	485	414	15.5	47.2	103.1	1.073	1.070	6.3	4.9	59.5	87.4	71.4
	Pallisade	***607***	469	527	351	17.4	68.6	96.3	***1.085***	***1.084***	4.4	4.2	63.9	65.4	***83.8***
	Umatilla	588	507	563	431	26.2	23.1	55.3	1.076	***1.081***	6.9	6.3	65.4	83.0	74.5
	W6234-4rus	569	433	552	365	14.7	16.0	45.1	1.074	1.071	***7.7***	6.3	62.5	86.0	65.2
	W8152-1rus	521	462	502	408	12.1	20.3	38.6	1.074	1.077	6.5	5.7	56.6	86.0	65.2
	Burbank	510	486	487	396	19.8	24.2	70.0	1.077	***1.081***	4.8	5.1	***68.3***	***90.4***	***79.2***
Dual	Mesa Russet	542	481	523	419	16.9	18.5	46.2	1.070	1.067	6.2	6.0	40.5	74.2	***79.2***
	Teton Russet	561	529	536	438	24.7	24.2	74.8	1.072	1.070	***7.8***	6.3	63.9	71.2	58.9
Yellow Flesh	Alegria	498	513	443	416	14.5	36.6	80.8	1.072	1.073	6.8	4.7	***66.8***	84.5	80.0
	MN04844-07Y	287	415	244	343	34.2	11.4	23.5	1.070	1.073	7.1	7.1	44.9	58.0	6.8
	Soraya	***719***	553	***629***	497	26.6	46.1	38.9	1.066	1.064	7.1	7.1	***72.7***	***90.4***	***84.7***
	W6703-1Y	447	490	419	447	20.6	9.4	21.2	1.073	1.075	7.1	6.8	53.7	68.3	78.4
	Yukon Gold	437	435	407	376	***10.9***	19.8	35.3	1.072	1.074	7.1	6.0	52.2	80.1	45.7

Table 2b. Tuber external characteristics and internal defects

		Tuber Length		Tuber Thicknes		Tuber Size		Tuber Eyes		Skin Set		Hollow Heart%		Brown Center%	Internal Brown Spot%		Vascular Discoloration%	
		Han	Ant	Han	Ant	Han	Ant	Han	Ant	Han	Ant	Han	Ant	Han	Han	Ant	Han	Ant
Short	Atlantic	2.8	3.0	7.6	***7.4***	8.0	***7.2***	5.1	5.2	4.7	4.8	15.1	10.4	0.4	5.1	1.1	4.7	8.2
	Accumulator	3.9	3.3	7.3	6.3	7.7	***7.2***	4.2	4.4	5.0	5.0	6.9	12.9	0.4	2.7	6.7	8.8	6.7
Long Storage Chippers	CO95051-7W	3.3	3.0	7.0	6.7	5.8	6.2	6.3	6.6	5.3	5.2	1.1	3.0	2.4	3.1	3.0	6.0	7.2
	Lamoka	3.6	3.9	6.7	7.2	6.8	6.1	6.8	6.6	5.7	5.5	1.1	1.4	0.4	3.1	1.1	6.7	8.2
	Lelah	3.0	2.9	6.1	6.5	5.9	5.2	***7.8***	***7.7***	***6.0***	***5.7***	1.1	5.5	4.4	1.7	3.0	6.7	7.7
	Nicolet	3.0	3.0	6.7	6.5	***7.7***	6.1	5.4	6.3	5.0	5.1	1.1	2.2	0.4	2.1	1.1	6.1	8.6
	Tundra	3.6	3.0	5.5	6.1	5.8	5.8	5.9	6.6	4.9	4.4	1.9	3.0	0.4	3.1	1.1	4.7	6.3
	W5015-12	3.0	3.3	5.3	5.7	5.9	6.1	5.9	6.1	4.9	4.1	1.1	3.8	0.4	3.1	2.3	7.5	7.2
	Snowden	3.0	3.0	7.0	6.8	7.0	6.3	4.6	5.2	4.2	4.8	1.1	4.6	0.4	1.7	2.3	9.5	10.1
Fresh Market Reds	ATTX98453-6R	3.1	3.4	6.7	7.5	6.7	6.3	7.4	6.4	5.9	5.3	5.7	3.5	2.2	2.8	1.2	5.0	6.9
	W6002-1R	***2.7***	***2.2***	***8.0***	7.7	6.8	6.8	***8.1***	***7.8***	5.9	5.8	1.0	1.1	0.4	1.9	2.4	2.6	5.4
	W8405-1R	4.8	4.8	5.8	6.8	6.8	6.2	***7.7***	***7.8***	6.4	6.5	1.0	1.1	0.4	7.3	9.3	4.0	6.9
	W8890-1R	2.8	***2.2***	***7.9***	7.7	6.4	6.1	***8.1***	***7.8***	5.8	6.1	1.0	1.1	2.4	3.9	2.4	15.8	7.3
