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SUMMARY OF POTATO RESEARCH ACCOMPLISHMENTS
2007-2011

by
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2011

Potato Germplasm with Resistance to Columbia Root-Knot Nematode *(Dr. Charles Brown, 509-786-9252)*
The Columbia root-knot nematode (CRN) is a major pest in most potato production areas of the Western US. There is no resistance among the standard varieties and control is only achieved by soil fumigation, which is a major cost for growers and may have adverse environmental impacts, therefore, is under scrutiny and could lead to a ban on the use of current fumigants. Resistance to CRN has been discovered in a Mexican wild potato and this trait has been incorporated into an advanced breeding line suitable for the processing industry of the Pacific Northwest. The adoption of this new breeding line as cultivar would remove the necessity of fumigation, saving the industry in Washington State alone 20 million dollars in cost of production.

Resistance to Black Dot and Powdery Scab in Potato *(Dr. Charles Brown, 509-786-9252)*
Changes in climatic condition and crop production systems bring about new disease pressures. Case in point, is a widespread increase in black dot and powdery scab diseases of potatoes in the Columbia Basin. Unfortunately there are no fungicides that adequately control these pathogens, therefore, developing resistant cultivar is the only approach to manage potatoes in affected production regions. We surveyed the advanced breeding lines' performance in infested fields for a number of years. The best indicator of resistance or tolerance to black dot and powdery scab is the ability to produce a high yield of large size tubers. This is also what the processing industry needs as raw material to produce French fries and other processed products. Potatoes resistant to these fungi have been found among newly named varieties being released by the Tri State Potato Improvement Program in the Pacific Northwest. A key characteristic is a large root system which has developed due to genetic vigor,

but also due an ability to keep ahead of the root damage caused by the fungi. Resistant varieties will increase the yield by 25% compared to susceptible varieties while not increasing the cost of production. Efficiency of production per unit land area is an important component of sustainable potato production.

Tuber borne Infection of Potato Purple Top Disorder *(Dr. James Crosslin, 509-786-9253)*

The potato purple top phytoplasma is an important pathogen of potatoes and other vegetable crops in the Columbia Basin of Washington and Oregon and was widespread in this region in 2002. This pathogen is transmitted from wild host plants to potatoes by the beet leafhopper but little information was available on the ability of the phytoplasma to be perpetuated in infected potato tubers. Over the course of three years, we showed that the phytoplasma was indeed transmitted through the tubers and that some of these tubers would give rise to infected daughter plants. This information alerts potato seed certification personnel and potato growers of the potential for tuber-borne infections which could result in a resurgence of purple top disease in this important potato growing region.

Understanding the Genetics of Potato Tuber Quality Traits, High Phytonutrients, and Yields *(Dr. Duroy Navarre, 509-786-9261)*

Recent surveys found that many consumers perceive potatoes to be unhealthy or lack nutrition. This perception is thought to be a primary factor in the decline of potato consumption threatening the sustainability of the US potato industry. We continue to work towards developing high-phytonutrient potatoes using independent approaches. We examined changes in phytonutrient gene expression and metabolite levels during tuber development and found immature tubers have more active expression of phenylpropanoid genes. Using potatoes grown in Alaska, Texas and Florida, we found that environment has a substantial influence on tuber phytonutrients and defined gene transcript and metabolite relationships. In a 2010 field trial we grew 90 genotypes, then screened them for phytonutrient content. These germplasm lines we identified several genotypes that had good yields of small tubers (essential for profitability), good appearance, taste and had antioxidant amounts that rival vegetables such as spinach and kale. We have made transgenic potatoes in which key genes in phenylpropanoid or protein metabolism have been altered and once we have tubers from these plants should gain insight into factors that influence tuber nutritional content. High-phytonutrient “baby potatoes” could help restore the healthful image of potatoes, increase demand and provide healthful choices for consumers.

