Assessing the Impact of Purple Top Disease Pathogen on Potatoes in the Columbia Basin

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Introduction

Since 2002, Columbia Basin potato growers in Washington and Oregon have experienced serious outbreaks of potato purple top disease that caused significant yield losses and a reduction in tuber quality (Munyaneza 2005). It has been determined that the beet leafhopper-transmitted virescence agent (BLTVA) phytoplasma (also known as the Columbia Basin potato purple top phytoplasma) is the causal agent of the disease in the Columbia Basin and that this pathogen is transmitted by the beet leafhopper (Lee et al. 2004; Crosslin et al. 2005; Munyaneza et al. 2006a). Despite the increasing importance of the problem, little is known about the impact of this disease on potato. To increase the understanding of the impact of this potato disease in the Columbia Basin, the following objectives were addressed in 2006: 1) assess the susceptibility of important potato cultivars grown in the Columbia Basin to the BLTVA phytoplasma and purple top disease under field conditions; 2) assess the impact of the phytoplasma and purple top on tuber quality in different potato cultivars under field conditions; 3) determine susceptibility of different potato plant growth stages to the phytoplasma under laboratory and field conditions; 4) determine the incidence of the phytoplasma in beet leafhoppers collected from potatoes throughout the growing season; and 5) test selected weeds and other crop plants for presence of the phytoplasma, to determine the potential source of this pathogen.

Materials and Methods

Potatoes were planted in May 2006 in small field plots (3 rows x 50 ft each) at the USDA-ARS Experiment Station at Moxee, WA. Potato cultivars include Ranger, Russet Burbank, Umatilla, Norkotah, Shepody, and Alturas. For each cultivar, treatments consisted of 3 untreated plots (no insecticides) and 3 plots that received insecticide applications. Plots were sampled weekly to document the presence/absence of leafhoppers and were visually monitored for purple top symptoms. Also, plant tissues were collected from plants and tested for BLTVA using PCR; plants testing positive for the BLTVA or found to be free of the phytoplasma were marked with flags, and then hand harvested at the end of the season. Tubers from clean and BLTVA-infected plants for each cultivar were properly stored and processed for tuber quality at desired intervals. To assess the tuber quality for each cultivar, samples of tubers from phytoplasma free and infected plants were measured for solids, fried to test for high sugar levels and sugar ends, and checked for internal defects. To increase the understanding of phytoplasma transmission through seed, tubers from individual BLTVA free and infected plants were tested for the phytoplasma to estimate the infection rate of tubers. Also, grow-outs of phytoplasma infected tubers were done in the greenhouse to estimate phytoplasma transmission rate in daughter tubers.

Different plant growth stages of phytoplasma-free plants of Ranger and Umatilla were exposed to BLTVA-infected laboratory reared beet leafhoppers in large transmission cages for a week in the laboratory. After exposure, the potato plants were transplanted outdoors, observed for purple top disease symptoms, and tested for BLTVA by PCR. In addition, two 200 ft long rows of potatoes were planted in the field for each of the two varieties. The rows were covered with Agribon fabric after potato planting and irrigated with sub-soil drip irrigation. Plants were uncovered at different intervals (plant emergence, 3 and 8 weeks after emergence) to expose plants of different growth stages to naturally occurring beet leafhoppers.

The plants were also observed for purple top disease and tested for presence of the phytoplasma. During the 2005 and 2006 growing seasons, beet leafhoppers were collected weekly from experimental potato plots and nearby weeds at Moxee and preserved in 70% alcohol. These leafhoppers were tested for BLTVA to determine the incidence of the phytoplasma in leafhoppers invading potatoes throughout the growing season. In addition, more than 120 weed and alfalfa samples were collected in 2006 and tested for BLTVA to investigate potential reservoirs of the phytoplasma.

Results and Discussion

Purple top foliar symptoms were observed in all of the tested cultivars, and plant samples collected and tested by PCR confirmed the presence of BLTVA. Purple top disease incidence in plants averaged 49.3, 26, 21, 10.7, 10, and 3% for Norkotah, Umatilla, Ranger, Alturas, Shepody, and Russet Burbank, respectively (Table 1). Incidence of the disease in the plots that received insecticide applications weekly was extremely low (0.2 to 1.5%).

Table 1. Susceptibility of different potato cultivars to the purple top phytoplasma under field conditions (trial conducted at Moxee, WA, 2006).