	Dark Red Norland	3.4	3.9	7.0	7.1	5.9	5.9	5.8	6.4	5.3	6.0	2.7	1.9	0.4	2.9	3.7	6.7	6.9
	Red Norland	3.9	4.2	5.8	6.9	7.1	***7.5***	4.9	5.6	5.1	5.6	1.8	4.4	0.4	1.9	1.8	4.0	6.4
Fresh Market Russets	A03158-2TE	6.9	7.1	***8.0***	7.3	7.1	***7.1***	6.1	6.9	4.1	4.3	2.1	4.2	0.4	1.7	1.0	6.1	7.4
	AF3362-1	6.7	***7.7***	5.3	6.8	***7.4***	***7.6***	5.5	6.4	4.4	4.2	3.8	2.6	2.2	2.6	3.5	14.7	9.3
	AOTX02136-1RU	6.2	6.1	***7.9***	7.3	5.9	6.1	7.3	***7.5***	4.1	4.3	3.7	1.8	0.4	4.2	1.6	6.1	7.9
	Canela	***7.2***	6.8	6.7	7.7	7.1	6.6	***7.8***	6.9	3.5	4.1	17.7	1.8	1.1	1.2	1.6	6.0	8.8
	CO03276-5RU	6.9	***7.8***	6.7	7.5	6.8	6.2	7.0	6.1	4.1	4.1	19.4	5.0	1.7	2.2	2.9	12.3	7.9
	CO99045-1W/Y	6.7	6.3	6.1	6.9	6.5	5.8	7.4	6.9	4.9	4.8	13.6	2.6	3.1	3.2	2.9	8.8	9.8
	MN0246ru/Y	7.1	7.0	6.7	7.3	6.2	5.1	***7.6***	6.7	4.1	4.1	15.2	15.7	0.4	1.2	1.0	6.7	8.4
	Silverton	6.7	7.0	7.0	7.1	***7.2***	6.8	7.0	6.7	4.5	4.6	6.2	10.8	1.1	1.7	1.6	5.4	6.0
	W9133-1rus	6.0	6.0	***8.2***	7.5	6.7	6.3	***7.6***	7.3	4.6	4.5	2.9	1.8	0.4	1.7	1.0	3.2	7.4
	Norkotah Sel 8	6.2	7.0	***7.9***	7.5	6.4	6.5	7.0	6.9	4.1	4.1	13.6	5.9	3.7	3.2	2.2	10.2	7.9
Processing Russets	AF3001-6	***7.8***	***7.8***	6.1	6.9	***7.4***	***7.8***	6.1	6.9	***5.6***	***5.6***	2.8	3.4	0.6	1.4	1.0	5.9	6.9
	AF4281-3	6.2	6.1	5.3	7.1	6.4	6.3	5.0	6.4	***5.6***	***5.0***	2.1	9.1	0.4	1.2	2.2	8.1	11.7
	Innovator	6.7	6.4	7.6	7.2	7.1	6.5	***7.6***	6.9	4.4	4.1	2.9	1.8	0.4	2.7	1.6	9.6	6.5
	Pallisade	6.2	6.7	7.6	7.5	6.8	6.2	7.0	6.1	***5.7***	4.2	11.1	11.6	0.4	1.2	1.6	6.1	11.7
	Umatilla	6.8	7.3	7.0	7.3	5.8	6.3	6.7	6.1	4.1	4.1	5.4	3.4	1.1	2.2	1.0	5.4	7.9
	W6234-4rus	6.4	7.0	***8.3***	7.5	***7.2***	6.8	7.3	6.7	***5.2***	4.8	4.5	5.0	0.4	1.7	2.9	5.4	7.4
	W8152-1rus	5.8	6.1	***8.2***	7.3	6.2	6.3	***7.8***	6.9	4.5	3.4	7.0	13.2	0.4	1.7	2.9	2.6	6.5
	Burbank	6.8	***7.7***	7.0	7.1	5.7	6.2	6.4	6.1	4.1	4.2	14.4	10.8	1.7	2.7	2.2	11.6	9.8
Dual	Mesa Russet	6.5	6.6	7.7	7.3	6.5	6.1	***8.1***	6.7	3.4	3.8	21.0	19.8	1.7	1.2	3.5	2.6	7.4
	Teton Russet	6.4	6.8	***8.0***	7.7	6.4	6.1	7.3	7.2	4.1	4.3	7.0	18.2	0.4	1.2	1.6	6.8	6.5
Yellow Flesh	Alegria	5.1	5.4	6.7	7.4	***7.5***	***7.3***	***8.1***	***7.8***	6.6	6.9	3.9	5.4	0.4	2.6	1.1	6.7	6.8
	MN04844-07Y	***2.3***	***2.3***	***7.9***	7.8	4.8	4.8	***7.9***	6.4	5.8	5.9	1.5	4.6	0.4	2.6	3.6	3.2	5.9
	Soraya	4.9	4.8	7.3	7.6	6.7	6.3	***7.9***	***7.8***	***7.2***	6.8	1.5	1.3	0.4	11.5	3.6	6.1	4.9
	W6703-1Y	3.1	3.1	8.0	7.8	***7.4***	6.5	5.8	6.1	5.8	5.9	1.5	1.3	1.1	3.6	1.7	6.0	6.3
	Yukon Gold	3.4	3.7	7.3	7.4	***7.4***	***7.5***	5.8	6.3	7.0	6.8	22.1	9.5	2.4	7.5	4.3	10.9	7.8