2010

New variant of cherry leaf roll virus identified in potato *(Dr. James Crosslin, 509-786-9253)*
Many viruses infect potato and other closely related plants. Some of these potato relatives possess characteristics that can be useful in potato breeding programs, such as resistance to frost, pests, or diseases. Because of these desirable genetic characteristics, some of these plants, including "wild potato", Solanum acaule, have been used in potato breeding programs. Plant material infected with the virus, designated JCM-79, was obtained under APHIS permit and the virus was maintained under quarantine at the USDA-ARS, Prosser, location. Over the course of the next few months, the virus was identified as a new variant of cherry leaf roll virus (CLRV), never previously reported in potatoes or potato relatives. Identification of the virus alerted personnel involved in potato breeding programs around the world that the virus posed a threat to these programs. Development of methods for the rapid, sensitive, and specific detection and identification of the virus provides a means for potato breeding programs to test for this new pathogen in their breeding materials.

Development of molecular markers for the prediction of super high carotenoids in potato genotypes *(Dr. Charles Brown, 509-786-9252)*
Potato is a good source of dietary lutein and zexanthin, components of the human retina. Breeding for higher levels of these components in the tuber flesh has been difficult because we have not known what gene alleles need to be assembled. We have found that the presence of two markers BCH-2 and zep are necessary for the expression of high levels of carotenoids. Now we have a test that can be applied to new potato genotypes when they are tiny plants. The value of high carotenoid potatoes is that the higher levels of lutein and zeaxanthin make the potato a superior food that promotes eye health. Now that we can predict carotenoid expression we will be able to produce varieties that have high yield and super-high carotenoids.

2009

Discovery of a new source of resistance to PVY associated with high antioxidants *(Dr. Charles Brown, 509-786-9252*; *Dr. James Crosslin, 509-786-9253)*
Potato Virus Y is the most important virus in the US. It is devastating to the seed industry because they cannot keep this virus, and all its new pathotypes, out of seed stocks. We have found a simply inherited resistance effective against the broad spectrum of strains in populations that also have very high levels of antioxidant xanthophylls that protect against the major causes of blindness in the US, macular degeneration, and cataracts.

Development of high-phytonutrient potatoes *(Dr. Duroy Navarre, 509-786-9261)*
Negative media coverage over the last few years has created a perception amongst some consumers that potato is not a nutritious vegetable. We recently identified some potato wild species that have exceptionally high levels of phenolic phytonutrients and antioxidants. These potatoes have more antioxidants than published values for spinach or kale. Furthermore, we found yellow-fleshed genotypes that have high phenolics, which is important because consumers prefer white or yellow fleshed potatoes over purple or red potatoes. As the most eaten vegetables in the US, phytonutrient-rich potatoes can have a strong impact on health. By targeting a consumer-oriented trait, these potatoes have the potential to improve the sustainability of the potato industry by increasing demand.

Identification of bacterial cause of "zebra chip"disease *(Dr. James Crosslin, 509-786-9253)*
Potato "zebra chip" (ZC) disease seriously affects the processing quality of potato tubers used for making potato chips. Processed chips show unacceptable fry color upon processing and ZC has caused serious economic damage in Texas, Mexico, and recently was reported in New Zealand. Potato tubers produced in California were observed to have symptoms similar to those of ZC. This was the first time the bacterium had been positively identified in potatoes grown in the state of California. The positive identification of ZC in California has alerted the potato industry in that state to the presence of the disease. Fieldmen, growers, and processors are now aware they need to scout for the disease and apply insecticides to control the potato psyllid and thereby reduce the losses due to ZC.

2008

Production of Beta-carotene in potato *(Dr. Duroy Navarre, 509-786-9261)*
Potato produces small amount of Beta carotene, an important pre-cursor of vitamin A in the human metabolism. Using a transgenic silencing of beta-carotene hydroxylase potatoes that contained 300 micro gram per 100 g FW of beta-carotene were produced. Varieites with this level of beta-carotene could supply substantial amounts of the daily requirement of beta-carotene to populations at risk, which specifically help infants and pregnant women who have beta-carotene deficient diets.

