# UPDATE ON THE POTATO PURPLE TOP DISEASE IN THE COLUMBIA BASIN

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## Introduction

An epidemic of purple top disease of potato occurred in the Columbia Basin of Washington and Oregon in 2002 growing season and caused significant yield losses to potato fields; there were also indications of reduced tuber quality resulting from diseased plants. The disease was also observed in 2003 and 2004 growing seasons, especially in organic potato fields. Symptoms in affected potato plants include a rolling upward of the top leaves with reddish or purplish discoloration, moderate proliferation of buds, shortened internodes, swollen nodes, aerial tubers, and early plant decline. These symptoms resemble very much those of purple top caused by psyllid damage or phytoplasma infection, and in some cases to those caused by potato leafroll virus (PLRV). Early investigation of the cause(s) of the disease indicated that leafhopper transmitted phytoplasmas may have played a significant role in this disease epidemic. The phytoplasma disease complex of potato is poorly understood. Most phytoplasma affected potato plants are broadly termed purple top, and the etiology is attributed to the aster yellows phytoplasma, as has recently been the case in Mexico. A Washington State Potato Commission funded multidisciplinary team, mainly made of entomologists and plant pathologists (above authors), was formed to investigate various aspects of the problem, including disease causal agent(s) identification, insect(s) vectoring the disease, disease epidemiology, and disease management.

## Disease Causal Agent Identification

During 2003 and 2004 growing seasons, samples of diseased potato plants were collected from potato fields throughout the Columbia Basin and were tested by the USDA-ARS laboratories at Prosser (WA) and Beltsville (MD) for phytoplasmas using the polymerase chain reaction (PCR) technique. Results indicated that all phytoplasmas detected from the diseased plants belong to the clover proliferation group (16SrVI), subgroup A (16SrVI-A) phytoplasmas. This subgroup currently consists of three members: clover proliferation (CP); potato witches'-broom (PWB); and vinca rosette (VR), a strain of beet leafhopper transmitted virescence agent (BLTVA) phytoplasmas. The 16S rDNA sequence analysis indicated that the detected phytoplasmas were most closely related to VR with 99.7% gene sequence homology compared to 99.2% with CP and PWB. Also, the results pointed out that the phytoplasmas detected in infected potatoes were nearly identical (99.8%) to phytoplasma strains associated with dry bean phyllody disease which recently occurred in the Columbia Basin. Furthermore, a similar phytoplasma was identified in infected radish seed from the area. These results verified that the phytoplasma associated with potato purple top disease in the Columbia Basin is different from the potato purple top phytoplasma reported from Mexico.

While the pathogen found in the Columbia Basin is in the clover proliferation group (16SrVI) of phytoplasmas, the one from Mexico is related to the aster yellows group (16SrI). This shows that a similar disease can be caused by two different pathogens. Recently, sequences of three fragments from PCR products obtained from phytoplasma-infected potatoes and leafhoppers were deposited in the GenBank data base as accessions AY692279-AY692281 by J.M. Crosslin. To distinguish it from the potato purple top phytoplasma in Mexico, the accession AY692280 was identified as the "Columbia Basin purple top disease phytoplasma", which is closely related to, or synonymous with, BLTVA.

## Disease Vector Identification

Phytoplasmas are usually transmitted by leafhoppers or psyllids. In 2003 and 2004, these insects were collected from several sites in the Columbia Basin and identified. Several leafhopper species were found during the sampling and included *Circulifer tenellus*, *Macrosteles* spp., *Ceratagallia* spp., *Dikraneura* spp., *Exitianus exitiosus*, *Ballana* spp., *Colladonus* spp., *Amblysellus* spp., *Paraphlepsius* spp., *Texananus* spp., *Balclutha* spp., *Latalus* spp., *Empoasca* spp., and *Erythroneura* spp. Although various species of psyllids were collected during the sampling, no potato psyllids were found in the samples.

Collected insects were tested by PCR individually or in groups of 5-10 for the presence of the potato purple top phytoplasma (BLTVA) at the USDA-ARS in Prosser. The phytoplasma was most often detected in the beet leafhopper (*Circulifer tenellus*) and less frequently in *Ceratagallia* spp. (Table 1). All other leafhoppers tested negative for the phytoplasma, including *Macrosteles*, the known vector of aster yellows phytoplasma. Because the phytoplasma was almost exclusively associated with the beet leafhopper and this insect was abundant throughout the Columbia Basin, it is likely that this leafhopper is an important vector of the potato purple top phytoplasma in this region.

