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# Histolytic Polyploidy in Root Tips of Maize<sup>1</sup>

By JOHN E. SASS

A sample of "Hopi Indian" maize from an unknown locale in New Mexico was brought into the writer's laboratory for the preparation of sections of the radicle for the study of the histogens. The sample consisted of a mixture of creamy white kernels, black kernels and kernels of intermediate shades of gray. Some of the paraffin ribbon of radicles was discarded because of the presence of a large cavity behind the root cap. The shape and consistent position of the cavity did not resemble the results of faulty infiltration, and a study of finished preparations showed that the cavities are the result of a cytohistological aberration in the meristem. The present report describes the salient features of the abnormality.

## MATERIALS AND METHODS

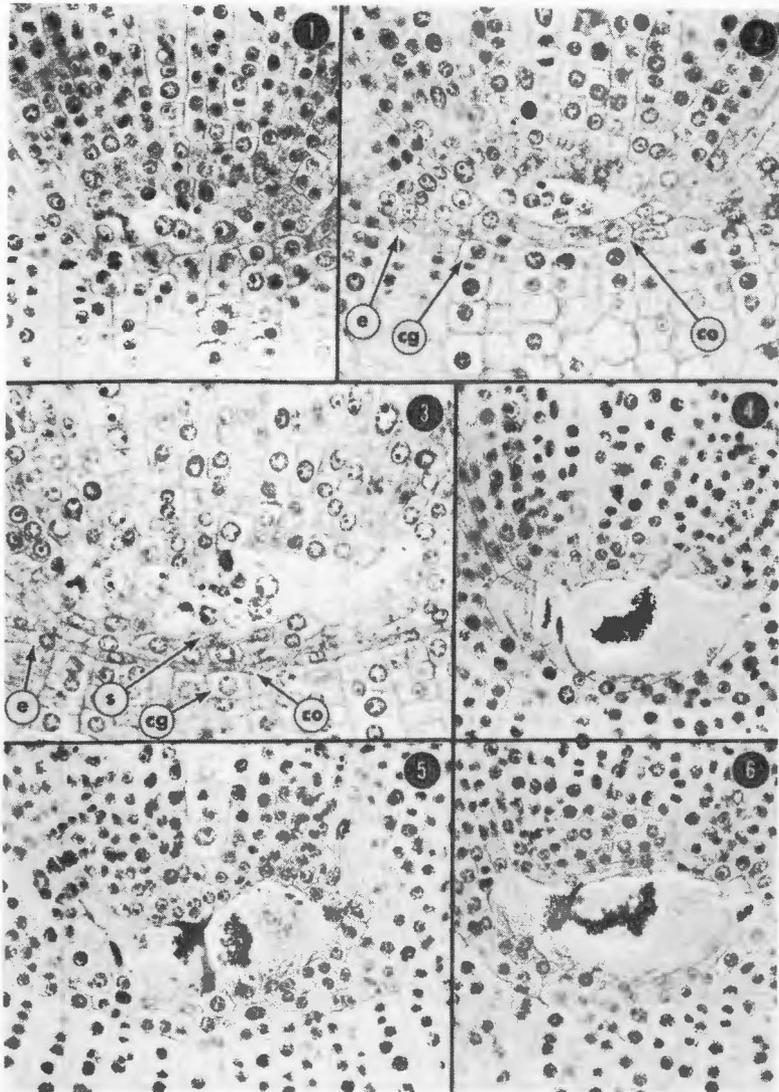
Kernels were sprouted on blotters in petri dishes. Tips of the emerging radicles were killed in a chrome-acetic-formalin solution (Craf 3), processed and embedded in paraffin, sectioned and stained. For cytological details, sections were stained in gentian violet-iodine. For the study of abnormalities of the histogens and their derivatives, sections were first stained by the iron hematoxylin procedure, thoroughly washed in water and stained for 2-3 minutes in hemalum. This combination accentuates cell walls without seriously obscuring cytological details, and gives good contrast in photomicrographs.