Development of potato resistant to corky ringspot disease *(Dr. Charles Brown, 509-786-9252)*

Many potato fields in the Northwest have stubby root nematodes carrying the tobacco rattle virus that causes corky ringspot disease. Extreme low levels of infection renders that batch of potato being rejected for processing. Researchers in Prosser, WA developed long russet processing potatoes with resistance to the virus by recurrent phenotypic selection in the field. These potatoes do not develop corky ringspot disease and they do not carry the virus asymptomatically. Corky ringspot disease is controlled by specific soil fumigants. Resistant varieities would allow producers to lower input costs and reduce non-point source contamination of ground water by fumigants.

Analysis of folate concentrations and gene expression during tuber development *(Dr. Duroy Navarre, 509-786-9261)*
Folate deficiency is one of the world's most severe nutritional deficiencies and even in the United States folate deficiency is not uncommon. We have analyzed folate concentrations throughout tuber development and found that tubers of about the one ounce size ("baby potatoes") have higher amounts of folate than mature tubers. No major changes in folate gene expression during tuber development were observed. Phytonutrient rich baby potatoes will likely appeal to consumers, create new market opportunities and increase the planted acreage.

First report of tobacco rattle virus associated with corky ringspot disease in Michigan potatoes *(Dr. James Crosslin, 509-786-9253)*
Tobacco rattle virus (TRV) is transmitted to developing potato tubers by the stubby root nematode. Once infected, tubers develop various internal defects including dark spots, rings, or corky tissue, called corky ringspot (CRS). These defects render the tubers unmarketable and can result in serious economic damage to the potato grower. Potato tubers with symptoms of CRS were recently identified in storage facilities in Michigan. Molecular tests and transmission studies confirmed that TRV was associated with the symptoms. The CRS disease has previously been reported from Washington, Oregon, Idaho, Colorado, and Florida. This is the first report of TRV on potatoes in the state of Michigan and alerts growers and processors to the problem so that control measures can be initiated in areas where the disease occurs.

Identification of genetic resistance to Columbia root knot nematode in the tuber *(Dr. Charles Brown, 509-786-9252)*
Columbia root-knot nematode is a widespread pest in the Western United States rquiring use of soil fumigants to control. After identification and mapping of a type of resistance in the roots, a separate resistance mechanism effective against a wide range of Root-knot species common in temperate and tropical environments active in the tubers was identified. Tuber resistance of the type

identified here could reduce the amount of fumigant used in fields saving growers in the Columbia Basin up to 20 million dollars of cost.

Further evidence that the potato psyllid is involved in the zebra chip disorder *(Dr. James Crosslin, 509-786-9253)*

Zebra chip is a disorder of processing potatoes that is causing significant economic losses in parts of the United States, Mexico, and some other countries. Last year, in conjunction with ARS researchers in Wapato, WA and Weslaco, TX, we showed the association of the potato psyllid, Bactericera cockerelli, with the zebra chip (ZC) syndrome by infesting caged plants with psyllids. This year we infested plants with psyllids from different populations and again showed their association with the disorder. Plants and tubers from these plots were tested for phytoplasma infection and found to be negative providing additional evidence that these pathogens are not involved in ZC. The data also suggests that some populations of psyllids may not induce zebra chip, suggesting some populations may be free of the putative causal agent. This additional evidence unequivocally shows the association of this insect with the disease and allows growers to target this insect for control and thereby reduce the economic impact of zebra chip.

Metabolic profiles of tubers showing zebra chip symptoms *(Dr. James Crosslin, 509-786-9253)*

The tuber browning characteristic of the zebra chip disorder causes affected potatoes to be unmarketable, resulting in 10s of millions of dollars in loses in the Southwest. We used LCMS to examine ZC tuber extracts and found major increases in tuber phenolics, including compounds characteristic of plant defense responses. Tyrosine concentrations were particularly high and this increase is likely a major component of ZC discoloration. This helps us understand the basis of symptom development in potato tubers, which in some cases is much more economically damaging than any associated yield lose. This data is a step towards being able to control symptom development in potatoes and suggests ZC may be a useful model system for analysis of tuber phenolic gene expression.

