VIRUSES OF PEACH

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Prunus necrotic ringspot virus (PNRSV) and *prune dwarf virus* (PDV) are the viruses most frequently encountered in southeastern peaches. PNRSV and PDV cause many different symptoms in peach. Both have the potential to cause considerable economic loss. Seed and scion sources for peach propagation should be screened to assure freedom from these viruses. When both PNRSV and PDV infect a tree simultaneously, they cause a distinct disease called peach stunt.

Less commonly seen in southeastern orchards are strains of *tomato ringspot virus* (ToRSV), which cause stem pitting at and above the graft union, with tree decline and death.

Cherry green ring mottle virus has been detected in South Carolina, but the affected orchard was subsequently removed.

Plum pox virus (PPV), the cause of plum pox virus disease, also known as Sharka, is the most damaging stone fruit virus worldwide; however, it is not currently present in the southeastern United States. PPV is a listed quarantine pest and all documented importations of Prunus germplasm into North America are subject to rigorous quarantine and testing prior to release to the importer. This quarantine process had been effective in excluding PPV from the continent for many years. However, in 1999 PPV was detected in Adams County, Pennsylvania, and in 2001 the virus was again detected in the peach production area of the Niagara Peninsula in Canada. No link between the two outbreaks has been demonstrated, although it is certain they are both the result of importations of propagative material (budwood) that avoided the quarantine systems. In both locations, intensive programs to eradicate the virus are underway. Because all viruses are easily transmitted by grafting and budding, screening of propagative material to preclude endemic viruses (PNRSV and PDV) should also include testing for PPV as a protection against the devastating disease caused by this virus.

SYMPTOMS

Prunus Necrotic Ringspot Virus

PNRSV exists as numerous strains, isolates, and biotypes that vary widely in pathogenicity. Depending on the virus strain, PNRSV can produce a variety of symptoms in different stone fruit species and even within the same species. Some PNRSV strains do not produce visible symptoms and can be detected only by inoculation to woody indicator plants, serological tests, or molecular detection techniques. Other strains can induce an extensive array of symptoms both in the field and in test plants.

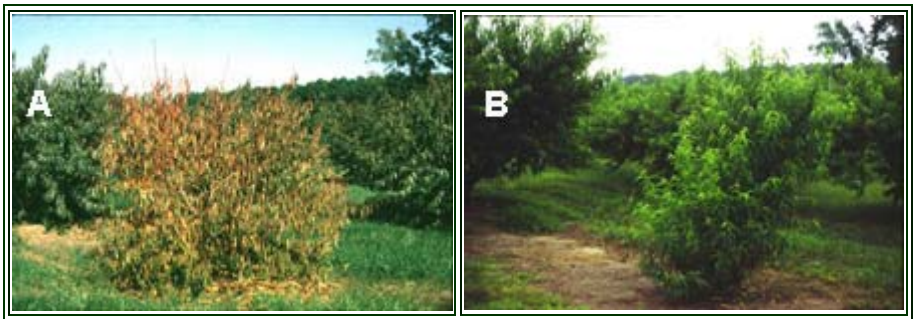
Figure 1. Shot holing, the classic symptom of infection with PNRSV, is temperature-dependent and not always diagnostic. These leaves were picked sequentially from a single twig, and ELISA assays indicated the presence of the virus in all leaves, not only those with shot holes. Shot holing can also be caused by excess sulfur, excess copper, or bacterial leaf spot.

PNRSV infection initially causes shock, then chronic symptoms in most woody hosts. Symptoms can be classified as chlorosis, necrosis, leaf deformity, stunting, and shot holes. Chlorotic symptoms on leaves include patterns of rings, lines, bands, spots, mottles, and mosaic. Necrosis occurs only during the initial acute stage. Buds, leaves, shoots, large branches, and roots may become necrotic. Epinasty, twisting, rugosity, and enations can be seen on infected leaves. The entire plant or portions of it may be stunted. PNRSV may cause small or large cankers on limbs and trunks. Some strains induce necrotic spots or shot holes on the young leaves during the first year of systemic infection (Figure 1), which are frequently described as the classic symptoms of infection by PNRSV. However, these symptoms are not consistently associated with the virus and can be confused with the effects of excess sulfur or copper, and with bacterial leaf spot. After the first or second year, when the chronic phase of PNRSV infection occurs, symptoms become less conspicuous and may disappear entirely. Other strains of PNRSV produce visual symptoms annually.

