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SYMPTOMS OF ADDITIONAL CUCUMBER-MOSAIC VIRUSES ON SUGAR BEETS

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OUTBREAK OF WESTERN CUCUMBER MOSAIC ON SUGAR BEETS[1]

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SUMMARY

Western cucumber mosaic occurs in the interior regions of California, and not in the coastal fog belt.

The symptoms of western cucumber mosaic on naturally infected sugar beets are: large, pale-yellow chlorotic areas; white or green veinbanding or interveinal chlorosis; blisterlike elevations on younger leaves, often accompanied by distorted midribs and veins or by outward-rolled leaf margins; and deformed or twisted young leaves.

The green peach aphid, *Myzus persicae* (Sulzer), is the most important vector of the virus to sugar beets. The bean or dock aphid, *Aphis rumicis* Linnaeus, rarely transmits the virus to beets.

Systemic infection was obtained with 20 per cent of the beets inoculated by the green peach aphid and 26 per cent of those mechanically inoculated.

INTRODUCTION

A serious outbreak of western cucumber mosaic on sugar beets occurred near Firebaugh and Mendota, in the middle San Joaquin Valley, California, in 1940. Economic and ornamental flowering plants and weeds of many species showed severe symptoms of the disease. Enormous flights of the green peach aphid, *Myzus persicae* (Sulzer), from the plains and foothills of the Inner Coast Range occurred in the beet fields that year. Ladybird larvae and adult beetles devouring aphids were teeming in the beet fields during the spring.

A similar relation between heavy aphid population and an outbreak of another virus disease occurred in 1927. During the spring of that year, aphids were extremely abundant and destroyed most of the pasture vegetation grow-

[1] Received for publication December 5, 1947.

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ing on the plains and foothills of the Inner Coast Range in the middle and northern San Joaquin Valley, as reported in a previous paper (Severin, 1933).[4] After the pasture vegetation became wilted and began to dry, swarms of winged aphids flew into the cultivated areas. That year most of the sugar beets in the middle and northern San Joaquin Valley developed symptoms of sugar-beet mosaic; however, no beets showing symptoms of western cucumber mosaic were found. The beet leafhopper, *Eutettix tenellus* Baker, could not have been an important factor in 1927 because its food supply was destroyed in March, before most of the nymphs had acquired the winged stage.

Freitag (1941) reported that ten species of aphids readily transmitted western-cucumber-mosaic virus to 104 of 271 squash plants.

Bennett (1944) described and illustrated yellowish primary lesions on sugar beets after juice inoculation with a strain of cucumber mosaic from sugar beets in the vicinity of Mendota. Systemic infection did not result from such lesions, he reported; but did result from inoculation by *Myzus persicae*.

The present paper reports observations on and experiments with western-cucumber-mosaic virus from 1940 to 1947. The phases investigated were distribution of the disease, methods of transmission of the virus, symptoms of the disease, and recovery of the virus. The symptoms are similar to those of celery calico and common cucumber mosaic on the leaves of sugar beets. To facilitate distinguishing them, a study was made of symptoms of the latter two diseases; this study is reported in the companion paper (Severin, 1948).

GEOGRAPHICAL DISTRIBUTION

The western-cucumber-mosaic virus occurs only in the interior regions of California and not in the coastal fog belt. Entomologists of the Spreckels Sugar Company made surveys of the sugar-beet fields in the southern and northern San Joaquin Valley and in the Sacramento Valley; but they found only an occasional plant to be naturally infected with this disease in 1940 and later years. An examination of the beet fields in the coastal fog belt in the Santa Clara Valley during the 1940 outbreak of the disease failed to show a single beet infected with this cucumber-mosaic virus.