Cultivar	***BLTVA infection (%) in plots without insecticides***	***BLTVA infection (%) in plots with insecticides***
Norkotah	49.3	1.3
Umatilla	26.0	1.1
Ranger	21.0	1.5
Alturas	10.7	1.1
Shepody	10.0	0.2
Russet Burbank	3.0	0.2

Our results clearly showed that most, if not all, of the cultivars grown in the Columbia Basin are susceptible to the purple top phytoplasma. Similarly to our previous laboratory study (Munyaneza et al. 2006b), Russet Burbank appears to be resistant to or tolerant of the disease and did not show disease symptoms until close to harvest.

Results of previous studies (Munyaneza 2006; Munyaneza et al. 2006b) indicated that there were differences in tuber solids and sugar content between BLTVA infected and non-infected potato plants. Working with Umatilla and Russet Burbank collected from the field, it was found that sugar levels were very high in BLTVA-infected Umatilla tubers and increased significantly while tubers were in storage. Russet Burbank tubers reacted significantly less to development of sugars over time as compared to Umatilla. Interestingly, results of the 2006 study did not show differences in fry color between tubers from BLTVA infected and healthy plants across the tested cultivars, immediately and 90 days after harvest. However, the tuber processing is still continuing and it is possible that differences in tuber quality could be observed after sometime in storage. Very few internal defects have been observed so far and consist mostly of hollow heart.

Our study also showed that the phytoplasma can be detected in potato tubers by PCR after being stored for more than 180 days and is transmitted to daughter tubers at a very high rate. Hand harvested tubers from individual phytoplasma free and infected plants were tested by PCR to determine how many tubers per plant were infected by the phytoplasma. None of the healthy plants produced BLTVA-infected tubers. In contrast, 92, 88, 80, 64, 60, and 25% of tubers per plant from Norkotah, Alturas, Umatilla, Shepody, Ranger, and Russet Burbank, respectively, were found to be infected with the phytoplasma (Table 2).

Table 2. Number of tubers from BLTVA phytoplasma-infected potato plants testing positive for the phytoplasma by PCR. Four to 5 tubers were randomly collected from each of the 5 plants and tested for each cultivar. None of the healthy potato plants produced BLTVA-infected tubers.

Cultivar	***Plant 1***	***Plant 2***	***Plant 3***	***Plant 4***	***Plant 5***	***Total***	***Percent***
Burbank	1/5	1/4	0/5	0/5	4/5	6/24	25
Norkotah	5/5	5/5	5/5	3/5	5/5	23/25	92
Shepody	2/5	3/5	3/5	3/5	5/5	16/25	64
Ranger	2/5	2/5	5/5	5/5	1/5	15/25	60
Alturas	5/5	3/5	5/5	4/5	5/5	22/25	88
Umatilla	5/5	3/5	3/5	5/5	4/5	20/25	80

Russet Burbank not only developed purple top symptoms later in the season, but also had the lowest infection of daughter tubers. In contrast, Norkotah was the most susceptible in the field and had the highest rate of infection in daughter tubers. Moreover, grow-outs of BLTVA infected tubers from greenhouse-grown plants showed that about 35% of infected tubers produced infected plants.

In addition, results of our exposure experiment indicated that younger plants were more susceptible to BLTVA than older ones. Ninety and 70.6% of plants exposed to BLTVA-infected leafhoppers at emergence under laboratory conditions tested positive for the phytoplasma for Umatilla and Ranger, respectively. In contrast, only 10 and 8.5% of Umatilla and Ranger plants, respectively, become infected with the phytoplasma after being exposed to leafhoppers when the plants were about 8 weeks old. Similar results were observed when the exposure was conducted under natural field conditions. BLTVA infection rate was 87.5, 70, and 18.4% for Umatilla, after the plants were exposed at emergence, 3 weeks, and 8 weeks, respectively. Similarly, 65, 52.3, and 14.3% of the Ranger plants became infected with BLTVA after being exposed at emergence, 3 weeks, and 8 weeks (Fig. 1). In all cases, Umatilla appears more susceptible than Ranger, when planted side by side.

