Virus Diseases of Sugar Beets

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In the Unitcd States there are two virus diseases of relatively wide distribution on sugar beets. These are curly top and beet mosaic. In addition to these there are several other virus diseases that are less commonly observed ; notably savoy, cucumber mosaic on beet, a vein-yellowing mosaic, and one or two others of lesser importance.

The viruses that produce diseases in plants fall into two general classes: (1) Those which increase and move in the phloem and which cause disturbances characterized by vascular proliferation and necrosis, and (2) those which increase and move in the parenchyma or ground tissue of the plant, and which cause disturbances characterized by spotting and mottling of the leaves. The virus of curly top belongs to the first group and the virus of beet mosaic to the second.

The majority of plant viruses are transmitted by insects. Most of the vectors are sucking insects, and feed on the vascular tissue of the plant. This type of feeding is probably essential in the transmission of a virus, such as that causing curly top. which is closely limited to the phloem. Many of the viruses causing mosaics also are transmitted by this type of insect.

The mouthparts and feedbig habits of sucking bisects, such as leafhoppers and aphids, are well adapted to transmission of plant viruses of all types, as may be illustrated by the beet leaf hopper, *Eutettix tenellus*. The beet leafhopper has *very* small but very strong setae which' penetrate the epidermis and underlying cells of the leaf and enter the phloem of the vascular bundle. *An* the tissue is penetrated the insect gives off a liquid excretion (saliva) which solidifies around the mouthparts. When the moulhparts are withdrawn this material is left in the leaf and marks the path taken by the moulhparts when they were inserted. This secretion evidently carries the virus which is liberated in the plant to cause infection.

In order to cause infection, however, the saliva must be introduced into the phloem. The beet leafhopper is very effective in accomplishing this, due to its remarkable ability to locate the vascular region. As shown by the salival sheaths left in the tissue, many of the punctures arc started from the leaf surface in directions which, if continued, would fail to contact the phloem. However, when the mouthparts come to within four or five cells of the general region of the phloem, they curve in the direction of the phloem until the vascular region is penetrated. Information bearing on the probable reason for this peculiar ability possessed by the beet leafhopper has been obtained.

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It is well known that the phloem of the plant has an alkaline reaction, whereas the parenchyma usually is acid. Fife and Frampton showed that between the alkaline phloem and the acid parenchyma there is a transition zone extending through a distance covered by four or five parenchyma cells, in which the cells become less and less acid as the phloem is approached. Apparently, the leaf hoppers are able to detect this gradient and follow it into the phloem tissue.

The beet leafhopper is able to introduce sufficient virus into a beet plant to cause infection in a feeding period of 1 minute. Also, in a feeding period of 1 minute, the insect is able to pick up enough virus from a diseased plant to render it able later to infect other plants. However, longer periods of feeding are more effective both for transmitting the virus to healthy plants and for acquiring the virus from diseased plants.

Once the virus is picked up from the plant, it enters the alimentary tract and passes into the blood of the insect. From the blood it passes into the salivary glands, from which it is returned to the plant through the medium of the saliva. This passage of virus from the blood to the salivary glands apparently is a very gradual process, for once the leafhopper has acquired virus it retains the ability to transmit disease for long periods. There is no evidence, however, that the virus increases in the insect.

Certain insects other than the beet leafhopper are able to pick up the curly-top virus and retain it for 3 weeks or more, but none of these is able to produce infection; presumably either because the virus cannot pass from the alimentary tract into the blood or, if it enters the blood, it cannot pass through the salivary glands.

The relation of the curly-top virus to the plant is also somewhat interesting. It has been found that when the virus is introduced into the tip of a beet leaf by the beet leafhopper it moves very rapidly away from the point of introduction toward the growing point. Six minutes after a leafhopper has started feeding on the tip of a beet leaf, the virus may have moved away from the point of introduction a distance of 6 inches or more. There is very good evidence that this movement takes place in the phloem.

Other evidence indicates that the curly-top virus is very closely limited to the phloem elements of the vascular bundles. For example, when rings breaking phloem continuity are placed in the internode of the stem of a tobacco plant the virus is unable to pass from the top of the plant toward the base and infect parts below the rings. Also, in a beet the liquid derived from the phloem, either as exudate from diseased petioles or as exudate from the cut surface of a beet root, contains high concentrations of virus, whereas an extract from parts of the beet containing no phloem has little or no virus.

Although the virus moves rapidly from the tip of a beet leaf toward the growing point, it moves very slowly from the growing point toward the tips of mature leaves. Also, in beets with two crowns, one crown may be infected and show curly top for a period of several weeks during which time the other crown may be free from disease. However, when the non-infected crown is placed in the dark, or defoliated, the virus moves into it and, within a period of a few days, produces typical curly-top symptoms. When etiolated beet leaves are kept in the dark and inoculated by means of leaf hoppers, the virus does not readily move out of the leaves and enter the crown of the plant. This evidence indicates a close correlation between the movement of the curly-top virus and the transport of carbohydrates in the beet plant. Similar evidence indicating a general correlation between virus movement and food transport has been obtained, using the virus of beet mosaic as well as certain viruses common on tobacco.

This apparent correlation between the movement of virus and the transport of carbohydrates in the plant may prove to be of considerable significance in the study of the factors responsible for the transport of food materials within the plant. Thus, knowledge obtained from the study of the movement of viruses through plant parts may aid materially in solving some of the problems of food transport.