

**INVITED REVIEW:**

**["Evolution and Management of the Irish Potato Famine Pathogen \*Phytophthora Infestans\* in Canada and the United States."](#)** [Yeen Ting Hwang](#), [Champa Wijekoon](#), [Melanie Kalischuk](#), Pgs 579-593

**Abstract:** Late blight, caused by [Phytophthora infestans](#) (Mont.) de Bary, is the most historically significant and economically destructive disease of potatoes (*Solanum tuberosum* L.). In addition to potato, *P. infestans* can also infect tomato and some other members of the Solanaceae, and this has contributed to the recent late blight epidemic in Canada and the United States. Propagation of *P. infestans* in Canada and the United States has been mainly through asexual reproduction and this has led to the development of several dominant clonal lineages. Various *P. infestans* markers have been developed that are invaluable in monitoring the evolution and movement of these *P. infestans* genotypes. Population diversity and disease incidence has increased through the development of systemic fungicide insensitivity and the transcontinental shipment of the pathogen on late blight infected potato tubers and tomato plantlets. Introduction of the *P. infestans* A2 mating type to several regions of Canada and the United States has also increased the opportunity for sexual reproduction and recombination, potentially contributing to greater *P. infestans* genetic diversity and pathogenicity. Advances in *P. infestans* molecular analysis have revealed a complex pathogen with a genome capable of evolving relatively quickly. Management of late blight will therefore require new, multifaceted strategies which include monitoring pathogen evolution and implementing sustainable production practices.

**Review:**

**["History and Origin of Russet Burbank \(Netted Gem\) a Sport of Burbank."](#)** [Paul C Bethke](#), [Atef M K Nassar](#), [Stan Kubow](#), Pgs 594-609

**Abstract:** The importance of Russet Burbank, the world's foremost French fry processing cultivar, requires a complete description of its origin. Its maternal lineage included Rough Purple Chili, Garnet Chili, Early Rose, and Burbank. An incorrect but widely disseminated account attributes the origin of Russet Burbank to Colorado potato grower Lou D. Sweet, with 1914 often given as the date of introduction. However, it is likely that Russet Burbank was originally released in 1902 as May's Netted Gem by L. L. May & Co. (St. Paul MN). The names Netted Gem and Russet Burbank were used synonymously for many decades. [Isoenzyme](#), multiplex PCR, and SNP data confirm Russet Burbank as a mutation of Burbank and do not support a seedling origin. Russet Burbank was found to be similar to Burbank in processing and nutritional characteristics. A goal of this effort is that descriptions of Russet Burbank's lineage and origins will be corrected by seed companies in lists of potato varieties and at world repositories holding Russet Burbank and its progenitors.

**["Production of Hybrids Between the 2EBN Bridge Species \*Solanum verrucosum\* and 1EBN diploid Potato Species."](#)** [A P Yermishin](#), [Yu V Polyukhovich](#), Pgs 610-617

**Abstract:** The potato crop has diploid wild relatives in the primitive 1EBN crossability group that have a wealth of desirable traits, but are currently difficult to access through conventional crossing. The objective of this study was to develop an efficient technique for using 1EBN species in breeding by crossing to 2EBN bridge species *S. verrucosum*. Success was obtained with several 1EBN diploid species: *S. bulbocastanum*, *S. pinnatisectum*, *S. polyadenium*, *S. commersonii* and *S. circaefolium*. Use of 2x(2EBN) *S. verrucosum* as a receptive female avoided prezygotic interspecific incompatibility, and double "rescue" pollination was done using haploid-inducing clone, *S. phureja* IvP35 to minimize postzygotic failure due to abortion of berries with few or small seeds. In total, 4,646 hybrid seeds were obtained in crosses between *S. verrucosum* and the 1EBN species. Rescue pollination particularly improved seeds per pollination for *S. pinnatisectum* hybrids. The hybrid seeds were normal in appearance and had high germination (47–88 %). They produced plants with the distinctive phenotypic characteristics and molecular markers specific to their 1EBN parents. Hybrids had poor male fertility, but crossed easily as females to diploid *S. tuberosum* at an average of 38 seeds per pollination.

