Cytology of Beet Yellows Virus Infection in *Tetragonia*

I. Parenchyma Cells in Infected Leaf

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With 24 Figures

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Summary

The distribution of beet yellows virus in parenchyma cells of *Tetragonia expansa* Murr. leaves and the pathologic changes in these cells were studied with light and electron microscopes. Segments of leaves of various ages were collected from systemically infected plants. Virus particles were in parenchyma cells of the veins and the mesophyll. In younger leaves virus particles were only in the cytoplasm, in older leaves virus was present also in the nuclei. The earliest abnormality in infected cells was the formation of vesicles containing networks of fine fibrils. The vesicles were in aggregates as large as or larger than the nuclei. In the highly vacuolated mesophyll cells, the aggregates protruded into vacuoles and assumed the form of amorphous inclusion bodies as seen with the light microscope. The vesicle aggregates contained virus particles. The chloroplasts were not materially affected by the infection except when the entire cell was undergoing necrosis. Mitochondria assumed ameboid forms in some cells, but appeared normal in most others. Certain membrane-bound enclaves, containing fragments of membranes, were possibly derived from mitochondria. Nuclei containing virus aggregates showed no other obvious abnormalities. In some cells ribosomes appeared to be degenerating.

1. Introduction

Light microscope studies of cytologic symptoms in the sugarbeet (*Beta vulgaris* L.) infected with the beet yellows virus (BYV) disclosed characteristic inclusions in mesophyll, vascular parenchyma, and epidermal cells (Esau 1960 a). A limited examination of *Tetragonia expansa* Murr. infected with BYV showed similar inclusions (Esau 1960 a). The inclusions varied in form and texture. Some were clearly circumscribed bodies, oval, spindle-

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shaped, or much elongated; others were aggregates of fibrous material compactly or loosely arranged. The circumscribed bodies appeared amorphous, alveolate, fibrous, or banded. The fibrous and banded inclusions were identified in the sugarbeet (Esau, Cronshaw, and Hoeffert 1966) as aggregates of virus particles arranged without a precise order (fibrous bodies) or in layers in which the particles were oriented parallel to each other (banded bodies). The structure of the amorphous bodies was not determined in that study. The amorphous inclusions were given special attention in the present investigation of BYV-infected Tetragonia leaves.

A study of BYV-infected sugarbeet seedlings with the light microscope provided information on the development of cytologic abnormalities (Esau 1960 b). The relation of the initial development of cellular degeneration in a young leaf or root to the maturation of the first sieve elements in those organs was demonstrated in that study. The first cytologic indication of infection was recognized in leaves five days after inoculation. Chromatic granular material appeared in phloem parenchyma and companion cells. Seven days after inoculation similar parenchyma cells showed organized inclusions. Chromatic material became evident in the starch sheath outside the phloem, an indication of spread of infection beyond the phloem. Still later inclusions occurred in the mesophyll, initially in cells close to the phloem, subsequently farther from this tissue and even in the epidermis (Esau 1960 a).

In the studies just reviewed, cytologic changes were detected before the sugarbeet plants showed external symptoms. Inclusions in Tetragonia were detected by light microscopy in numerous cells of phloem and mesophyll in the youngest symptomless leaves of systemically infected plants. A comparison of ultrastructure of leaves of different ages, however, showed differences in the extent of spread and kind of aggregation of virus in conducting and parenchymatic cells. The patterns of distribution and aggregation of virus and the effect of infection on host cell components are described in the present and two subsequent papers.

2. Material and Methods

Tetragonia expansa Murr. plants grown in a greenhouse at Salinas, California, were inoculated with BYV when they were two weeks old. The aphid, Myzus persicae (Sulzer), previously fed on BYV-infected Beta vulgaris L. plants, was used as the vector. Leaves of different ages (the youngest about 1 cm long, the oldest fully expanded) were collected from systemically infected plants 60 days after inoculation. Beginning with the youngest and smallest leaves near the apical meristem, which were free of symptoms, the leaves showed increasingly more advanced

Fig. 1. Transection of a minor vein from an older leaf (eighth from youngest sampled). Sieve element (S) and two companion cells above it contain virus particles (V). Tracheary elements have secondary wall (SW). Parenchyma cell next to them contains vesicles (Ve). Virus also was present in this cell. N = nucleus, P = plastid. ×18,000