2007

A rapid and precise PCR test for identification of Potato virus Y necrotic strain "N". ***(Dr. James Crosslin, 509-786-9253)***
Various strains of Potato virus Y (PVY) exist in nature. Some of these strains are called necrotic or "N" strains and can cause symptoms in potato tubers. Traditional tests such as ELISA have difficulty identifying all of the "N" strains. A rapid molecular-based test (coupled, one-tube, extractionless RT-PCR) was developed for quick detection and identification of "N" strains. This new test makes possible rapid and reliable identification of these strains and should be useful for certification agencies, regulatory personnel, and researchers.

Identification of potato psyllid as the causal organism for "Zebra Chip" disorder in potatoes. ***(Dr. James Crosslin, 509-786-9253)***
A disorder of processing potatoes called "zebra chip" has recently been identified in potatoes grown in Texas, Nebraska, Mexico, and several other areas. The exact cause of the disorder has not been positively identified. Significant progress has been made by identifying potato psyllid (a sucking insect) as the causal organism for this disorder. This finding has allowed growers to target this insect for control and thereby greatly reduce the economic losses they have been suffering due to "zebra chip".

Discovery of Russian thistle (a common weed) as an alternate host for BLTVA. ***(Dr. James Crosslin, 509-786-9253)***
The potato purple top phytoplasma, also called BLTVA, affects all cultivars of potatoes grown in the Columbia Basin. The phytoplasma has a wide host range and infects many other crop plants and weeds. The phytoplasma is transmitted by the beet leafhopper from weed hosts to potatoes. Although it was known that many wild mustard-type plants carried the phytoplasma, recent studies have led to the discovery of "wild" Russian thistle plants, a common weed in the area. Since the Russian thistle is also a preferred host of the beet leafhopper, we feel that finding the phytoplasma in this plant has implications for the epidemiology of purple top disease in the Columbia Basin.

Developing root-knot nematode resistant potato germplasm. ***(Dr. Charles Brown, 509-786-9252)***
Columbia root-knot nematode is widespread in the Columbia Basin causing damage that is preventable only by fumigation. We have developed a line of potato that is resistant to all root-knot nematodes in the Pacific Northwest. It has limited root resistance but a strong and broadly active tuber resistance. It is also

resistant to corky ringspot disease transmitted by the stubby root nematode. A grower can save up to 350 dollars per acre by not fumigating for these two pests, or 15 % of the cost of production. Growers could reduce fumigation costs in Washington by 20 million dollars. In addition, this would protect ground water from contamination by the fumigants metam sodium and 1, 3 dichloropropene.

Metabolic profiling of potato phytonutrients. ***(Dr. Duroy Navarre, 509-786-9261)***

Negative media coverage over the last few years has created an unjustified perception amongst some consumers that potato is not a nutritious vegetable. In actuality, as the most eaten vegetable in the United States, potato has tremendous potential to be developed as an important contributor of vitamins and phytonutrients to the diet. Germplasm mining can take advantage of potato's genetic diversity to enhance its phytonutrient content. Folate deficiency is a leading cause of birth defects and has numerous other negative consequences. We measured folate concentrations in more than 80 potato genotypes and found an over 3-fold range between high and low. We found that folate is stable or increases during potato cold storage, unlike the case with Vitamin C. We found differences in expression of specific folate metabolic genes among high and low germplasm. Phenolic compounds can have multiple health promoting effects. We found over a 10-fold range in total phenolics among genotypes, and the highest total phenolic potatoes in particular have substantial amounts that compare very favorably to other vegetables. We found one potato variety that had 30-fold higher flavonols than the lowest flavonol variety. We found that "baby potatoes" from all 3 varieties examined so far have substantially higher folate and phenolic concentrations than mature tubers. This work is showing that potatoes can have high amounts of health-promoting compounds and has the potential to create new marketing opportunties.