SYMPTOMS

On Experimentally Infected Beets. On leaves of experimentally infected sugar beets in the greenhouse, the sequence of symptoms of western cucumber mosaic is as follows: Beet leaves 7 to 10 days after inoculation show numerous, large, pale-yellow, chlorotic areas, 5 to 10 mm in diameter, each with a circular, chlorotic center enclosed in a narrow dark ring, and with the margins of the areas diffusing into the surrounding green portions of the leaf (fig. 1, *A*). On some inoculated outer leaves, small, chlorotic spots develop among the large yellow areas, and white veinbanding of the midrib and veins occurs (fig. 1, *B*). Later, each yellow area becomes surrounded by a green or yellow ring, and the center becomes purple or pink (fig. 1, *C*). Accompanying these symptoms, veinbanding (fig. 2, *A*) or a reticulate pattern (fig. 2, *B*) may develop. Each circular, chlorotic area becomes necrotic (fig. 1, *D*) and persists after the leaf becomes dry (fig. 2, *C*). Necrosis of the midrib and lateral veins

[4] See "Literature Cited" for citations, referred to in the text by author and date.

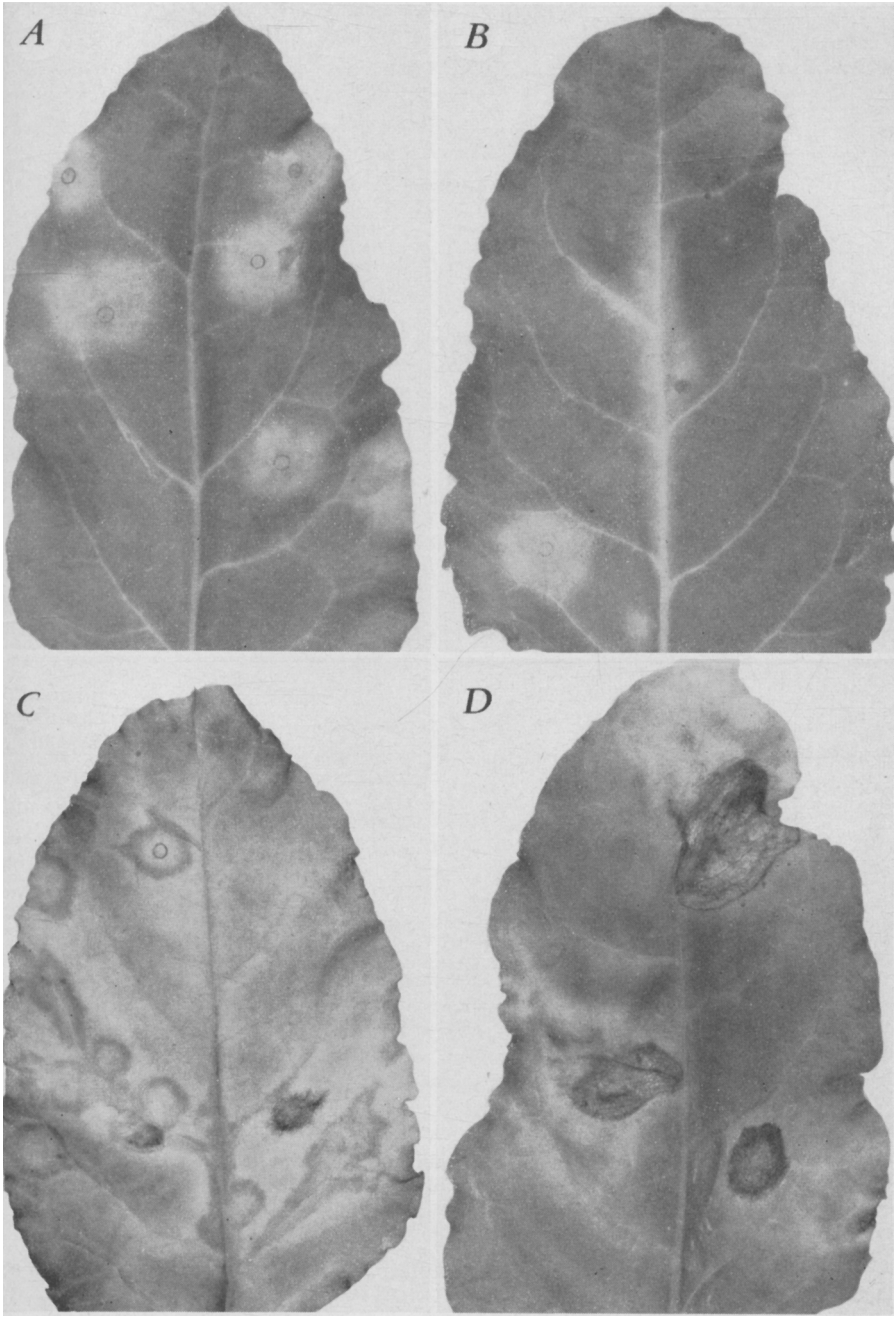

Fig. 1. Symptoms of western cucumber mosaic on leaves of experimentally infected sugar beets: *A*, large, circular, pale-yellow, chlorotic areas with margins diffusing in surrounding green portion; *B*, small and large yellow areas and white veinbanding of midrib and veins; *C*, green or yellow rings enclosing pale-yellow areas with purple or pink centers; *D*, necrotic, circular areas, formerly yellow.

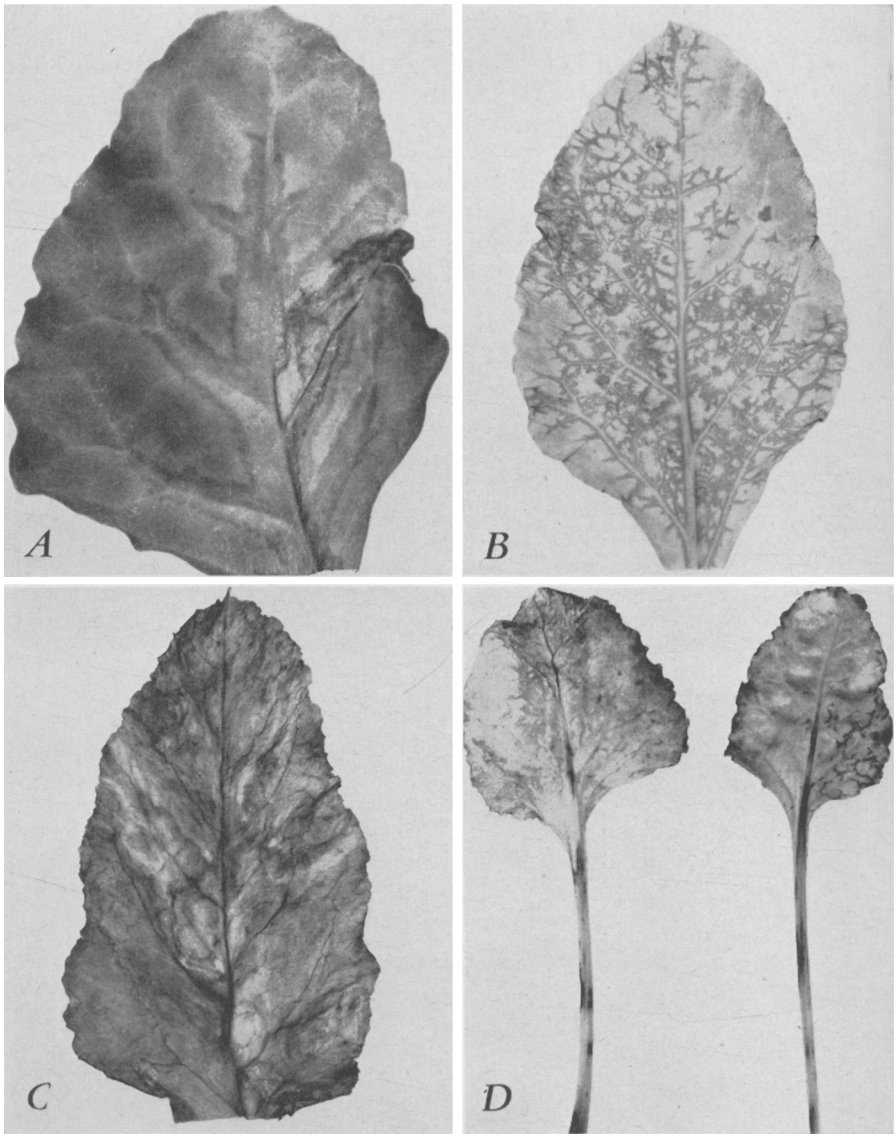

Fig. 2. Symptoms of western cucumber mosaic on leaves of experimentally infected sugar beets: *A*, necrosis and veinbanding; *B*, reticulate pattern; *C*, dried leaf showing necrotic circular areas; *D*, necrosis of petioles, midribs, and rings surrounding chlorotic areas.