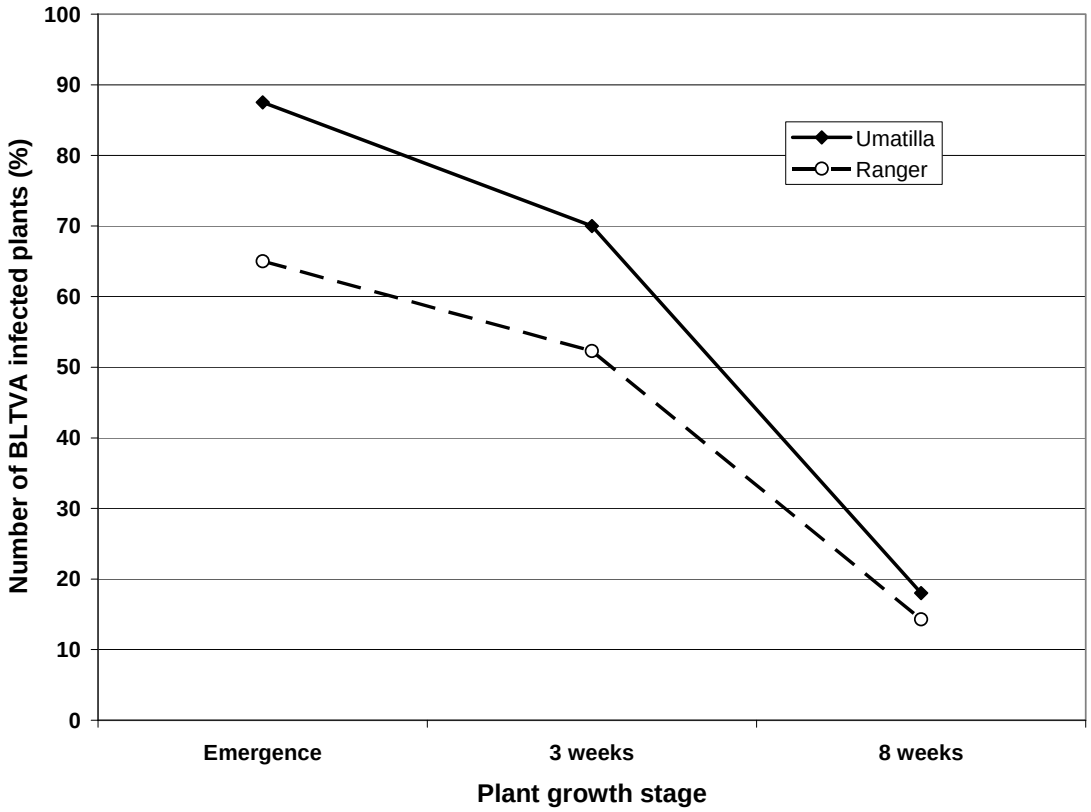

Figure 1. Susceptibility of different plant growth stages to BLTVA phytoplasma. Umatilla and Ranger plants were exposed to naturally occurring BLTVA-infected beet leafhoppers under field conditions. Exposure was made by removing the row cover (Agribon fabric) at plant emergence, 3 and 8 weeks after emergence.

In a previous study, beet leafhoppers were found to be present in the Basin potatoes throughout the season (Munyaneza 2005). Results of our beet leafhopper testing in 2005 indicated that BLTVA incidence in the leafhoppers collected in potatoes and surrounding weeds was very high and averaged 18 and 23.5% in leafhoppers collected from the potatoes and weeds, respectively (Fig. 2) whereas the incidence in 2006 was 36 and 21% in leafhoppers found in potatoes and weeds, respectively (Fig. 3). Infected leafhoppers were found in both potatoes and weeds throughout the growing season (Figs. 2 and 3), suggesting that potatoes could be infected anytime during the season. However, to date, Columbia Basin potato growers have managed to keep the purple top disease under manageable levels by applying insecticides against the beet leafhopper early in the season (Munyaneza et al. 2006b). These observations strongly support the suggestion that older potato plants are less susceptible or more tolerant to the BLTVA phytoplasma. More leafhopper testing and studies to look into this factor are planned in 2007. Resulting information will help in the prediction of the proper timing of insecticide applications.

