ALLELOPATHIC EFFECTS OF THORNAPPLE, *DATURA STRAMONIUM* L.

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Summary. The phytotoxic potential of thornapple, *Datura stramonium* L., has been documented in controlled environments and in the field. The tropane alkaloids, scopolamine and hyoscyamine, washed from thornapple seeds, have been identified as allelochemicals. Secondary, readily observable, effects of these compounds include reduced germination and interference with seedling development of several crop species. Evidence is presented in support of the hypothesis that the primary, growth-inhibiting, effects of thornapple allelochemicals result from a disruption of the cellular metabolism of starch in young sunflower seedlings. Such disruption may be important in the context of herbicide development.

INTRODUCTION

Thornapple, a Solanaceous plant present in all Australian states and widely distributed overseas, is a major weed of irrigated summer cropping in north-western N.S.W. where it reduces crop growth through competition for light, water and nutrients (2). Subsequent work has demonstrated the allelopathic potential of thornapple against linseed, *Linum usitatissimum* L. (12), sunflower, *Helianthus annuus* (L.) (10), barley, *Hordeum vulgare* L. and wheat, *Triticum aestivum* L. (11).

Allelopathic activity by thornapple is associated with the tropane alkaloids, scopolamine and hyoscyamine, which are readily released from the thornapple seed coat following wetting in soil (8) or under controlled conditions (11). From the sixth day of germination, thornapple seedlings themselves have the potential to synthesize phytotoxic alkaloids (4) and release them into the soil from roots (13).

Germination and seedling growth of the crop species named above, are impaired to varying degrees by thornapple allelochemicals. Such responses may be regarded as secondary manifestations of primary events (14). Few studies of such events have been published but they may include structural damage to organelles in root tip cells (9). Some published evidence indicates that cellular metabolism in sunflower seedlings is disrupted by thornapple alkaloids (8). Specifically, changes in the amount of stored food materials present in root tip cells suggest that interference with release of stored energy may be responsible for inhibition of seedling growth.

In this paper we report on further investigations of changes in root tip cells of sunflower treated with thornapple allelochemicals.

METHODS

After thornapple seed had been in soil in the field for seven months, an estimated 0.2 mg total alkaloid/g soil was recovered (7). This represents 0.1% total alkaloids in the soil solution; 0.5% total alkaloids in aqueous solution are phytotoxic (8). Germination and seedling growth of the crop species named above, are impaired to varying degrees by thornapple alkaloids.

An experiment in which the effects on root tip cells of young sunflower seedlings of thornapple seed washings, containing a maximum of 0.05% alkaloid,

has previously been described (8). Ultra-thin sections of root tips prepared after 48 h growth were examined on a Philips EM 300 transmission electron microscope. In light of recent work (11) we have re-examined electron micrographs taken as part of the previous experiment (8).

RESULTS AND DISCUSSION

We confirm the previous finding that root tip cells from alkaloid-treated sunflower seedlings show no gross structural damage (8) despite the concentrations applied being sufficient to reduce radicle elongation. Root tip cells which received sterile water show distinct nuclei with small vacuoles and amyloplasts (Fig. 1).

In similar cells which had received 0.05% alkaloids, aggregations of large amyloplasts appear around the nuclei (Fig. 2). Vacuoles in these cells are enlarged when compared with controls. The nucleus may be much reduced in size (Fig. 3). Treated cells also contain larger numbers of microbodies (possibly glycosomes: Fig. 4) relative to control (Fig. 1).

The abundance of amyloplasts and microbodies in the allelochemical-treated cells (Figs. 5a and 5b) indicate a probable slowing down of the metabolism of food reserves, a process which takes place rapidly during the early phases of germination.

A close association between amyloplasts and microbody membranes can be observed (Fig. 5b). Membranes of mitochondria may be absorbed into the amyloplast wall (Fig. 5c). Some microbodies are very large (1-2 μm diameter: Fig. 5b) and different views of them can be observed in the same section, probably depending on the surface of the cut (Fig. 4).

The amyloplasts often contain microbodies (Figs. 4 and 5c), a number of which appear to be in the process of dissolution (Fig. 5a).

Increase in size and number of microbodies (Fig. 4 and 5) may be followed by intense activity of the vesicles which, in turn, play an important role in the formation of the primary and secondary cell wall. Evidence for malformation of the cell wall appears in Fig. 3. It is possible that this indicates a response to allelochemicals analogous to that reported following viral, fungal and nematode infections (1, 5, 6).

Microbodies have been the subject of recent research. Like mitochondria, they are known to participate in the uptake of oxygen and the respiratory gas exchange of cells (3). We suggest that the increased size of amyloplasts and number of microbodies in root tip cells of sunflower treated with thornapple allelochemicals tends to confirm the hypothesis that the primary effect of such allelochemicals is to interfere with metabolism of energy sources in the cells of germinating seedlings.