## Beet Leafhopper Phenology and Population Dynamics

To determine the seasonal occurrence and abundance of the beet leafhopper, leafhopper monitoring and sampling were conducted from early spring to late fall in 2003 and 2004 at several locations throughout Yakima Valley and the Columbia Basin using a combination of yellow sticky traps and sweep nets. Sweep sampling was conducted in both years and sampling sites were mainly located in the south Columbia Basin and Yakima Valley and included areas near Boardman, Umatilla, and Hermiston in Oregon and Alderdale, Paterson, McNary, Pasco, Wallula, and Moxee in Washington. In addition, a region-wide leafhopper trapping system using yellow sticky traps was also conducted in the Columbia Basin; yellow sticky traps were deployed at 35 locations in Oregon (Umatilla and Morrow counties) in both 2003 and 2004, and at 70 locations in Washington (Adams, Grant, Lincoln, Franklin, Benton, and Walla Walla counties) in 2004. Most of the sampling sites were located in and/or near commercial potato fields that had been significantly affected by the purple top disease in 2002 and along the hills overlooking the Columbia River and Yakima River. Weeds at the sampling sites included grasses, mustards, kochia, filaree, Russian thistle, rabbitbrush, sagebrush, prickly lettuce, hoary cress, and pigweed. Heavy duty sweep nets (BioQuip Products, Inc., Gardena, CA), with a 15-inch net hoop were used for sweep samples. At least four 100-sweep samples were taken at each location on each sampling date.

Sweep samples were taken weekly, placed in plastic bags, and brought to the laboratory at the USDA-ARS in Wapato, WA, where leafhoppers were sorted, identified, and counted. Yellow sticky traps consisted of 3x5 inch sticky cards (Olsen Products, Inc., Medina, OH) mounted on wooden stakes. The stakes were 12 inches long, with about 3 inches inserted in the ground. The bottom edge of each card was about 5-10 cm above the ground, and the cards were held onto the stake with a large paper-binding clip. All vegetation within 2-3 feet of the trap was kept trimmed to a height of less than 3 inches. Yellow sticky traps were collected and replaced weekly, taken to the Washington State Potato Commission office in Moses Lake, WA, where samples were processed for leafhoppers similarly to the sweep samples. Two potato fields were planted in both 2003 and 2004 at USDA-ARS farms at Moxee and Paterson in Washington; these fields were left untreated with insecticides. Leafhopper sampling in these fields was also conducted using sweep nets and samples were processed as previously described.

Results are summarized in Table 2 and Figures 1-5. As mentioned earlier, a number of leafhopper species were found in collected samples (Table 2). Leafhopper species composition was almost the same at most of sampled locations but the abundance of different leafhopper species varied depending on types of vegetation at the sampling locations and growing season during which the samples were collected. Most of the leafhopper species found in weeds and crops in the vicinity of potatoes were also present within potato fields. Although leafhoppers were observed in weeds near potato fields very early in spring, most leafhopper species seemed to invade potatoes in early summer as weeds matured and died. The beet leafhopper was by far the most abundant species on yellow sticky traps (Table 2), and was also one of the most abundant species in the area taken during the sweep sampling (Table 2). *Dikraneura* species which were by far the most abundant in 2003 sweep samples are mainly grass feeders and have not been implicated in phytoplasma transmission. The beet leafhopper was very abundant in weeds near potato fields from mid-April to mid-October (Figs. 1-3) and had at least 3 generations per year (Fig. 4). The beet leafhopper moved into potato fields sometime in mid-May and was present in potatoes throughout the remainder of the growing season (Fig. 5). This leafhopper was more abundant in potatoes in early summer than in late summer, suggesting that potatoes most likely are infected with the purple top disease during this time of the growing season; however, it is not clear how far into the growing season that potato infection occurs.

## Planting Time and Variety Trial

In this trial, four different potato varieties (Ranger Russet, Russet Norkotah, Shepody, and Russet Burbank) were planted in Eltopia, WA, at different times (March 15, March 22, March 29, April 5, April 12, and April 19) during the spring of 2004 to determine if planting dates had any effect on BLTVA transmission. Six plantings of four varieties for a total of 24 treatments, each replicated four times were used in the trial. Five varieties of radishes and a mustard crop were planted on March 23 as trap crops to attract leafhoppers. This trial consisted of a randomized complete block design. Plots were 8 rows x 20 ft with a 5 ft buffer in between plots. Potatoes were planted using a four-row planter. The radish and mustard crops were treated with a low rate of Roundup to mimic the natural desiccation of weedy mustards. It was expected that resident leafhoppers would move from the trap crop to the potato plots. No insecticides were applied to the potatoes during the course of the trial. For evaluation, one yellow sticky card was placed in each plot, sampled, and replaced once a week. On August 23, five leaves for each variety per plot were sampled for BLTVA using nested PCR analysis.

