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Hormone-like Effect of a Natural Lipid, Lysophosphatidylethanolamine, Can Mitigate Calcium Deficiency Injury in Potato Shoot Cultures: Cultivar Variations for Calcium Requirement

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Lysophosphatidylethanolamine (LPE) is natural lipid that has been shown to act as a signaling molecule. Recent evidence suggests that LPE can act like auxin promoting shelf life and growth of plant tissues. Using potato shoot cultures we have shown that calcium deficiency can result in shoot tip necrosis resulting in the loss of apical dominance and development of axillary shoots. In the present study we investigated the possibility of promoting root growth by including LPE in the media thus enhancing calcium uptake and mitigating calcium deficiency injury. Shoot cultures of three potato cultivars were grown in the presence and absence of 400 ppm LPE in a calcium deficient media. Shoot tip health and development of axillary shoots was recorded. Three cultivars vary in the media calcium levels for the development of calcium deficiency symptoms suggesting genetic variations for this trait. For each cultivar inclusion of LPE in the media mitigated the calcium deficiency symptoms at a specific thresh hold of media calcium concentration. For example this thresh hold of media calcium concentration was about 60 mM for the cultivar Snowden whereas for the cultivar Burbank this concentration was almost 700 ppm. Visual observations showed that root growth was promoted by including LPE in the media. Our results support the evidence that LPE can have an auxin like effect on potato plants and the requirements for calcium in the root zoon were different for each cultivar to get normal growth.

Preparing Potato for Climate Change: Breeding, Selection and Efficient Use of Genetic Resources for Abiotic Stress

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Due to the implications that climate change will no doubt have on potato yields and production patterns, CIP's breeding program is developing new generations of broad-based disease resistant populations better-adapted to drought and heat. More than 300 clones and selected progenies were evaluated under water-limiting and high temperature conditions in the desertic coast of Peru and in India, Bangladesh, Uzbekistan and Tajikistan. Elite clones with high yield indexes and superior progenitors of stress tolerance were identified and information incorporated for collaborative breeding across environments. Meanwhile, in order to assess wider diversity of cultivated potatoes, a set of 918 potato accessions including landraces, improved varieties and advanced breeding material has been evaluated under full and limited irrigation conditions in Peru. Significant differences were found for tuber yield, tuber number and tuber size among accessions and cultivar groups in both treatments. Early generation screening methods were developed to screen new families for heat tolerance under in vitro conditions targeting ability to tuberize at 25°C night and 19°C day temperatures. Physiological parameters and drought tolerance mechanisms have been studied in complementary approaches: Evaluation of water use efficiency toward the identification of tolerance to dehydration revealed differences in transpiration efficiency and conductance; and evaluation of survival under drought, permitted the identification of genotypes with high osmotic adjustment. The use of remote perception tools such as infrared thermometer, reflectance, infrared camera, measuring NDVI indexes and canopy temperature, is combined with germplasm evaluation and assist and accelerate screening and breeding for drought tolerance.

Selection of Potatoes for Resistance to *Bactericera cockerelli*, Tomato-Potato Psyllid and Zebra Chip in New Zealand

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Tomato-Potato Psyllid (TPP) was first identified in New Zealand in 2006 and has caused major problems to the potato industry, particularly in the North Island. TPP and Zebra Chip (ZC) resistance are now major priorities in Plant & Food Research's potato breeding programme. Results of resistance studies to TPP and ZC over two seasons are presented.
Twelve potato lines were assessed in yield trials at three insecticide levels: intensive (pre-plant plus 13 foliar insecticide applications through the season), low (four foliar applications) and no insecticide. In the first year's work there was a substantial yield reduction from the intensive to the low insecticide to the no insecticide treatment. In most cases a similar trend was seen in dry matter and in ZC levels recorded in crisp slices before and after frying. Even with the fresh market cultivar 'Nadine,' in which almost no ZC was recorded in any raw

tubers of any of the insecticide treatments, marketable yield with no insecticide was almost half that of the intensive insecticide treatment. In a second series of trials all commercially grown potato lines in New Zealand and advanced breeding lines and parental lines from Plant & Food Research's potato breeding programme were screened for ZC after being grown under the low insecticide regime as above. ZC in both raw and fried crisps was assessed. Results in the first year were highly variable, but some lines showed possible resistance to ZC. Despite a low level of statistical significance, the results were used to plan crosses for the next cycle of seedling populations.

Variation for Tuber Greening in the Wild Potato *Solanum microdontum*

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Greening of the tuber skin is an undesirable defect. Tubers of 90 *Solanum microdontum* families represented by 12 individuals each were generated in the winter greenhouse in 2009–2010. These were evaluated in two trials of family bulks after 4 days of exposure to 200 ft candles of fluorescent white light at room temperature. This light intensity was similar to that measured in local grocery stores, and according to preliminary tests, was known to turn some *microdontum* tubers very green. A qualitative score of green (G) or white (W) was assigned to each tuber, but notes on shade of green were also made. Tubers of about 80 families were uniformly G or variable, with 10 families noted as mostly W (especially PI 595506 from Argentina). When nine families were selected for replicated follow-up testing on an individual clone basis, the results matched those of the bulk tuber trials, and there was virtually no variation within clone. Two replicates of about 65 G and 65 W individual tubers were selected from a variety of families, and planted in the summer greenhouse to create a new clonal generation of tubers. Those second generation tubers showed a response to illumination which was consistent with that of their mother tubers. In comparison, when 160 named *tuberosum* cultivars were illuminated in the same way, none from Europe or North America scored W. We are in the process of intermating G and W clones of *microdontum* to investigate the genetics and physiology of the trait, with a view to eventual breeding of strong greening resistance into cultivars.

Atmospheric Ethylene Concentrations in Research and Commercial Potato Storages

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Ethylene has detrimental effects on product quality for many vegetables. Because of this, atmospheric ethylene content is monitored and managed in many vegetable storage facilities. Comparable monitoring is not done in potato storages and, as a consequence, the concentration of ethylene present in the atmosphere of ventilated potato storages is not known. It is known that potato tubers are highly sensitive to ethylene. Well-characterized responses of potato tubers to ethylene include an increase in tuber respiration rate and an accumulation of reducing sugars that can cause dark chip and fry color. High atmospheric carbon dioxide concentrations exacerbate the negative effects of ethylene on fry color. In order to better understand the impact that ethylene may be having on potato tuber quality and how it may influence potato storage management, we monitored the ethylene concentration in the return air in research storages at the Wisconsin Potato and Vegetable Research Storage Facility and in commercial potato storages. Research storages contained chip, fry processing or fresh market potatoes, and commercial storages contained chip and fry processing potatoes. Atmospheric ethylene was monitored every 1 to 2 weeks using either a portable ethylene analyzer or gas chromatography. Ethylene was observed at concentrations of greater than 0.10 ppm, but this was rare and occurred where tuber rot was extensive. Most frequently, the observed amounts of ethylene were less than 50 ppb. The significance of these findings will be discussed in the context of recommended best practices for potato storage management.

Changes in Ascorbate Content of Developing Tubers Relative to Transcription of Genes in the Smirnoff-Wheeler Pathway

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Understanding the mechanisms regulating ascorbate (AsA) content in potato (*Solanum tuberosum* L.) is prerequisite to developing high vitamin C genotypes. Transcript levels of genes in the AsA biosynthetic pathway (Smirnoff-Wheeler) increased as tubers developed to 10 g, suggesting that *de novo* synthesis by tubers contributes to AsA content early in development. Transcript of GGPP (GDP-L-galactose-1-phosphate phosphorylase), a potential rate limiting step in biosynthesis, increased as tubers developed from non-tuberized stolons to the 0.6- to 1.5-g tuber stage, in parallel with an increase in AsA concentration of tubers. High levels of GGPP expression continued through 84 DAP (~54-g tubers) when 75% of the final AsA concentration of fully mature (240-g) tubers had been established. Expression of other key genes in the AsA pathway was also temporally correlated with AsA accumulation during tuberization and early bulking. Tuber AsA levels began to fall during vine senescence and declined progressively through maturation and storage, with losses reaching 65% over an 8-month storage period. The rate of loss was genotype-dependent. Wounding of tubers induced gene expression for AsA biosynthesis, recycling, and accumulation, indicating metabolic competence for AsA synthesis in the detached organ. Storage of tubers under reduced O_2 attenuated AsA loss, suggesting a regulatory role for oxidative metabolism in AsA loss/retention. Attenuating postharvest loss of AsA in tubers could greatly increase the contribution of potatoes to Vit C in our diet. Crop breeding and postharvest handling strategies for enhancing tuber AsA content will evolve from a better understanding of the regulation of these biochemical processes.

Recent Refinements in Horizontal Ventilation Sweetpotato Storage

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In the last 20 years, approximately 15 million bushels of on-farm sweetpotato storage has been built in North Carolina utilizing horizontal ventilation. Horizontal ventilation facilities have also been widely built in other sweetpotato producing states as well as a number of foreign countries. Through cooperation between growers, building contractors, equipment supplier and university researchers, much has been learned that has allowed us to refine the systems that are being presently built in many beneficial ways. Compared to buildings built in the early 1990s, the latest built sweetpotato facilities are larger, more economical, more energy efficient and give a much higher level of environmental control than a few years ago. For example, the incorporation of booster fans has allowed room length to increase to 120 ft or more. The use of supervisory control and data acquisition (SCADA) systems

now are widely used to monitor and control room conditions with very little effort. By utilizing variable frequency drives (VFD) on the fan motors, facilities can be more precisely controlled while saving a significant amount of electrical costs. We have also learned to optimally operate these facilities despite variations in harvest conditions or seasonal changes in weather throughout the 10 plus months the sweetpotatoes can be held in storage.

The Influence of Ethephon, 1-MCP, 2,4-D and Flower Removal on Color and Appearance of Red LaSoda

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Sub-lethal applications of the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) have been used to enhance the color of red-skinned potato cultivars for many years. Relatively little is known about the mode of action of this compound as it relates to enhancing pigment development. A trial was conducted at Parma Research and Extension Center during 2010 to evaluate the effects of foliar applications of the growth regulators 2-chloroethylphosphonic acid (Ethephon), 1-methylcyclopropene (1-MCP), and 2,4-D on skin color of the cultivar Red LaSoda. Manual removal of inflorescence buds was also included to determine the impact of anthocyanin sink competition between tubers and flowers on tuber skin color. Ethephon treatment caused significant floral abscission in treated plants and reduced plant height compared to other treatments and the untreated control. Application of 2,4-D caused foliar injury, but did not affect marketable yield or average tuber size. Ethephon treatment slightly increased the yield of <57 g tubers. Both Ethephon and 2,4-D enhanced tuber skin color. In contrast, 1-MCP and flower removal had no effect on yield, tuber size or skin color. Based on the results of this study, the proposed mode of action for 2,4-D in skin color enhancement in red-skinned potatoes is by the production of ethylene, which increases the rate of anthocyanin synthesis.

Transposon Based Activation Tagging in Doubled Monoploid Potato

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An activation tagging construct, *AcDs*ATag-Bar_gosGFP, carrying GFP, hyg and tpase on the *Ac* element, with glufosinate resistance and a p35s tetramer on the *Ds* element, was used to transform monoploid potato clone BARD 1–3 516 using *Agrobacterium tumefaciens* strain EHA105. Of 50 transgenic plants evaluated, 12 were tetraploid and 33 were diploid. Progeny were derived by crossing the transgenic diploids with a wild type pollinator and grouped into families according to parentage. Progeny were screened by painting seedlings with 0.03% glufosinate herbicide, followed by multiplex PCR to identify putative launch pad plants capable of generating activation tagged lines. For 25 families, the expected 1 transgenic:1 wild type segregation was observed, indicating a single gene insertion without transposition of *Ds*. Six other families segregated 3 transgenic:1 wild type, indicating two insertions without transposition. Unexpected segregation patterns were found among progeny of three independent transgenics, where evidence of active transposition was obtained in the form of 50% *Ds* only plants, with 15 independent activation tagged lines identified. TAIL-PCR revealed launch pad 36B was situated on PGSC0003DMB000000017 with 11 of 15 of its *Ds* lines transposed locally to other sites on scf17 and the remainder transposed to other linkage groups. These lines include tags near genes of interest for late blight resistance. Crosses of *Ds* lines to the DM will result in activation tag seed stocks.

An Experimental Study of Pressure Bruise Development in Four Russet Potato Cultivars with Differences in At-Harvest Tuber Moisture Loss

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Pressure flattening (or pressure bruise) is a common and economically significant physiological disorder that occurs during long term storage of potatoes. The cause of pressure flattening is hypothesized as a result of the interaction of three factors; downward pressure within the potato pile, storage duration, and moisture loss from tubers. Four russet potato cultivars (Canela Russet, Centennial Russet, Rio Grande Russet, and Russet Norkotah) were treated to induce moisture loss and then evaluated for the development of pressure flattening. The cultivars and treatments were evaluated for pressure flattening after 3, 6 and 7 months of storage using an experimental design developed at SLV Research Center/Colorado State University that is able to induce pressure flattening utilizing conditions similar to those present in commercial potato storage. The design relies on ventilated containers of potatoes containing experimental samples maintained between layers of other potatoes. Significant differences in pressure flattening were observed within a cultivar that had been subjected to different amounts of tuber moisture loss, as well as differences in pressure flattening development among the cultivars. It is likely that cultivar specific traits have an important role in pressure flattening development in addition to moisture loss, pile height (pressure), and duration of storage.

Evaluating the Efficacy of Fungicide Programs for the Control of Potato Early Blight in the Central Sands of Wisconsin

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Potato early blight is a perennial and potentially destructive disease caused by the fungus *Alternaria solani.* Appropriately-timed, effective fungicides are necessary to limit yield and quality loss. In 2010, we evaluated 38 fungicide programs for early blight control at the University of Wisconsin Hancock Agricultural Research Station on 'Russet Burbank.' Programs included an untreated control, conventional and organic grower standard programs, and newer chemistries, all replicated 4X and arranged in a randomized complete block design. Programs were initiated on 16 Jun and all other production inputs were commercial standard. Plots were treated every 7 days and evaluated for disease bi-weekly using a modified Horsfall-Barratt scale. Plots were machine-harvested on 22 Sep and tubers were graded for size and yield. No tuber early blight was observed and the specific gravities of tubers from top yielding programs were not significantly different. Programs that had the lowest Area Under the Disease Progress Curve values were the highest yielding. The highest yielding program was the Wisconsin conventional grower standard. Organic treatments were ineffective. Several newer chemistries and modified standard programs were effective. At this time, and in the registration pipeline, there are excellent fungicides for the control of potato early blight that will contribute to good fungicide resistance management practices.

Tuber Transmission of Potato Purple Top Phytoplasma

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Since 2002, growers in the Pacific Northwest have experienced outbreaks of potato purple top disease. Purple top in this region is caused

by a phytoplasma and the beet leafhopper, *Circulifer tenellus*, is the vector. It is widely believed that phytoplasmas do not commonly survive in tubers and that infected tubers may fail to sprout or produce hair sprouts. Yet, little information is available on the tuber transmission of phytoplasma in important cultivars. This study was conducted to determine if the phytoplasma was transmitted to tubers on infected plants and the frequency of transmission from infected tubers to daughter plants. In 2006, 2007, and 2008, Alturas, Russet Burbank, FL1867, FL1879, Russet Norkotah, Ranger Russet, Shepody, and Umatilla Russet were planted near Moxee, WA. Plants become infested with native populations of the beet leafhopper. Symptomatic plants were tested by PCR for phytoplasma and positive plants were identified. Tubers were harvested from positive plants and tested for phytoplasma. A subset of phytoplasma-positive tubers was planted and resulting daughter plants were tested for phytoplasma. Among all eight cultivars, the frequency of tuber transmission ranged from 4 to 96% over the three year period. The transmission rate from infected tubers to daughter plants ranged from 0 to 50% depending upon cultivar and the year. Across the eight cultivars an average of 22%, 15%, and 16% of infected tubers gave rise to infected daughter plants in 2006, 2007, and 2008, respectively. These data indicate that this phytoplasma is transmitted to tubers and daughter plants at a relatively high rate and that the potato seed industry needs to be aware of the threat of tuber-borne phytoplasma infections.