occurs (fig. 2, *D*). When infection is systemic, blisterlike elevations develop on the younger leaves. This symptom is like that shown for natural infection in figure 4, and is a reliable indication of systemic infection (page 529). It also helps to distinguish this disease on mechanically inoculated beets from celery calico and common cucumber mosaic, which show somewhat similar chlorotic symptoms. This is further discussed in the companion paper (Severin, 1948).

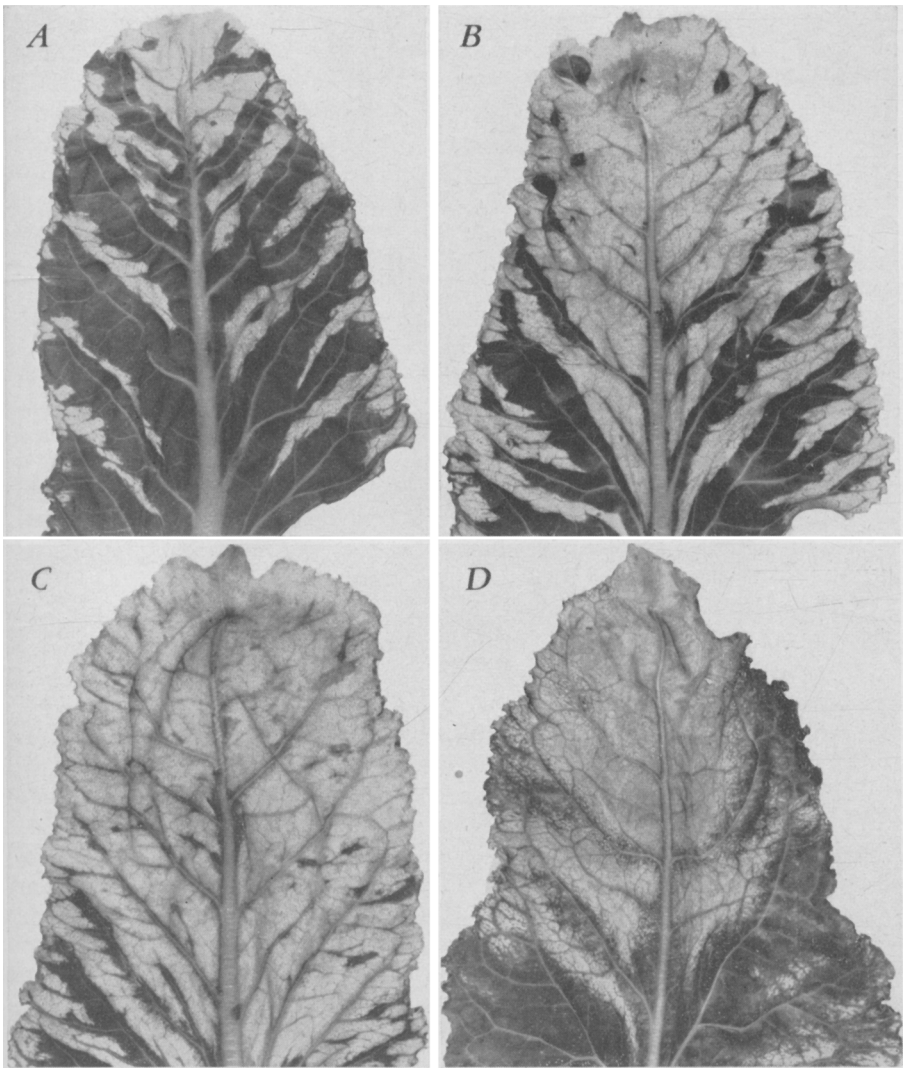

Fig. 3. Symptoms of western cucumber mosaic on young leaves of naturally infected sugar beets: *A*, white or green veinbanding; *B*, chlorosis of apical portion of leaf, interveinal chlorosis, and green veinbanding; *C*, chlorosis of most of the leaf, interveinal chlorosis, and green veinbanding; *D*, chlorosis of upper half of leaf showing interveinal chlorosis, and green, reticulate veinbanding.