Results indicated that Russet Burbank plantings on April 12 and April 19 and the Ranger planting on April 19 tested positive for BLTVA. The implications of these results are not clear; however, the three positive treatments were later plantings which might suggest that later planted potatoes were more vulnerable to BLTVA. The relatively low disease pressure in the trial caused the inconclusive results.

**Insecticide Efficacy Trial**

Seventeen different insecticidal treatments were used to determine efficacy against leafhopper and transmission of BLTVA in 2004. Insecticide application methods included seed treatment, in-furrow, and foliar directed treatments. Russet Burbank potatoes were planted in Eltopia, WA, on April 8 using a two-row planter for seed treatment applications and a four-row planter for all other treatments. Plots were 8 rows x 20 ft in a randomized complete block design with 4 replications. On March 23, five varieties of radishes and a mustard crop were planted as trap crops to attract leafhoppers. As in the previous trial, the radish and mustard crops were treated with a low rate of Roundup to mimic the natural desiccation of weedy mustards; it was expected that resident leafhoppers would move from the trap crop to the potato plots. Foliar applications of insecticides began on May 12 and were applied at 14 day intervals until June 23 (4 applications).

Leafhoppers were monitored by placing one yellow sticky card in each of the 4 replicated regions. These cards were collected and replaced once a week. Mite counts were also taken on July 22 and July 28 to evaluate possible flaring from insecticide applications. On August 2, 5 leaves per plot were sampled and analyzed for the presence of BLTVA using nested PCR analysis. Of the eighteen treatments (seventeen insecticidal treatments and one untreated check), two tested positive for BLTVA: Genesis and Admire. These results would appear to buttress the theory that planting time treatments do not provide protection from BLTVA. The results, however, were rendered less than ideal by the low disease pressure.

Assessments of other insect pests, such as green peach aphid (GPA) and Colorado potato beetle (CPB), did not provide any evidence that BLTVA treatments influenced their population levels negatively. Treatments that normally controlled CPB did so when CPB populations coincided with treatment intervals. Aphid populations did not flare during the treatment intervals; however, aphids did not appear in the trial post-application suggesting that in this trial the treatment programs did not flare aphids. It should be noted that overall aphid populations in the local vicinity were below normal compared to recent years. In this trial, it should also be noted that mite populations were present very early as compared to all other potatoes in the vicinity. Some treatments had mite numbers above that of the untreated check. Information on the impact of the 18 beet leafhopper treatments on mite populations is provided in Table 3.

## Conclusion

Information from the present study indicated that the potato purple top disease in the Columbia Basin is caused by the BLTVA and not aster yellows phytoplasma. The beet leafhopper is likely the major vector of the potato purple top phytoplasma in this region. Weeds immediately surrounding fields play an important role in the dispersal of the beet leafhopper and epidemiology of the potato purple top disease. Leafhoppers seem to invade the Columbia Basin potato fields around mid-May to mid-June. Late planted potatoes seem to be vulnerable to the disease. Foliar insecticide applications are effective in controlling the leafhoppers but timing is crucial to reduce the number insecticide applications and to avoid flaring aphids and mites. More research on the epidemiology and management of the potato purple top disease in the Columbia Basin is planned. Future research objectives include investigating the importance of weeds as hosts to both beet leafhopper and BLTVA phytoplasma, determining the sources of infective leafhoppers, investigating the susceptibility of different potato cultivars and plant stages to BLTVA, determining the effects of BLTVA on potato tubers, and establishing action thresholds for the disease.

