THE UNIVERSITY OF ARIZONA
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Beet Curly Top Virus In Industrial Hemp

Jiahuai Hu and Robert Masson

Introduction

Curly top of sugar beet, caused by Beet Curly Top Virus (BCTV), was first reported in Nebraska in 1888. BCTV has since become widespread in the arid and semiarid parts of the Western United States, the Mediterranean Basin and Middle East. It has caused frequent and often very destructive outbreaks on many commercial crops throughout the Western United States. In Arizona, BCTV is a very serious plant virus affecting hemp and hundreds of ornamental and commercial crops. Hemp appears to be a highly susceptible host for the virus, in particular young plants are most susceptible to infection spread by the beet leafhopper insect. BCTV typically causes upward curling of the leaves associated with vein clearing and the tumorous outgrowths (enations on the lower surface of veins) as well as a reduction in chlorophyll content and the rate of photosynthesis. The resulting curly top disease significantly reduces yield potential of the plant if it is infected at young age. Due to the wide distribution of beet leafhoppers and abundant range of host plants for the virus, BCTV may become one of the most yield limiting factors affecting the emerging industrial hemp production systems in Arizona.

Early stages of stunting and yellowing

Yellowing and necrosis

Early mosaic symptom of BCTV on hemp leaf

Geographic Range

BCTV is widespread in California, Arizona, New Mexico, Utah, Washington, Oregon, and six other states. It is also found in ten other states. BCTV was first reported on outdoor industrial hemp of North Fork Valley, Delta County, Western Colorado, in all seasons between 2015 and 2020. In 2019, BCTV was also noted in hemp plants grown in California. In 2020, severe outbreaks of BCTV were observed in several hemp fields in Arizona, where disease incidence and severity were considerably high, up to 100% crop loss occurring in some fields. This publication will primarily focus on BCTV found in Yuma County Cooperative Extension variety trials planted in Yuma and commercial hemp fields located in Safford valley, Graham county, AZ.

Pathogens

BCTV is a member species of Curtovirus in the family of Geminiviruses. It is a small DNA virus (less than 50 nm; 1 nm = 25 millionth of an inch) that has circular single stranded DNA genomes (approximately 2,800 base pairs) encapsidated in two small virions. Major strains include Cal/Logan, Worland, and CFH strains. To date, only Worland strain has been detected in field grown hemp plants across the state of Arizona. BCTV is confined to the phloem tissue, where it causes degeneration. Virus particles exhibit considerable resistance to a number of common disinfectants and can remain active for 4 months in dried beet tissue and 6 months in dried beet leafhoppers.

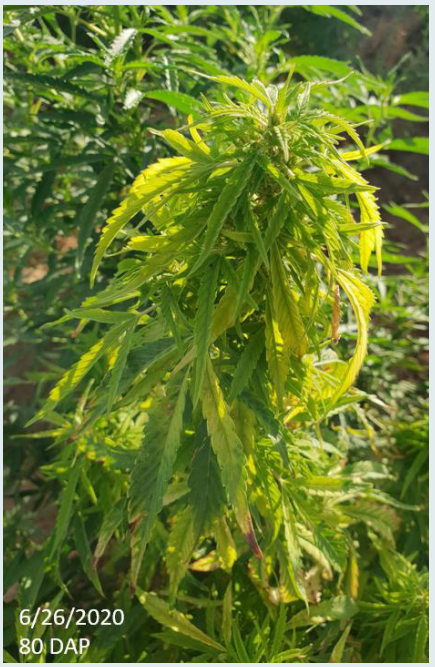
Host Range

BCTV is endemic to 300 species of dicotyledonous plant of 44 families (mostly confined to the Chenopodiaceae , Compositae , Cruciferae , Leguminosae , and Solanaceae). This very wide host range includes many commercial crops, ornamentals, and weed species. In Arizona, commercial crops include peppers, beans, melons, cabbage, spinach, cucurbits, and tomatoes. Weed species include kochia, lambsquarter, halogeton, Russian thistle, greasewood, four wing saltbrush, filaree, hoary cress, tumble mustard, flixweed, and pigweed.