Prune Dwarf Virus

PDV also exists as many different strains that produce unique disease symptoms in different Prunus species, although some PDV symptoms can be confused with those caused by PNRSV. Chlorosis, necrosis, leaf distortion, stunting, and gum flow may be observed during the acute phase of infection. PDV-infected peach trees exhibit mild to severe stunting of internodes, rosette formation in developing shoots, and reduction in plant growth and fruit production. Stunted plants generally do not show characteristic leaf symptoms. In the cultivar Garnet Beauty, inoculation with an isolate of PDV caused bark splitting, reduced trunk circumference, and increased watersprout production. The classic symptom from which the virus gets its name occurs in prune, where dwarfed leaves appear and the dwarfing progresses from the infection site toward the trunk of the tree.

Peach Stunt. Trees co-infected with both PNRSV and PDV (suffering from peach stunt disease) generally display more severe symptoms than are shown with either virus alone (Figure 2). In Garnet Beauty, trees inoculated in the fall with both viruses defoliated by the end of August of the following growing season. Non-inoculated trees, and trees inoculated with PNRSV or PDV alone, showed no visible effects. Similarly, co-infected trees showed more profound reduction in trunk circumference and a doubling in production of watersprouts when compared with trees infected with either virus alone.



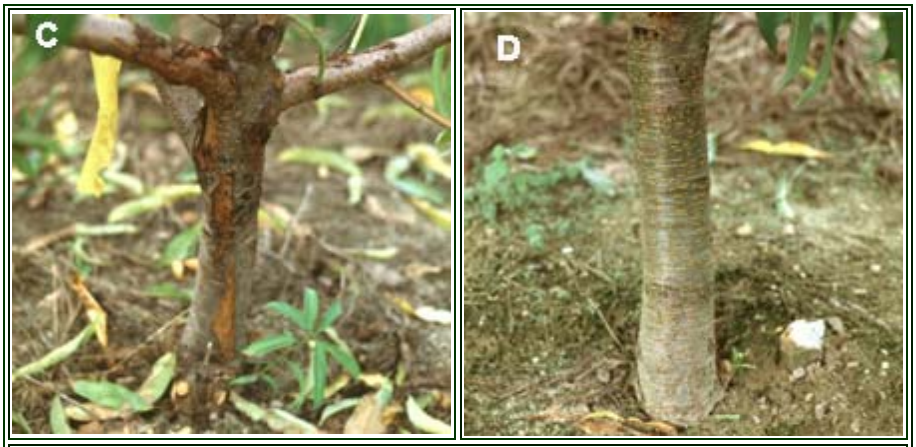


Figure 2. Peach stunt in Garnet Beauty peach. The photograph was taken in August and the tree had been inoculated with both PNRSV and PDV 10 months earlier (A). The surrounding trees are infected with PNRSV or PDV alone or are healthy. Premature defoliation was consistent through a trial with 20 replications. The tree almost died, but recovered slowly. Three years after the initial photograph, the tree survived, but produced little or no fruit (B). Other trees infected with PNRSV and PDV were less affected, but there had been an average of 55% yield loss. Bark splitting was noticeable on trees with both PNRSV and PDV (C), but absent in non-infected trees (D).

Stem Pitting. Trees infected by ToRSV have a girdled appearance, fail to grow normally, and decline (Figure 3A). The leaves appear drought-stressed and leaf drop is premature. Fruit from affected trees generally ripens early, sizes poorly, and is of poor eating quality. Trees displaying such marked symptoms do not generally survive through the winter. Noticeable trunk enlargement may occur at or below the soil level. The bark in this area is two to four times thicker than comparable bark of healthy trees and may extend up the trunk in the form of an inverted V. When the thickened bark is removed, elongated pits and/or grooves may be seen in the wood (Figure 3B). The severity of the pitting varies with variety and stage of disease development. In a few severe cases, the thickening of the bark can extend well into the canopy of the tree, and scaffold limbs of affected trees are soft enough to be squeezed by hand. Affected trees frequently break off at or below the soil line due to weak wood structure caused by the pitting. This symptom should not be confused with classic graft incompatibility, where a more-or-less clean break occurs at the bud union. Even though some peach varieties may be resistant to stem pitting, three of the commonly available rootstocks in the Southeast (Lovell, Nemaguard, and Halford) are known to be susceptible. Because there is no information on Guardian rootstock, it is perhaps best assumed that all of our peach trees are susceptible.

Figure 3. Stem pitting. A tree showing reduced growth, stunting, and reddening associated with stem pitting (A). Thicker than normal bark was present at the base of the trunk and when this was removed, massive pitting and grooving were revealed (B).