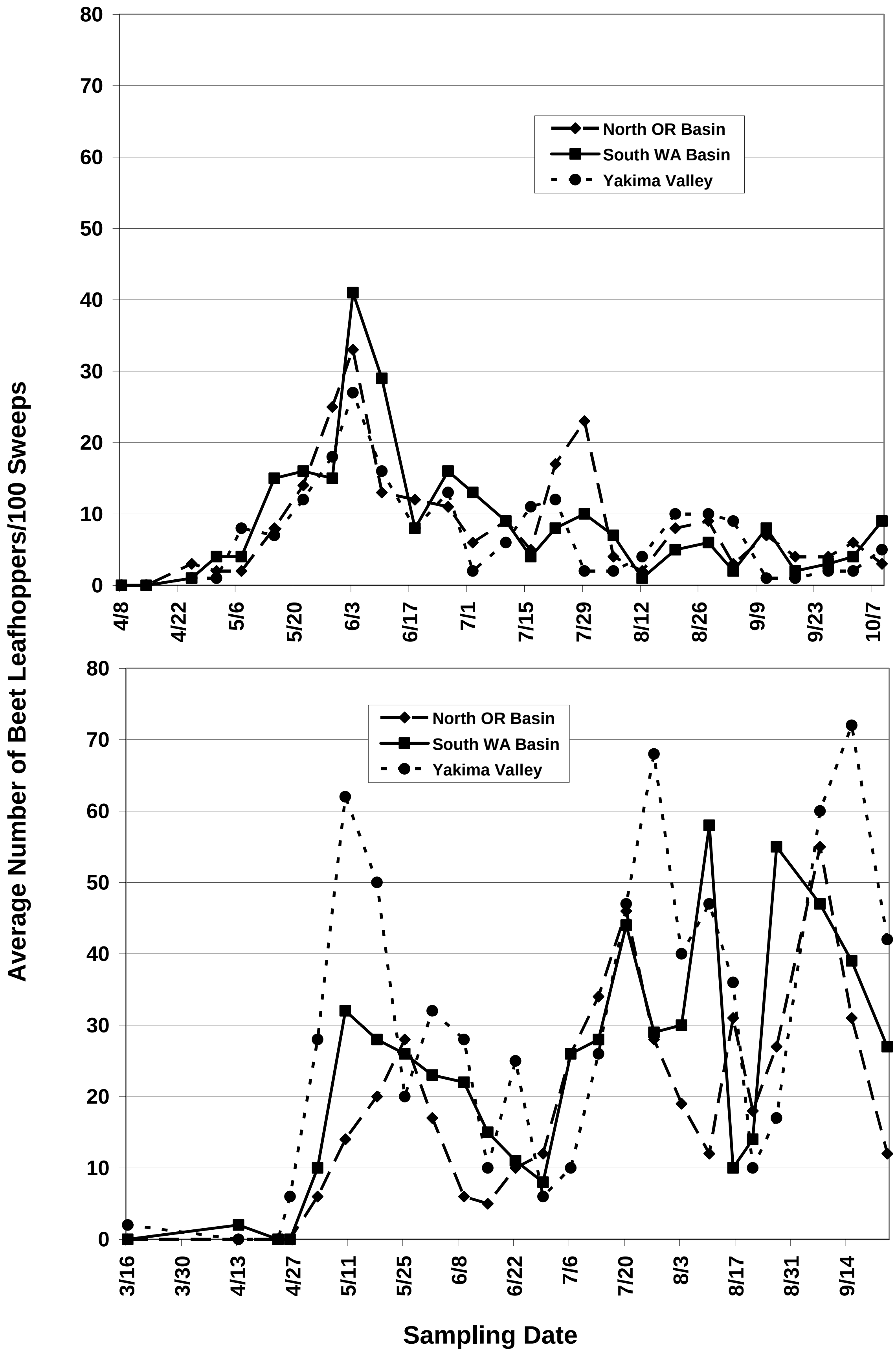


**Figure 1**. Average number of beet leafhoppers per 100 sweeps on each sampling date in 2003 (A) and 2004 (B). Sampling was conducted weekly in weeds near potatoes.

