

ULTRASTRUCTURE OF CORN LEAF TISSUE INFECTED WITH THE ND18 STRAIN OF BARLEY STRIPE MOSAIC VIRUS

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ABSTRACT

The cytopathology of the ND18 strain of barley stripe mosaic virus (BSMV) in corn leaf tissue was studied with the electron microscope. Few ND18 BSMV particles were found in systemically infected leaf tissue. Paramural bodies, intraprotoplasmic osmiophilic bodies, and extraprotoplasmic sacs were located in leaf cells. Chloroplasts were often swollen, contained deranged membrane systems and had BSMV particles attached to their limiting membrane.

INTRODUCTION

Barley stripe mosaic virus (BSMV) is of particular interest, since demonstration in barley that BSMV increases the frequency of triploid and aneuploid seeds (Sandfaer, 1973) and in corn that BSMV causes a genetic abnormality, designated "Aberrant Ratio" (AR) (Sprague et al., 1963; Sprague and McKinney, 1966; Sprague and McKinney, 1971; Pring, 1971). The AR effect is a significant deviation from expected Mendelian ratios in F_1 and backcrosses in corn. Pring (1974) established that the ND18 strain of BSMV induces the AR phenomenon in corn.

Thin section studies have demonstrated the presence of BSMV particles in barley pollen (Gardner, 1967), embryos (Carroll, 1969; Carroll, 1972), egg sac and egg cells (Mayhew and Carroll, 1974), and sperm and vegetative cells of barley pollen (Carroll, 1974). Ultrastructural studies of BSMV in diseased barley leaf mesophyll and guard cells have found particles in the cytoplasm (Shalla, 1959; Shalla, 1966; Gardner, 1967) and nuclei (Gardner, 1967). No research reports concerning the ultrastructure of BSMV in corn have appeared. This investigation was initiated to determine the ultrastructural appearance of BSMV in corn.

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MATERIALS AND METHODS

The inoculation of several corn (*Zea mays* L.) cultivars was accomplished by rubbing the first emerging leaf of plants in the three leaf stage with sap from diseased barley plants. The virus isolate was obtained from R. G. Timian and has been designated as ND18 (Pring and Timian, 1969). All experimental and control plants were grown under greenhouse conditions. Samples taken from chlorotic stripes of systemically infected leaves of inbred 'SD-P2' corn plants were prepared for electron microscopy according to the procedures described elsewhere (McMullen et al., 1977a,b).

RESULTS

Several corn cultivars were inoculated with the ND18 strain of BSMV in an attempt to find suitable material for ultrastructural studies. Symptom development was very erratic within these test plants. However, symptoms did occur in inbreds 'SD-P2', 'OH45' and 'R18-1-9'. Inbred 'SD-P2' was selected as experimental material. Systemic symptoms of ND18 infection appeared 10 to 30 days postinoculation. The symptoms consisted of several chlorotic stripes running nearly the entire length of the leaf blade with short flecks scattered up and down the leaf. No local lesions or distinctive symptoms were observed on the inoculated leaf. Infectivity of corn leaf tissue exhibiting symptoms could not be demonstrated.

Ultrastructural studies of early systemic tissue revealed a low concentration of BSMV particles. Cytoplasmic bulges containing virus were uncommon (Fig. 1). Occasionally virions were observed attached to the outer membrane of mesophyll chloroplasts. Developing tissue necrosis was observed in chlorotic areas of the leaf as evidenced by cells containing large amounts of densely stained cytoplasm (Fig. 1). Paramural bodies, intraprotoplasmic osmiophilic bodies and structures similar to extraprotoplasmic sacs found in early systemic tissues of barley (McMullen et al., 1977a) also were located in corn (Fig. 2). Chloroplasts of the agranal type with stroma lamellae arranged in parallel rows were observed in bundle sheath cells. The peripheral region of these chloroplasts in healthy and diseased tissue contained a system of anastomosing vesicles or peripheral reticulum. However, bundle sheath chloroplasts in diseased tissue were often swollen and contained disarranged stroma lamellae (Fig. 3). Aberrant mesophyll cell chloroplasts with tubular networks and vesicles (Fig. 4) resembled those referred to as type 1 in barley by McMullen et al. (1977b).