Effect of Cultivar on Processing Colour Response to CO_2 and Trace Ethylene Singly and in Combination

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Finished colour remains a major concern within the processing potato industry. Elevated CO_2 and trace ethylene in the storage atmosphere together have been shown to affect fry colour of tubers. Previously this response was studied in Russet Burbank only, with short trials beginning in January and March. More recently, the response of four cvs (Russet Burbank, Shepody, Innovator, Dakota Pearl) to continuous exposure through an entire storage season (November to June) to 0 or 2% CO_2 and 0 or 0.5 $\mu L \cdot L^{-1}$ ethylene in a factorial arrangement was studied. The response varied somewhat among cvs,. Dakota Pearl was relatively unaffected by all treatments, whereas Shepody was quite sensitive. The pattern of response changed in some cvs. as the duration of storage increased, such as darkening attributable to the CO_2 alone after prolonged exposure, and/or complete recovery from the darkening attributable to ethylene. The importance of managing both of these gases in the potato storage atmosphere is emphasized.

Controversial Aspects of PVMI, its Mission and Activities

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Since its inception in 2005, the Potato Variety Management Institute (PVMI), a non-profit, grower controlled company, has been marketing and administering new potato varieties coming out of the Tri-State Breeding Program. The primary mission has been to increase the awareness of the new varieties as well as to provide much needed funds to the research program. Positive side effects have included: earlier awareness of and access to new releases; added value to seed growers with specific variety management information being more readily available; the capacity to work with specific parties to develop niche varieties and lines that would otherwise be discarded; and increased international awareness and interest in the new varieties. The earlier awareness brought about by PVMI's marketing and promotion, has resulted in the new varieties becoming widely established more quickly. If there is a weakness in a new variety that could be managed beneficially, the problem may affect more growers than if its adoption was slower; *Classic Russet* is an example. Some areas of controversy have emerged. For example, developing otherwise discarded new lines is controversial as one member of the industry may be seen as taking advantage of a resource that is not available to others. Exclusive licenses by their very name indicate that the variety is not available to all, but varieties with limited markets might not be commercialized unless made available to one exclusive license. Lastly, international demand for new varieties is perceived as a potential threat to industry which exports processed product. However, if Tri-State varieties are not used for this purpose other varieties will be chosen and would provide no royalty return. For more information see www.pvmi.org.

Predicting Genetic Richness at Wild Potato Collection Sites in Southeastern Arizona

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It takes a lot of time and money to collect even a fraction of the potential geographic range of wild potato species, so there is efficiency to gain if one could predict diversity "hot spots" for collecting. A previous experiment that used AFLP markers to compare "remote" versus "easy" collection sites within three mountain ranges identified the Santa Catalina Mountains (CAT) of SE Arizona as making a particularly large contribution of to the unique alleles in germplasm existing in the genebank, despite CAT collections being few and all close to roads. This situation motivated a collecting expedition in September 2009 to more thoroughly collect CAT. That expedition resulted in 25 samples, most from new sites never previously described or collected. A new AFLP study was done, examining the same three mountain ranges and including a fourth, and now adding the 2009 CAT collections. Results confirmed the prediction of CAT as a collecting "hot spot" since this location had nearly twice as many unique alleles as any other mountain range. Such studies exemplify the power of using DNA markers as a means to empirically reveal genetic richness, which then can serve as a guide for the most efficient allocation of resources for collecting, preservation, and evaluation of germplasm.

The National Chip Processing Trial: Early Generation Testing on a National Scale

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The US Potato Board is providing support to conduct national testing of early generation selections from US public potato breeding programs for the purpose of finding replacements for Atlantic and Snowden in the chip processing industry. There are nine testing sites: FL, CA, NC, TX (2010) / MO (2011) in the south and NY MI, WI, ND and MN (scab and PVY testing) in the north. A uniform data collection guide and a searchable database were created so that the tested clones can be compared across locations and years for yield, specific gravity, tuber appearance, chip color, defects and breeder merit. Early generation selections are first tested in single observation 15-hill plots. The more promising selections are retested in year two in two replications. Selections with promise will be candidates for the national USPB/SFA trials and/or fast-tracked into tissue culture for seed increase so that larger

scale trials can be conducted. In 2010 about 220 selections were evaluated in the southern and northern states in non-replicated plots. In 2011, 65 lines were selected for retesting with about half of them in replicated plots. Some lines are only being tested in either the northern or southern sites based upon 2010 merit. In addition, there are about 130 new early generation lines being evaluated for the first time. Data will be summarized and discussed from the first year and half of trials. Early generation national trials can create commercial breeding efficiency in the chip processing sector.

Development of a SNP-Based Genetic Map for Potato

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With advances in genomics, opportunities exist to create SNP-based genetic markers for potato. Through the USDA/AFRI-funded SolCAP project, approximately 70,000 SNPs were identified that meet the Illumina Infinium design parameters. Ten thousand SNPs were selected for the Infinium potato array from candidate genes (2,769 SNPs), genetic markers (508 SNPs) and the draft genome scaffolds (6,769 SNPs) to maximize coverage (650 Mb of the 727 Mb of the draft genome). Of these ten thousand SNPs, 8,303 passed the initial Illumina filtering. Over 400 diploid and tetraploid potato lines and mapping progeny were genotyped for these 8,303 SNPs. These SNPs were used to analyze a diploid cross between DM1-3 (doubled monoploid) and 84SD22, of which, 3,060 were heterozygous in 84SD22. A genetic map was created using JoinMap 4 with 2,577 high quality SNPs segregating in the population. A total of 666 unique map locations distributed over 12 linkage groups were defined for the 788 cM genome. Clusters of distorted segregations were observed for some SNPs. In the coming months, the SNPs will be mapped to the draft genome to look at concordance between the sequence and genetic maps. These SNPs can be used for further genetic studies and QTL mapping in potato.

Maximizing Nitrogen Use Efficiency for Optimum Tuber Yield and Quality of a New Colorado Potato Cultivar

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Nitrogen (N) rate and in-season N management is critical to any successful potato production system. New potato cultivars that are being developed in recent years respond differently to N management compared to older cultivars. Field studies were conducted in the San Luis Valley of Colorado to evaluate the effect of N application rate and in-season N application timing on tuber yield and quality of a new advanced russet selection CO99053-3RU. Nitrogen application rate treatments ranged from 67 to 202 kg N ha^{-1}. A control treatment was included where no N fertilizer was applied. Maximum total and marketable tuber yields were obtained at N rate of 67 kg N ha^{-1}[122 kg N ha^{-1} available N (soil + irrigation water + applied N)]. Total and marketable tuber yield increased by 7% and 10%, respectively, at the optimum N (67 kg N ha^{-1}) rate, compared to all other N application rates. Large marketable tuber size (>170 g) yield was increased by 15% at the optimum N rate, when compared to all other N rate treatments. Total external defects were reduced by 48% at the optimum N rate. The increased tuber yield and quality of CO99053-3RU observed at the 67 kg N ha^{-1} application rate was due to maximum N use efficiency. The increased tuber yield at the optimum N rate could also be attributed to increased tuber set and increased tuber bulking during the later part of tuber bulking. Results of this study indicate that for an economically sustainable and environmentally responsible production of CO99053-3RU, available N rate should not exceed 122 kg N ha^{-1}.

Monitoring Current Season Spread of *Potato Virus Y* in Seed Potato Fields

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Potato virus Y (PVY) can cause significant yield and tuber-quality losses in potatoes. *PVY* has increased in recent years all over North America including New Brunswick, Canada. This increase has been attributed to planting susceptible varieties that do not clearly express visible symptoms. Crop management practices can also impact *PVY* incidence. This study investigated *PVY* spread in New Brunswick in 11 fields with Adirondack Red, Calwhite, Goldrush, Innovator, Russet Burbank and Shepody cultivars during 2009 and 2010. One hundred randomly selected plants from each field were monitored throughout the growing season. Leaf samples were collected three times at an interval of 20–25 days starting from the end of June to mid-August, and evaluated for the presence of *PVY* using ELISA and Real-time RT-PCR. Tubers were collected from each plant in August and then at the end of the growing season, after topkill, in September. Tubers were tested for *PVY* using Real-time PCR. All cultivars had low *PVY* incidence (0–4%) early in the crop season (end of June to mid -July). *PVY* levels in the field increased rapidly between late-July and mid-August. In some fields, *PVY* incidence reached over 30%. In 2010, the first aphid sample that tested positive for *PVY* was found on June 16. This suggests that spread started early in the season and continued spreading throughout the season in NB in both years. The timing of protectant oil spray had a significant effect on virus spread in 2010. Results from leaf sample ELISA and Real-time PCR were highly correlated for all cultivars at all sampling times in 2009 and 2010.

Resistance of Alternaria Populations in Idaho to Commonly Used Fungicides and its Effect on Potato Early Blight Management in Idaho

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Early blight, caused by the fungus *Alternaria solani*, is an important disease on potato in Idaho. In recent years growers have reported a reduction in efficacy of fungicides traditionally used to control early blight. In 2010, a preliminary survey was carried out to screen *A. solani* isolates collected in summer 2009 for resistance to azoxystrobin, pyraclostrobin, boscalid and famoxodone. Fungicide sensitivity testing was done using spiral plate dilution gradients. Fungicide solutions were applied to PDA in a 2.5-log dilution in a continuous radial concentration gradient using a spiral plater. Fungal inoculum was placed in radial lines across the gradient. Fungicide sensitivity was expressed as an EC50, the fungicide concentration at which a fungal isolate's radial growth was equal to 50% of the average growth of the isolate on non-amended PDA. Results showed that of 39 isolates screened, all were resistant to azoxystrobin and three were resistant to boscalid. None were resistant to pyraclostrobin or famoxodone. In summer 2010 new isolates of *A. solani* and *A. alternata* were collected and the fungicide resistance survey was expanded to include more fungicides. The results, to be presented, will be used to compare any differences in susceptibility between the two *Alternaria* species and

will be used to develop a more sustainable potato early blight control program for Idaho growers.

Studies of Amylose Content in Potato Starch

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Potato starch is typically low in amylose (~20–25%), but high amylose starch has superior nutritional qualities. The amylose/amylopectin ratio is the most important property influencing the physical properties of starch. Amylose content has been determined in tuber samples from 107 accessions representing 39 *Solanum* species with an average AAC of 30.5%. The top five species for mean amylose percentage are *S. commersonii, S. acaule, S. stenotomum, S. raphanifolium* and *S. circaefolium* (34.9–37.7%), while the lowest three species are *S. lignicaule, S. berthaultii* and *S. morelliforme*, with amylose percentages ranging from 20.2% to 24.2%. Additionally, 181 American and foreign potato cultivars were evaluated in 2009 and 2010 for AAC in tuber starch. In both years, a wider range of amylose content was found in the foreign varieties (27.2%–39.1% and 21.3%–34.7%, respectively) than in the American ones (28.2%–36.6% and 20.5%–31.7%). In addition, a higher mean amylose content was found in the foreign (34% and 28.2%) than in the American cultivars (31.4% and 26.8%). In another study, amylose content sometimes increased during storage, implying that the starch pathway in storage is dynamic and there might be some breakdown and resynthesis of starch. Also, AAC was determined for 11 cultivars at different tuber developmental stages. The samples were harvested weekly at Hancock, WI and Rhinelander, WI from 47 to 121 days after planting. The amylose content remained statistically stable throughout the growing season. Finally, a screen of 200 SolCAP clones was performed to determine AAC from tubers harvested in NY (2009), OR (2010) and WI (2010). These results, in conjunction with molecular SNP data, will be used for association mapping studies, diagnostic tool development and molecular breeding approaches.

Development of Markers for Δ9-Stearoyl-ACP-Desaturase (SAD) to Screen for Cold Acclimation

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A change in the membrane lipids from. fluid to solid is considered as a key mechanism of injury by cold and freezing stress in plants. We have previously shown that an increase in the proportion of unsaturated lipids during cold acclimation is associated with an increase in freezing tolerance in potato species. Δ9-Stearoyl-acyl carrier protein desaturase (SAD) is a key enzyme that catalyzes the desaturation of membrane lipids thereby regulating the membrane lipid fluidity. Recently we have reported an increase in Δ9 desaturase gene transcripts is associated with an increase in freezing tolerance during cold acclimation in hardy potato species. The objective of the present study is to develop molecular markers based on SAD gene to screen potato germplasm for cold acclimation. Two potato species with different levels of freezing tolerance and cold acclimation capacity were used; *S.commersonii* (cmm, freezing tolerant and able to cold acclimate) and *S.cardiophyllum* (cph, freezing sensitive, unable to cold acclimate). We have designed seven pairs of primers based on the sequence of SAD gene. From the comparison of the PCR products of the two species, using two of the primers, we detected 28 SNP sites for this gene. The sequences including SNP were analyzed by dCAPS Finder 2.0 to look for appropriate restriction enzymes. Analyses of the restriction enzymes products (Mfe I and EcoR I) revealed distinct differences among the two species. These markers are being tested for the development of screening tools using a population derived from cmm x cph.

The Effects of Seed Potato Exposure to Low-rates of Chlorpropham on Field Performance

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Chlorpropham (CIPC) is a highly effective sprout inhibitor in potato. Some export regulations require CIPC or other sprout inhibitor to be applied to potatoes for phytosanitary considerations. In addition, due to trucking and temporary storage issues, seed potatoes are sometimes inadvertently exposed to CIPC. This 2-year research study was undertaken to document the effects of low rates of CIPC application or contamination on emergence, yield, and grade in the subsequent crop. CIPC-EC (emulsifiable concentrate formulation) was diluted and sprayed on whole 'Russet Burbank' seed at rates of 0, 1.2, 2.5, 5.0, and 10 ppm CIPC. Seed was sampled for CIPC residue at planting. Seed was cut, planted and produced under typical commercial practices. Tuber CIPC residue levels correlated to application rates, delayed emergence and decreased yield. Some seed treated with 5 or 10 ppm CIPC failed to emerge. Even low rates of CIPC (1.2 and 2.5 ppm) applied to tubers resulted in significant delays in emergence compared to the untreated control. Total yield decreased in 2009 from 26% (2.5 ppm CIPC) to 78% (10 ppm CIPC) of the untreated control. In 2010 total yield decreased from 36% (1.2 ppm CIPC) to 94% (10 ppm CIPC) of the untreated control. Harvested size profile was significantly altered by CIPC applications. These dramatic reductions in yield reinforce the importance of avoiding all potential for CIPC contamination of seed and documents consequences of planting commercial potatoes treated with CIPC for export purposes.

Optimization of a Chemiluminescent Dot-blot Immunoassay for Detection of Potato Viruses

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Determination of potato tuber health by identifying the causal agents of disease is critical for developing disease management strategies. Potato is a host for many viruses and vegetative propagation of potato leads to accumulation of viruses, resulting in significant tuber yield losses and reduced quality. The most widely used method of diagnosis of viral infections is the post-harvest test, for which the enzyme-linked immunosorbent assay (ELISA) is used. This method is efficient, and relatively inexpensive, but the large number of samples processed means that even small improvements can result in significant savings. Others have shown that ELISA can be modified by substituting polyvinylidene fluoride (PVDF) membranes for microtiter plates to develop a more flexible and inexpensive assay. We have optimized a dot-blot immunoassay with viral proteins bound to PVDF membrane and detection of viral proteins with alkaline phosphatase labeled antibodies and chemiluminescence reagent. We describe here the method for detection of potyviruses, potexviruses, carlaviruses, luteoviruses, tobamoviruses, nepoviruses, and cucumoviruses. The cost of this assay is approximately one tenth of a standard ELISA. We are also attempting to optimize an antibody array spotted

onto PVDF and testing potential uses for this array as a diagnostic tool for plant viruses.

