College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Plant Disease
August 2014
PD-104

Zucchini Yellow Mosaic

Jamie Komata, Michael Melzer, and Scot Nelson
Department of Plant and Environmental Protection Sciences

Zucchini yellow mosaic, caused by *Zucchini yellow mosaic virus* (ZYMV), is an economically damaging disease of important cucurbit crops in Hawai'i. ZYMV occurs globally on cucurbits and was first discovered in Hawai'i on zucchini (*Cucurbita pepo*) in 1988 (Ullman et al. 1991).

Infection by ZYMV during the early stages of plant development can cause significant losses in yield. Infected plants are undersized and their fruits are often distorted and unmarketable: in a greenhouse study of cucumbers inoculated with ZYMV, nearly three-fourths of the fruit was unmarketable. In this article we describe the symptoms and spread of zucchini yellow mosaic and suggest integrated management practices for the pathogen, its vectors, and the disease.

Distorted, twisted, and mottled leaves of zucchini infected by ZYMV.

Pathogen

ZYMV is a member of the genus *Potyvirus*, family *Potyviridae*, and exists as a long, flexuous virus particle containing a single-stranded RNA genome. ZYMV is closely related to other damaging potyviruses found in Hawai'i such as *Dasheen mosaic virus* on taro and *Papaya ringspot virus* on papaya.

Host Range

Cucurbitaceae is the host family for different varieties of squash, gourds, and melons. These cucurbits are economically important in the state of Hawai'i. According to the latest data from the year 2008, 540 vegetable and melon farms were in production statewide. Most of this production was cucumbers (*Cucumis sativus*) at 4.8 million lbs. and a farm value exceeding $2.7 million. Following cucumbers, in rank of production, were zucchini (1.48 million lbs.), oriental squash (*C. maxima*) (350,000 lbs.), bittermelon (*Momordica charantia*) (150,000 lbs.), and pumpkin (*C. maxima*) (90,000 lbs.). Farm values for these crops were $888,000, $217,000, $126,000, and $59,000 respectively (USDA 2010). Weed species such as weedy bittermelon (*M. charantia*), wild cucumber (*Cucumis dipsaceus*), and bottle gourd or *ipu* (*Lagenaria siceraria*) are alternative hosts for ZYMV (Ullman et al. 1991). Few non-cucurbit hosts of ZYMV have been identified.

Transmission

ZYMV is transmitted by certain species of aphids, by plant sap containing the virus, and, for zucchini, through infected seeds. Aphids transmit ZYMV in a

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, under the Director/Dean, Cooperative Extension Service/CTAHR, University of Hawai'i at Mānoa, Honolulu, Hawai'i 96822.

non-persistent manner. This means only a few seconds of feeding are needed for an aphid to acquire the virus from an infected plant and transfer it to a healthy plant. Ten species of aphids are known vectors, but the cotton or melon aphid (*Aphis gossypii*) and the cowpea aphid (*A. craccivora*) are probably the most important vectors in Hawai'i. A study found that the cowpea aphid transmits the virus more efficiently than the cotton or melon aphid (Yuan and Ullman 1996). This is might be due to the shorter amount of time needed for the cowpea aphid to probe a plant with its stylet in comparison to the cotton or melon aphid. The cowpea aphid does not colonize zucchini plants so is more likely to probe a zucchini plant, acquire the virus, and disperse shortly thereafter, leading to a more rapid spread of the virus to surrounding plants.

Symptoms

Symptoms of zucchini yellow mosaic disease can vary depending on the host and stage of infection. Zucchini plants are stunted, with yellow mosaic-like symptoms on the foliage, reduced flowering, and distortion of existing flowers. The fruit is smaller, twisted, and often distorted by lumps, and it has a knobby appearance. Mosaic is severe on cucumbers, as are deformities of the leaves and fruit. On melons, leaves develop a mosaic pattern and are reduced in size and deformed, with serrated edges. Melon fruits are discolored, with internal hardening of the fleshy areas, seed deformities, and external cracks (Desbiez and Lecoq 1997).

Crops infected early in their development are more susceptible to aborted fruit and a reduced yield than plants infected after the first fruit set. Certain temperatures and mixtures of ZYMV with other viruses, such as *Cucumber mosaic virus* (CMV), can also lead to more severe symptoms of zucchini yellow mosaic disease (Desbiez and Lecoq 1997).