DISCUSSION

The inability to achieve consistent systemic symptoms of BSMV infection in corn has been reported previously (McKinney and Greeley, 1965; Pring, 1974). Our ultrastructural evidence of low

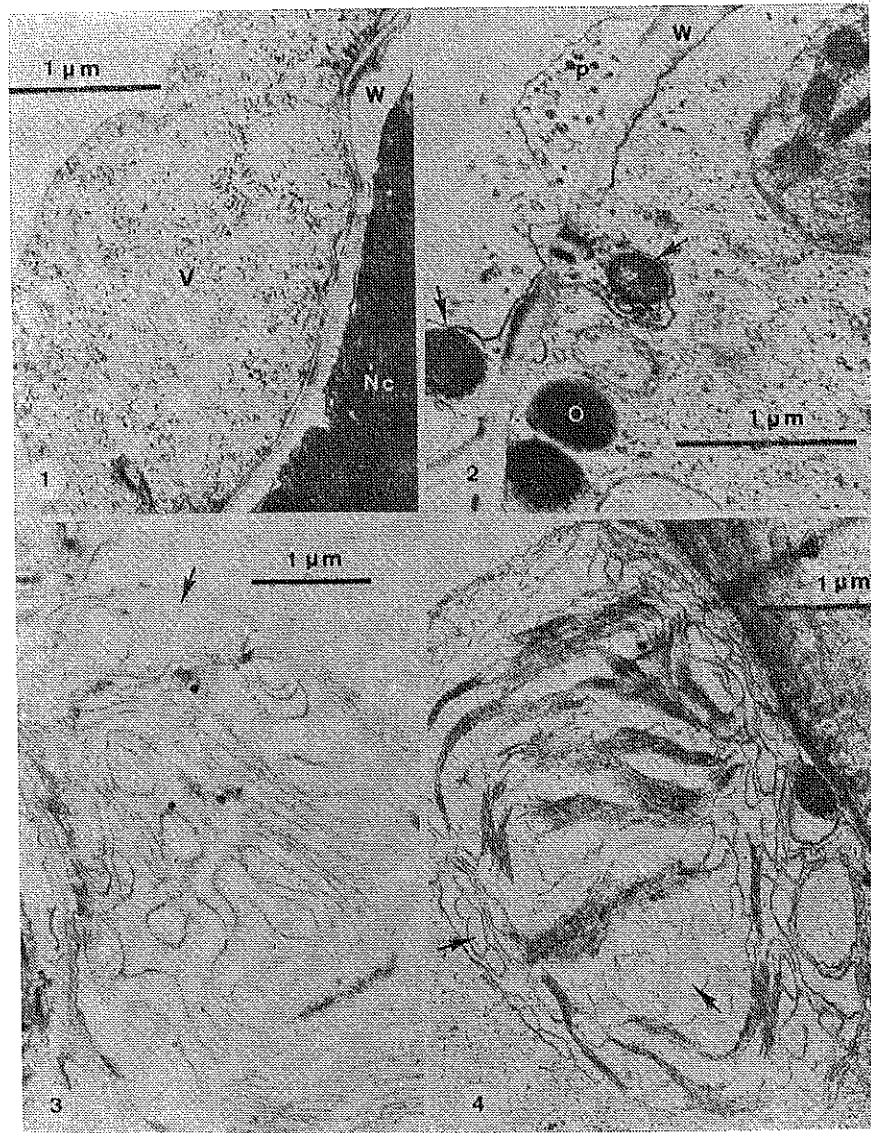


Figure 1. Bulge of cytoplasm containing virus particles (V) adjacent to necrotic cell (NC) in a corn leaf cell from chloride stripe area. W = cell wall.

Figure 2. Paramural body (P), extraprotoplasmic sacs (arrows) and intraprotoplasmic osmiophilic bodies (O) in early systemic tissue.

Figure 3. Swollen bundle sheath chloroplast with deranged stroma lamellae commonly observed in chlorotic tissue. Note peripheral reticulum indicated by arrow.

Figure 4. Mesophyll chloroplast with electron-lucent stroma composed of convoluted membranes forming tubular networks (arrows). G = grana.

ND18 BSMV population in corn leaf tissue is consistent with biochemical studies of corn-ND18 BSMV interaction in which Pring (1974) found high concentrations of virus RNA in systemically invaded corn leaf tissue. However, intact nucleoprotein levels were inversely correlated with virus RNA. He suggested "the corn variety was thus deficient in either the synthesis of viral coat protein or in assembly mechanisms." A similar explanation was offered for low levels of intact ND18 BSMV particles in the inoculated leaf of barley (Pring, 1971).

Intraprotoplasmic osmiophilic bodies were frequently seen in diseased corn tissue. As in barley, the osmiophilic bodies had no limiting membrane and occurred scattered in the cytoplasm or adjacent to extraprotoplasmic sacs; accompanying paramural bodies were similar to those found in barley tissue (McMullen et al., 1977a).

The relationship of the ND18 strain of BSMV to plastids in corn was similar to that reported for barley leaf tissue. The occurrence of virions attached to chloroplasts, membrane deformation and swelling has been well documented in barley with several strains of BSMV (Gardner, 1967; Carroll, 1970; McMullen et al., 1977b). In contrast to peripheral vesicles found in barley plastids (McMullen et al., 1977b), the vesicles comprising the peripheral reticulum in corn were also observed in control chloroplasts and did not appear to be formed by invagination of the outer limiting membrane. The occurrence of peripheral reticulum in the bundle sheath chloroplasts of corn has been reported by Bachmann et al., 1973.

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