Baseline Sensitivity of Difenoconazole, Fludioxonil, and Thiabendazole Fungicides Against *Fusarium* Species Associated with Dry Rot of Seed Potato Tubers in Michigan

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The discovery of thiabendazole (TBZ) and fludioxonil-insensitive isolates of *Fusarium* has instigated the need to determine the sensitivity levels of different *Fusarium* spp. to fungicides in order to manage Fusarium dry rot. *Fusarium* spp. (*F. sambucinum, F. oxysporum, F. equiseti, F. solani, F. avenaceum, F. acuminatum, F. torulosum, F. tricinctum, F. sporotrichioides, and F. cerealis*), causing dry rot in Michigan, were screened for sensitivity to TBZ, fludioxonil, and difenoconazole. EC_{50} values were determined using spiral gradient dilution (SGD) and serial dilution plate methods. Both methods gave EC_{50} values within the same range. All the *Fusarium* isolates were sensitive to difenoconazole with EC_{50} values less than 5 mg/L. All isolates of *F. sambucinum* were insensitive to TBZ with EC_{50} values greater than 100 mg/L, while the rest of the isolates were sensitive to TBZ with EC_{50} values less than 5 mg/L. Both fludioxonil-sensitive and insensitive isolates of *F. sambucinum* and *F. oxysporum* were reported, while all the other isolates were sensitive with EC_{50} values less than 5 mg/L. The fludioxonil-insensitive isolates had EC_{50} values greater than 100 mg/L. Difenoconazole can be used to control dry rot. TBZ can still be used to control *Fusarium* spp. causing dry rot other than *F. sambucinum*. There has been no compelling evidence to suggest that fludioxonil has failed to perform because of insensitivity to *Fusarium*. The occurrence of such strains necessitates the development and registration of partner chemistries that can preempt any future concerns on lack of performance of products in use.

Identification of *Fusarium* spp. Responsible for Dry Rot of Seed Potato Tubers in Michigan

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Fusarium dry rot of potato (*Solanum tuberosum* L.) is a postharvest disease caused by several *Fusarium* spp. In Michigan potato production, *F. sambucinum* was the predominant species according to a report in 1993. A survey was conducted in summer 2009 and 2010 to determine the current species responsible for dry rot of seed potato tubers in Michigan. A total of 370 samples of dry rot symptomatic tubers were collected and used for recovery of *Fusarium* species. Morphological characters were used for identification of the *Fusarium* spp. Species identity was confirmed through molecular techniques. A total of 228 *Fusarium* isolates were recovered and identified into 11 species. *Fusarium oxysporum* was the most commonly isolated species comprising 30.2% of total *Fusarium* species. The second most common isolated species was *F. equiseti* species complex comprising 19.7%. *Fusarium sambucinum* and *F. avenaceum* were third in prevalence, each comprising 13.6%. The lesser prevalent *Fusarium* spp. within the range of 4–10% included *F. cerealis (=F. crockwellense)*, *F. solani,* and *F. acuminatum*. Other *Fusarium* species identified but least in prevalence (<3%) included *F. sporotrichioides, F. torulosum, F. tricinctum*, and *Gibberella zeae* (teleomorph of *F. graminearum*). All the *Fusarium* species were pathogenic to potato tubers (cv. Red Norland). However, *F. sambucinum* was the most aggressive species. Presence of high proportions of different species may have implications for chemical management strategies for dry rot.

Economic Impact of Zebra Chip in Potato

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Zebra Chip (ZC) can have a devastating economic impact on potato growers in some regions. One of the goals of a UDA-funded project is to develop a comprehensive environmentally sound disease management program for ZC control. Our role in the project is to conduct economic analysis of alternative disease management strategies. We used Texas A&M University insecticide spray recommendations to estimate 2010 ZC control costs in eight regions of Texas, Kansas and Nebraska. We also surveyed experts to estimate ZC costs in terms of reduced yields and reduced quality. Economic losses vary by season but results show that growers spend hundreds of dollar per hectare on insecticides and still suffer yield and quality losses.

Biochemical Markers for Fast-Track New Potato Variety Development

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Potato breeding is a tedious, time consuming process. With the growing requirements of the potato processing industry for new potato varieties, there is need for effective tools to speed-up new variety development. The purpose of this study was to develop cost effective and reliable tools for the development of new potato varieties that are resistant to cold-induced sweetening (CIS). We studied two key enzymes in the hexogenesis pathway and explored their relationship with reducing sugar accumulation and processing quality. The study was conducted for 4 years (2007–08, 2008–09, 2009–10 and 2010–11). Thirty advanced potato breeding clones were stored at 42°F storage temperature for 6 months. The clones were analyzed for total acid invertase activity, presence of A-II isozymes of UGPase, total glucose and sucrose concentration and chip color. All the clones were divided into Class A (best resistance to CIS), Class B (intermediate resistance to CIS) and Class C (very low or no resistance to CIS). Clones with low acid invertase activity showed low reducing sugar accumulation and therefore better processing quality (chip color). There was year to year variation in terms of acid invertase activity but the CIS class did not change over years. Data will be presented to show that these biochemical markers are reliable and could be used as a screening tool for CIS to select promising potato clones.

Characterization of Early Blight Resistance Derived from the Wild Potato Species *Solanum berthaultii*

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Early blight (EB), caused by the fungal pathogen *A. solani,* is a ubiquitous potato disease of world-wide significance. Fungicides are the main method of control, as cultivated varieties offer only a few sources of moderate resistance, most of which are associated with late maturity. Strong levels of resistance have been identified in the wild potato species *Solanum berthaultii* (2n=2×=24) using a detached leaf assay, and breeding efforts to introgress this resistance into cultivated

potato offer promise in increasing the sustainability of potato production. In order to understand the genetic basis of resistance in this species, 12 breeding populations were developed through interspecific hybridization of three *S. berthaultii* individuals to four cultivated haploids (2n=2×=24) of *S. tuberosum*. These populations were evaluated for disease under natural field conditions without fungicides for two seasons in a major potato production area of Wisconsin. Field resistance was rate-limiting, wide-ranging, and continuously distributed, suggesting quantitative inheritance of this trait. Repeatability of population means was low (0.1644–0.2398), implying segregation of many genes for EB resistance. However, there were still many indications of strong potential for resistance breeding with this species, including the presence of transgressive segregants within each population and the detection of significant differences among populations. Combining ability analyses revealed that the choice of cultivated parent, not the wild parent, caused these differences among populations. Among the cultivated parents examined, US-W973 had the best combining ability for EB resistance, while US-W4 had the worst.

Impact of Tuber-borne Infection by Potato virus Y (PVY) Strains on Symptom Expression and Tuber Quality in Eight Cultivars of Potato

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Potato virus Y (PVY) strains can cause foliar and/or tuber symptoms reducing yield and tuber quality. These symptoms vary depending on cultivar and virus strain from current season infections but symptoms from seed infections have not been adequately cataloged, particularly from a field situation. The intent of this study was to investigate effects of seed borne PVY infection on eight cultivars using two isolates each of PVY^{O}, $PVY^{N:O}$, and PVY^{NTN}. Seed from PVY positive plants grown in 2009 were planted in a screen house and grown in separate isolate blocks which prevented aphid movement and introduction of viruses, but allowed for the plants to be exposed to near field growing conditions. Plants were evaluated on emergence, percent infection, foliar symptom development, yield, and tuber symptoms. Delayed emergence was observed in nearly all cultivars compared to healthy controls; Alturas being the most impacted. Emergence was inhibited greatest in plants infected with $PVY^{N:O}$. Foliage symptoms varied by strain, isolate, and cultivar. Leaf mosaic severity differed between isolates of each strain and among cultivars. The number of infected plants was lowest when the seed originated from parent plants infected with PVY isolates $T3V2^{NTN}$ and $CO35^{O}$. Also, plants growing from seed originating from infected Premier Russet and Yukon Gem plants had fewer PVY positives than the other six cultivars. Tuber symptoms differed by stain, isolate and cultivar and percent symptomatic tubers varied by virus strain and cultivar. Internal tuber symptoms were observed most frequently in Yukon Gem, Ranger Russet, and Yukon Gold.

Preemergence Weed Control with Fomesafen in Potato

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Field research was conducted at the NPPGA Irrigation Research site near Inkster, ND to evaluate crop tolerance and weed control of fomesafen +/− S-metolachlor or +/− S-metolachlor + metribuzin as a pre-emergence treatment in Russet Burbank, Ranger Russet and Shepody potatoes compared to local standards. Potatoes were planted May 24, hilled June 3, and harvested September 29. Herbicides were applied June 4 with approximately 1 inch of soil covering the sprouts using a CO_2 pressurized sprayer equipped with 8002 flat fan nozzles, spray volume of 20 GPA, and pressure of 40 psi.
All treatments were applied 1 day after hilling. At 14 DAA the treatment with 0.5 lb/A fomesafen alone had significantly better common lambsquarters control compared to 0.25 lb/A fomesafen for all three varieties with an average of 96% control. At 31 DAA similar results occurred with common lambsquarters. However, tank-mixing 0.25 lb/A fomesafen with 0.98 lb/A S-metolachlor + 0.23 lb/A metribuzin showed significantly better control than fomesafen alone at 0.25 lb/A or 0.5 lb/A.
Yields varied among the three varieties. The untreated Ranger Russet. had a yield of 374 cwt/A, while 0.0156 lb/A rimsulfuron tank-mixed with 0.75 lb/A dimethenamid-P was highest at 551 cwt/A. The highest yielding Russet Burbank treatment was 0.25 lb/A fomesafen tank mixed with 0.98 lb/A S-metolachlor + 0.25 lb/A metribuzin at 544 cwt/A. The untreated was 424 cwt/A. The highest yielding Shepody treatments were 0.5 lb/A fomesafen with 528 cwt/A, while the untreated yield was 460 cwt/A.
Fomesafen at a rate of 0.5 lb/A always had a higher yield than the 0.25 lb/A treatment. 0.25 lb/A fomesafen tank-mixed with either 0.98 lb/A S-metochlor + 0.23 lb/A metribuzin or 0.95 lb/A S-metolachlor always had a higher yield than 0.25 lb/A fomesafen alone.

Does Glyphosate Drift Droplet Concentration affect Irrigated Potato Yield?

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Field research was conducted at the NPPGA Irrigation Research site near Tappen, ND to evaluate the effect of glyphosate droplet concentration when applied to Russet Burbank potato at different growth stages. Glyphosate was applied at one-sixth, and one-twelfth the standard use rate (0.125 and 0.0625 lb ai/A) and three spray volumes (1,5, or 20 GPA in 2009 and 5, 10, or 20 GPA in 2010) and three growth stages: tuber initiation (TI), early tuber bulking (EB), and late tuber bulking. Visual injury symptoms from glyphosate applications were subtle (chlorosis at growing points) regardless of glyphosate rate or application timing in 2009. Plants treated with 0.13 lb/A glyphosate at the TI stage when applied at 20 GPA or at the EB stage when applied at 5 GPA had significant marketable and total yield loss from the reduction in tuber size. Plants treated with glyphosate produced similar number of tubers in comparison to the untreated except when plants were treated with 0.06 lb/A glyphosate applied at 20 GPA at the TI stage, which had significantly more tubers. There were no significant yield or grade differences in 2010. However, there was a tendency at each growth stage (TI, EB, or LB), for yield to decrease as the rate of glyphosate increased with the exception for 20 GPA at TI and LB. When glyphosate was applied at the TI stage, total tuber counts (averaged 291 tubers) were less than tuber counts for plants treated with glyphosate at the EB and LB stages as well as untreated plants with 329, 310, and 318 tubers/25 ft, respectively. Results suggest that droplet concentration with sub-lethal glyphosate rates may not increase absorption to the point where potato yield is affected.

Glyphosate Drift Injury to Three Red Potato Cultivars

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Field research has been conducted the past 4 years at the NPPGA Dryland Research site to evaluate potato injury from simulated glyphosate drift. Glyphosate was applied at rates one-third, one-sixth, and-twelfth, and one-twenty-forth the standard use rate (0.25, 0.125, 0.0625, and 0.0313 lb ai/A) at the tuber hooking (TH), tuber initiation (TI), early tuber bulking (EB), and late tuber bulking stages (LB).

Results suggest that 'Red Norland', the most commonly planted cultivar in the region, was the most sensitive to glyphosate drift. Red cultivars may be more sensitive to glyphosate drift due to visual tuber symptoms that reduce fresh marketability. The pattern of yield reduction (current season or following season) from glyphosate drift to specific growth stages was similar to those observed with 'Russet Burbank' under irrigation. Cultivar sensitivity was 'Red Norland' > 'Red Lasoda'>'Sangrie' for the 2 years evaluated. Glyphosate drift to red cultivars may cause greater losses due to visual symptoms and the inability for most graders/sorters to eliminate visually unattractive tubers. Further research is focusing on cultivar sensitivity for russet types as well as round white cultivars used for chips.

Phosphorus Use Efficiency Improvement with Organic Acids

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Phosphorus (P) fertilizer is essential for profitable potato production. However, reduction of P fertilizer is warranted, as it is a source of nutrient pollution in surface waters (eutrophication leading to hypoxia) and is derived from non-renewable mineral resources. A lab study was conducted to determine P flux through soil as a result of combining a humic/fulvic acid (Carbond® P) with P fertilizers. An untreated control was compared to ammonium polyphosphate (liquid APP; 34% P_2O_5), monoammonium phosphate (solid MAP; 52% P_2O_5), and Carbond® P (liquid CB; 24% P_2O_5) applied either as a band or mixed with three unique soils in 25 cm tall columns at 20 or 80 kg ha^{-1} P_2O_5. Mobility of P was evaluated at 24, 48, 110, and 365 days after application by applying ~2 pore volumes of water. All fertilized treatments resulted in significant increases in P mobilization for all soils and rates with no interactions with fertilizer source. Accordingly, results were averaged across soils and rates. For the banded applications, CB had 300, 205, 117, and 15% greater P mobilization than MAP and 25, 38, 4, and 5% greater than APP at 24, 48, 100, and 365 days after application, respectively. For the mixed applications, CB had 1, 71, 95, and 7% greater P mobilization than MAP and 22, 54, 29, 16% greater than APP over the same period. This enhanced P mobilization resulted in increased early season growth, P uptake, and P efficiency in other trials with potato and other crop plants. Field trials with Russet Burbank potato showed that a full rate of APP fertilizer and a 30% reduced rate of CB yielded the same and that the reduced rate of CB resulted in significantly more (5.6 Mg ha^{-1}) US No. 1 yield than APP applied at the same rate. These results show that CB can increase P use efficiency without reducing yields.