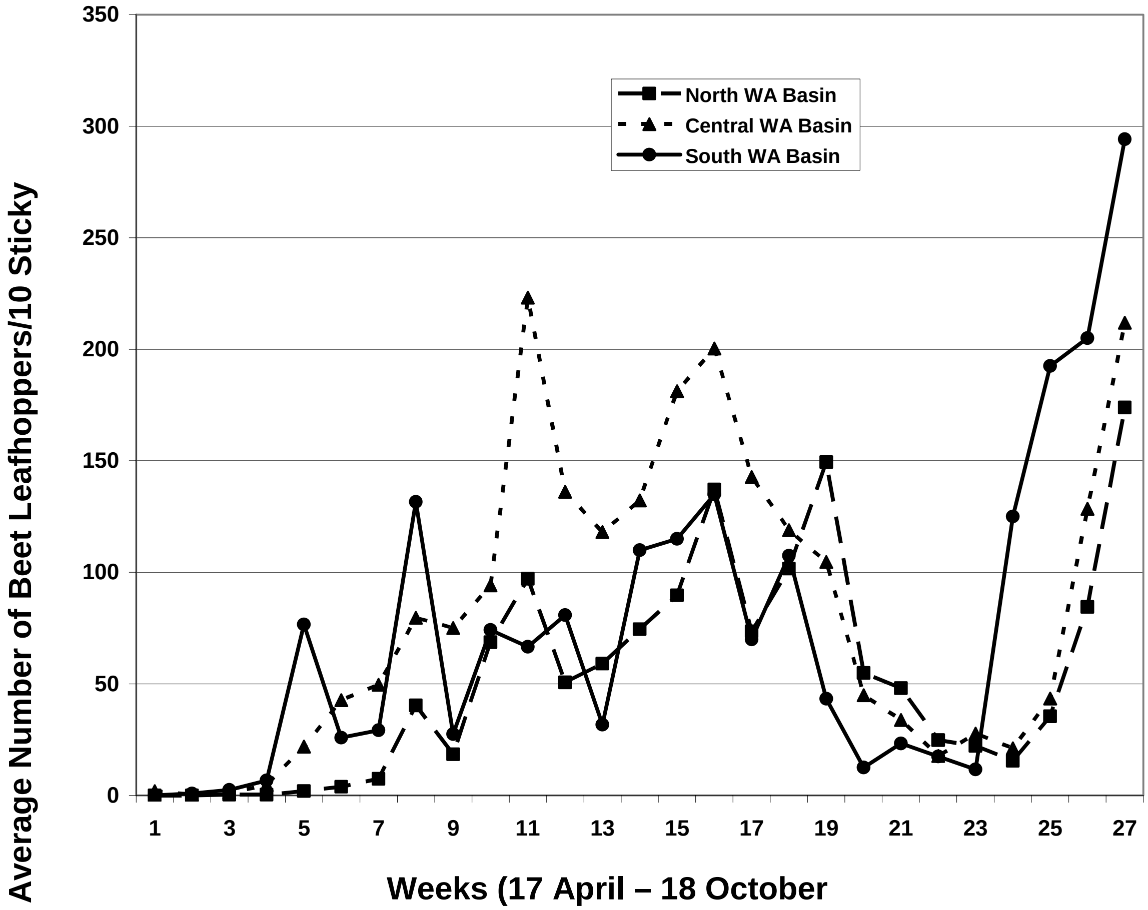


**Figure 2**. Average number of beet leafhoppers per 10 yellow sticky traps collected weekly at various locations in the Columbia Basin of Washington. The trapping was conducted in 2004 only and traps were placed near potato fields.