Management

The following management practices can be used to minimize the effects of zucchini yellow mosaic on zucchini and other cucurbit crops:

- **Resistant varieties.** Some seed companies offer cucurbit varieties with resistance to important pathogens such as ZYMV. Often this protection comes from introducing resistance genes from other cucurbits through traditional breeding practices. The level of resistance is limited, generally meaning that symptoms are less pronounced than in varieties that do not possess this resistance. The use of resistant varieties together with other management strategies offers the best opportunity for successful crop production.
- **Cropping systems**. A crop protection strategy that attempts to delay infection may be useful (Blua

Symptoms of zucchini yellow mosaic in Hawai'i, caused by *Zucchini yellow mosaic virus*. Photograph by John Hu.

Close-up of foliar distortion and mosaic symptoms on zucchini infected by *Zucchini yellow mosaic virus*.

and Perring 1989). Planting barrier crops around a field is a cultural practice used to interfere with aphid feeding on the cash crop. It can be effective because aphids tend to start feeding at the outer edges of a crop. Initial probing by aphids on the barrier plants may help reduce the amount of virus transmitted to the primary crop (Hooks et al. 2007). Establishing tall barrier crops (such as grasses) that are not hosts of aphid vectors or ZYMV prior to planting the cucurbit crop can also be a useful management strategy.

- **Deterring aphids**. Using reflective mulches or installing yellow sticky traps or pan traps are also methods of interfering with aphid behavior.
- **Removal of infected plants**. Fields should be routinely surveyed during the growing season to identify diseased plants, which serve as a source of ZYMV and should be promptly removed. If aphids colonize the plants, they should be sprayed with a contact insecticide to prevent them from moving to nearby healthy plants. The diseased plants should then be bagged and removed from the growing area.
- **Removal of weed hosts**. Weeds that serve as a host to either aphids or ZYMV should be removed or controlled by physical (weed mat) or chemical (herbicide) means. Even weeds that are not hosts should be removed, as they may serve as hosts to other insect pests or pathogens.
- **Promote natural predators of aphids**. Ladybird beetles and hoverflies can be effective at naturally controlling aphid populations. Releasing these insects and landscaping with plants that support their populations can be part of an overall management strategy.

Table 1. Insecticides Registered in Hawai'i to Control Aphids on Zucchini

Product Name*	Active Ingredient (%)	Formulation
Admire® 2 Flowable Insecticide	Imidacloprid (21.4)	Flowable (liquid)
Arena® 50 WDG Insecticide Granules	Clothianidin (50)	Water-dispersible granules
Tempo® Ready-to-Use Insecticide (Bayer Advanced Vegetable & Garden Insect Spray)	Cyfluthrin (0.003)	Spray (RTU)
Baythroid® 2 Emulsifiable Pyrethroid Insecticide	Cyfluthrin (25)	Emulsifiable concentrate
Bifen 25% EC Insecticide/Miticide	Bifenthrin (25)	Emulsifiable concentrate
Drexel Carbaryl 4L Insecticide	Carbaryl (43.4)	Liquid
Sevin® 80 WSP Carbaryl Insecticide	Carbaryl (80)	Water-soluble packet
Neem oil 70% (various product names)	Clarified hydrophobic extract of neem oil	(70%) Soluble concentrate
Permethrin	Permethrin (38.4)	Emulsifiable concentrate
Scorpion® 35SL Insecticide	Dinotefuran (35)	Liquid concentrate
Timectin (AgMectin) 0.15 EC AG Insecticide/Miticide	Abamectin (1.9)	Emulsifiable concentrate

*Availability is subject to state pesticide registrations, which are subject to change. Information in the table is current as of September 2014. Source of information: National Pesticide Information Retrieval System (NPIRS http://nspirs.ceris.purdue.edu/).

Always consult and follow pesticide label instructions. Other product names with similar active ingredients may not be displayed in this table.

- **Cross protection**. Some cucurbit growers manage zucchini yellow mosaic successfully via cross protection, which consists of inoculating plants with a mild strain of ZYMV (John Hu, personal communication). The mild-strain infection protects the plants from infections by severe strains, thereby ensuring higher yields. For more information about cross protection, contact UH-CTAHR.
- **Chemical control of aphids**. Contact and systemic insecticides are effective at reducing aphid populations, but this usually has a minimal impact on the spread of zucchini yellow mosaic. Unless directly contacted by an insecticide, aphids can acquire and transmit ZYMV before being killed by a lethal dose (Perring et al. 1992). In addition, insecticides may also kill natural enemies of aphids, such as ladybird beetles. Although chemical control of aphids is not usually recommended for disease management, Table 1 lists insecticides that can be used to reduce aphid populations.