Plum Pox Virus

Classic plum pox virus symptoms may appear on leaves or fruit, but the virus is latent in some peach cultivars. Foliar symptoms are more evident in spring when chlorotic spots, bands or rings, vein clearing, or even leaf deformation may be seen. The symptoms may be transitory and distributed unevenly throughout the tree or individual branches and twigs. Infected fruits may show chlorotic spots or rings; symptoms are highly variable. Fruit quality and size are profoundly affected by PPV. Much of the affected fruit ripens prematurely, as much as 20 to 30 days early, and fruit are of poor flavor. Timely PPV updates and an extensive array of PPV images can be seen by referring to USDA and university fact sheets, as well as websites such as http://www.apsnet.org/online/feature/PlumPox/Top.html and http://www.aphis.usda.gov/ppq/plumpox/.

OCCURRENCE AND INCIDENCE

PNRSV is found with great frequency in stone fruit orchards throughout the United States and in other regions of the world. In the 1980s, surveys of trees in 14 peach orchards in Georgia revealed that 41% of the trees were infected with PNRSV; in West Virginia, 1,264 trees were surveyed and 29.5% were found to be infected with PNRSV; in South Carolina, an extensive survey of 5,833 trees from seven cultivars in 114 peach orchards determined that incidence levels of PNRSV were 6.9% in Harvester, 10.6% in Junegold, 15.0% in Redglobe, 39.5% in Loring, 41.1% in Blake, 52.9% in Coronet, and 74.5% in Redhaven. In some Redhaven orchards, the virus was detected in all trees sampled. More recent data (2000 and 2001) indicate that PNRSV is prevalent in orchards of some of the older varieties (Redhaven, Fay Elberta), but absent in orchards of more recently introduced varieties (Blazeprince, Summerprince).

PDV incidence in peach orchards is less well documented. In South Carolina in 1991, some orchards of Redglobe and Coronet were entirely infected with PDV. Ten years later, the virus was detected in only 5 out of 2,650 tested trees from 46 cultivars growing in both Georgia and South Carolina, and was not detectable in either of two orchards of Redglobe that were sampled. Again in 1991 in South Carolina, **peach stunt**, co-infections of both PNRSV and PDV, was absent in some orchards of Coronet and Redglobe, although in other orchards 80% of the trees were infected with both viruses. In 2000 and 2001, co-infections of PNRSV and PDV were detected in only 3 trees out of 2,650 tested.

Stem pitting can occur on peaches and other Prunus species wherever the trees are grown. It was observed in Spartanburg and York Counties, South Carolina, in 1968 and 1988, respectively, and in Georgia in 1978 on plums in Dooly County and in 1985 on peaches in Houston County. Although other occurrences have been reported, the disease is not common in the Southeast. The importance of stem pitting increases as one moves north through the Carolinas into Virginia and Pennsylvania, where entire orchards may be lost to the disease after five to six years.

PPV infections in North America presently appear confined to specific areas of Pennsylvania and Canada. Nationwide surveys of stone fruit production have not identified additional PPV-infected orchards. PPV is widely distributed in Europe, where the incidence of infestation varies with country. PPV is found in many other stone fruit production areas worldwide, including the Middle East, parts of Asia, and Chile.

TRANSMISSION AND SPREAD

All viruses of peach are easily transmitted by grafting and budding. Natural viral spread occurs in orchards, with viruses frequently spreading to adjacent trees rather than over long distances. Viral transmission along root grafts is also well documented.

PNRSV and **PDV** are transmitted through seed. In non-certified seed lots, infection rates of 16% (PNRSV) and 10% (PDV) have been documented. The number of infected seedlings that develop from infected seeds is usually considerably less. Both viruses are also transmitted through pollen. There is considerable circumstantial evidence that pollen from infected trees is blown onto plant surfaces where it is fed upon by flower thrips (*Frankliniella* spp.) that inoculate the virus into the plant in a mechanical manner. However, no finite demonstration of pollen-transmitted virus has been reported for peach. Experimental evidence and spatial patterns of natural spread of PNRSV among Prunus trees following the blooming period indicated that the virus infects healthy trees during the pollination process.

ToRSV is transmitted by the dagger nematode, *Xiphinema americanum*, whichis responsible for natural spread of the virus. The nematode feeds on roots of infected plants, acquires the virus, and in subsequent feeding transfers the virus to healthy plants.