**["Stability and Broad-Sense Heritability of Mineral Content in Potato: Copper and Sulfur."](#)** [C R Brown](#), [K G Haynes](#), [M Moore](#), [M J Pavek](#), Pgs 618-624

**Abstract:** Sulfur and copper are important for human health. Sulfur deficiency is rare, but may occur in the elderly. However, a large percentage of the U.S. population is deficient in copper. The purpose of this study was to determine the range of values for sulfur and copper available in advanced potato germplasm and varieties and estimate how much genetic variation exists for these two elements. Potato breeding lines and varieties in three multisite trials were

evaluated for copper and sulfur content by wet ashing and Inductively Coupled Argon Plasma Emission [Spectrophotometer](#) analysis. Stability and broad-sense heritability were determined. Among genotypes, copper content ranged from 2.0 to 4.5  $\mu\text{g}\cdot\text{g}^{-1}$  DW. This was a 2.25-fold difference. In these three trials, environment was never significant, while genotype by environment interactions were always significant. Genotype was significant in two of the regional trials. Broad-sense heritabilities were estimated to be 0.0, 0.93 and 0.51 for the Tri-State, Western Regional Russet and Western Regional Red/Specialty trials, respectively. Among genotypes, sulfur content ranged from 991 to 1488  $\mu\text{g}\cdot\text{g}^{-1}$  DW. The highest value was 50 % higher than the lowest. In these three trials, environment was never significant, while genotype x environment interactions were always significant. Genotype was significant in two of the regional trials. Broad-sense heritabilities were estimated to be 0.53, 0.68 and 0.88, for Tri-State, Western Regional Russet, and Western Regional Red/Specialty trials, respectively. For both sulfur and copper, selection in the Western Regional Russet and Western Regional Red/Specialty trials is likely to lead to an increase in content. Selection for sulfur in the Tri-State would result in a gain as well. These results suggest that genetic improvements could be made to potato to enhance the concentrations of these minerals.

**[“Clopyralid and Dicamba Residue Impacts on Potatoes and Weeds.”](#)** [Steven S Seefeldt](#), [Rick A Boydston](#), Pgs 625-631

**Abstract:** Clopyralid and dicamba are used in Alaska to control certain invasive and agricultural weed species; however they may have an extended soil half-life in interior Alaska resulting in carry-over injury in potatoes. Field studies at experiment stations in Delta Junction, Fairbanks, and Palmer, Alaska were established to determine the dose-response of weeds and above and below ground potato growth to soil-applied clopyralid or dicamba (0, 35, 70, 140, 280, and 560  $\text{g ae ha}^{-1}$ ). Both Norwegian cinquefoil (*Potentilla norvegica*) and narrowleaf hawksbeard (*Crepis tectorum*) were susceptible to clopyralid with over 90 % control in Delta Junction; whereas only flixweed (*Descurainia sophia*) was partially controlled (70 %) with dicamba. In Palmer narrowleaf hawksbeard was controlled (87 %) with clopyralid. At Delta Junction and Fairbanks, clopyralid applied at 140  $\text{g ae ha}^{-1}$  injured potatoes greater than 25 %, whereas at Palmer visual injury was greater than 25 % at 70  $\text{g ae ha}^{-1}$ . Above ground dicamba injury was greater than 25 % at 140, 70, and 35  $\text{g ae ha}^{-1}$  at Delta Junction, Fairbanks and Palmer, respectively. Potato tuber production was reduced by clopyralid at rates of 35 and 140  $\text{g ae ha}^{-1}$  at Delta Junction and Palmer, respectively. At Delta Junction, dicamba did not reduce potato tuber production, however in Palmer, dicamba rates at 70  $\text{g ae ha}^{-1}$  and greater reduced potato tuber production more than 50 %. Sub-samples of potato tubers from Delta Junction and Palmer were grown out to determine if clopyralid and dicamba content in tubers would reduce subsequent growth. Dicamba at rates of 140  $\text{g ae ha}^{-1}$  or greater injured plants grown from daughter tubers and reduced shoot height, but had no effect on the number of emerged shoots. Clopyralid at all rates injured plants that emerged from daughter tubers and injury increased with increasing rate. At Palmer, clopyralid in daughter tubers rates at 140  $\text{g ae ha}^{-1}$  or greater reduced shoot height and at 280  $\text{g ae ha}^{-1}$  or greater reduced shoot number. At Delta, clopyralid in daughter tubers reduced shoot height at 280 and 560  $\text{g ae ha}^{-1}$ , but had no effect on shoot number.