Acknowledgements

The authors thank Fred Brooks and John Hu (UH-CTAHR) for their thoughtful reviews of this manuscript.

References

Blua, M.J. and Perring, T.M. 1989. Effect of *Zucchini Yellow Mosaic Virus* on development and yield of cantaloupe (*Cucumis melo*). *Plant Disease* 73:317–320. http://www.apsnet.org/publications/PlantDisease/BackIssues/Documents/1989Articles/PlantDisease73n04_317.pdf (accessed 25 February 2014).

Desbiez, C. and Lecoq, H. 1997. Zucchini yellow mosaic virus. *Plant Pathology* 46:809–829. http://onlinelibrary.wiley.com/store/10.1046/j.1365-3059.1997.d01-87.x/asset/j.1365-3059.1997.d01-87.x.pdf?v=1&t=hs7ydj6p&s=2649c17dd529607ef3e613cfb334b3f8fb9f34db (accessed 1 February 2014).

Dorman, M. and Nelson, S. 2012. Root-Knot Nematodes on Cucurbits in Hawai'i. College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa, PD-84. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-84.pdf (accessed 1 February 2014).

Hooks, C.R., Fereres, A., and Wang K-H. 2007. Using Protector Plants to Guard Crops from Aphid-Borne Non-Persistent Viruses. College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa SCM-18. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/SCM-18.pdf (accessed 25 February 2014).

Virus-like symptoms on zucchini, probably caused by *Zucchini yellow mosaic virus* (ZYMV). Photographs by Jensen Uyeda.

Kline, W.L. and Kline, S.T. Summer Squash and Zucchini Squash IPM Field Guide. http://njveg.rutgers.edu/assets/pdfs/ipmfg/Summer%20Zucchini%20Squash%20IPM%20Insect%20and%20Disease%20Field%20Guide.pdf (accessed 31 January 2014).

Lecoq, H., Lemaire J.M., and Wipf-Scheibel, C. 1991. Control of zucchini yellow mosaic virus in squash by cross protection. *Plant Disease* 75:208–211. http://www.apsnet.org/publications/PlantDisease/BackIssues/Documents/1991Articles/PlantDisease75n02_208.PDF (accessed 14 February 2014).

Perring, T.M. et al. 1992. Research reveals pattern of cucurbit virus spread. *California Agriculture* 46:2. http://onlinelibrary.wiley.com/store/10.1046/j.1365-3059.1997.d01-87.x/asset/j.1365-3059.1997.d01-87.x.pdf?v=1&t=hs7ydj6p&s=2649c17dd529607ef3e613cfb334b3f8fb9f34db (accessed 21 February 2014).

Simmons, H.E., Holmes, E.C., and Stephenson, A.G. 2008. Rapid evolutionary dynamics of zucchini yellow mosaic virus. *Journal of General Virology* 89:1081–1085. http://vir.sgmjournals.org/content/89/4/1081.full.pdf (accessed 14 February 2014).

Ullman, D.E., Cho, J.J., and German, T.L. 1991. Occurrence and distribution of cucurbit viruses in the Hawaiian islands. *Plant Disease* 75:367–370. https://www.apsnet.org/publications/PlantDisease/BackIssues/Documents/1991Articles/PlantDisease75n04_367.pdf (accessed 1 February 2014).

USDA. 2010. Annual Hawaii vegetables. http://www.nass. usda.gov/Statistics_by_State/Hawaii/Publications/ Archive/xveg08.pdf. (accessed 21 February 2014).

USDA. 2011. Number of crop farms, by county, 2007–2011. http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Annual_Statistical_Bulletin/stat11-09.pdf. (accessed 14 February 2014).

Yuan, C., and Ullman D.E. 1996. Comparison of efficiency and propensity as measures of vector importance in *Zucchini yellow mosaic potyvirus* transmission by *Aphis gossypii* and *A. craccivora*. *Phytopathology* 86:698–703. http://www.apsnet.org/publications/phytopathology/backissues/Documents/1996Articles/Phyto86n07_698.pdf (accessed 1 February 2014).