## OBSERVATIONS

A brief review of the normal organization and activity of the apical meristem of the root of *Zea* will aid in the subsequent description and interpretations of the abnormality under investigation. The tissues of the root are produced by three apical, contiguous generating layers. The root cap is produced by the distal layer, the calyptragen, which produces stratified, radiating files of derivatives (Figs. 2, 3). The epidermis, cortex and endodermis are derived from the second generating layer, a single layer of cells, 3 to 5 cells across. The term "cortical initials" will be used herein for the latter layer (Figs. 2, 3, 12). The third generating layer, which is less sharply defined in lateral extent as well as in depth, consists of the stelar initials, from which all tissues of the stele are derived (Figs. 3, 12).

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Figs. 1-12. Longitudinal sections of root tips of "hopi" maize. 400x.

- Fig. 1. Early stage of lysis in stelar initials; nuclei in cavity are slightly larger than normal.
- Fig. 2. Large lytic cavity contains many nuclei of approximately normal size. Cortical initials (co) and calyptrogen (cg) are not involved. Epidermal layer (e) has been established.
- Fig. 3. Cavity in region of stelar initials (s) contains enlarged as well as approximately normal nuclei. Calyptrogen (cg), cortical initials (co) and epidermis are intact.
- Fig. 4. Polyploid metaphase figure in large cavity. Edge view of smaller metaphase figure at left.
- Fig. 5. Necrotic material between two cavities. Metaphase chromosomes in cavity at right.
- Fig. 6. Multipolar metaphase figure in cavity.

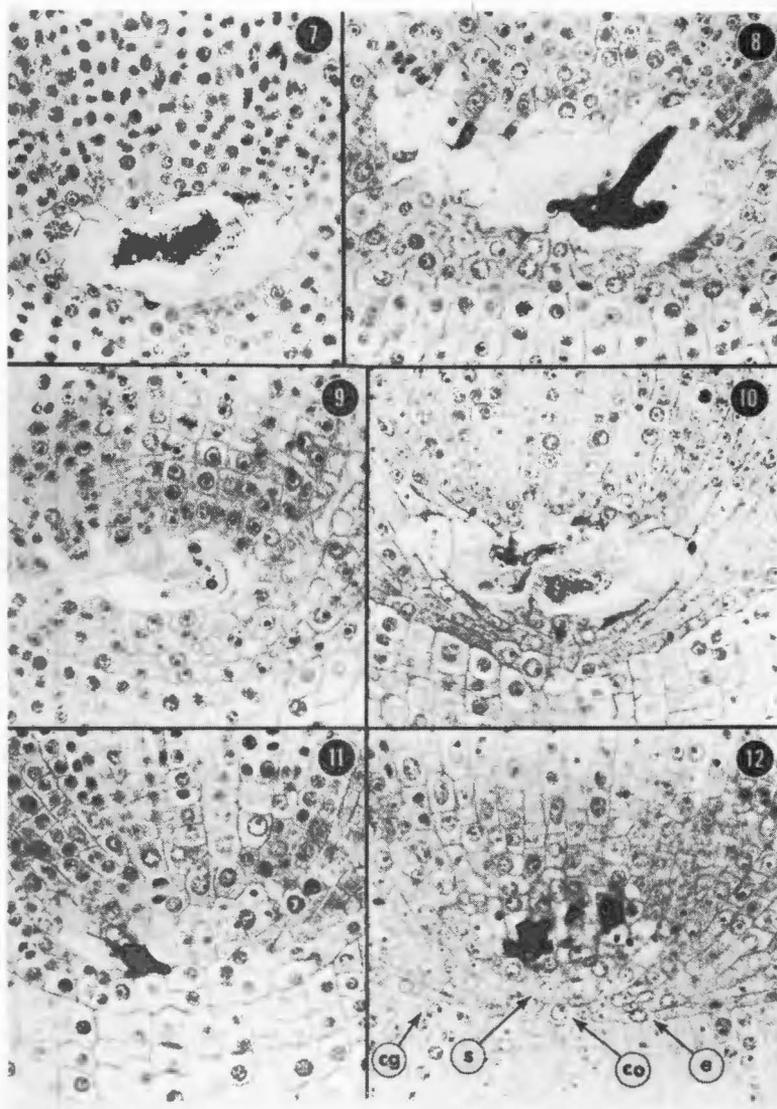


Fig. 7. Polyploid multipolar metaphase. Progressive lysis of cell walls evident on margins of cavity.