PPV is spread most efficiently by budding and grafting of infected plant material, with all movements of the virus over extended distances being traced to movement of infected budwood or nursery stock. Spread within and between adjacent orchards and trees is by aphids in a non-persistent manner. The distribution of infected trees in newly infected orchards is scattered as a result of infection from migratory aphids. Aphids that colonize peach are not thought to be of importance in the movement of the virus. Both infestations of PPV in North America have been shown to be caused by the D (Dideron) strain of the virus, which is inefficiently transmitted by aphids. However, epidemiological studies within the quarantine areas suggest that aphid transmission has occurred. Seed transmission has been reported for the M (Markus) strain of PPV, but is not considered to be important for the D strain. Evidence that aphids can acquire and transmit the virus from ripe fruit has been shown.

ECONOMIC LOSSES

The effects of infection with **PNRSV** and/or **PDV** on peach are heavily dependent on the combination of the host cultivar and strain of virus involved. The deleterious effects of viral infection on tree performance and longevity are experienced even when no visible symptom of viral infection is present (i.e., the viral infection is latent).

PNRSV has been reported to cause reductions in tree growth of between 12% to 70%. Although bloom date may vary, fruit set may be substantially reduced, and ripening date may be altered considerably. Yield losses of 5% to 70% have been reported, with the fruit having lower soluble sugar content. Infection with PNRSV has also been reported to result in reduced response to fertilizer, increased susceptibility to cold, and reduced root development that leads to drought stress and tree loss in dry years.

The effects attributable to infection with **PDV** are by and large the same. **Peach stunt**, co-infection of PNRSV and PDV, has been shown to cause an average of 55% loss in fruit yield in Garnet Beauty, while at the same time increasing the number of watersprouts by 900%. In the same report, infection with PNRSV alone produced an average yield loss of 5% and a 410% increase in the number of watersprouts.

ToRSV kills trees within four to five years and, if a significant proportion of the trees within an orchard are infected, the economic lifespan of the orchard is severely reduced. In addition, the presence of ToRSV precludes replanting on the same site, which may be a problem if orchard sites are in short supply.

PPV-infected trees, and the orchards in which they are growing, are destroyed according to federal quarantine regulations to limit spread of the virus.

CONTROL

There is no cure for a virus-infected tree. Control of viral diseases is through planting virus-tested material, removal of infected individuals, and control of the avenues by which natural spread occurs in the field.

The most critical control measure is planting orchards using virus-tested stock. Growers should purchase trees from certified programs. Ask exactly what the program certifies before committing to a purchase. Programs should propagate virus-tested budwood on virus-tested rootstocks. Virus-tested means that the material has been tested for the presence of specific viruses. It is more accurate than the previously used term virus-free, which implied that the material contained no viruses but, in fact, meant that it was only free of those viruses for which tests had been completed. In the southeastern United States, testing should focus on PNRSV, PDV, and PPV.

Attempts to eliminate thrips from an orchard to prevent pollen-borne transmission of PNRSV and PDV are not feasible. Thus, it has to be accepted that there may be a slow increase in the incidence of these two viruses during the life span of the orchard. Even though trees affected with these viruses may show no symptoms whatsoever, the losses that they cause are more than sufficient to offset any premium paid by the grower for certified trees.

ToRSV is not a major concern in much of the Southeast. However, in areas where stem pitting is observed regularly, control of the disease involves factors in addition to the use of virus-tested stock. Routine pre-plant fumigation is recommended. Peach orchards should not be planted on sites of apple orchards that have experienced union decline and necrosis, which is also caused by ToRSV. Some weed species (dandelion, common chickweed, and sorrel) are alternate hosts for ToRSV and, to the degree possible, they should be eliminated from orchards. Isolated cases of stem pitting in the orchard can be treated by immediate removal of both the diseased tree and adjacent trees. However, it would be prudent to sample soil from the affected area and have it tested for the presence of *X. americanum.* If the nematode is present, a decision as to whether to replant must be made. The presence of *X. americanum* in soil samples does not necessarily mean stem pitting strains of ToRSV are infesting the site. Depending on the remaining life span of the orchard, it may make economic sense not to replant young trees, as any replant is likely to succumb to the same condition in four to five years or earlier. If forced to plant on old orchard sites, it would be wise to assume the dagger nematodes present are carrying the stem pitting virus. In this case, the land should be fumigated prior to planting and/or rotated through a series of grass or small grain crops for two to four years.

Control of PPV is dependent on testing of seed and scion sources to prevent spread via infected nursery stock. If PPV is detected, destruction of infected orchards and adjacent trees, as is mandated by federal quarantine regulations, is the only available means of limiting spread and/or eradicating the virus.

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