Such interference may be important in the context of developing new herbicides, particularly as the effects observed are achieved with relatively low concentrations of chemical which reduce the level of metabolic activity but, presumably, leave the affected plant less able as a potential competitor.

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Captions for Figures 1 to 5

Figure 1. Root tip cell of sunflower after 48 h germination; sterile water control. N = nucleus, V = vacuole.

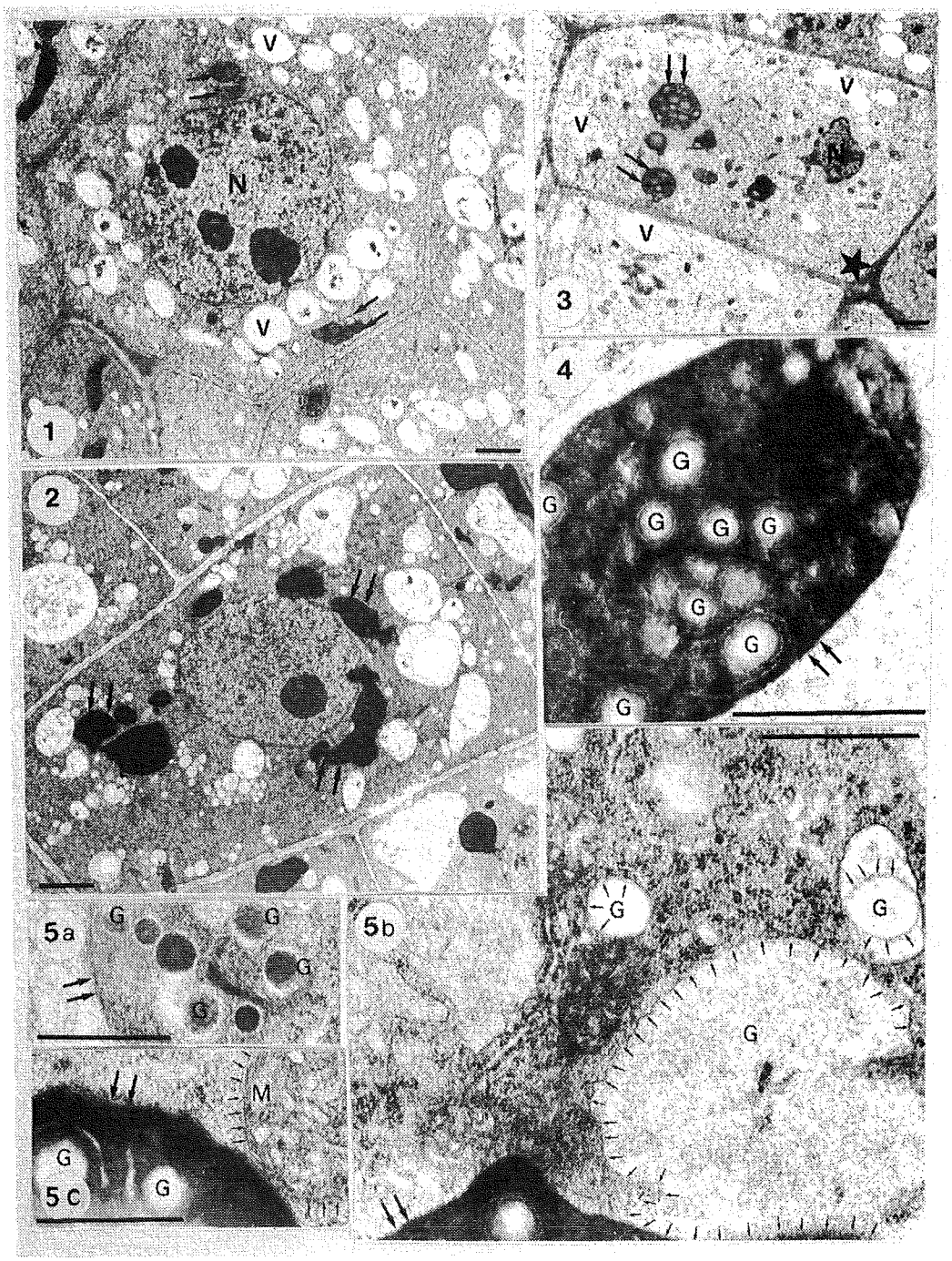
Figures 2-5. Root tip cells of sunflower after 48 h germination; treated with 0.05% thornapple alkaloids.

2, 3 Arrows indicate amyloplasts.

3. Star indicates malformation of cell wall.

4. Microbodies (glycosomes? G) within amyloplast. Arrows indicate amyloplast wall.

5. Details of microbodies (G). Increase in number correlates with dissolution of amyloplasts (5a, b and c - indicated by large arrows). Close association between amyloplast and microbody membranes can be observed (5b - indicated by small arrows). Mitochondria are also assoicated with amyloplasts (5c - small arrows indicate large mitochondrial attachment). Scale bar = 1 µm.


1
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2
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