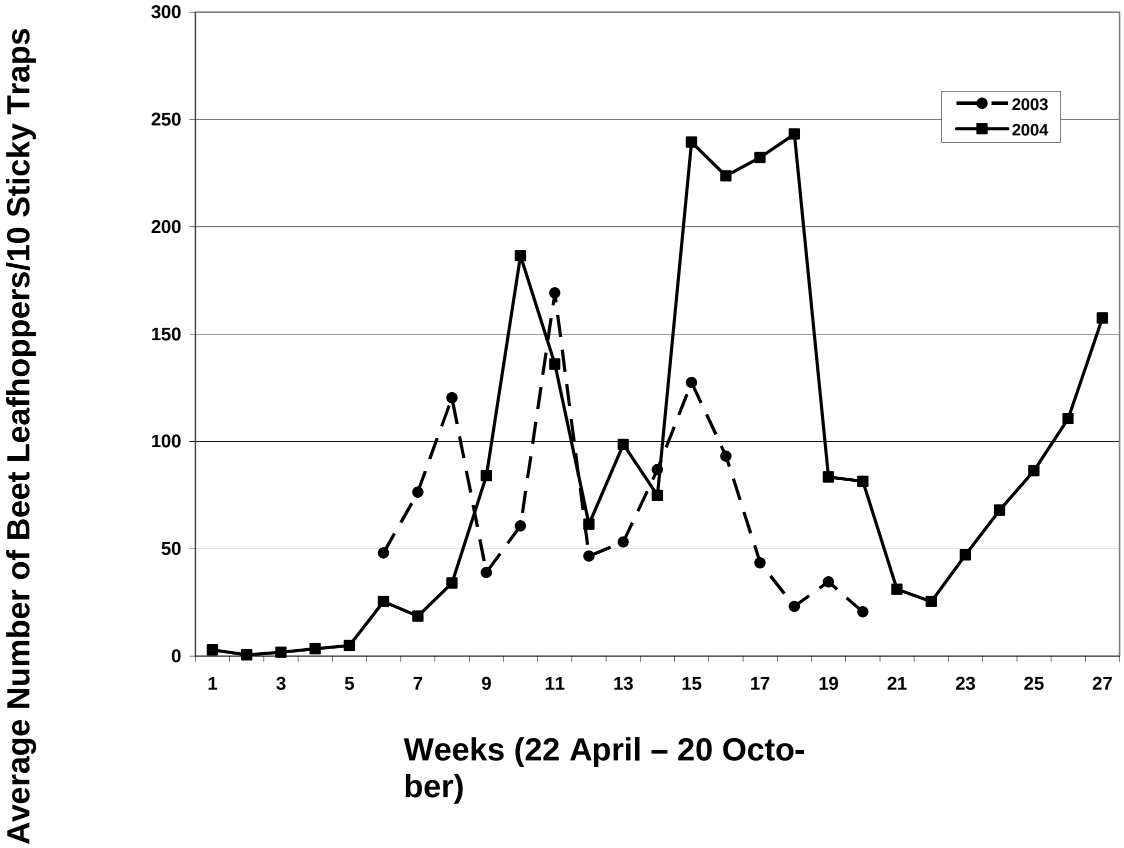


**Figure 3**. Average number of beet leafhoppers per 10 yellow sticky traps collected weekly in both 2003 and 2004 at various locations in the Columbia Basin of Oregon. The traps were located near potato fields.

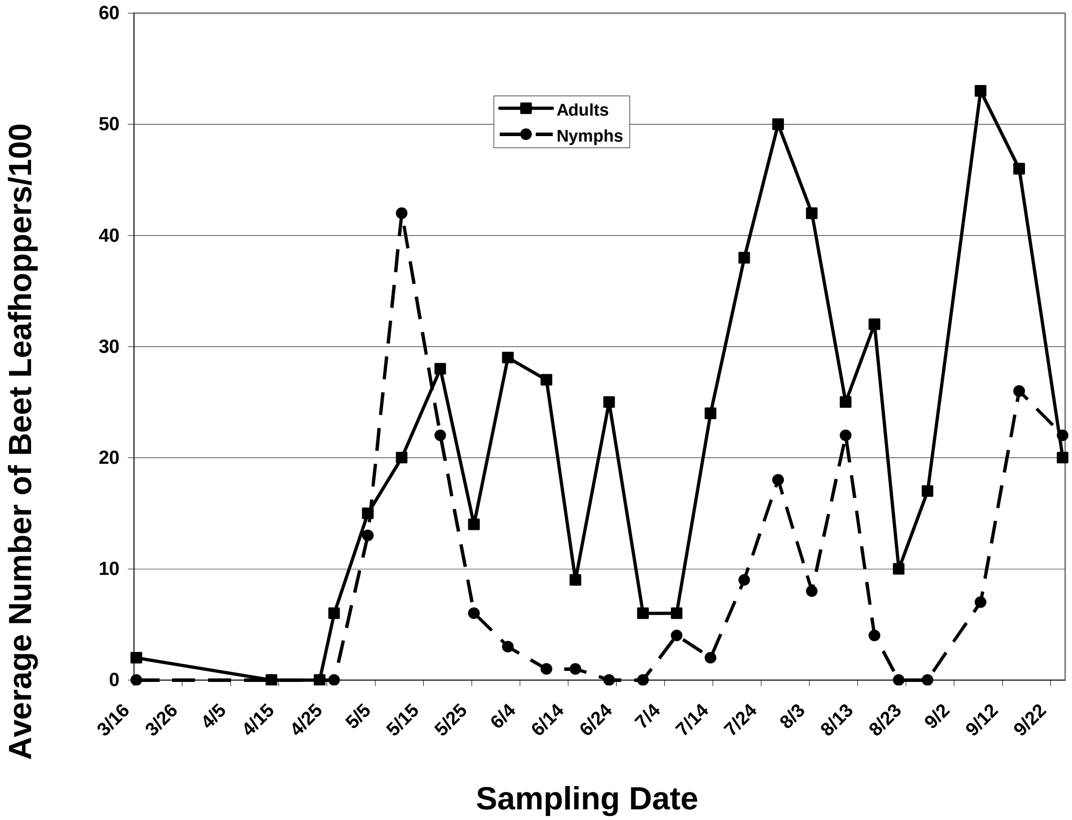


**Figure 4**. Average number of beet leafhopper adults and nymphs per 100 sweeps on each sampling date in Yakima Valley in 2004 growing season. Sampling was conducted in weeds near potato fields.