Nitrogen Fertilizer Use Efficiency and Greenhouse/Reactive N Gas Losses in Potato Production

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Potato (*Solanum tuberosum*) production is sensitive to a steady, adequate supply of nitrogen (N). Synergistically optimizing grower profits while maximizing N use efficiency (NUE) is critical to conserve nonrenewable natural resources used to manufacture N fertilizer and minimize N pollution to water and the atmosphere. Twelve studies were performed on Russet Burbank potato with urea, split-applied urea, and polymer coated urea (PCU) fertilizer at rates of 0, 33, 67, and 100% of the expected optimum N rate. Urea and PCU were applied at time of plant emergence with soil incorporation via hilling. The split applied urea was applied 50% at hilling and the remaining applied at 8–11 day intervals after the onset of tuber bulking phase. Averaged across rates, the polymer coated urea (Environmentally Smart N or ESN) resulted in significantly higher US No. 1 yield than hilling and split applied urea an average of 8.5 and 5.2 Mg ha^{-1}, respectively. Total yield was not significantly impacted in all fields. Tuber size increased an average of 38 g per tuber. Subsequent glasshouse and field studies with ESN show that uncoated urea results in significantly more volatilization of ammonia (>110%) and more emission of nitrous oxide (>65%). Nitrate leaching trended lower for ESN than urea, but the difference was not significant. In addition to financial losses to the grower, ammonia and nitrous oxide losses are detrimental to the environment. Ammonia can be an odor problem, deposits N in water and sensitive ecosystems, and is a contributor to smog. Nitrous oxide is a potent, long lived greenhouse gas that is ~310 more potent than carbon dioxide. Use of properly manufactured polymer coated urea, such as ESN, is a best management practice for potato production.

Influence of pH, Sulfur, Chloride, and Potassium on Infection Severity of *Verticillium dahliae* in Russet Burbank Potato Roots

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Verticillium dahliae is a soil-borne pathogen that causes a vascular disease and is the primary causal agent of potato early dying disease (PED), which can reduce yields by 30–50%. Optimal pH, sulfur (S), chloride (Cl), and potassium (K) concentrations were used to grow potato to determine impacts on *Verticillium* infection. This was accomplished by inoculating plants grown in hydroponic solutions with varying pH and concentrations of S, Cl, and K. Solution pH levels were maintained at 5.0, 6.0, 7.0, and 8.0 using MES buffer and daily adjustment with HCl or KOH. Low, moderate, optimum, and toxic concentrations of S, Cl and K were used to determine influence on *Verticillium,* all other essential nutrients were kept constant. Impacts on *Verticillium* development were tested by inoculation of each treatment solution with 40 ml of a 100,000 spores / ml. Infection was evaluated in two ways; first, culturing on modified potato dextrose agar (mPDA) and second, DNA extraction and quantitative PCR. Comparative analysis of DNA produced infection coefficients (IC) relating the total DNA of both potato and *V. dahliae.* As pH levels increased from 5 to 8 the IC increased indicating higher levels of *V. dahliae* in the potato roots. Neither solution K nor Cl levels significantly influenced IC levels. However, as solution S levels increased, the IC values significantly increased, suggesting that S nutrition promotes higher infection of *V. dahliae*. There was also a significant Cl × S interaction on infection. Our preliminary findings suggest a need to minimize S application in fertilizers to reduce PED in Russet Burbank potatoes.

Starch Granule Variability in Tubers from Wild and Cultivated *Solanum* Species

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Because most of the dry matter in potato tubers is starch, an understanding of starch properties is important in potato improvement programs. Starch granule properties influence tuber quality parameters. This study was undertaken to characterize differences among wild *Solanum* species and cultivated potato clones with respect to starch granule properties, including surface area, length, width, and shape. These properties were found to be variable among species, accessions, and plants within accessions. Small starch granules were observed

in *S. gourlayi*, *S. oplocense*, and *S. infundibuliforme*, while large starch granules were found in *S. commersonii*. In addition, significant differences in starch granule size were observed among potato cultivars. Studies are underway to elucidate the genetic basis of starch granule size.

Volatile Compounds Analysis in Colorado Potato Cultivars and Advanced Selections Using Solid Phase Micro Extraction Technique (SPME)

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Potato is a staple dietary vegetable across the world and can be stored for prolonged periods. Potatoes are cooked before consumption, traditionally by boiling, baking or microwaving. There are over 250 compounds have been isolated from baked potatoes, but few have them have significant impact on flavor. Potato flavor results from the combination of taste, aroma and texture. Flavor is an important trait since it brings added value to the both the consumer and grower. We studied nine different flavor compounds in potato including alpha copaene, isobutyl 3 methoxy pyrazine, isopropyl 3 methoxy pyrazine, furfural, decanal, limonene, careen, pinene and methional using gas chromatography and mass spectrometry (GCMS). Volatile compounds were captured using a solid phase micro extraction technique (SPME) with on-fiber derivatization. We quantified some of these flavor compounds for three cooking methods: microwaving, boiling and baking. Our results indicate that cultivar differences exist in amounts and number of flavor compounds. In general russets have fewer flavor compounds compared to other cultivar studied. Methional concentrations were higher in microwaved potatoes compared to baked potatoes.

Recent Trends Suggest Optimism for the Sweetpotato Processing Industry

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Growing consumer interest in and consumption of sweet potatoes during the past 10 years has created a ramp-up in year round usage, new products within the food service and retail sectors, expanding processor capabilities, increases in acreage devoted to production, increases in farm revenue, and increases in farm sector employment. Relatively modest increases in per capita consumption (USDA data) (2009 3.7 lb per person versus 2009 5.3 lb per person) have had a significant impact upon the sweet potato growing industry (61% increase in tonnage produced, a 62% increase in farm value, and an 18% increase in acreage). No region has been more beneficially impacted than North Carolina which since 1999 has witnessed a 62% in acreage and since 2006 has experienced a 49% increase in farm value for sweet potatoes while all other states have realized a 30% increase. North Carolina's good fortune has not been attained accidentally. Today's presentation will briefly discuss the methods and successes at strategy development begun nearly a decade ago, the historic but critical linkage to tobacco production, and the early strategy implementation steps. Recent market trends (i.e. significant growth of sweet potato fry/chip processing and sales, etc.) will be presented coupled with insights into the future and mpediments to long term success, including transitioning from a fresh market focus to include a processed the expansion of processing dedicated to value added sweet potato products. Key challenges and/or i product focus, managing costs, weevil management, etc., will be reviewed with a focus upon the current planned activities. The presentation will conclude with a period for questions and discussion followed by four sweet potato technical presentations by representatives of NCSU and USDA.

Genetic Characterization of the *Rlr$_{etb}$* locus in Two Backcross 4 Families

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Potato leafroll virus (PLRV) is a primary virus pathogen of potato. PLRV-infected seed results in stunted and weak plants having dramatic reductions in tuber yield and quality. Plants infected with PLRV during the growing season can produce tubers displaying tuber net necrosis, ranging from a slight reduction in crop value to complete crop loss. Control of net necrosis by growers involves the application of insecticides to control aphids that vector PLRV. Use of potato varieties resistant to PLRV would contribute to sustainability in potato production by reducing insecticide applications during the growing season and increasing potato seed quality through reduced PLRV levels. However, of the ten most widely grown potato varieties in the U.S., none are resistant to PLRV. A gene, *Rlr$_{etb}$*, derived from the wild potato species *Solanum etuberosum*, has been identified and characterized as showing stable expression through successive backcrossing to cultivated potato. Genetic mapping localized *Rlr$_{etb}$* to potato chromosome four with linkage to COSII molecular marker C2_At1g42990. Utilizing tomato and potato genomic sequence data additional molecular markers have been developed on chromosome 4 distal to C2_At1g42990. Many of these markers reveal polymorphism for the *S. etuberosum* fragment in selected BC_2, BC_3 and BC_4 individuals. This effort has successfully identified markers that work in a BC_4 family (A05379) which could not be screened with the more distantly linked C2_At1g42990.

Effectiveness of Alternative Fungicides for Prevention of Late Blight (*Phytophthora infestans*) Transmission in Potato Seed

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Late blight-infected seed may remain viable during winter storage, depending on potato cultivar, *Phytophthora* genotype and storage temperature. During handling and subsequent storage of cut seed, healthy potato pieces may be infected by spores or mycelium from such tubers. Seven Oomycete-specific fungicides were compared with the two fungicides currently labeled for seed treatment, mancozeb and cymoxanil. Assessed were protection against infection by sporangia, infection by mycelia growing from infected tubers and suppression of mycelium growing out of infected tuber tissue. Of these three, infection by spores was most sensitive to fungicidal inhibition. At standard rates, mancozeb and mancozeb's various commercial bark formulations did not adequately prevent tuber-to-tuber spread of blight. With this type of inoculation, treated seed pieces developed internal infections without showing external signs or symptoms. Cymoxanil was adequate only at its highest labeled rate, but was the material most prone to inciting bacterial development ("sliminess") on cut surfaces. Applied to seed at 1/10 the amount labeled for the equivalent foliage produced, Forum, Presidio, Reason, Revus Top and Zampro all provided good to excellent suppression of mycelial growth and tuber-to-tuber spread of blight. Ranman and Previcure Flex did not. None of these five systemics delayed or reduced shoot emergence or gave indications of significant bacterial growth problems. They all appear to be effective candidates either for inclusion in potato seed protection

formulations or for tank mix partners with liquid seed treatments and would complement products lacking *Phytophthora* activity.

Tuber Production and Weed Competition as Influenced by Dairy Compost

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The addition of compost to cropping systems increases sustainability and crop productivity by building soil organic matter and improving soil quality. However, organic amendments such as compost may increase the competitive ability of weeds and reduce crop yield and quality. A field study was established in 2010 in Montcalm County to investigate the effect of compost on weed competition in potato. Three rates of cured dairy compost (0 kg C ha^{-1}, 4,000 kg C ha^{-1}, and 8,000 kg C ha^{-1}) were applied and incorporated to a 10 cm depth in late April, and 'Snowden' variety potatoes were planted mid-May. Starter fertilizer rate was adjusted based on expected compost N mineralization. Plots received three nitrogen (N) applications in addition to starter fertilizer at planting for a total of 205 kg N ha^{-1}. Plots were irrigated to maintain field capacity. Hairy nightshade, giant foxtail, or common lambsquarters seedlings were transplanted into the potato row at 5.3 weeds m row^{-1} at cracking. Plant height and biomass were recorded bi-weekly. Data was subjected to analysis of variance with significance determined at $\alpha \leq 0.05$. Common lambsquarters produced more biomass than hairy nightshade or giant foxtail, and adding compost did not increase the biomass of any weed species compared to where no compost was applied. Common lambsquarters reduced potato yield by 48%; whereas giant foxtail and hairy nightshade reduced potato yield by 20%. Adding 8,000 kg C ha^{-1} of compost increased total and marketable tuber yield by 15% when compared to the non-amended, regardless of weed competition. The 8,000 kg C ha^{-1} compost supplied more potassium, implying potassium limited potato production. Compost may increase potato yield without increasing the competitiveness of weeds.

Exogenous H_2O_2 in Potato Plants Infected by Phytoplasma Promoted Antioxidant Activity and Productivity Under Drought Conditions

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Interaction of plant water stress- phytoplasma on the occurrence of symptoms mediated by H_2O_2 and antioxidant response was studied in phytoplasma infected plants. In vitro plants phytoplasma positive and negative were transferred to greenhouse and sprayed twice a week with H_2O_2. Water condition: phytoplasma decreased water potential, catalase (CAT) activity and increased H_2O_2 content significantly. H_2O_2 significantly enhanced minituber weight and starch content in positive plants. Drought condition: minitubers produced by positive plants sprayed showed significantly more starch than the controls. Weight of minitubers was reduced in both negative and positive plants; however, H_2O_2 in presence of phytoplasma enhanced significantly the weight of minitubers, CAT activity and H_2O_2 content. H_2O_2 treatment induced higher internal H_2O_2 concentration which was associated to positive effects in infected minitubers, such as weight, reduction of number, starch content, sprouting, and tolerance to drought, a signal role for H_2O_2 in lessening symptoms is suggested

Small RNA Profile of Potato Leaves

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Small RNAs (sRNAs) from 18 to 25 nucleotides are abundant in all living cells and can be involved in gene regulation at the transcriptional and post-transcriptional level. There are multiple sources of sRNAs including non-specific transcript degradation; and sequence specific cleavage by different DICER proteins to form regulatory micro RNA (miRNA) and small inhibitory RNA (siRNA) that are associated with ARGONAUTE containing RNA induced silencing complexes (RISC) involved in gene regulation. The sRNAs from potato cv. Atlantic leaves were sequenced using high-throughput sequencing with the Genome Analyzer IIx. The 10,000 most abundant sequences were selected for further analysis. After elimination of erroneous and duplicate sequences (~370), 13% of sRNAs were attributable to tRNA, rRNA or chloroplast in origin. In most cases, the shorter (<19 bases) and longer sequences (>24 bases) belonged in one of these subgroups. There were 8,726 sequences (excluding the previous groups) between 19 and 24 bases. The 24mer sequences accounted for 66%, and 21 and 22mer sequences accounted for 20 and 11%, respectively. The sequences were compared to conserved miRNA families in miRBase (microRNA database; http://www.mirbase.org). A total of 79 sRNA from 20 to 24 bases were identified as belonging to 23 miRNA families. Potential miRNA and siRNA 21and 22mers were compared to the tomato sRNA database (Tomato Functional Genomics Database; http://ted.bti.cornell.edu/cgi-bin/TFGD/sRNA/home.cgi). The sRNAs and miRNAs unique to potato leaves were further examined for potential source/target sequences and precursor sRNA folding structures. The 9,727 cv. Atlantic sequences are publicly available in the USDA Potato Small RNA Database (http://potato.pw.usda.gov).

Using Cover Crops for Weed Suppression in Dryland Potato Production

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Weed control in dryland organic potato production relies on effective cultivation, harrowing, and weed suppressing varieties. Unfortunately, regular precipitation and slow soil drying with heavy textured soils make timely cultivation difficult and often impossible in the Red River Valley. A potential alternative, that maximizes early season weed suppression, uses winter annual cover crop species. When potato is planted into a desiccated cover crop residue, the residue acts to minimize weed seed germination. Cover crop treatments including no cover crop, winter triticale, winter rye, turnip/radish, and winter rye/canola were compared to current weed control methods in organic potato. Winter annual cover crops were desiccated chemically or mechanically prior to planting 'Red Pontiac' and 'Red Norland'. Weed counts and visual evaluations within a 0.093 m^2 quadrat were taken 17, 34, and 49 days after planting. Weed control was similar for all cover crop treatments. When looking at desiccation treatments, roller-crimping and disk tilling were superior to herbicide for weed weight and weed density factors, but no differences occurred between desiccation methods for overall weed control. The cover crop desiccation methods and subsequent planting presented mechanical difficulties, as seed were planted into no-till, high residue, and heavy clay soil. Yields were generally low for all treatments due to cultural factors. Some yield differences were seen between cover crop treatments, with an

intriguing yield drop for both winter rye treatments. Soil moisture sensors will be used to determine if moisture stress may have caused the yield decrease. The use of winter annual cover crops to suppress weeds in organic potato production may provide an alternative method for producers wanting sustainable weed control methods.

Weed Suppression with Cover Crops in Irrigated Potatoes

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Weed control in irrigated organic potato production relies on the effectiveness of cultivation, harrowing, and weed suppressing varieties. A potential alternative that maximizes early season weed suppression is the use of winter annual and annual cover crop species. When potato is planted into a desiccated cover crop residue, the residue acts to minimize safe sites for weed seed germination. A study was conducted to determine if cover crop treatments including no cover crop, winter triticale, winter rye, turnip/radish, and winter rye/canola were more effective than current weed control in organic potato. Cover crop residue was sufficient, and reached an average high of 5,892 kg/ha with the winter rye/canola combination. Cover crops were desiccated chemically or mechanically prior to planting the two potato cultivars 'Russet Norkotah' and 'Yukon Gold'. Weed counts and visual evaluations within a 0.093 m^2 quadrat were taken three times throughout the growing season; 14 days after planting (DAP), 29 DAP, and 51 DAP. Treatments that included a cover crop had similar weed control to treatments with no cover crop. Differences were also seen between the three cover crop desiccation methods, with the rototill treatment leading the way with the highest weed control from visual evaluations over disk tilling and herbicide. The three cover crop desiccation methods and subsequent potato planting presented mechanical difficulties, as potatoes are typically planted into well worked soil, as opposed to no-till or high residue soil. It was found that these mechanical differences did not result in a yield reduction, as yields were similar throughout all treatments. The use of cover crops to control weeds in organic potato production shows promise as an alternative method for producers looking for sustainable weed control methods.

