LONG-TERM STORABILITY OF POTATO VIRUS Y INFECTED TUBERS

Principal Investigator(s).

Russell L. Groves, Assistant Professor and Entomology Extension Specialist, Department of Entomology, University of Wisconsin—Madison

Amy Charkowski, Associate Professor, Department of Plant Pathology, Russell Laboratories, Department of Plant Pathology, University of Wisconsin—Madison

A. J. Bussan, Associate Professor and Horticultural Crops Extension Specialist, Department of Horticulture, University of Wisconsin—Madison

Alex Crockford, Langlade County Agricultural Extension Agent

Cooperator(s):

Stewart Gray, USDA-ARS, Plant Protection Research Unit and Professor, Department of Plant Pathology, Cornell University, Ithaca, NY

Robert Coltman, Program Director, Wisconsin Seed Potato Certification Program Antigo, WI

Rick Hafner, Senior Field Inspector, Wisconsin Seed Potato Certification Program, Antigo, WI

Kevin Bula, Senior Field Inspector, Wisconsin Seed Potato Certification Program, Antigo, WI.

Scott Chapman, Associate Research Specialist, Department of Entomology, University of Wisconsin—Madison

Abstract. In recent years, Potato Virus Y has reemerged as a serious disease problem in many potato production areas in the northern United States and eastern Canada. Asymptomatic cultivars which express mild or no symptoms when infected with PVY combined with an increase in recombinant strains of this virus prevent accurate field identification and rouging of infected plants. There is a lack of effective strategies to reduce the incidence of PVY infected plants and tubers, and there is a need to improve cost-effective methods of determining PVY levels in seed lots and further understanding the impact of current season virus infection on tuber storage and quality attributes. Limited information currently exists to document the impact of PVY infection on quality aspects tuber storage performance. In the first year of preliminary research, we have documented significant reductions in storage quality parameters including percent solids and shrinkage. This area of investigation seems extremely important towards limiting continued storage losses and further assessing the impact of plant disease (PVY infection) on seed tuber physiological age.

Project Description: This is the second year of a project that was initiated in the 2007 growing season. Objectives outlined in this research are directly related to the recent and problematic re-emergence of Potato Virus Y (PVY) in potato seed production in Wisconsin. The proposed
project will continue to generate new information regarding the relative responses of selected potato varieties to infection by novel, recombinant PVY strains in Wisconsin while also providing practical guidance towards documenting the impact of virus infection on long-term tuber storage. Knowledge of how PVY strains move and distribute within developing potato tubers of these commercially important cultivars has not been described.

Infection with PVY is the main reason that seed potato lots are rejected from certification and this virus has resulted in rejection of up to 4% of seed lots in the past decade, which is a significant loss to the seed industry. In addition, PVY is the main cause of downgrading lots from foundation class to certified class, which can be costly to seed growers if they had planned on increasing a particular lot for another year on their seed farm. The return on investment to growers will be 1) an improved understanding of the potential impact(s) virus infection may have upon storage losses; successful storage is dependent upon growers having a through understanding of the factors that can influence tuber health and quality. And 2) increasing the Wisconsin Seed Potato Certification Program’s ability to accurately identify novel, problematic strains of PVY and ensure seed quality for participating growers. For commercial growers, beginning with clean seed greatly facilitates the incorporation of reduced risk pest management into the arsenal of pest control; an approach which is central to achievement of the WPVGA / WWF / UW collaboration goals.

**Background and Rationale.** In recent years, PVY has reemerged as a serious disease problem in many potato production areas in the northern United States and eastern Canada (5). Three recently introduced cultivars, ‘Russet Norkotah’, ‘Shepody’, and ‘Silverton’ are widely grown and express mild or no symptoms when infected with PVY. Furthermore, recent investigations into the diversity of PVY isolates prevalent in these production areas have revealed a significant increase in the proportion of PVY<sub>N</sub> and PVY<sub>O</sub> recombinants (PVY<sub>N,O</sub>) (3). The lack of symptoms often associated with these cultivars and recombinant viruses prevents accurate field identification and roguing of infected plants resulting in higher levels of virus inoculum and greater disease pressure. There is a lack of effective strategies to reduce the incidence of PVY infected plants and tubers, and there is a need to improve cost-effective methods of determining PVY levels in seed lots of these two important varieties.

Briefly, PVY occurs as a population of strains or pathotypes, many of which have overlapping characteristics. These strains have been described as the ordinary strain (PVY<sub>O</sub>), a tobacco necrotic strain (PVY<sub>N</sub>), a tuber necrotic strain (PVY<sub>NTN</sub>), and a common, or stipple-streak strain (PVY<sub>C</sub>) (2, 3). The PVY<sub>N</sub> strains were first detected in North America in the early 1990’s when an outbreak occurred in the Canadian maritime region. Shortly thereafter, reports of the tobacco necrotic strains began occurring in the Western US and by 2005 this strain was becoming fairly prevalent across several potato production areas in the US. Sequence analyses of several strains from across the country have now identified strains which contain elements from both the PVY<sub>N</sub> and PVY<sub>O</sub> strain types; and these are now referred to as PVY recombinant strains (PVY<sub>N,O</sub>). Historically in Wisconsin, the most prevalent strain of PVY has been the ordinary strain, PVY<sub>O</sub>. Recent molecular analyses performed by Dr. Stewart M. Gray at Cornell University have revealed a subtle shift in the composition of PVY strains present in Wisconsin. Since 2004, the proportion of recombinant strains has increased and these may become a more frequent component of the population of PVY strains in the state.
Specifically, we continue to expand on the previous year’s research by, 1) investigating the efficiency of tuber infection in plants inoculated with different strains of PVY (PVYO, and PVYN:O) at different plant developmental stages, and 2) documenting the quality losses associated with inoculations of each PVY strain prior to and during long-term storage. This area of investigation seems extremely important as there have been no studies to quantify or define the consequences of long-term storage of tubers infected with PVY. To address these questions, this project has begun to document and quantify the potential of current-season, PVY infections to impact the long-term storage of selected cultivars with respect. This information will ultimately provide basic information needed to emphasize the importance of seed certification management efforts to reduce viral inoculum in foundation and certified seed stocks.