On Naturally Infected Beets. Striking symptoms on naturally infected sugar beets. when viewed from the roadside, are the general yellowing of the outer leaves and dark-green intermediate and younger leaves. A closer examination of the outer yellow leaves shows numerous circular, chlorotic areas, like those in experimentally infected beets (fig. 1, *A*); on old outer and on dried leaves these are necrotic. White or green veinbanding or interveinal chlorosis occurs on the intermediate or younger leaves (fig. 3, *A*, *B*, *C*).

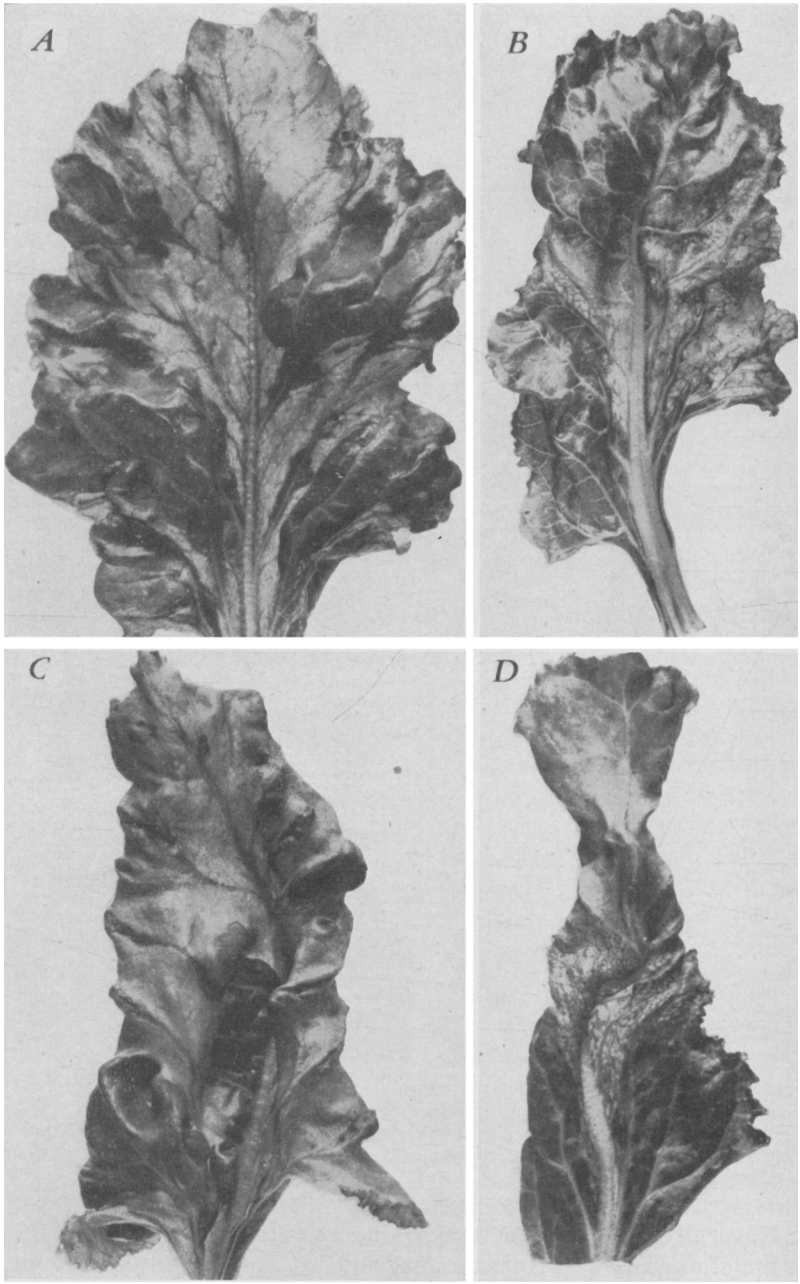

Fig. 4. Symptoms of western cucumber mosaic on leaves of naturally infected sugar beets: *A*, large, green, blisterlike elevations on intermediate leaf; *B*, lower surface of blistered young leaf showing distorted midrib and some of the veins; *C*, outward-rolled margins of blistered young leaf; *D*, deformed young leaf with corkscrew twist. All of the leaves in this figure show chlorosis; but blistering may appear on such intermediate and younger leaves before chlorosis is evident.