**[“Effect of Genotype and Storage on Glycoalkaloid and Acrylamide Content and Sensory Attributes of Potato Chips.”](#)** [Fauzi S Amer](#), [Lavanya Reddivari](#), [Gaurav P Madiwale](#), Pgs 632-641

**Abstract:** Potato chips are the most popular snack foods consumed in Western countries. Potato chips contain beneficial bioactive compounds such as resistant starch, polyphenols etc. along with naturally occurring glycoalkaloids (GA) and processing induced acrylamide (AL). Information on the effect of genotype and storage on both GA and AL are limited. In this study the effect of cultivar and storage on both GA and AL content in potato chips was evaluated using four potato cultivars. In addition, reducing sugars and sensory attributes were measured in response to storage time and cultivar. Potato chips made from fresh and stored tubers were analyzed for total GA and AL using [High Performance Liquid Chromatography](#) and Ultra Performance Liquid Chromatography, respectively. Raw potatoes were analyzed for reducing sugars using a spectrophotometer. Sensory attributes of potato chips were assessed using 114 untrained panelists. The effect of storage on GA and AL content is cultivar dependent. Purple-fleshed cultivars were more susceptible to storage induced increase in AL content. Storage of potatoes at low temperature (4 °C) resulted in a significant increase in GA, AL and reducing sugar content after 90 days. Positive correlations were observed for the overall acceptability, texture, taste, ranking and GA/AL content, emphasizing the positive role of GA/AL on sensory qualities. These results indicate that an increase in GA and AL content with storage is dependent on cultivar. Thus, it is critical to select cultivars and optimize the storage conditions to lower GA/AL content in the potato chips, while retaining the sensory attributes and health-benefiting compounds.

**[“Effect of Potato Virus S Infection on Late Blight Resistance in Potato.”](#)** [Yu-Hsuan Lin](#), [Dennis A Johnson](#), [Hanu R Pappu](#), Pgs 642-648

**Abstract:** Late blight, caused by [Phytophthora infestans](#), is a destructive disease of potato. Defender is the only cultivar in the U.S. with foliar and tuber resistance to this disease. However, this cultivar exhibits susceptibility to infection by Potato virus S (PVS) and severe symptoms appeared on leaves after infection with PVS. PVS is widespread in potato fields in the U.S. To investigate potential interactions between *P. infestans* and PVS, detached

leaves of Defender and Ranger Russet (susceptible to late blight), that were either PVS-infected or non-infected, were inoculated with *P. infestans* BF-05. The amount of sporulation and the extent of lesion expansion on inoculated leaves were measured to estimate late blight severity. When inoculated with *P. infestans* only, as expected, Defender exhibited discrete, relatively small, dark purple to black hypersensitive reaction-like spots and on an average had twenty times fewer sporangia compared to Ranger Russet. However, in Defender plants infected with PVS, lesion expansion and sporulation increased significantly compared to PVS-free Defender. The increased severity of late blight in PVS-infected Defender suggests that PVS negatively impacts late blight resistance in this cultivar. This study demonstrates that late blight resistance in cultivars to be released should be screened for PVS susceptibility.