Spread

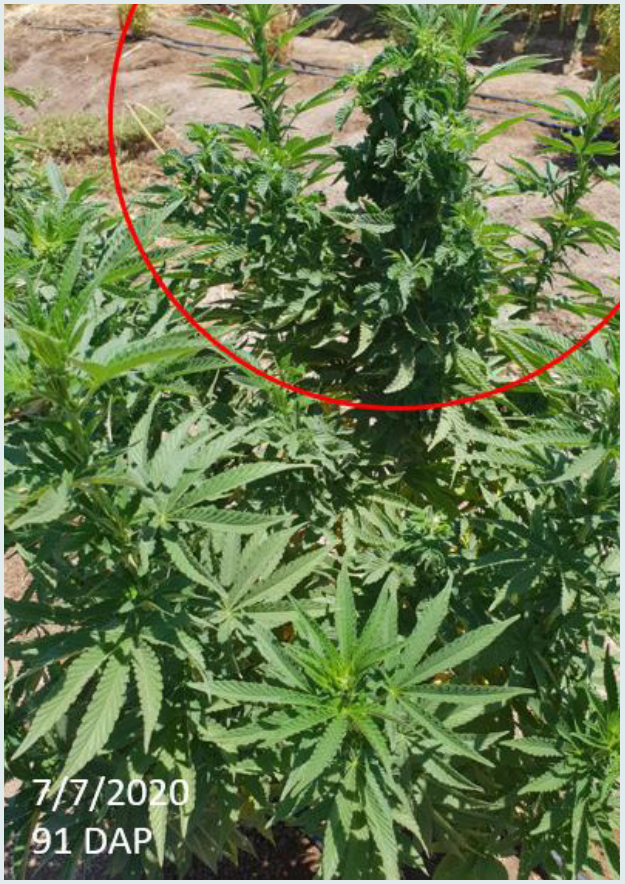
BCTV is spread primarily by the phloem feeding leafhoppers: *Circulifer tenellus* (beet leafhopper) in the United States, *C. opacipennis* in the Mediterranean Basin, and *C. haematoceps* in the Middle East. Beet leafhoppers are migratory sap sucking insects that feed primarily in phloem, where they rapidly acquire the virus (as short as 1 min). The virus cannot replicate in the insect, but the insect can remain infective for most of their lifetime; although the amount of virus and the ability to transmit the disease declines with time between feedings on BCTV infected material.

Adult beet leafhoppers overwinter on weeds from which they acquire the virus, then migrate to nearby cultivated areas during spring where they reproduce several generations on weeds and crops to which they transmit the disease. In fall, the adult beet leafhoppers migrate back to their overwintering areas. Adult beet leafhoppers are most active in high temperatures.

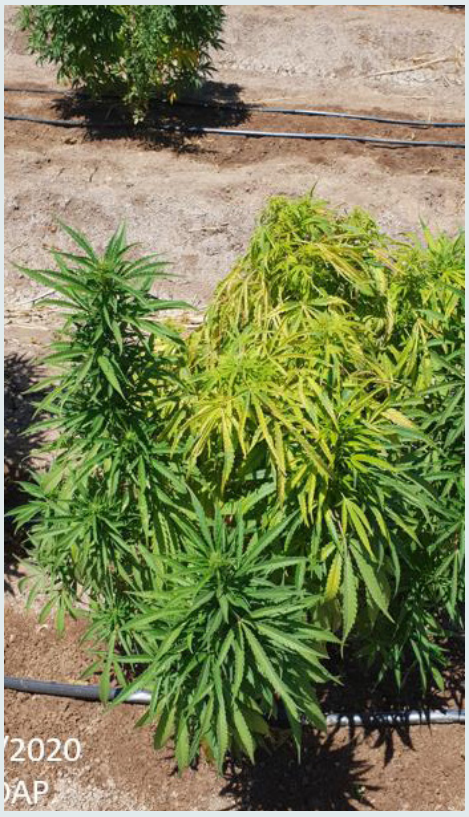


Yellowing and stunting (note asymptomatic side branches)

Dull pale green symptom



Severe leaf twisting and chlorosis symptoms of a hemp plant infected with BCTV



Mid-stage of yellowing and stunting (note side branches appear to be symptoms free)

leaf curling and yellowing

Late-stage severe yellowing, stunting, and death of hemp plants infected with BCTV

Symptoms

A wide range of symptoms have been observed at different infection stages. Symptom expression depends on plant growth stages at the time of infection. Early stage symptoms manifest as light green to yellowing of new growth, similar to sulfur or micronutrient deficiency, usually combined with older leaves with dark green "blotchy" mosaic mottling overlaying light green chlorosis. Mosaic mottling of older leaves continues into mid growth stage, and is coupled with more severe yellowing and witch's broom (stunted leaves and shortened internode length of stem) of apical meristematic tissue. Curling and twisting of new leaves has also been observed. Symptoms manifest at or above the point of infection and appear to be isolated to individual branches, with other branches showing no visual symptoms, often outgrowing and covering affected branches. Late stage symptoms include severe leaf curling with or without twisting, continued stunting, and necrosis of yellow leaves, resulting in significant yield reduction. Severely affected plants dwarfed by the virus experienced high mortality rates later into the season, most likely attributed to reduced ability to overcome abiotic stress conditions. There are reports of the virus being seed borne in petunia. It is not clear whether BCTV can be transmitted through contaminated seeds in hemp. The virus is not easily transmitted by mechanical means.