Chlorosis begins from the apical portion of the leaf and spreads toward the basal margin (fig. 3, *B*, *C*), with green or reticulate green veinbanding (fig. 3, *D*). A prominent symptom on many of the intermediate and younger leaves is numerous, dark-green, blisterlike elevations (fig. 4, *A*), which may persist after chlorosis of the leaf occurs. The midribs and veins of blistered leaves are frequently distorted (fig. 4, *B*). The margins of the younger, blistered leaves may be rolled outward (fig. 4, *C*). The young leaves may be deformed (fig. 4, *C*), sometimes with a corkscrew twist (fig. 4, *D*).

TRANSMISSION AND RECOVERY OF THE VIRUS

Aphid Vectors. Several species of aphids were tested as vectors of western-cucumber-mosaic virus; the methods used have been described previously (Severin and Freitag, 1938). The following species, reported to occur on beets under natural conditions (Gillette and Palmer, 1934; Patch, 1938), proved to be vectors:

Cotton or melon aphid, *Aphis gossypii* (Glover)
Bean or dock aphid, *Aphis rumicis* Linnaeus
Green peach aphid, *Myzus persicae* (Sulzer)

The green peach aphid is the most important vector of the virus to sugar beets. The bean aphid rarely transmits the virus to beets. The cotton aphid is an efficient vector of the virus to melons and cucumbers. The potato aphid, *Macrosiphum solanifolii* (Ashmead), which also occurs on beets, has not been tested as a vector of this disease.

Mechanical Inoculation Compared with Aphid Transmission. Except where otherwise indicated, the virus was transmitted by mechanical inoculation with the carborundum method (Rawlins and Tompkins, 1936); the expressed sap from sugar beets and other host plants was used.

Mechanical inoculation was compared with the transmission of the virus by the green peach aphid, *Myzus persicae*. The formation of blistering on the youngest leaves of beet seedlings was used as the criterion of systemic infection (see next paragraph). A large population of aphids was reared on 7 sugar beets showing blisterlike elevations on the youngest leaves. Five lots of 20 aphids each were transferred from each diseased plant to healthy beet seedlings, 1 lot to a seedling. The virus extract from each infected plant, on which the aphids had fed, was also inoculated mechanically into 5 healthy beet seedlings. Blistering on the youngest leaves developed on 7 of 35 beets, or 20 per cent, inoculated by the green peach aphid; and on 9 of 35 beets, or 26 per cent, mechanically inoculated. Contrary to Bennett's (1934) results with juice inoculations, previously mentioned, the type of infection was systemic with mechanical inoculation as well as with aphid transmission.

Recovery of the Virus. When the outer leaves of large beets were inoculated, symptoms developed on them; but blistering appeared on the youngest leaves in only about one fourth of the plants. When such blistering did appear, the virus was recovered from the outer, intermediate, and inner leaves of naturally and experimentally infected sugar beets and transferred to healthy sugar beets by mechanical inoculation. When it did not appear, the virus was recovered only from the outer, inoculated leaves showing symptoms. Thus blistering proved to be a reliable criterion of systemic infection.

HOST RANGE, NATURAL INFECTION

The following economic plants were demonstrated to be naturally infected with the virus:

Chenopodiaceae:

Sugar beet, *Beta vulgaris*
Garden or red beet, *Beta vulgaris*
Swiss chard, *Beta vulgaris* var. *cicla*
Spinach, *Spinacia oleracea*

Compositae:

Lettuce, *Lactuca sativa*

Cucurbitaceae:

Honey Dew melon, *Cucumis melo* var. *inodorus*
Cucumber, *Cucumis sativus*
West Indian or bur gherkin, *Cucumis anguria*

Solanaceae:

Tomato, *Lycopersicon esculentum*

Umbelliferae:

Celery, *Apium graveolens* var. *dulce*

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