**[“Evidence of a Monogenic Nature of the Nz Gene Conferring Resistance Against Potato virus Y Strain Z \(PVY<sup>Z</sup>\) in Potato.”](#)** [Mohamad Chikh-Ali](#), [Jenny S Rowley](#), [Joseph Kuhl](#), Pgs 649-654

**Abstract:** Hypersensitive resistance (HR) to Potato virus Y (PVY) in potato (*Solanum tuberosum*) is conferred by strain-specific N genes. Two such genes have been identified in potato so far, Ny<sub>tbr</sub> conferring HR to PVY<sup>O</sup>, and Nc<sub>tbr</sub> conferring HR to PVY<sup>C</sup>. A third, putative gene Nz<sub>tbr</sub> was proposed to confer HR against a distinct strain PVY<sup>Z</sup>. However, due to the scarcity of the PVY<sup>Z</sup> isolates of PVY, no formal proof of the monogenic nature of this new gene, Nz<sub>tbr</sub>, was available until now. Here, we report on a genetic study of the Nz<sub>tbr</sub> inheritance in three crosses between cultivars Maris Bard (Ny:Nz) and King Edward (ny:nz), and Maris Bard (Ny:Nz) and Russet Norkotah (ny:nz). A fully-sequenced PVY<sup>Z</sup> isolate, L26, was used to screen the parents and progeny for a virus-induced HR phenotype in foliage. Based on the phenotypic analysis of 203 progeny, segregation of HR phenotype in the PVY<sup>Z</sup>-infected plants was found to be 1:1, indicating a monogenic, dominant nature of the Nz<sub>tbr</sub> gene. Since the PVY<sup>Z</sup> strain includes PVY<sup>NTN</sup> isolates associated with tuber necrotic ringspot disease (PTNRD) in susceptible potato cultivars, the Nz<sub>tbr</sub> gene represents a valuable source of HR against PTNRD-inducing PVY isolates. This is the first demonstration that Nz<sub>tbr</sub> is a single, dominant N gene in potato conferring resistance to the PVY<sup>Z</sup>-NTN strain.

**[“Effects of Curing Treatment on the Browning of Fresh-cut Potatoes.”](#)** [Zhiqiang Hou](#), [Yanyan Feng](#), [Shaochong Wei](#), Pgs 655-662

**Abstract:** Browning is one of the adverse factors that affects quality and shelf life of fresh-cut potatoes. The present paper investigates the effects and mechanism of a curing treatment to control the browning of fresh-cut potatoes. Potatoes were placed in curing conditions (16 ± 1 °C, 90 % RH) for 10 days immediately after harvest. The purpose of curing is to rapidly heal any damage inflicted during harvest and thus to minimize decay and water loss. Potato slices treated with curing retained good color until day 12. Moreover, the extent of discoloration was much lower and the overall sensory quality was much better than the control, which were accompanied with an increase in polyphenol oxidase (PPO) activity and contents of gallic acid, chlorogenic acid and protocatechuic acid. Compared to control, curing treatment reduced electrolyte leakage and respiration rate, and inhibited the gene expression of phenylalanine ammonia-lyase (PAL) and polyphenol oxidase (PPO) in fresh-cut potatoes. The present data suggest that the curing treatment has the potential to improve the quality of fresh-cut potatoes and extend its shelf life.

**[“A Sampling Plan for Liriomyza huidobrensis \(Diptera: Agromyzidae\) on a Potato \(Solanum tuberosum\) Plantation.”](#)** [Flávia M Alves](#), [Juno F S Diniz](#), Pgs 663-672

**Abstract:** No sampling plans specifically developed for mines associated with the pest *Liriomyza huidobrensis* in potato fields have been published to date. Thus, the objectives of this study were to determine the sampling unit and to establish the number of samples needed for the application of this study's sampling plan. For this purpose, we evaluated 16 commercial fields of the potato cultivar Agata (24.5 ha). We evaluated the number of mines located in the apical, middle, and basal canopy-sections of plants. Higher mine densities were found in the leaves in the middle and basal section of plants than in the apical section. The middle canopy-section was best suited for sampling the mines. The result showed that the negative binomial distribution fit the mine density of *L. huidobrensis*. Fifteen samples/24.5 ha was determined to be appropriate for use in conventional sampling. The cost for sampling was US \$5.32 per ha. The cost of performing the sampling was significantly lower than the cost of insecticide application.