Potato Yield and Early Dying Response to Green Manures and Organic Amendments in Manitoba

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Verticillium dahliae Kleb. is a persistent soil-borne fungus of potato (*Solanum tuberosum* L.) and responsible for the Verticillium wilt of potato. The objectives of this research were to evaluate select green manure (oat-pea, Canada Milk Vetch, fall rye, sorghum-sudan, 2-year sorghum-sudan, 2-year alfalfa), organic amendments (composted cattle manure, mustard seed-meal) and fumigation (Vapam) treatments for their ability to reduce propagule densities of *V. dahliae* in soil, incidence and severity of Verticillium wilt, and enhance potato yield. Compost and seed-meal treatments reduced disease incidence to 30% and 40% ($P<0.001$), but only seed meal reduced propagule densities in soil. Overall, 1 or 2-years of green manures did not lower propagule densities or improve potato yield. Application of metam sodium (Vapam) was effective in reducing propagule densities at the beginning of the potato season, but not at the end of the season. Potato marketable yield increased only with application of composted beef cattle manure. The seed-meal treatment did not increase marketable yield because of excessive soil nitrogen. Compost and oriental mustard seed-meal amendments have promise as an alternative strategy for the control of *V. dahliae*.

Impact of the Potato Psyllid and Zebra Chip Disease on Potato Seed Quality

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Zebra chip (ZC), a newly emerging and economically important disease of potato in southwestern United States, Mexico, Central America, and New Zealand, is associated with the bacterium "*Candidatus* Liberibacter solanacearum" transmitted by the potato psyllid, *Bactericera cockerelli*. The disease severely affects both fresh and processing potatoes and is causing millions of dollars in losses to the potato industry. Studies were conducted to increase the understanding of the role of the potato seed in ZC spread. Tubers produced from potato plants exposed to liberibacter-free and liberibacter-infective psyllids under controlled field cage conditions were planted in small field cages in Washington and Texas and observed for plant emergence, viability, ZC incidence, and yield. Results indicated that plant emergence for potato seed produced by psyllid-free plants and those exposed to liberibacter-free psyllids averaged 95.8% 2–3 weeks after planting and all produced ZC-free plants and tubers. No difference in yield was observed between these two treatments. In contrast, emergence of ZC-infected tubers from plants exposed to liberibacter-infective psyllids averaged 10% and occurred 8 weeks after planting. Although these emerging ZC-infected tubers initially produced hair sprouts which later turned into weak plants, none of the plants tested positive for liberibacter by PCR or produced tubers with ZC symptoms. These results provide further evidence that ZC-infected potato tubers do not play a major role in ZC disease spread as they do not sprout and if they do, usually produce ZC-free plants.

Genetic Diversity of *Potato Virus Y* (PVY) in Seed-lot Potatoes in New Brunswick

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Potato virus Y (PVY) has reemerged as a major problem in seed potato production in North America. It has been suggested that a change in the genetic composition of PVY has contributed to high PVY incidences. This study investigated the genetic diversity of PVY in seed-lot potatoes in New Brunswick (NB), Canada, in 2009 by testing 2000 tubers from 11 cultivars of 20 seed-lots. Multiplex RT-PCR, serological and biological assays were used to reveal and characterize the strain identities. Results indicated that PVY^{O} was the predominant strain in the province. However, recombinant strains, namely $PVY^{N:O}$ and European (Eu)-PVY^{NTN}, were also widespread in NB. $PVY^{N:O}$ was identified in 13 of the 20 seed-lots while Eu-PVY^{NTN} was identified in 11 of the 20 seed-lots. North American (NA)-$PVY^{N/NTN}$ was not detected in the 2000 tubers. Mixed infections with PVY^{O} and $PVY^{N:O}$ or PVY^{O} and PVY^{NTN} were found in 6 of the 20 seed-lots. Three PVY^{O} variant groups, i.e., PVY^{O}-Oz/-FL, PVY^{O}-139/-RB, and PVY^{O}-SASA-110-like/uncharacterized PVY^{O} type, were identified. The PVY^{O}-Oz/-FL was the predominant variant type followed by PVY^{O}-SASA-110-like/uncharacterized PVY^{O} type. Incidences of PVY^{O}-139/-RB isolates were low. PVY^{O}-Oz/-FL variant generally produced more severe symptoms in all 11 cultivars than other PVY^{O} types and PVY strains. These results clearly demonstrate the diverse nature of PVY in New Brunswick, Canada.

Nicolet: A New Long Storage Potato Chipping Variety with High Yield Potential

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Nicolet, previously known as W2133-1, was selected from a population of Snowden x S440 made in 1994. S440 provides cold chipping ability. Snowden provides high yield and wide adaptation. Nicolet was tested in un-replicated plots at the Rhinelander Research Station. During 2000–04, Nicolet was tested in replicated trials at the Hancock and Rhinelander Agricultural Research Stations. During 2005–07, Nicolet was evaluated in USPB/Snack Food Association trial locations and during 2006–2008, Nicolet was evaluated in the North Central Region. This variety has been evaluated in disease trials including common scab, early and late blight, Verticillium wilt, PVY resistance and expression. Nicolet was promoted in 2005 to seed production and on-farm trials in WI and in 2007 by the USPB-Fastrack project for commercial evaluation. The strengths of Nicolet as compared to Snowden are similar high yield potential and specific gravity, good internal quality and appearance, good tuber size and better cold storage ability retaining chip quality a month longer under 7.2–10°C. In addition, Nicolet has larger size profile as compared to Snowden. The sugar profile of Nicolet and Snowden out of 7.2 and 10°C were very similar from August to April. After April, Snowden's glucose and sucrose grew exponentially. Increase in glucose and sucrose was delayed for 1 month or more for Nicolet. Nicolet usually fries better than Snowden, especially when Snowden goes off-color after March-April. In addition, Tundra has strong vine type, and tolerance to Verticillium wilt and early blight similar to Snowden. We expect that Tundra provides a better choice for chip potato growers that require longer storage ability than Snowden.

Tundra: A New Long Storage Potato Chipping Variety with Consistently High Specific Gravity

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Tundra, previously known as W2310-3, was selected from a population of Pike x S440 made in 1995. The clone S440 provides cold storage chipping ability. Pike is appreciated for its common scab tolerance. Tundra was tested in un-replicated plots between 1997–2001at the Rhinelander Research Station. During 2001–04 Tundra was tested in replicated trials at the UW Hancock and Rhinelander Research Stations. During 2006 and 08, Tundra was evaluated in the North Central Variety Trial, and in 2010 in the USPB/Snack Food Association trial and from 2006 to 08 at several US locations. This variety has been also evaluated in disease trials including common scab, early and late blight, Verticillium wilt, PVY resistance and expression. Tundra was promoted in 2007 to seed production and on-farm trials in WI and in 2010 by the USPB-Fastrack project for commercial evaluation. The strengths of Tundra as compared to Snowden include producing better chip quality in long cold storage through six to nine months, consistently higher specific gravity over more than twenty replicated experiments carried out between 2001 and 2010, and better scab tolerance. This variety has low tuber internal defects. The glucose and sucrose profile of Tundra out of 7.2°C and 10°C is better than Snowden especially after 6 or 7 months in cold storage. Glucose and sucrose typically occurs 1 month or more for Tundra as compared to Snowden. In addition, Tundra has strong vine type, and tolerance to Verticillium wilt and early blight similar to Snowden. We expect that Tundra provides a better choice for chip potato growers that require longer storage ability and more consistently higher specific gravity than Snowden.

Responses of Potato Cultivars to *Potato Virus Y* Strain Groups

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Potato virus Y (PVY) is one of the most economically important viruses of the potato crop worldwide, causing significant yield losses and quality degradations. Multiple strains have been recognized. PVY^{O} and PVY^{N} were the basic strains, and from which, various recombinant strain groups including $PVY^{N:O}$ and PVY^{NTN} emerged. To better understand the interactions between potato cultivars and PVY strain groups, 14 common potato varieties were individually mechanically inoculated with PVY^{O}-FL (a severe PVY^{O} isolate), PVY^{O}-RB (a mild PVY^{O} isolate), $PVY^{N:O}$-Mb58, PVY^{N}-Jg or PVY^{NTN}-Sl in the greenhouse. The infection was confirmed by ELISA at 3 weeks post-inoculation. Foliar symptoms were monitored daily after the inoculation until harvest; and tuber symptoms, mainly potato tuber necrotic ringspot disease (PTNRD), were checked at the harvest and at 2 months post-harvest. The symptoms in plants varied significantly, depending on potato cultivar and virus strain. Cultivars 'Cal White' and 'Red La Soda' did not develop obvious symptoms regardless of PVY strains/isolates; and 'Russet Burbank' and 'Russet Norkotah' developed mild mosaic by PVY^{O}, $PVY^{N:O}$ or PVY^{NTN}. On the other hand, 'Jemseg', 'Ranger Russet', 'AC Chaleur' and 'Yukon Gold' developed local lesions and systemic necrosis in leaves by PVY^{O}, mild mosaic/mottle by PVY^{N}, severe mosaic by $PVY^{N:O}$, and milder but visible systemic necrosis by PVY^{NTN}. PTNRD was only observed in PVY^{NTN}-infected 'AC Chaleur', 'Cherokee', and 'Yukon Gold'.

A Scrutiny of the Two Week Wound Healing Recommendation for Cut Potato Seed

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The recommended, 2 week healing interval for cut potato seed was scrutinized across a range of varieties and post-harvest dates in this series of studies. Wound barrier formation was measured on cv. Klondike Rose immediately after digging, cv. Russet Norkotah at a post-harvest interval of 4 weeks and cv. Russet Burbank at a post-harvest interval of 3 months. Free-hand sections of living tuber were observed using fluorescent and incandescent microscopy for the presence of suberin, phellogen and phellem at intervals of 2, 4, 7, 10 and 14 days after cutting. Variations in the rate of wound barrier development were observed between the three cultivars but none were outside of acceptable parameters. At the end of each of the 14 day studies the tubers all had a well developed wound periderm. We concluded that the recommendation for a 2 week wound healing interval is appropriate.

Impact of Tri-Species Potato Germplasm on Behavioral Responses of Adult Potato Psyllid and Implications for Transmission of the Bacterium Associated with Zebra Chip Disease

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Unique germplasm derived from the wild potato species *S. etuberosum* and *S. berthaultii* has been shown to exhibit resistance to many insect pests of potato including green peach aphid, Colorado potato beetle, and wireworm. Based on the multiple insect resistances, this germplasm would seem to be a good candidate for resistance to potato psyllid, the insect vector of *Candidatus* Liberibacter solanacearum (CLso, syn. *Ca*. L. psyllaurous) which is associated with Zebra Chip disease. The haploid *tuberosum* x *S. berthaultii* parent and four generations of progeny from backcrossing to cultivated potato were screened for resistance to adult potato psyllid and to CLso in greenhouse evaluations. Relative to the potato variety Atlantic, significant reductions in psyllid probing occurrences and resting duration were observed in several of the evaluated breeding clones, suggesting resistance to potato psyllid; one clone also an increased duration of time off leaflet relative to Atlantic. In addition, the percentages of CLso- infected plants were significantly reduced relative to Atlantic for three clones representing three backcross generations. Of interest, was the observation that clone A00ETB12-3, with no apparent psyllid resistance, was among the three clones identified as having the lowest percentage of CLso- infected plants. This observation suggests possible resistance to CLso, and not just the psyllid vector, may be contributing to reduced CLso infection.

A Comparison of the Responses of Five Potato Cultivars to Chloride Stress from Either Sodium Chloride or Calcium Chloride

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Using an in vivo shoot culture system we have recently shown genetic variations for tolerance to salinity (NaCl) stress among major cultivars. We have shown that chloride stress results in injury when NaCl is used as a source but not from calcium chloride as a source. The present study was conducted to verify this in field conditions. For this purpose field trials were conducted using five cultivars, Snowden, Superior, Russet Burbank and Dark Red Norland. Standard cultural practices were used. Randomized complete design was used with four replications. At two times (7 and 11 weeks after planting) plants were given chloride salt treatments at the rate of about 100 Kg per hectare from NaCl, $CaCl_2$ or a combination of 50% NaCl and $CaCl_2$. Tuber were harvested and graded by the machine. About 70 A grade tubers from each replication were cut and examined for internal defects. From each treatment periderm and non-periderm tissue calcium concentration were measured. For this purpose a composite sample of 20 tubers was combined for Ca analysis from each replication. Our results show: (i) NaCl (salinity) stress reduced tuber yield in all the cultivars, however, this reduction was not as dramatic in the cultivar Superior. (ii) NaCl also reduced specific gravity (by about 5%) and tuber tissue calcium concentrations. (iii) Same amount of chloride supplied from calcium chloride as a source increased tuber tissue calcium concentrations in all cultivars and no negative impact on either tuber yield or specific gravity. These results support our previous studies that the negative impact of chloride on potato is only present when the source of chloride is NaCl.

The Use of Diabetic Test Kits to Assess Glucose Concentrations in Potatoes

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Process potato growers are acutely aware of how important glucose content is to final fry or chip color. Recently, fresh market growers and packers are concerned with tuber glucose content due to the increased demand for fresh-cut fries. The objective of this study was to evaluate currently available diabetic glucose test kits for accuracy and reliability in analyzing tuber tissue glucose levels. A total of 76 tubers consisting of six different varieties from four storage temperatures (3, 5, 7, and 9°C) were evaluated using two brand-name diabetic glucose meters and disposable test strips. Each tuber was cut longitudinally in half, center tissue slightly macerated, and resulting liquid measured via the glucose meter. The remaining tissue of each tuber was prepared in a buffer solution and analyzed utilizing a Yellow Springs Instrument (YSI) sugar analyzer. Values from the diabetic glucose meter (mg/dL) were correlated to glucose values from the YSI analyzer (%fwt). Both test kits gave correlation coefficient values of approximately 0.9 indicating a strong correlation with the YSI value. In this study, diabetic test values of approximately 75 mg/dL equated to 0.05% fwt glucose level in the tuber and values of 270 mg/dL equated to 0.20% fwt glucose. Values of 130 to 140 mg/dL equated to 0.1% fwt glucose. High diabetic test kit values (300 to 600 mg/dL) equated to 0.2 to 0.5% fwt glucose. These diabetic test meters displayed error readings for tubers with extremely low and high glucose levels. There appears to be value in utilizing diabetic test strips to follow the general level of glucose in stored potatoes or after transport and for retail markets to assess whether potatoes are acceptable for fresh-cut fries.

Addressing the Impact of Temperature stress on Potato Production: Merging Physiological and Genetic Approaches

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Two general approaches can be undertaken to develop strategies for sustainable production in a changing climate. (i) Understand and exploit the genetic and physiological variations that exist in the germplasm in relation to abiotic stresses. Studies should be aimed at identifying physiological and genetic traits that are linked to abiotic stresses. This basic information could be used to develop strategies for moving desirable traits to the cultivated potatoes. (ii) Develop production practices for mitigating the impact of abiotic stresses. Before implementing these approaches we need to understand the physiological and genetic mechanisms. Specifically, information is needed on mechanisms of injury and survival as well as on mechanisms of acclimation to abiotic stresses. We have made significant progress on these mechanisms in potato. Using potato as a model crop, this presentation will illustrate how we may develop strategies for sustainable production in a changing climate. We find that: (i) Genetic resources are available that can be deployed for improving the performance of cultivated potatoes under temperature stresses. There is a significant genetic variations among potato species for freezing and heat tolerance as well as for acclimation ability to temperature stresses. (ii) Cold and heat stresses impair cell membrane functions that appear to be mediated by changes in cellular/membrane calcium and changes in membrane lipid composition. Calcium can mitigate the response of potato plants to both heat and cold stresses; (iii) Precise screening for frost tolerance and acclimation ability has allowed us to improve frost hardiness of cultivated potatoes. By combining physiological and genetic approach we may address the issues related to climate change.

