Prevention and Management of Viruses in Cucurbit Crops

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A complex of viruses can cause devastating diseases and affect the profitability of cucurbit crops in the northeastern U.S. Aphids are the primary vectors for the major viruses that attack cucurbits. The use of high quality seeds and resistant cultivars are some of the measures that should be considering in preventing and managing viruses in cucurbit crops.

Major Viruses of Cucurbit Crops. Major viruses of cucurbit crops in the northeastern U.S. are *Cucumber mosaic virus* (CMV), *Watermelon mosaic virus* (WMV) and *Papaya ringspot virus* type w (PRSV). CMV is the most widely distributed and most important virus in cucurbit crops followed by WMV and PRSV. Mixed infection by CMV and WMV can be common. Minor viruses in cucurbit crops in the northeastern U.S. are *Squash mosaic virus* (SqMV), *Tobacco ringspot virus* (TRSV), *Tomato ringspot virus* (ToRSV), *Zucchini yellow mosaic virus* (ZYMV), and *Clover yellow vein virus* (CYVV).

Effect of Viruses on the Performance of Cucurbit Crops. Viruses can reduce plant growth and cause substantial yield losses in cucurbits crops. Fruits are smaller in size, distorted, mottled, and/or discolored, and thus, are not marketable. The effect of viruses on crop performance is often more severe at a very early development stage. As a consequence, yield losses can be dramatic if infection occurs at a pre-bloom development stage. In contrast, marketable fruits can usually be harvested if virus infection occurs at a post-bloom development stage, although foliar symptoms can be dramatic. There is no cure for virus-infected cucurbits in the field; once a vine is infected by a virus it will remain infected for the duration of the planting.

Diagnostic foliar symptoms consist of chlorotic mottle, distortion, mosaic, green mosaic, blistering, and downward cupping. However, it is difficult to attribute symptoms to one specific virus because mixed infections, in particular with CMV and WMV, are common. Only laboratory tests can reliably identify viruses in cucurbit crops.

Transmission of Viruses by Aphids in Cucurbit Fields. Aphids transmit most of the viruses (CMV, WMV, ZYMV, PRSV and CYVV) in cucurbit crops. Spring aphid flights are important for disease spread in and between fields. Several aphid species can vector viruses, although most of them do not colonize cucurbit crops and do not cause direct, serious injury.

The transmission mechanism by which aphids transmit viruses is well characterized. It takes a limited time (a few seconds to less than one minute) for the virus to be acquired and further transmitted from plant to plant. Often a few plants become infected early in the season and these initially infected plants serve as primary virus source for secondary aphid-mediated spread. A viruliferous aphid can retain the virus for a short time (less than one hour). However, it can potentially carry it over long distance.

When visiting a cucurbit, aphids make two types of probes on the surface of leaves, test probes and feeding probes. Virus transmission occurs during rapid test probes and not during longer-lasting feeding probes. During test probes, the virus is sucked into the aphid's stylet where it can stick to the lining of the food canal. If the aphid moves to a susceptible healthy plant and initiates a test probe, the virus can detach and be released when the content of the food canal is expelled. Viruses do not increase in the aphid and do not circulate within the aphid's body. Viruliferous aphids lose viruses if they probe on nonhost species. In the northeastern U.S., CMV is often the major culprit in cucurbit crops early in the season followed by WMV later in the season.

Other Transmission Means of Viruses in Cucurbit Crops. None of the viruses in cucurbit crops is transmitted through seeds, except SqMV, which is seed-borne in melon. SqMV is transmitted by cucumber beetles whereas TRSV and ToRSV are transmitted by the dagger nematodes *Xiphinema americanum*.

Weeds as Virus Reservoirs. CMV and WMV, the two major viruses of cucurbit crops in the northeastern U.S., as well as TRSV, ToRSV and CYVV, can overwinter in many weeds, including annuals (pigweed, milkweed, horseweeed and Sherperd's purse) and perennials (milkweed, sowthistle, dandelion, chickweed and clover), among others. Infected weeds can serve as primary reservoir for viruses in cucurbit crops. As a result, virus epidemics in cucurbit crops can originate from infected weeds that are visited by aphids.

Management Recommendations of Viruses in Cucurbit Crops. Due to the mechanism of virus transmission by aphids, insecticides are of limited efficacy at limiting aphid vector populations. Actually, the use of insecticides is not recommended for the control of aphid-borne viruses in cucurbit crops unless epidemics are severe. Adjusting the planting date, i.e. delaying the timing of planting after the peak of aphid flights, and the use of reflective mulches to deter aphid vectors in combination with stylet oils to prevent aphid probing can help mitigate the impact of viruses although severe epidemics may not be prevented.

The use of resistant cultivars is the most effective control measure. Resistance to multiple viruses is desirable because mixed infections are common. Resistance to viruses is available in several cucurbit crops cultivars.

In cucumber (*Cucumis sativus*), resistance to CMV has been successfully incorporated into numerous cultivars by conventional breeding, and resistance to CMV, WMV, ZYMV and PRSV is available in cultivars Cobra, Cortez, Cutter, Darlington, Diomede, Eureka, Fortune, Indio, Indy, Lider, Mcpick, Orient Express, Sultan, Supremo, Talladega, Thunderbird, Viper, Zapata and Zipangu.

In yellow summer squash (*Cucurbita pepo*), resistance to mixed infection by CMV and WMV, or CMV, WMV and ZYMV, or CMV, WMV, ZYMV and PRSV has been developed through conventional breeding techniques (cultivars Cougar and Lioness) and biotechnological approaches (cultivars Conqueror III, EX 1832 III and Liberator III). Similarly, in zucchini squash, resistance to CMV or ZYMV or WMV and ZYMV, or PRSV and ZYMV, or CMV, WMV and ZYMV or WMV, PRSV and ZYMV, or CMV, WMV, ZYMV and PRSV has been achieved through conventional breeding techniques (cultivars Linda, Paycheck, Plato, Radiant and Reward) and biotechnological approaches (cultivars Justice III and Judgement III).

In muskmelon (*Cucurbita melo*), limited resistance to WMV, PRSV and ZYMV is available (cv. Hannah's Choice and Sugar Cube). In pumpkin, resistance to ZYMV, or WMV, PRSV and ZYMV, or CMV, WMV and ZYM is available (cultivar Munchkin).

In winter squash (*Cucurbita moschata* and *Cucurbita maxima*), limited resistance to ZYMV is available (cultivars Speckled Hound and Speckled Pup).

In watermelon (*Citrullus lanatus*), no source of resistance is recognized in commercial cultivars.

For SqMV, the selection of disease-free seeds and management of striped and spotted cucumber beetles is recommended for management purposes. Control of cucumber beetles is important as these insects also vector the causal agent of bacterial wilt in cucumber, squash, muskmelon, pumpkin and gourd.

Conclusions. Based on the ecology of viruses in cucurbit crops and the fact that there is no cure for virus-infected cucurbits in the field, a careful selection of resistant cultivars and high quality seeds is recommended to prevent viral diseases and mitigate their impact. Managing weeds that can serve as virus reservoirs can delay disease development. However, numerous annual, biennial and perennial species should be targeted in order for this strategy to be effective. Also, weeds should be controlled not only at the farm level but also at a regional scale for this virus management strategy to be beneficial. This might not be feasible and economically viable. Under consistently severe epidemics, adjusting the planting date and using reflective mulches in combination with stylet oils are other options that can help delay the onset of disease.