Fig. 8. Lobed, polyploid interphase nucleus in cavity.

Fig. 9, 10. Lobed and disintegrating nuclei in cavity.

Fig. 11. Necrotic mass in zone of slightly enlarged stelar initials.

Fig. 12. Necrotic masses in region of nearly normal stelar initials (s). Epidermis (e), cortical initials (co) and calyptragen (cg) are intact.

The first indication of abnormality in the root tips of Hopi maize is enlargement of cells in the region of the stelar initials. The nuclei of the enlarged cells at first undergo apparently normal mitosis, but cell wall formation is inhibited. The expanding cavities that contain abundant cytoplasm and many nuclei that are little, if any larger than the nuclei of surrounding cells (Figs. 1-3). Subsequent nuclear division in the lytic cavity occurs by typical c-mitosis, which builds up a large chromosome complement (Figs. 4-7). Multipolar separation of groups of chromosomes produces separate restitution nuclei that vary in size and chromosome number. Large, elaborately lobed nuclei are also formed (Figs. 8-10).

During the development of the lytic cavity, the calyptrogen and the cortical initials may remain intact and apparently function normally (Figs. 2, 3, 12). This indicates that abnormality begins most commonly in the stelar initials. However, in some roots, the radiating, filar arrangement of the cortical initials, calyptrogen and their derivatives becomes obscured by irregular expansion of cells (Figs. 1, 8, 11). This suggests at least a minor involvement of the cortical initials and the calyptrogen.

Necrosis of cell contents is evident in some preparations. Masses of deeply stained material may become evident at an early stage in histolysis (Figs. 11, 12), and these masses may be evident after considerable enlargement of the lytic cavity has occurred (Fig. 5). In some preparations the indistinct outlines of interphase nuclei in the cavity suggests nuclear lysis which may precede or accompany necrosis (Figs. 9, 10).

The incidence of abnormality was found to be very low, only 14 of the 208 root tips that were sectioned to date showed any evidence of aberration. Abnormality was not correlated with kernel color.

#### DISCUSSION

The abnormality described above is very rare, and may be limited to the strain of maize in which it was found. It is unlikely that the large cavities would have eluded attention in view of the vast numbers of root tips that have been sectioned over the years. The involvement of all three generating layers of the root tip is to be expected on the basis of the common origin of these layers.

No clues to the causation of the abnormality have been found, no invading organisms or injuries to the caryopsis have been detected. The limited extent of the cavity backward from the root tip, the early cessation of lysis, and the early onset of necrosis suggest that the stimulus to abnormality is of short duration and of limited spatial range.

The ultimate fate of abnormal roots is not shown. It is unlikely that means can be devised to identify and recover affected roots from field-grown plants. Further studies will explore the presence of abnormality in seminal roots, aerial nodal roots and stem apices.

The few remaining kernels of the original sample have been planted and the resulting plants have been selfed and outcrossed to determine the possible heritability of the abnormality.

#### SUMMARY

A collection of maize from New Mexico exhibits abnormal activity of the apical meristem of the radicle.

The abnormality develops in the following sequence: enlargement of stelar initial cells, and less commonly of cortical initials; lysis of cell walls in this zone, which produces a large multinucleate cavity; formation of giant, polyploid nuclei as well as smaller nuclei in the cavity; necrosis of protoplasm in the cavity.

The absence of visibly necrotic root tips, at least in the seedling stage, suggests recovery from the abnormality.

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