Fitting Winter Wheat in Potato Rotations

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The desired planting date for winter wheat in the High Plains is around the middle of September but potato and other summer crops in rotation with winter wheat are not harvested until late September or early

October. Stimulating seedling wheat growth under cooler conditions could allow wheat to be planted later and be established for winter survival. Gibberellic acid (GA_3) is the most active gibberellin hormone and naturally causes plants to grow taller. The objective of this study was to increase seedling growth of winter wheat under cool soil conditions. Field studies were conducted from 2005 to 2009 at Scottsbluff, NE. Seeds of cvs. Goodstreak, standard type, and Wesley, semi-dwarf, were treated with GA_3 at 0, 125, 250, 500, and 1,000 ppm and planted 18–20 Sep, 1–4 Oct and 10–15 Oct. Plant heights were measured in Nov (pre-winter), Mar (winter recovery), May (early growth), and July (final growth). Biomass was sampled in May, and grain yields harvested in July. Goodstreak treated with 250 ppm GA_3 planted later than mid Sep were as tall or taller than untreated plants sown earlier. Wesley showed the same effect when seed was treated with 1,000 ppm GA_3. In May, there was no effect of GA_3 on height or weight. In July, height, yield and seed viability showed no deleterious GA_3 effects. GA_3 will promote early growth of winter wheat when applied to the seed. It can stimulate growth sufficient to overcome a two-week delay in planting.

Impact of Limited Irrigation and Nitrogen Levels on the Chip Potato Atlantic

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Droughts are common in western Nebraska and recent irrigation restrictions were enacted in areas. A 3-year study began in 2009 to determine periods during potato production in which limiting irrigation by six inches would least impact market yield of the chipping cultivar Atlantic. The 2010 trial results will be presented. Planted in May, Atlantic was exposed to full irrigation, 61 cm total adjusted for rain, or to a limited irrigation regime when 15 cm of water were withheld, early season, late season, and some early and some late. Plots were subdivided by three N levels, 101, 168 and 235 kg/ha. Soil water was directly correlated to irrigation regime. Soil N and petiole N were higher under reduced irrigation indicating low N uptake and low N use. Vine growth was inhibited when water was limited but partially recovered when full watering returned; N level showed no mitigating influence. Tuber yield was reduced by all three limiting regimes but less so when the 15 cm were withheld between 8 and 13 weeks after emergence (WAE). Stress between 3 and 8 WAE resulted the greatest yield loss. Increased N partially overcame yield losses. Limiting water between 5 and 8 WAE resulted in lower tuber specific gravity, darker chips and greater incidence of common scab. These results will promote a better understanding of water and N interaction on market yield of potato in semi-arid environments. Growers forced to reduce irrigation of potato will know better how to manage the available water.

Sweetpotato Breeding and Genetics: Challenges in Developing Processing Varieties

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Sweetpotato breeding has mainly been focused on the primary market for sweetpotatoes, fresh market, with new cultivars being tested for suitability for canning. With the emergence of fries as a potential significant part of the market share, breeding programs are beginning to focus on traits that produce a better fry product. While many of the traits are the same as for the fresh market, yield and disease resistance for example, some are completely new. Little attention has been focused on the sugar profiles of raw sweetpotatoes since consumer quality is assessed on cooked product where native amylases have considerable influence over sweetness. The high temperatures and shorter cooking requirements of fries and chips leaves little time for the development of sugars, so raw sugars are of greater import. The quantity and distribution of reducing and non-reducing sugars is critical to control browning and affects consumer preference scores in taste trials. Adding traits to a breeding objective increases the amount of material to be screened to achieve the goal. However there are traits such as skin smoothness, skin color and lenticel prominence that can be relaxed if a cultivar was to be grown specifically for processing. An overview of the breeding methods used in sweetpotato breeding will be presented and related to the shift in importance of traits from tablestock to fry processing.

Suppressing Fungicide-resistant *Fusarium* spp. Causing Potato Seed-piece Decay and Post-harvest Dry Rot

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In recent years, strains of *Fusarium* spp., particularly *F. sambucinum*, with resistance to thiabendazole/thiophanate-methyl and fludioxonil have been recovered from tubers in storages across Canada. This fungicide resistance has limited the effectiveness of seed and post-harvest treatments resulting in increased disease at planting (seed decay) and in storage (dry rot). Trials in field and storage settings were established in Prince Edward Island, Canada from 2008 to 2010 to define alternative disease control strategies to manage fungicide-resistant strains of *Fusarium* spp. In one series of trials, cut potato seed was inoculated with a virulent strain of *F. sambucinum* that was resistant to both thiophanate-methyl and fludioxonil and then treated with one of a variety of chemical products (water control). Following chemical application, half the treated seed was incubated at 15°C for 6 weeks to observe the progress of decay; the remaining seed pieces were planted in the field according to a replicated experimental design. The same fungicide-resistant strain of *F. sambucinum* was used to inoculate wounded potatoes at harvest in a series of storage studies. Following inoculation, potatoes were treated with one of a variety of fungicide mixtures (water control) prior to 8 months storage in a climate-controlled facility. Seed treatments containing mancozeb or difenoconazole completely suppressed seed decay caused by a fungicide-resistant strain of *F. sambucinum*. Similarly, fungicide mixtures containing difenoconazole were able to significantly reduce post-harvest dry rot when applied as a liquid spray to tubers entering storage. Difenoconazole would appear to be a useful chemistry that has application both at planting and post-harvest for control of fungicide-resistant *Fusarium* spp.

Evaluation of Potentially Zebra Chip-tolerant Advanced Selections in Insect Preference Trials

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Zebra Chip (ZC) disease is a serious threat to potato production. The pathogen is a phloem-restricted bacterium known as '*Candidatus* Liberibacter solanacearum' (*C*Ls) vectored by the potato/tomato psyllid, *Bactericerca cockerelli*. Symptoms of *C*Ls-infected potatoes include stunting, leaf curling, chlorosis or purpling, swollen internodes, aerial tubers, and reduced yield. Other symptoms include darkening of the tuber medullary rays, especially during chipping, rendering tubers unsuitable for chip production. Over 400 selections/named varieties have been evaluated for tolerance/resistance to ZC one or more times as part of the Texas Potato Breeding Program. Data from repeated field trials throughout Texas and in Washington suggest that certain advanced

selections are ZC-tolerant, at least in small scale trials. Both insect preference and other unidentified mechanisms of tolerance appear to play roles. Seven potentially ZC-tolerant advanced selections were evaluated in caged field trials where insects were allowed to chose between selections replicated twice in each of six cages. Within cages, selections were randomized into groups of four plants and five psyllids per plant were introduced into the center of the four plants. Insecticide was applied to kill adults and progeny 7 and 14 days later. Results indicated that 100% of the replicates of the potentially ZC-tolerant advanced selection NDTX059828-2W produced tubers with no ZC symptoms. For two other advanced selections, TX05249-11W and NY138, 25 and 29% of the replicates produced tubers with no ZC symptoms. PCR was used for pathogen detection in both symptomatic and non-symptomatic tubers.

Soil and Fertilizer Effects on Blackspot Bruise Susceptibility, Specific Gravity, and Chip Color of 'Atlantic' Chipping Potatoes

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Fertilizer costs have increased dramatically in recent years and as a result there is an increased need for efficient use of fertilizers and soil nutrient reserves. Stringent quality specifications of processing contracts and potassium's strong effects on quality necessitate that recommendation systems consider crop yield and quality, as well as efficient fertilizer use. Research conducted at Aroostook Research Farm, Presque Isle, ME was designed to determine whether potato yield and quality could be optimized by controlling total K supply from soil and fertilizer sources. Potatoes (cv. Atlantic) were grown with or without potassium fertilizer (224 kg/ha, K_2O as KCl) for three years (2008–2010) on a non-irrigated field site with varying background soil potassium levels. Current-season K significantly improved chip color in all 3 years and increased yield and tuber size during two of three seasons. Current-season K decreased specific gravity (1.108 vs. 1.096) and blackspot bruise susceptibility. Over the range of soil-test K observed in this study, chip color improved with increasing total K availability (soil + fertilizer K, ~110 to 500 kg/ha) and tuber K concentration (1.0 to 2.2% d.m. basis). Yield increased linearly with total K availability, while hollow heart incidence decreased in two of three seasons. Blackspot bruise susceptibility and specific gravity decreased linearly with increasing total K availability and tuber K concentration. The information gained from this study will be used to help assure that soil-test recommendations provide a reasonable balance of costs, yield and processing quality.

Challenges to Sustainable Potato Production in a Changing Climate: A Research Perspective

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Potato production systems face constant changes in climate conditions and the projections for the future indicate that changes in temperature and precipitation are expected in certain regions of the world. The impact will depend on what we do today to avoid negative consequences. Climate projections might have mixed repercussions on crops. Some crops and areas will benefit and some will be negatively impacted. These projections are difficult to implement in data scarce countries where surrogate data must be constructed. The most likely temperature increases will not only have direct consequences on yield but are expected to produce an outburst of pest and diseases with consequences on productivity, use of toxic chemicals, and incorporating natural carbon sink locations into agriculture to guarantee food production. This might generate a vicious cycle that must be avoided. The challenge is to generate and promote appropriate technologies, management practices and policies that might not only maintain or increase yield but also reduce the dependency on incorporating more land into agriculture and the use of toxic chemicals that affect the environment and people's health. The presentation will highlight some of the research the International Potato Center is conducting in developing countries, mainly on the development of tools and methods to better assess the challenges to sustainable potato production.

Purple Potato Anthocyanins, Even After Processing, Exert Anti-cancer Properties in vitro and Suppress Oxidative Stress in Obese Pigs

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Anthocyanins, found in colored-flesh potatoes are known to possess anti-oxidant and anti-cancer properties both in vitro and in vivo. Thus, colored potatoes could be a promising delivery vehicle for these health-benefiting dietary compounds. However, potatoes are mostly processed (baked, chipped etc.) before consumption. The aim of this study was to determine the effect of processing on potato anthocyanin metabolites (UPLC/MS), its bioactivity in vitro (anti-cancer properties), and in vivo (oxidative stress; obese pig model). Principal component analysis revealed that metabolite profile of the potato (Atlantic and Purple Majesty) did not vary between fresh and baked samples; however, chipping altered the profile significantly. Extracts of baked and chipped potato suppressed HCT-116 human colon cancer cell proliferation and induced apoptosis, however, processing attenuated (chips > baked) the anti-cancer activity. To further assess the beneficial effects of colored potatoes, we measured oxidative stress marker 8-isoprostane in obese pigs provided with high-fat diets containing 10% or 20% white/purple potato chips for a 5 week period. Potato diets had no effect on food intake, weight gain and back-fat thickness. However, purple potato chips suppressed serum levels of 8-isoprostane, a sensitive marker of systemic oxidative stress. This study suggests for the first time reports that processed purple potatoes retain their bioactivity. Future experiments will assess the effect of raw vs. processed colored-flesh potatoes on colonic-systemic inflammatory cascade.

Mining the Potato Germplasm to Prepare For Sustainable Production in a Global Climate Change Scenario

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In its Andean homeland the potato is challenged by drought, heat and cold stresses and is adapted to a variety of edaphic environments. The genetic variation available to breed potato for the current and future problems of sustainability can be expected to be greatest in wild potato species which are exposed to the most extreme environments, high in Andean landraces, and lower in the Chilean landraces which are adapted to a damp climate and which contributed greatly to the high yielding varieties grown across the world today. This presentation will show how linkages can be made between different approaches to deliver new tools for breeding. The development and potential of two types of population capturing Andean diversity in useful form will be described. These populations exhibit broad variation for rooting traits, mineral uptake and redistribution and other tuber traits. For tuber mineral traits, an integrated approach will be described which brings together multivariate analysis of tuber mineral levels in wild, landrace diversity populations and modern potato with genetic analysis using

both diversity and biparental genetic mapping populations. Progress on understanding the mechanisms of mineral accumulation, and genetic analysis linking quantitative trait loci to potato genome locations and candidate genes at these locations will be described. Finally, wild potato species may add additional traits not already present in cultivated germplasm. The rooting profiles and tuberization strategies of a panel of wild species will be described to indicate their potential to enhance further sustainability traits in cultivated potato. The prospects will be discussed for the use of knowledge gained from the marriage of appropriate genetic resources with genomics.

Purple Potatoes Alter the Gut Microbiota and Inflammatory Eicosanoids in Obese Pigs Consuming High-fat Diet

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Colored potatoes are becoming popular for their putative health benefits. The purpose of this study was to determine the effects of purple and white potato chips on gut microbial signature and colonic and systemic inflammatory markers in obese pigs. Pigs on the high-fat diet for 12 weeks were provided with diets containing 10% or 20% unsalted white or purple potato chips. Experimental diets had no effect on food intake, weight gain and back fat thickness. Using pyrosequencing bacterial lineages were determined in the ileum, proximal and distal colon, and fecal material 5 week after starting on the experimental diets. Distal colon microbial signature was similar to that of fecal material and purple potatoes (20%) increased the diversity of bacterial taxa compared to white and control diet. Purple potatoes not only suppressed colonic pro-inflammatory eicosanoids elevated during ulcerative colitis (PGE2, 12-HETE and 15-HETE; LC-MS-MS) but also alleviated the systemic inflammatory markers such as serum 8-isoprostane (ELISA technique) levels. Thus, this study provides the first evidence that purple potato diet increased the diversity of bacterial taxa in the colon and concomitantly suppressed the potential colonic-systemic inflammatory cascade in obese pigs via eicosanoid pathway.

Defense Induction in Potatoes Against *Phytophthora infestans* (Mont. De Bary) by Fungicides

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Recent studies on the mode of action of fungicides also consider their influence on the host defense mechanisms. In order to quantify some host defense stimuli triggered by early exposure to fungicides, combined with natural infection by *Phytophthora infestans*, in the Toluca Valley, México, potato seed-tubers cv. Alpha, susceptible to *P. infestans*, were sprayed with fungicides at planting (Azoxystrobin, Boscalid-Pyraclostrobin, Pyraclostrobin, or Fosetil-Al). Additional treatments included one foliage spray 30 days later. No foliage protection was observed when plants were seed-treated only. The infection in these treatments was similar to that of the control with no fungicides. On the other hand, final infection reached 60–80% of that of the control when foliage was additionally sprayed once 30 days after planting. When treatments were only to the seed, there was similar synthesis and/or activity on metabolite patterns among treatments, with high correlation among variables. As infection levels increased, so it did phenols (FEN), peroxidase (POX), and phenylalanine ammoniolyase (PAL). When seed and foliage-treated, the plants showed inconsistency in POX and superoxide dismutase (SOD) activity. However, Fosetil-Al did stimulate SOD and PAL much more than the other products, although correlations were limited to SOD-infection and SOD-POX, while PAL effect was independent. The products included in this study did stimulate non-specific host reactions, but not enough as to protect the plants against *P. infestans*, which is not directly affected by the products, except by Fosetil-Al.