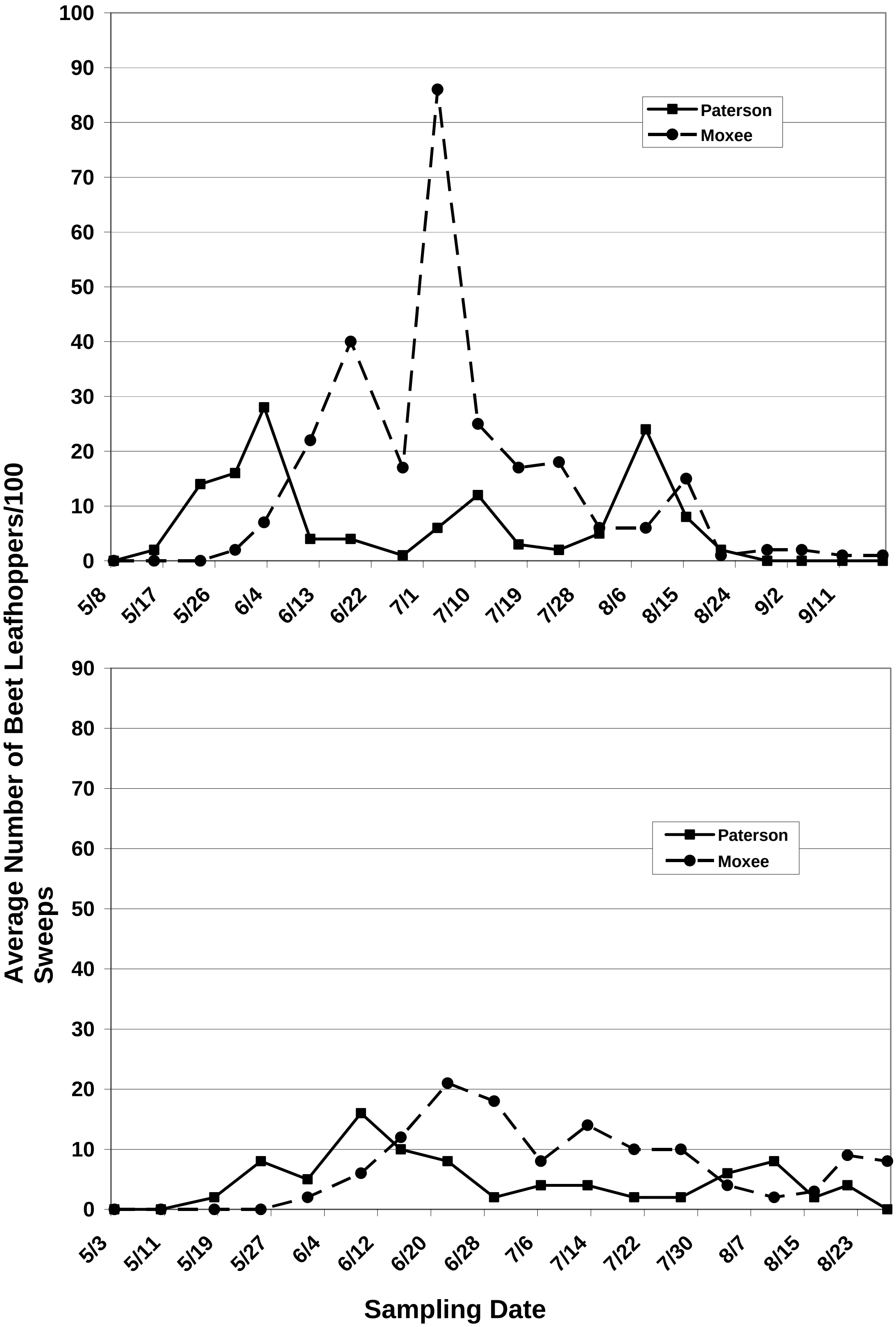


**Figure 5**. Average number of beet leafhoppers per 100 sweeps on each sampling date within potato fields at Paterson and Moxee in 2003 (A) and 2004 (B) growing seasons.

Table 1. Association of phytoplasma with leafhoppers and planthoppers collected in 2003 and 2004.[1]

| **Leafhopper Taxon** | **Collected in 2003** | **Collected in 2004** | **Total of both years** |
|---|---|---|---|
| | | | |
| *Amblysellus* | 0/4 | -[3] | 0/4 |
| *Balclutha* | 0/2 | - | 0/2 |
| *Ballana* | 0/1 | 0/4 | 0/5 |
| *Ceratagallia* | 0/7 | 2/16 | 2/23 |
| *Circulifer tenellus* | 16/30 | 31/60 | 47/90 |
| *Colladonus geminatus* | 0/2 | 0/2 | 0/4 |
| *Colladonus montanus* | 0/2 | - | 0/2 |
| *Dikraneura* | 0/6 | - | 0/6 |
| *Erythroneura* | 0/2 | - | 0/2 |
| *Exitianus exitiosus* | 0/8 | - | 0/8 |
| *Latalus* | 0/4 | - | 0/4 |
| *Macrosteles* | 0/7 | 0/11 | 0/18 |
| *Paraphlepsius*[2] | 0/3 | - | 0/3 |
| *Texananus*[2] | 0/2 | - | 0/2 |
| Unknown Cicadellidae | 0/1 | - | 0/1 |
| Unknown Delphacidae | 0/2 | - | 0/2 |

[1]Insects were captured with sweep nets, identified, and stored in 70% ethanol. Nucleic acid was extracted from groups of five insects. Numbers are the number of groups of five insects positive for phytoplasma over the number tested. PCR primers were rp3/rp4, which amplify a 660 base pair region of the ribosomal protein genes of phytoplasmas in the clover proliferation group (16SrVI). With the exception of the unknown Delphacidae, all of the insects listed belong to the family Cicadellidae.