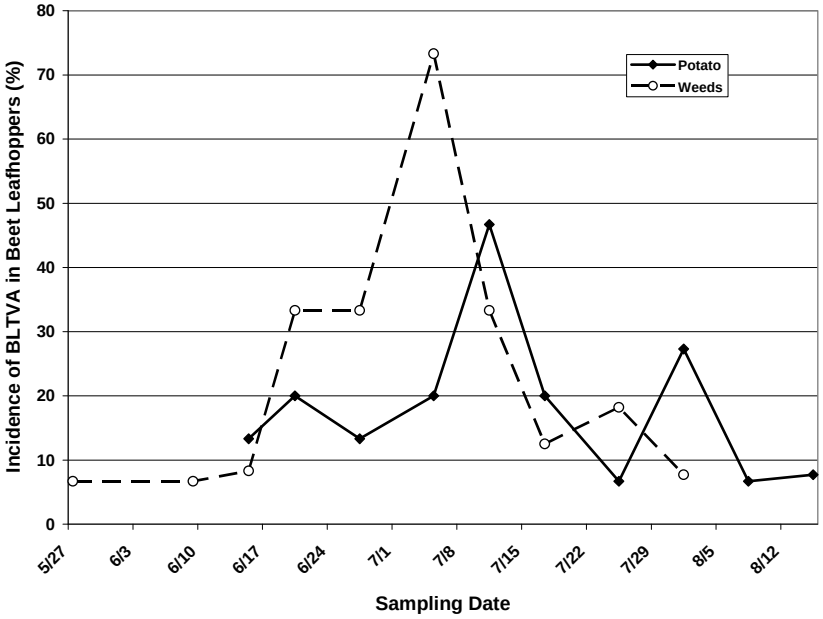

Figure 2. Incidence of BLTVA phytoplasma in beet leafhoppers collected from potatoes and nearby weeds in 2005 at Moxee, WA.

Of more than 120 weed (kochia, Russian thistle, pigweeds, mustards, etc.) and alfalfa samples collected from Prosser and Moxee and tested for BLTVA, only a few Russian thistle samples collected late in the season from Moxee tested positive for the phytoplasma. This was the first time that field-collected Russian thistle had tested positive for the BLTVA. Russian thistle may indeed be important in the epidemiology of the BLTVA phytoplasma because it is an important host of the beet leafhopper in the middle and late summer. More weed testing is planned in 2007. Information from this study will increase our understanding of the sources of BLTVA phytoplasma and potato purple top in the Columbia Basin and will help in formulating effective management strategies for this potato disease.

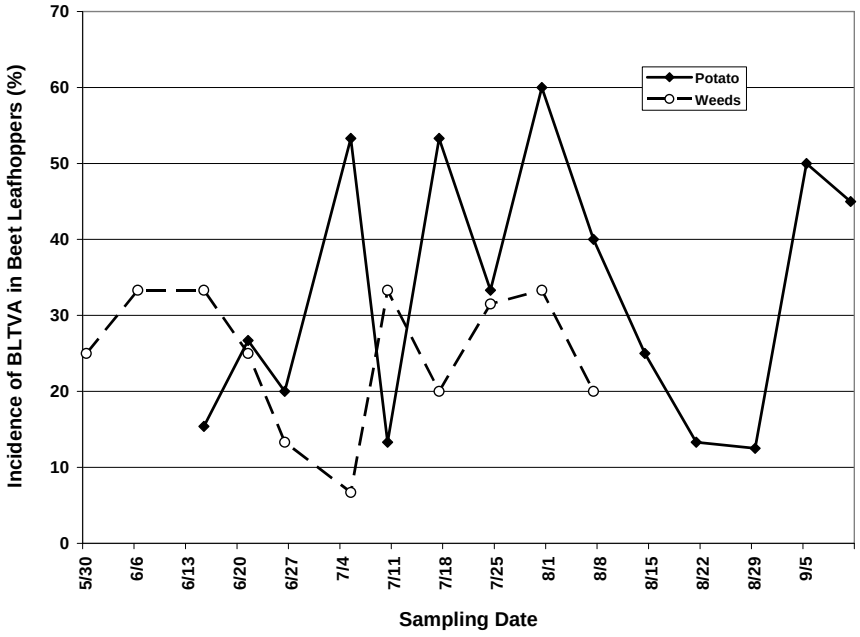

Figure 3. Incidence of BLTVA phytoplasma in beet leafhoppers collected from potatoes and nearby weeds in 2006 at Moxee, WA.

Conclusion

Most, if not all, of the potato cultivars grown in the Columbia Basin are susceptible to the purple top phytoplasma; however, Russet Burbank appears resistant to or tolerant of this plant pathogen or the disease. Younger potato plants seem also vulnerable to the phytoplasma. BLTVA is effectively transmitted to daughter tubers at a very high rate. Interestingly, Russet Burbank tends to produce fewer infected tubers. In contrast to 2005 results, no differences in fry color between tubers from BLTVA infected and healthy potato plants have been observed immediately after harvest and after 90 days in storage. Very few internal defects in tubers from BLTVA infected potato plants have been observed so far. A high proportion of beet leafhoppers in potatoes and nearby weeds were found to carry the BLTVA phytoplasma throughout the whole season. Russian thistle seems to play an important role in the epidemiology of the potato purple top disease in the Columbia Basin as it was found for the first time to be host to BLTVA phytoplasma in the field and is a well known summer and fall host for the beet leafhopper. More studies are planned for the 2007 growing season to gain more understanding of the impact of the BLTVA on potato.

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