Population Characterization of *P. infestans* in Michigan During 2008 to 2010

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Isolates of *Phytophthora infestans* characterized as the new genotype US-22 collected from potatoes and tomatoes from 2008 to 10 in Michigan, USA differed in pathogenicity after cross-inoculation studies over the two crops and in other characteristics. The appearance of this new clonal lineage, which started in tomato plants was sudden and has displaced the US-8 clonal lineage in Michigan at least in potato crops. This study focused on the analysis of *P. infestans* isolates obtained during 2008 to 2010 in Michigan, and compared them to reference isolates. Characterization included mating type, GPI allelozymes, virulence, resistance to mefenoxam, mitochondrial DNA haplotype (mtDNA) and DNA fingerprinting based on simple sequence repeats (SSR). Most of the isolates were mating type A2, 100/122 GPI profile and Ia mtDNA haplotype. These characteristics were attributed to a new clonal lineage US-22, recently found in the US. Resistance to mefenoxam (EC_{50}) ranged from <0.1–91 μg/mL, where most of the isolates were classified as intermediate. Race composition and tuber pathogenicity were also variable among isolates, but those obtained from tomato were less pathogenic in tubers than those obtained from potato. To further characterize the population, SSR were used and revealed different genotypes within the US-22 designation from isolates collected from tomato and potato. Despite the different virulence races observed, the genotypic diversity observed was low. The continuous tracking of changes within *P. infestans* population could yield evidence of genetic shifting due to introduction of new genotypes to the region or due to variability generated by management, environmental conditions and cultivars.

Research Update on Potato Zebra Chip Disease in Toluca, Mexico

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Potato zebra chip is affecting most of the potato growing areas in Mexico. In the middle of the nineties the disease started to be an important constraint on potato production in The Toluca Valley. Initially, it was assumed that a phytoplasma was the causal agent and leafhoppers the vectors. However, recent studies have shown that the bacterium *Candidatus* Liberibacter *psyllaurous* is the principal causal agent of the disease and the potato psyllid *Bactericera cockerelli* is the vector. Phytoplasmas have been found in only 3.5% of the diseased tubers, however the interaction between phytoplasmas and the bacterium has not been determined. The climatic conditions in The Toluca Valley are favorable for the potato psyllid development. This insect may survive during the winter feeding on diverse plants and growing in population during the spring, summer and fall. Monitoring of adult insects has shown picks of 26 insects/week trapped in yellow sticky traps of 22×22 cm size. The PCR analysis of adult insects has shown that 30% are positive to the

bacterium *Candidatus* Liberibacter *psyllaurous* , which indicates a high infection pressure. Even though the potato crops are weekly sprayed with insecticides, the potato tubers produced in The Toluca Valley have shown between 50 and 90% of zebra chip symptoms. Researchers of INIFAP have been breeding and evaluating potato genotypes looking for zebra chip resistance. Only few potato clones have not shown foliar symptoms, and internal tuber browning has been observed in a wide range of intensities. So far, no good genetic resistance source has been found.

Effect of Steam and Microwave Cooking on Total Anthocyanins and Antioxidant Activity in Purple, Red, Yellow, and White Fleshed Potato Genotypes

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There is currently a great interest in increasing the nutritional antioxidant content of foods to improve long-term human health. Anthocyanins in colored-flesh potatoes are an under-utilized source of antioxidants, but may be negatively impacted by domestic cooking methods. We examined the effect of steam and microwave cooking on total anthocyanins and the antioxidant activity of white, yellow, purple, and red-fleshed potato cultivars and advancing selections over a 3 year period. Anthocyanin content was positively correlated with antioxidant activity measured by the FRAP assay and was responsible for 79% of the antioxidant activity. Red-fleshed genotypes had an average of seventeen-fold more, and purple-fleshed genotypes had an average of eight-fold more anthocyanin, compared to white and yellow-fleshed genotypes. Both cooking treatments affected total anthocyanins in all 3 years. Anthocyanin concentration was reduced by cooking in the first 2 years, but was increased by cooking in the last year. Thus, cooking potato tubers does not necessarily reduce antioxidant activity and its benefits.

Oospore Potential of Newly Introduced Genotypes of *Phytophthora infestans*

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Late blight caused by *Phytophthora infestans* is the most destructive potato disease worldwide. In 2009 and 2010 genotypes of *P. infestans* never before documented in Wisconsin were identified on tomatoes and potatoes. 33 isolates were characterized for allozyme genotype using cellulose acetate electrophoresis revealing 3 banding patterns indicating US-22, 23, and 24. Mating type analyses identified US-22 isolates as A2, and US-23 and US-24 as A1. While isolates of opposite mating types were geographically isolated, the potential exists for oospores, which could challenge current management strategies. We evaluated the ability of the 3 genotypes to produce oospores on detached leaves of susceptible potato (Katahdin) and tomato (Brandywine Red, Bonny Best, Zebra Green) cultivars. Leaves were inoculated with sporangial suspensions of opposing mating types, A1 (US-23 and 24) and A2 (US-22), and incubated in 100% relative humidity chambers at 12, 16, and 20°C for 3 weeks prior to evaluation for oospores by microscopy. Oospores were produced with all mating type pairs in the leaf tissue of all cultivars. Tomato cultivars were better hosts for oospores than potato, with a mean of 44.5 oospores/mm^2 leaf area for tomato and 30.5 oospores for potato. Oospore production occurred at all temperatures, but was greatest at 16°C. The co-inoculation of US-22 with US-24 produced, on average, 46 oospores/mm^2 leaf across hosts and temperatures. Co-inoculation of US-22 with US-23 produced, on average, 32 oospores/mm^2 leaf across hosts and temperature treatments. In the laboratory, we have demonstrated the potential for oospore production with newly introduced *P. infestans* genotypes. Continued careful management of late blight is necessary to maintain the current geographical separation of these genotypes.

Key Sweetpotato Cultural Management Practices and Production Efficiencies to Consider for the Processing Industry

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Economically, sweetpotato (SP) is the most important vegetable crop grown in North Carolina (NC) and valued at $170 million in 2009. NC is the leading state producer of SP accounting for 47% of the crop sold in the U.S.; its climate and infrastructure is well suited for the production of this tropical crop. The primary focus of the SP industry is the fresh market. Key processors have had double digit growth in SP fry sales the last 5 years, thus the processing market has received increased attention. The Micropropagation Unit and Repository at NC State University was established in 1996 – it is a model program and insures that only the highest quality SP propagules are reproduced annually and distributed to the industry. Much hand labor is required to produce SP, a substantial cost being plant establishment. To reduce plant establishment costs, we are searching for genetic material and production practices that will produce high yields and quality roots using cut seed pieces. Unlike white potato which uses the tuber for planting, SP roots currently cannot be used as a propagule. Other areas of production importance and research focus are soil moisture and irrigation, planting considerations, and pest management. Key elements in each area will be reviewed. Harvest in NC is mainly by hand and is the other high cost component related to SP production. The crop must be handled with care as the skin of the SP is easily damaged during harvest. Since the crop is primarily sold for fresh market, the cosmetic condition of the root is very important. Mechanical harvest of the SP crop will be an important means in which to reduce production costs. A shift in paradigm is necessary to best meet the needs of the SP processing industry.

Evaluation and Application of Molecular Markers within the Australian Potato Breeding Program

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Implementation of marker-assisted selection (MAS) within the Australian potato breeding program is highly desirable to increase the efficiency in generating improved cultivars, with the highest priorities being the development of cultivars resistant to potato cyst nematode *G. rostochiensis* Ro1 (PCN) and potato virus Y (PVY). The TG689 marker linked to the PCN resistance gene, *H1*, was evaluated across 281 tetraploid cultivars; however there was loss of linkage between the locus and marker in 7 cultivars. Recently an alternative SCAR marker was identified flanking the *H1* locus and was evaluated across the same 281 cultivars for association with PCN resistant phenotypes. With one exception, the presence of a diagnostic product from the 57R marker was predictive of the PCN phenotype. Screening of 103 un-characterised parental lines identified an additional 30 PCN resistant cultivars through genotyping alone. In parallel, over 550 parental and breeding lines were genotyped for PVY resistance with two molecular markers, RYSC3 and STM0003, linked with the resistance genes Ry_{adg} and Ry_{sto}; however only 5 cultivars amplified the diagnostic product from either marker. To implement genotyping in the most efficient manner,

all PCN and PVY markers have been converted to fluorescently labelled markers resolved on capillary electrophoresis platforms in multiplexed formats and have been screened across early generation breeding lines in Australia.

Irrigation Systems and Bed Configurations Influence Potato Variety Performance

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Irrigation methods for potato production should be conducive to high tuber yield and quality while ensuring minimal water losses to deep percolation and runoff. Furrow, sprinkler, and drip irrigation systems with variable bed confirmations were compared for the production of four commercial varieties; 'Russet Burbank', 'Ranger Russet', 'Umatilla Russet', and 'Premier Russet'. In all six irrigation system plus bed conformations were tested. Bed conformations included hilled beds for furrow and sprinkler irrigation and flat beds for drip and sprinkler irrigation. Irrigation criteria were based on soil water tension. Also drip irrigation was tested on flat beds with an ETc irrigation criterion. The sixth treatment combined sprinkler irrigation, flat beds, and straw mulch. Both the irrigation systems and hilled rows made clear differences in potato performance across the cultivars studied. The drip-irrigation was conducive to the production of U.S. No. 1 tubers and the furrow-irrigation was least conducive. Furrow irrigation was the least productive system tested. There were tendencies for flat beds to be advantageous compared to hilled rows. None of the varieties tested expressed hollow heart, brown center, internal brown spot, or vascular discoloration in any of the irrigation treatments. Russet Burbank had significantly lower grade and specific gravity, and darker stem-end fry color. Potatoes grown with drip irrigation on flat beds had among the lightest fry colors. Premier Russet had the largest proportion of US No. 1 tubers and the largest yield of marketable tubers compared to the other cultivars.

Development of a Super Spud through Repeated Cycles of Marker-free Transformation

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The potato industry is faced with numerous issues related to disease susceptibility, tuber quality, and, most importantly, acrylamide formation. A new approach to genetic engineering (GE) was developed to overcome many of these problems while addressing negative public perception issues that are associated with conventional GE methods. Using marker-free and all-native DNA transformation, we introduced a first series of traits into five potato varieties. The ten resulting "intragenic" or Innate™ events displayed black spot bruise tolerance and reduced cold sweetening, and also had an acrylamide-forming potential that was four-fold lower than that of untransformed controls. A petition for deregulation of the events will be submitted to the USDA in 2011. Efforts have been initiated for the marker-free stacking of three additional traits: further enhanced cold sweetening, late blight resistance, and resistance to potato virus Y. Frequencies for backbone-free transformation were about 5% for simple plant-derived transfer (P-) DNAs, 1.5% for more complex P-DNAs containing inverted repeats, and 0.5% for P-DNAs containing a late blight resistance gene. These commercially-feasible frequencies were achieved by using optimized tissue-culture media and super-virulent *Agrobacterium* strains.

Association of Soil Properties, *Verticillium* Propagules and Plant-parasitic Nematodes with Potato Early Dying and Yield in Manitoba

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Two field studies were conducted to determine the relation of soil properties, Verticillium propagule and plant-parasitic nematode soil numbers to the visual incidence of potato early dying (PED) in Manitoba. In late August 2003, 21 commercial potato fields planted to cv. Russet Burbank were sampled. Soil organic matter (SOM) concentration was most related to the incidence of PED. An increase in SOM from 2 to 6% (ww^{-1}) resulted in high incidence (>80%) to low incidence (<10%). In 2004, four commercial cv. Russet Burbank fields were analyzed for soil properties, abundance of *Verticillium* soil propagules and plant-parasitic nematodes to determine their association with PED and tuber yield and quality. Soil was collected from asymptomatic (Healthy) and symptomatic (Diseased) patches in late August. Abundance of *Verticillium* propagules was higher in Healthy patches compared to Diseased patches. Regardless of patch type, abundance of *Verticillium* propagules were consistently high, being >74 g^{-1}soil, which is well above disease threshold levels. Multiple regression and principal components analyses revealed SOM and electrical conductivity to explain variation PED. Compared to Diseased, Healthy patches had higher SOM and moisture but lower electrical conductivity and pH. Greater PED disease incidence promoted lower fry quality dark end tubers and smaller tubers. These findings indicate the importance of soil conditions especially SOM and salinity, in managing PED and promotion of yield.

Biochemical Changes in Sweetpotatoes during Storage and Implications for Processing of Value-added Products

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Consumer demand for processed foods from carotene-rich sweetpotatoes (SP) especially SP French fries, chips and puree-based products has increased in recent years in the United States. However, variation in root quality among the cultivars during long-term storage remains a challenge in large-scale production of these thermally processed products. For commercial success, the products should be of consistent quality regardless of root storage duration. At harvest, the commercial SP cultivars contain 18–22% dry matter, 10–13% starch, 0.2–1.2% reducing sugars (glucose, fructose) and 2–3% sucrose. After 1 week of curing at 30°C and 85–90% relative humidity (RH) as commonly practiced for fresh SP markets, reducing sugars increased by 2–6 folds while sucrose slightly increased by 1.2–1.5 folds. These sugars had sharp increases up to 6 weeks in storage at 13–15°F, 85–90% RH then followed by incremental increases until 48 weeks. The levels of dry matter, starch and beta-amylase activities decreased while alpha-amylase activities increased during long-term storage. The higher concentrations of reducing sugars are often associated with more browning and acrylamide formation in processed products. On the other hand, high levels of sucrose, starch and amylase activities can have beneficial effects on sweetness and textural properties of SP fries and purees. Therefore, selection of genotypes with low reducing sugars (<0.2%), high sucrose content coupled with appropriate postharvest handling practices and processing techniques should be considered as an integrated approach to provide SP with suitable quality for the food processing industry.

Control of Blemish Diseases on Potato

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Potato blemish disease complex caused primarily by *Helminthosporium solani*, *Colletotrichum coccodes,* and *Rhizoctonia solani*, is characterized either by scurfy-silvery patches on the tuber skin or sclerotia which reduce the value of seed potatoes and production potential, and cause re-infection of daughter tubers grown from infected seeds. The damage caused by these diseases became a major problem in potato production due to an increased demand for washed potatoes with a high-quality appearance.
Israel imports 25,000 t of seed tubers each year from northern Europe (mainly from the Netherlands and also from Scotland (83%). With the imported seed tubers, various seed-borne pathogens are imported as well, affecting both the spring yield (including seed tubers harvested early in spring and planted during the autumn and winter), and the winter yield. Furthermore, part of these seed-borne pathogens which are also soil-borne, establish in the soil and become a major problem which requires frequent soil fumigation or other treatments to reduce soil infestation. A survey done during the last decade indicated that 74% of the imported seed lots were infested with *R. solani*, 84% with *H. solani* and 48% with *C. coccodes*.
Seed tuber, in-furrow or other soil treatments should be considered according the levels of contaminations with all pathogens involved in the blemish disease complex. Evaluation of seed tuber and in-furrow treatments for controlling the disease, with emphasis on environmental-friendly methods will be discussed.

Effect of Purple and White Potato Extracts on Prostate Cancer Development in Athymic Nude Mice

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Bioactive compounds are widely noted for their role in chemoprevention. Potato is a vegetable with high per capita consumption and thus an ideal delivery system for beneficial compounds. The anti-proliferative and pro-apoptotic properties of potato bioactive compounds in vitro have been reported using human prostate cancer cell lines. In vivo studies are limited, and more information is needed to determine the bioavailability and chemopreventive properties of potato in the diet. The objective of this study was to evaluate the effects of potato bioactives on prostate cancer in vivo using a mouse model. Thirty athymic nude mice received xenografts of human prostate cancer cells (PC-3). Following tumor development, the mice were randomized by tumor volume and weight and placed into three treatment groups, which included treatment with water or extracts from *S. bulbocastanum* or CO112F2-2 (a purple fleshed selection). Treatments were administered by oral gavage every other day for a total of 15 treatments. Neither purple nor white potato extracts affected weight gain or the weight of vital organs (liver, kidney and lung), indicating that these extracts are not toxic. No differences in tumor growth rate and tumor volume were observed. Effects of potato extracts on angiogenic and metastatic factors will be reported.