Diagnosis

Witch's broom caused by Phytoplasmas and certain nutrient deficiencies produce somewhat similar symptoms as BCTV. Molecular diagnostic tests based on polymerase chain reaction (PCR) or whole genome sequencing approach should be used to provide a definitive diagnosis. Symptomatic leaves and shoots should be collected and wrapped in a dry paper towel, placed in a plastic bag, cooled in refrigerator, packed in a Styrofoam cooler with cold pack, and shipped OVERNIGHT to the University of Arizona's Extension Plant Pathology Laboratory in Tucson. All submissions should be accompanied by completed Plant Disease Diagnostic Form

Management

There is no cure for curly top. Resistant hemp varieties are currently not available. Breeding resistant varieties has been successful in sugar beet and bean, but not in tomato, as the genetic basis for resistance is not well understood. Integrated pest management practice to manage curly top should focus on reducing the incidence of BCTV infection in hemp below a level of economic importance. As young plants are most susceptible to infection, a significant reduction in disease incidence and severity may be attained by protecting seedlings using either a physical barrier to prevent leafhopper access or by timing the emergence of the crop to avoid leafhopper spring migration from the overwintering grounds. "trap crops" can also be planted along field borders to contain the pest for targeted sprays. Sugar beets are a favored food of the beet leafhopper may make a suitable trap crop for these purposes. It is advisable to scout nearby crops and weedy areas for presence of leafhopper vector and treat those breeding areas with soil treatments, such as those containing imidacloprid, and foliar sprays such as dimethoate, to manage populations before migration to the hemp crop can occur. A intensive survey program should be formulated to locate, monitor and manage breeding beet leafhopper populations on a variety of host plants in rangeland and idle agricultural lands prior to the migration of adults into susceptible crops throughout the year. There are pesticides labeled for hemp that have efficacy at controlling beet leafhopper, but most approved pesticides rely on soft chemistries, with variable results.

Additional Resources

Anabestani, A. *et al*. 2017. Seed transmission of beet curly top virus and beet curly top Iran virus in a local cultivar of petunia in Iran. Viruses-Basel 9 (10)

Giladi, Y. *et al*. 2020. First Report of Beet Curly Top Virus Infecting *Cannabis sativa* in Western Colorado. Plant Dis. 104(3) PDIS-08-19-1656-PDN

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Hudson, A. *et al.* 2010. Comparison of the feeding behavior and genetics of beet leafhopper populations from California and New Mexico". Southwestern Entomologist. 35 (3): 241–250

Latham, J.R. *et al.* 2002. Introduction of plant cell division by beet curly top virus gene C4. The Plant Journal 11(6): 1273-1282

Munyaneza, J. E. and Upton, J. E. 2005. Beet leafhopper (Hemiptera: *Cicadellidae*) settling behavior, survival, and reproduction on selected host plants. Journal of Economic Entomology. 98 (6): 1824–1830

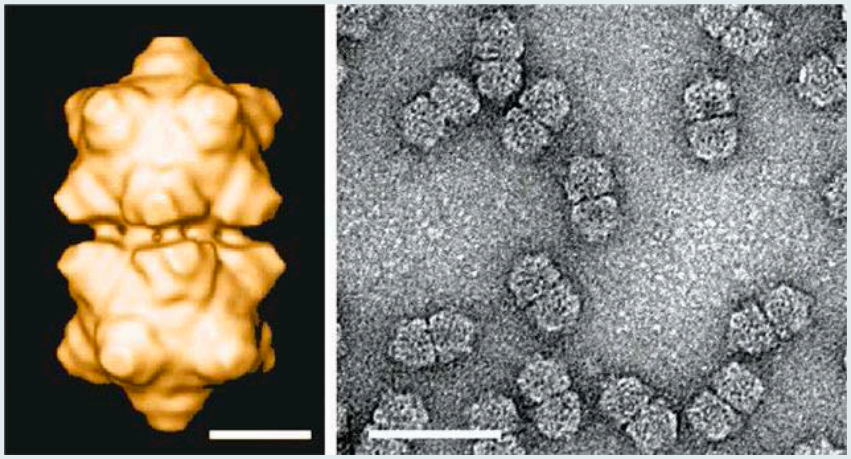
Stanley J., et al. 2005. *Geminiviridae*. In: Fauquet CM, Mayo MA, Maniloff J, Desselberger U, and Ball LA (eds.) Virus Taxonomy: Eighth Report of the International Committee on Taxonomy of Viruses, pp. 301–326. San Diego, CA: Elsevier

Zhang *et al.* 2001. Structure of the Maize streak virus geminate particle. Virology 279(2): 471-477

Severe stunting and death of a young infected plants in mid-growing season

Severely stunted hemp plant with side branches that may (left) or may not (right) outgrow the BCTV infection

Late stage disease symptoms: Severe stunting and yellowing



Geminivirus particles, left: cryo-electron microscopic reconstruction of maize streak virus (MSV); purified particles of MSV showing typical twinned quasi isometric subunits (From Zhang *et al*., 2001; courtesy of R. McKenna)

The adult beet leafhopper (0.12 inches in length) and greenish, yellow, tan or olive in color, with or without darker markings on its wings and body (Photos by G. Oldfield and A.C. Magyorosky, USDA, Bugwood.org)

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AUTHORS

Dr. Jiahuai Hu
Assistant Cooperative Extension Specialist and Plant Pathologist, School of Plant Sciences

Robert Masson
Assistant Agricultural Agent

CONTACT

Jiahuai Hu
epp@email.arizona.edu

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