[2]Due to the low number of available insects and their relatively large size, these insects were tested in groups of three.

[3]None tested.

**Table 2. Abundance of the leafhopper species commonly found in weeds near potato fields in the Columbia Basin of Washington and Oregon. Leafhoppers were collected on yellow sticky traps and in sweep net samples in 2003 and 2004.**

| Leafhopper Species | Average Number of Leafhoppers/10 Sticky Traps | Average Number of Leafhoppers/100 Sweeps | |
|---|---|---|---|
| | 2004 Season | 2003 Season | 2004 Season |
| *Circulifer tenellus* | 1921.9 | 22.0 | 36.9 |
| *Macrosteles* spp. | 470.3 | 8.0 | 17.6 |
| *Exitianus exitiosus* | 409.3 | 15.0 | 18.2 |
| *Ballana venditaria* | 361.2 | 17.1 | 10.8 |
| *Empoasca* spp. | 293.8 | 5.7 | 3.4 |
| *Ceratagallia* spp. | 206.2 | 38.0 | 29.4 |
| *Dikraneura* spp. | 144.2 | 63.8 | 21.3 |
| *Latalus* spp. | 115.5 | 8.3 | 7.7 |
| *Amblysellus* spp. | 112.3 | 8.2 | 13.1 |
| *Paraphlepsius* spp. | 100.7 | 4.3 | 6.2 |
| *Colladonus montanus* | 24.1 | 1.2 | 0.7 |
| *Ballana* sp. | 17.1 | 0.8 | 0.3 |
| *Texananus* spp. | 15.4 | 2.1 | 1.8 |
| *Balclutha neglecta* | 12.3 | 0.7 | 1.5 |
| *Colladonus geminatus* | 3.8 | 2.3 | 2.7 |
| *Balclutha impicta* | 3.5 | 0.3 | 0.6 |
| *Erythroneura* spp. | ---- | 0.8 | 0.4 |

| **Table 3. Impact of beet leafhopper insecticide treatment program on mite populations on potato, 2004.** | | | | | |
|---|---|---|---|---|---|
| **Treatment** | **Application Method** | **Product Rate** | **Number of Mites/Leaf[1]** | | |
| | | | **22 Jul** | **29 Jul** | **Total** |
| Untreated | ------ | ------ | 3.7a | 1.1b | 4.8c |
| Messenger | Foliar | 2.5 OZ/A | 0.9a | 0.4b | 1.3c |
| Admire | At planting | 16 FL OZ/A | 2.2a | 0.5b | 2.7c |
| Imidan | Foliar | 16 OZ/A | 2.3a | 0.4b | 2.7c |
| Sevin | Foliar | 2 QT/A | 2.3a | 4.9b | 6.2c |
| Temik | At planting | 20 LB/A | 2.3a | 6.0b | 8.3bc |
| Gaucho MZ | Seed treatment | 0.75 LB/CWT | 3.0a | 3.9b | 6.9c |
| Genesis | Seed treatment | 0.8 OZ/CWT | 3.5a | 3.2b | 6.7c |
| Monitor | Foliar | 32 OZ/A | 3.6a | 1.3b | 4.9c |
| Provado | Foliar | 3.75 OZ/A | 4.2a | 6.1b | 10.3bc |
| Vydate | Foliar | 1 PT/A | 4.2a | 9.7b | 13.9bc |
| Asana | Foliar | 5.8 FL OZ/A | 5.4a | 3.3b | 8.7bc |
| Imidan | Foliar | 22.9 OZ/A | 6.0a | 1.6b | 7.6bc |
| Platinum | At planting | 8 FL OZ/A | 7.1a | 3.1b | 10.2bc |
| Baythroid | Foliar | 1.5 OZ/A | 7.2a | 8.5b | 15.7bc |
| Actara | Foliar | 1.5 OZ/A | 11.4a | 3.1b | 14.5bc |
| Cruiser | Seed treatment | 4.85 OZ/CWT | 17.6a | 21.1a | 38.7a |
| Leverage | Foliar | 3.75 OZ/A | 18.4a | 10.1b | 28.5ab |