**[“Identification and Selection for Tuber Calcium, Internal Quality and Pitted Scab in Segregating ‘Atlantic’ x ‘Superior’ Reciprocal Tetraploid Populations.”](#)** [Cinthya Zorrilla](#), [Felix Navarro](#), [Sandra Vega](#), Pgs 673-687

**Abstract:** Developing chipping cultivars with improved tuber quality and disease resistance is a major interest for breeders and the potato industry. A popular chipping cultivar ‘Atlantic’, is desired for its high yield and gravity. However, this cultivar suffers from poor internal tuber quality and high scab susceptibility. On the contrary, cultivar ‘Superior’ is known to have excellent tuber internal quality and moderately scab resistance. In addition, this cultivar is known to have high tuber calcium as compared to ‘Atlantic’. The present study intended to generate populations that

can be suitable for the genetic study of tuber calcium, internal quality, common scab, and other commercially important traits such as yield, specific gravity and chip quality at the tetraploid level. Two populations obtained by reciprocally crossing the cultivars 'Atlantic' and 'Superior' were evaluated during 2009 to 2012 at Hancock, Wisconsin. Significant genotype effects and moderately low to high broad-sense heritabilities were identified for all traits evaluated indicating that the observed phenotypic variation has an important genetic component. In addition, the parents differed significantly for all traits across trials, and most genotypes performed in between the two parents but some genotypes were more extreme than the parents. Furthermore, evidence of reciprocal effects was found for some traits. In addition to learning about the genetics of these important traits we were able to identify some genotypes that combined the commercially desired traits of the two cultivars.

**["Ethylene in the Atmosphere of Commercial Potato \(\*Solanum Tuberosum\*\) Storage Bins and Potential Effects on Tuber Respiration Rate and Fried Chip Color."](#)** [Paul C Bethke](#) Pages 688-695

**Abstract:** Careful storage management is required to maintain post-harvest potato tuber quality. The plant growth regulator ethylene has well documented effects on potato tuber respiration rate, fried product color, and sprouting, but data on the amount of ethylene present in ventilated potato storages and how ethylene may affect tubers in commercial storage are not available. To address this need, ethylene concentration in ventilated commercial storage bins located in central Wisconsin was quantified using gas chromatography from shortly after bin filling until unloading. Samples of the storage atmosphere were collected approximately every other week from 17, 18 and 14 storage bins in 2010, 2011 and 2012, respectively. Ethylene was present transiently, and only rarely at concentrations greater than 20 nl l<sup>-1</sup>. In laboratory-scale experiments, chipping potato tubers responded to ethylene at 20 nl l<sup>-1</sup> with an increase in tuber respiration rate, but not with an increase in post-fry chip darkening. These data indicate that the impact of atmospheric ethylene on tuber quality and storage management in ventilated potato storages is likely to be small, except near localized regions of high ethylene production.

**["Differential Accumulation and Degradation Of Anthocyanins In Red Norland Periderm is Dependent On Soil Type And Tuber Storage Duration."](#)** [Mikel R Roe](#), [Justin L Carlson](#) Pgs 696-705

**Abstract:** To determine how soil type, 2,4-dichlorophenoxyacetic acid (2,4-D) treatment, and storage affects color and anthocyanin accumulation of Red Norland potatoes, tubers were grown in sand or peat, with or without 2,4-D treatment, and measured at vine kill, harvest or after storage. Tubers grown in sand were less red and accumulated fewer anthocyanins than tubers grown in peat. 2,4-D treatment increased redness regardless of soil type. Redness loss varied greatly among tubers with storage. Tubers that lost color with storage had a two-fold reduction in anthocyanins, and a two-fold increase in benzoic and cinnamic acids compared to harvest, indicating chemical degradation of anthocyanidins via B-ring cleavage and autoxidation. Sand-grown potatoes did not exhibit greater cinnamic acids compared to peat-grown potatoes, suggesting that their color differences were due more to differences in biosynthesis than degradation during skin set. To improve Red Norland tuber color, research should focus on increasing biosynthesis of anthocyanins.