Challenges and Opportunities for a Hobby Potato Varietal Development Program

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Plant Breeders Rights legislation in Canada provides opportunity to private potato breeders to gain royalties from the seed sales of their released varieties. Twenty years ago the senior author started a varietal selection program as a hobby alongside commercial potato farming. The program depended on obtaining true potato seed of desired crosses from public breeding programs, particularly Cornell University, where the senior author had spent a sabbatical. To date 3 varieties with attributes related to scab resistance and chipping quality are registered. These varieties presently cover about 300 ha. Many more promising varieties are in the pipeline including varieties with glandular trichomes, which taste good. Will the materials developed have an impact on potato production?
Several challenges have become obvious. Breaking into the market remains daunting. Competition with large private and public sector breeding programs leaves the small program at a major disadvantage. These challenges could discourage the future of these small hobby programs that presently exist in 3 provinces of Canada.
Opportunities exist. Public private partnerships between Public breeding programs, who develop the desired populations and hobbyists who evaluate the tuber families and select the winners, would be a win-win scenario. The division of royalties would be an issue to resolve. A similar partnership would need to be developed between the hobby breeder and the companies who need or want potato varieties with specific attributes. There would need to be agreements in place that would be beneficial to all parties. Clearly the small hobby breeder needs to align with others in the chain to have a greater chance of successful impact.

Resistance to Early Blight in Hybrids Between a *Solanum tuberosum* Haploid and *S raphanifolium*

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Early blight of potato (*Solanum tuberosum L.*), caused by the foliar fungal pathogen *Alternaria solani* is a major cause of economic loss in many potato growing regions. Genetic resistance offers an opportunity to decrease fungicide usage while maintaining yield and quality. In this study, an early blight resistant clone of the diploid wild species *S. raphanifolium* (rap 119–2, PI 473369) was crossed as a male to the haploid US-W4 (2n=2×) of cultivated potato. Hybrids were backcrossed to both parents. Eight families were created and evaluated for early blight resistance in the field. Families created by backcrossing to the wild species parent were more resistant than those from backcrossing to the cultivated parent. Clones were identified with high levels of early blight resistance and adaptation to the photoperiod of a temperate production region. Male sterility, likely due to nuclear-cytoplasmic interactions, was observed in some US-W4 x rap 119-2 hybrids. Pollen-pistil incompatibility was also observed in some crosses involving the hybrids.

Evaluating the Spread of Potato Powdery Scab in Storage

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Powdery scab, caused by the plasmodiophorid pathogen *Spongospora subterranean*, is a potato disease that has recently become a great concern in potato-growing regions of North America. Persistent resting spores (cystosori) can survive in soil for more than 6 years and their ability to cause disease are promoted by cool, moist weather and poorly drained soil conditions at tuberization. Cystosori are created in scab lesions that erupt through the periderm and can cause infection at and post-harvest. In this 2-year study we investigated the spread of powdery scab from field-infected tubers to asymptomatic tubers in storage at the University of Wisconsin Hancock Storage Research Facility. In 2009, after 82 days in storage, 8 treatments composed

of serial distributions of symptomatic and asymptomatic tubers resulted in 76–100% infected tubers. All treatments resulted in correlation between powdery scab infection and tuber desiccation. In 2010, the disease-spread experiment at 45 days resulted in low disease severity and slight desiccation on wounded tubers. All treatments, including those with ambient ozone (emitted at 10% O_3 to O_2 rate) and phosphorous acid salts, did not result in significant differences at this initial rating. Variable results between years may be resolved with extended ratings out to 90 days in storage as disease is allowed to progress. Statistical differences among treatments will be evaluated with a second rating at 90 days, as well as comparisons between the current and the 2009 experimental data. Due to the longevity of this pathogen in soil, and the heightened risk of infection to red-skinned potato varieties, it is critical that we better understand the role and risk of powdery scab in Wisconsin potato production and storage.

Impact of Alfalfa on Soil-Borne Enzymes in Potato Systems

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Potatoes are commonly grown in two-year rotations with corn, wheat or other annual crops in MI. Due to the expense and lack of marketability, long-term cover crops like alfalfa are not usually included in the rotation. Four fields were selected in Mecosta Co, MI to evaluate the impact of alfalfa on soil enzymes (β-1,4-glucosidase, N-acetyl glucosaminidase, phosphatase, tyrosine aminopeptidase, and phenol oxidase), carbon mineralization potential and nematode community structure; compared to potato-seed corn rotation. The sites have been used for potato production since the 1970's. Two of these fields, however, were taken out of potato production and used to grow alfalfa hay for 10 years. These fields were returned to potato production in 2009. The sites were sampled in 2009 and analyzed. The research tested three hypotheses: 1) alfalfa production results in greater soil enzyme activity in Mecosta and Covert sands compared to a seed corn-potato rotation, 2) continuous alfalfa production results in greater carbon mineralization than that associated with a potato-seed corn rotation, and 3) nematode community structure is more diverse in alfalfa production compared to a potato seed corn rotation. The results indicated that phosphatase and tyrosine aminopeptidase activity was significantly greater in soil from the alfalfa than soil from the potato-seed corn rotation. Carbon mineralization of soil from the continuous alfalfa was significantly greater ($P<0.05$) than that from the potato-seed corn rotation. There were significantly more omnivorous and herbivorous nematodes associated with the continuous alfalfa, compared to the potato seed corn rotations. These results indicate that soil quality can be influenced through use of a cover crop such as alfalfa.

Achieving Sustainable Potato Production Through the Use of New Potato Varieties with Reduced Fungicide Requirements

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One of the primary goals of the potato industry is to enhance sustainability by optimizing the efficient use of agronomic inputs. One approach to achieving this goal is to exploit the higher levels of disease resistance in new potato varieties. The Northwest Potato Variety Development Program (NPVDP) has developed new varieties with higher disease resistance than the standard, Russet Burbank. The objective of this study was to determine the extent to which fungicide inputs for newly released NPVDP potato varieties can be reduced. The performances of five NPVDP varieties and Russet Burbank were evaluated in traditional and reduced-fungicide management programs. Plots were fumigated with metam sodium at zero, low, medium and high rates prior to planting to control Verticillium wilt. Fungicide treatments consisted of a seed treatment, in-furrow treatment and one foliar fungicide application, a seed treatment, in-furrow application and four foliar applications, and no fungicides. Foliar disease severity of early blight and white mold over the season was rated as the relative area under the disease progress curve. Levels of Verticillium wilt were estimated in the field by visually rating plant wilt and soil levels of the wilt pathogens *V. dahliae* and *Colletotrichum coccodes* were assessed by qPCR. Yield data were collected at harvest. Overall results showed that all NPVDP varieties performed well under reduced-fungicide management programs and significantly better than Russet Burbank.

A Regional Sampling Network for Insect Pests of Potato in the Columbia Basin of WA

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A regional sampling program for insects was established in the Columbia Basin of Washington to provide potato growers with current information about the size and location of important insect pest populations. The sampling network functions as an early warning system that prompts growers to intensify scouting in and around their potato fields when pests are identified in the area. It also contributes to a better understanding of the movement and biology of insect pests in the region. The program targets three key insect pests: green peach aphid (*Myzus persicae*) (GPA), beet leafhopper (*Circulifer tenellus*) (BLH), and potato tuberworm (*Phthorimaea operculella*) (PTW). Each of these pests must be observed closely and managed when needed to minimize yield and quality losses that can result from the insects feeding, and in the case of GPA and BLH from the plant pathogens they transmit to potatoes. Potato fields across the Columbia Basin are monitored weekly from May to October using yellow sticky traps for BLH, pheromone traps for PTW, and plant samples for GPA. Observations of other foliar arthropod pests (Colorado potato beetle, thrips, lygus bug, and two-spotted spider mite) and natural enemies (big-eyed bug, damsel bug) from plant samples are also recorded. Results from the sampling network are presented to growers in weekly "potato pest alerts" sent via e-mail. The results are also posted on the project website, which includes area maps showing the insect counts at each location, graphs of insect population trends, and pest management recommendations. At the end of each season, insect population trends are evaluated and reported to potato growers.

The Use of Natural Plant Volatile Compounds for the Control of Potato Blemish Diseases

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Many naturally occurring plant volatiles are known for their anti-fungal properties. However, they have limited use because they diffuse rapidly after coming in contact with air. In an initial study, acetaldehyde and 2E-hexenal were chosen as prototype volatiles in order to investigate the use of volatiles for control of blemish pathogens in fresh-pack potato packaging. Pure cultures of the three main potato blemish pathogens, *Colletotrichum coccodes*, *Helminthosporium solani*, and *Pectobacterium atrosepticum* were used in the study. Pathogen cultures were exposed to the pure volatiles in sealed jars for 7 days at 23°C. Results showed that

2E-hexenal was the more effective of the two volatiles with 2.5 uL providing complete inhibition of growth for all three pathogens. In the current study, experiments were repeated using inoculated tubers instead of pathogen cultures. The potatoes were inoculated by means of spore or bacterial suspension onto sterile filter paper that was placed onto a single point of wounding on the tuber surface. Pure volatile organic compounds were injected using a syringe into the headspace of sealed jars through an airtight valve. The headspace of the jars was sampled daily using SPME, and the volatile concentration measured by GC/MS. Fungal and bacterial growth were measured daily. Results are presented and discussed in relation to the future use of these volatile compounds in active packaging systems for the control of potato blemish diseases.

Utilizing Pathogen Detection Test Kits for Rapid In-field *Potato virus Y* Diagnosis

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The ability to quickly identify *Potato virus Y* (PVY) infected plants in the field using a serological test would benefit growers, fieldmen, extension and research personnel. The objectives of this study were to evaluate accuracy and identify strengths and weaknesses of commercially available serological test kits for PVY and PVY^N virus detection in foliar plant tissue. Diagnostic test kits were purchased from four major companies to test for PVY and PVY^N specific test kits from two companies. Potato leaf samples collected in fields or submitted grower samples were tested with the kits and analyzed for virus verification using conventional ELISA or RT-PCR protocols. PVY symptomatic and non-symptomatic leaf samples were collected and tested. A result reported as a "false positive" is a test kit result of positive but the ELISA and RT-PCR result was negative. Conversely, a "false negative" is when a test kit indicated a negative result and the ELISA and RT-PCR result was positive. Approximately 115 samples were tested using 154 PVY kits and 44 samples tested using 60 PVY^N kits. PVY test kits from the four companies were 96, 97, 94, and 94% accurate. One company's PVY test kits had 3% false negative and 5% false positive results. The remaining three companies' test kits showed 5 to 9% false negative and 0% false positive tests. Results indicate that PVY test kits displayed broad reactivity and correctly detected PVY^O, $PVY^{N:O}$, or PVY^{NTN}. The PVY^N test kits were 90% accurate overall and gave 1 false negative and two false positives. The PVY^N test kits showed a false positive for PVY^N when result was PVY^O. Results indicated the kits tested were reliable and accurate, but some limitations were apparent. In this study, using a general PVY test kit identified infection by common strains of PVY.

Molecular Markers Assisted Pyramiding of Genes for Extreme Resistant (ER) to PVX (Rx1), Hypersensitive Resistant to PVX (Nb), ER to PVY (PVY_{adg}), and Potato Pale Cyst Nematode Resistant (*Globodera pallida*) (Gpa2) in Potato

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Potato cyst nematodes and viruses such as PVX and PVY cause significant crop losses. One of the best strategies to control potato pests and diseases is the use of genetic resistance. With recent advances in molecular genetics several resistant genes have been mapped, cloned and molecular markers were developed to be used in breeding programs. The main purpose of this project was to use molecular markers to pyramid PVY, PVX and potato pale cyst nematode resistant genes. A cross was made between advanced clone OR00054-1 with Ry_{adg} and Nb genes and GemStar Russet with Rx1, Nb and Gpa2 genes. A population of 88 full-sib progeny from the cross was screened with molecular markers. Allele specific primers were used for Rx1 and Gpa2 genes. Very tightly linked markers were used to screen the Nb and Ry_{adg} genes. Segregation ratios of F1 progenies were calculated. Ry_{adg} gene segregated in a 1:1 ratio confirming that resistant in OR00054-1 was simplex. The Nb gene segregated in 3:1 ratio confirming that both parents are simplex for this resistance gene. With regard to Rx1 and Gpa2 both genes segregated in 3:1 ratio. It was previously reported that the Rx1 and Gpa2 which are located on chromosome XII are tightly linked and showed high homology with resistant genes Rx2 and R1 on chromosome V. We will further investigate if additional resistant genes are involved to explain the segregation pattern. Bioassays will be done to confirm all the results. The results showed that molecular markers can be used to pyramid resistant genes.

Respiratory Acclimation of Tubers to Temperature Change Reflects LTS Responses of Resistant/Susceptible Genotypes

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Premier Russet, GemStar Russet, and Defender differ substantially in their resistance to low temperature sweetening (LTS) and associated metabolism. Gemstar and Premier have moderate and high resistances, respectively, while Defender sweetens and loses processing quality progressively during storage at 9°C and has virtually no resistance to LTS at 4.4 and 6.7°C. At 4°C, Premier maintained low levels of sucrose (suc), glucose (glu) and fructose (fru), GemStar accumulated suc with little inversion to glu and fru, and Defender accumulated glu and fru but comparatively little suc. Respiratory acclimation responses to temperature change (9 to 4°C) reflected the varying degrees of sweetening of these cultivars and were thus diagnostic of the LTS phenotype. In response to an immediate drop from 9°C to 4°C, tuber respiration decreased 42%, reaching a minimum within 45 h for all cultivars, and then increased to a new maximum over the next 4.5 d before decreasing to establish a constant basal rate at 4°C over the next 14 days (acclimation response). The acclimation maxima were 56, 28, and 14% greater than the final resting basal respiration rates at 4°C for Defender, Gemstar, and Premier, respectively. The acclimation responses thus correlated with the extent of LTS from these genotypes and likely reflected the level of metabolic energy required to catabolize starch to suc, glu and fru end products. The ratio of fru to glu during LTS was also an effective predictor of LTS resistance in these genotypes. Heat stress during tuber maturation abolished the LTS resistant phenotype of Premier. This information is critical in selecting durable modes of LTS resistance that cannot be compromised by late season heat stress.

Over-expressing the Vacuolar Antiporter CAX1 in the Potato Variety 'Atlantic': Phenotypic Variation of the Transformed Clones

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CAX1 is a tonoplast H^+/Ca^{+2} antiporter that was identified and cloned in *Arabidopsis thaliana*. The over-expression of this gene in carrots, potato and tomato has showed increased calcium content in the plant. Previous studies have shown that increased calcium levels in potato tubers can improve quality by reducing the incidence of internal defects. The potato variety 'Atlantic' contains less tuber calcium than other varieties such as Superior; and also shows high incidence of internal defects such as hollow heart, internal brown spot and black spot bruise. The aims of this study are (*i*) to evaluate the effect of

increased calcium transport into the vacuole on the tuber calcium content in a potato variety with low tuber calcium and poor internal quality; (*ii*) and to determine if increased calcium levels in the vacuole could contribute to a better internal tuber quality. In vitro-grown 'Atlantic' plantlets were transformed with an *Agrobacterium* strain LBA4404 harboring the short version of the CAX1 gene driven by the 35S promoter, 35S::sCAX1. Tissue culture evaluations showed calcium deficiency symptoms in several transgenic clones when growing under adequate calcium content (3 mM $CaCl_2$) and many clones needed at least double the calcium content (6 mM $CaCl_2$) to grow without symptoms. In our greenhouse evaluations, internal defects were observed in the transgenic clones but absent in the control clones. Our preliminary results suggest that increased transport of calcium into the vacuoles results in calcium deficiency for the plant. This accumulation in the vacuole could result in a higher demand for calcium for normal growth in the transgenic plants.