**Objective.**

Investigate how the timing of PVY infection within the growing season and PVY strain (PVY\textsubscript{O}, and PVY\textsubscript{N,O}) can affect the efficiency of tuber infection and the resulting long-term storability of harvested tubers.

**Objectives and Experimental Approach.**

Replicated field plots of four cultivars including ‘R. Norkotah’, ‘Silverton’, ‘Shepody’ and ‘Atlantic’ were established at the Hancock, Agricultural Research Station in 2008. Replicated plots were arranged in a randomized complete block design and consisted of 20 plants arranged in 4, 20-plant rows. A double guard row of PVY-resistant, ‘Villetta Rose’ was planted between varieties and surrounding the experimental plot to minimize interplot interference. Twenty plants in each experimental plot were mechanically, sap-inoculated using an artists airbrush with the three following PVY treatment combinations (PVYO, PVYN:O, and untreated control) at the 3-5 true-leaf developmental stage after emergence from the soil (early inoculation) and again on different replicates following the flowering stage (late inoculation). At the conclusion of the experiment, all plants in the experiment were subjected to double antibody sandwich, enzyme-linked, immunosorbant assay for confirmation of infection. A subset of inoculated plants determined to be infected with PVY strains were individually hand harvested from each experimental replicate and all tubers placed in harvest bags labeled according to variety, inoculation time, PVY strain, replicate, and plant number within row. A subset of non-inoculated, healthy plants from each variety / replicate combination was hand harvested and tubers placed in individually labeled bags.

Following harvest, tubers collected under individual plants were thoroughly washed, and tuber fresh weight (g) recorded. Washed tubers will then be air-dried and specific gravity determined. All tubers collected under plants serologically determined to be infected with PVY were then individually bagged and placed in storage. Quality parameters (tuber fresh weight, specific gravity, and percent sprouting) were assessed on stored tubers at regular intervals post-harvest throughout the cold storage period extending up to 36 weeks. Fresh market cultivars (e.g. ‘Russet Norkotah’ and ‘Silverton’) were maintained in storage at a constant 40° F and 95% RH while processing cultivars (‘Russet Burbank’ and ‘Atlantic’) were held at 48° F and 95% RH.
To date, replicated field experiments have resulted in some interesting overall differences in tuber quality estimates among the varieties tested. Differences in percent solids (specific gravity), (Fig. 1) and mean weight loss (shrinkage) were detected in both ‘Russet Norkotah’ and ‘Silverton’ (Fig. 2). The efficiency of tuber infection in the 2007-08 field experiment did vary among cultivars when plants were infected at different developmental stages (e.g. preflower & postflower). With increasing plant age at the time of infection, reductions in the mean proportion of PVY-infected shoots resulted in the cultivars ‘Atlantic’ and ‘R. Burbank’. This pattern of reduced tuber infection with increasing age of infection is consistent with the previously described phenomenon of mature plant resistance. However, the asymptomatic cultivars ‘Silverton’ and ‘R. Norkotah’ possessed daughter tuber mean infection rates that did not vary between infection times. Finally, no differences in the frequency of tuber infection were observed between the two PVY strains used in the experiment, PVYO and PVYN:O between the two asymptomatic cultivars.

**Figure 1.** Mean specific gravity of fresh market (e.g. ‘Russet Norkotah’ and ‘Silverton Russet’) and processing cultivars (‘Russet Burbank’ and ‘Atlantic’) held in storage over 40 weeks comparing non-inoculated, control plants (●●●) to PVYO (●→) and PVYN:O (●—●) inoculations.
In the coming season (2009), we propose to continue this area of investigation to determine if infection by PVY can influence the tuber physiological age and resulting emergence, stem number and tuber set. During development, the potato tuber passes through very definite stages which relate to the accumulation of physiological age. Furthermore, tuber production is directly related to physiological age of the seed piece which results from the combination of stresses imposed upon the plant. Plants with multiple stems, high tuber numbers and early plant maturity are highly desirable for the production of a seed potato crop. This type of plant arises from a seed tuber which has accumulated sufficient physiological age to have multiple sprouts. If seed physiological aging progresses too far, however, the sprouts will become progressively weaker and form branches. The resulting plant will be weak and will mature before maximum yield is attained. Potato seed grown with infection by PVY, which can stress the crop considerably, would be expected to be physiologically older at harvest than tubers from an un-infected plant. This area of investigation also seems extremely important as there have been no studies to quantify or define the consequences of long-term storage of tubers infected with PVY or the impact of this virus upon physiological age of tubers.

References.