**["Efficacy of Mineral Oil-Insecticide Mixtures for Protection of Potato Tubers Against PVY and PVM."](#)** [Sławomir Wróbel](#) Pgs 706-713

**Abstract:** The impact of a dozen mixtures of the most commonly applied aphicides: Mospilan 20 SP (acetamiprid), Pirimor 500 (pirimicarb) and Karate Zeon 050 CS (lambda-cyhalothrin), combined with the mineral oil Sunspray 850 EC, was researched in field conditions to assess their effectiveness in limiting potato tuber PVY, PVM and PLRV infection. In spite of the greatest reduction in the number of aphids occurring following application of Mospilan 20 SP, this treatment was not as effective in limiting PVY infection as, for example, applying Sunspray 850 EC mineral oil. Mineral oil, when used on its own or in a mixture with Pirimor 500 WG, was found to be the most effective measure for limiting PVY infection (the incidence of tubers infested with PVY was reduced by 64 % relative to control, i.e. no protection). A slightly weaker effect was observed in the case of a combination of the mineral oil with full doses of Karate Zeon 050 CS with a half of a dose of Mospilan 20 SP insecticide, however only for protection against PVY. A similar trend was observed for PVM even though a significant difference was only observed for Sunspray 850EC + Pirimor 500WG. In conclusion, the application of insecticide mixtures with mineral oil in protecting against PVY infection is not always as effective as the application of the oil itself only. Addition of the insecticide may sometimes improve the efficacy of protection, however, due to the extra costs involved, not always does it have to be economical.

["Economic Impact of Zebra Chip Control Costs on Grower Returns in Seven US States."](#) [Gina Greenway](#) Pgs 714-719.

**Abstract:** [Zebra](#) Chip (ZC) disease exposes growers to the risk of large economic losses. Enterprise budgets are developed to evaluate how the competitive position of eight major US potato producing regions could be impacted by ZC infestations. When using three year (2010–2012) average marketing year prices for "all potatoes" and three year average (2010–2012) yields obtained from USDA-NASS, results highlight the inability of Pacific Northwest growers to sustain a profit if they adopt a routine insecticide program for ZC protection that begins at plant emergence. The uncertain threat of psyllid control costs are also considered within the context of processor contract price negotiations.

\*Short Communication: "[High Stability of a Mitochondrial Genetic Marker \*mtCOII\* in Polish Colorado Potato Beetle Populations.](#)" [Arnika Przybylska](#), [Marta Budziszewska](#)... Pgs 720-725

**Abstract:** Colorado potato beetle (CPB) (*Leptinotarsa decemlineata* (Say in Journal of the Academy of Natural Sciences of Philadelphia 3: 298–331, [1824](#))) (Coleoptera: [Chrysomelidae](#)) is one of the most serious potato pests. It has been reported worldwide, from North America to Europe and Asia. In this study we analyzed the genetic diversity of a mitochondrial DNA marker – a second subunit of cytochrome oxidase (*mtCOII*) in Polish CPB populations to assess the possible changes of this gene sequence over time and over the country, influencing the intra-specific variability of CPB. During a three-year survey in Polish potato fields the beetles were collected from 20 evenly spaced locations of varying climatic and geographic conditions, and the nucleotide sequence of this marker was analyzed. Our research revealed that in spite of three years of sampling the mitochondrial haplotype in all individuals was fixed, and no single nucleotide change was found in any individual, indicating a high stability of this maternally inherited marker in *L. decemlineata*. This finding about the level of biodiversity is of importance for plant protection strategies.