OBSERVATIONS ON THE ULTRASTRUCTURE AND FUNCTION OF THE DORSAL OESOPHAGEAL GLAND CELL IN XIPHINEMA INDEX

BY

W. M. ROBERTSON and U. WYSS

Scottish Horticultural Research Institute, Invergowrie, Dundee, DD2 5DA, Scotland, U.K.
and Institut für Pflanzenkrankheiten und Pflanzenschutz der Universität, Hannover, B.R. Deutschland

In Xiphinema index the dorsal gland cell extends along the length of the basal oesophageal bulb on the dorsal side and the anterior half of the ventral side. The cell has a system of six ducts formed by deep infolds of the limiting cell membrane. Two ducts extend almost the entire length of the bulb on the dorsal side and four extend half-way on the ventral side. The ducts join anterior to the gland nucleus to form a transverse, fan-shaped main duct. Folds in the lining of the ducts facilitate dilation and depletion of the duct system seen in feeding nematodes.

Electron-dense granules, closely associated with dictyosomes were aggregated near the ducts in nematodes which had been ingesting food, but only a small amount of electron-dense material was found at the apices of the folds in the duct lining and an electron-dense plug was observed where the main duct opens into the food canal. This orifice is a longitudinal slit opened by four radial dilator muscles just anterior to the pump chamber. Three other groups of radial muscles attach to the ventral and lateral sides of the food canal to balance the pull of the dilator muscles. Observations with the light microscope on nematodes which were feeding suggested that the part of the main duct near the food canal, which is lined with a thin layer of cuticle, may act as a one-way valve whilst the slit is dilated.

There have been several descriptions of Xiphinema index feeding on plant roots in agar (Fisher & Raski, 1967; Cohn, 1970; Cotten, 1973; Weischer & Wyss, 1976; Wyss, 1977 a, b, c). Wyss (1977 a, c) observed structures considered to be ducts in the basal oesophageal bulb of X. index filling and emptying during feeding. The present study was undertaken to determine the structure of the dorsal gland cell and its associated ducts and to relate these to the action of the dorsal gland cell system in feeding X. index.

METHODS

X. index was obtained from populations maintained on fig plants grown in the glasshouse. Specimens for fixation were extracted from soil by the sieving and decanting technique (Flegg, 1967). This extraction method apparently affected the fixation of most specimens, frequently resulting in greatly dilated gland ducts and separated cell membranes. X. index that had been feeding on roots of fig seedlings in agar plates lacked these fixation artefacts and were therefore used for later observations.

Specimens for study with the electron microscope were fixed and embedded by two methods:
(a) 3% glutaraldehyde in 0.1 M sodium cacodylate buffer (pH 7.3) postfixed in 1% osmium tetroxide in 0.1 M veronal acetate buffer (pH 7.3). Specimens were embedded in Araldite by the method of Robertson & Taylor (1975).

(b) 3% glutaraldehyde in 0.1 M PIPES buffer (pH 8) postfixed in 1% osmium tetroxide in 0.1 M PIPES buffer (pH 6.8) (Salema & Brandão, 1973; Baur & Stacey, 1977).

The specimens were then dehydrated in a graded ethanol series, two changes of epoxy propane and embedded in EMIX resin (Emscope Laboratories Ltd., 474 Wandsworth Road, London, England, SW8 4TE) at 60°C for up to 3 days. Method (b) gave more consistent fixation between specimens than (a) but X. index did not fix as well as X. diversicaudatum. Sections were stained for 2 min in a saturated solution of uranyl acetate in 50% ethanol and 7 min in lead citrate using the bulk staining technique of Robertson & Roberts (1972). They were examined in an Hitachi HS-8 electron microscope at 50 KV.

OBSERVATIONS

Observations with the light microscope

X. index feeding on root-tips of fig seedlings were observed by the method described by Wyss (1977a). Detailed observations of the basal oesophageal bulb showed apparent depletion of gland ducts immediately after penetration of each root cell and during short pauses in the subsequent period of ingestion. Immediately after the last stylet thrust, when a root cell was being penetrated, the ducts became strongly dilated concurrent with a slight elongation of the oesophageal bulb. A few seconds later the ducts rapidly and progressively narrowed from posterior to anterior whilst the bulb remained extended. Immediately after this, the oesophageal bulb shortened slightly and ingestion began.

During ingestion the ducts progressively dilated, but they again depleted during short pauses in ingestion (Wyss, 1977a, c). It appears that fluids are rapidly flushed forwards to a common or main transverse duct anterior to the gland cell nucleus which was observed rapidly closing and opening during depletion of secretions in the duct system. Scenes 14-16 in the Encyclopaedia Cinematographica film E2375, (Wyss, 1977c) show that just before the ducts empty, the periphery of the oesophageal bulb close to the main duct, is drawn in, probably by muscles dilating the opening of the duct system into the food canal. After the ducts empty, these muscles relax and the oesophageal bulb shortens slightly. Ingestion then begins and the ducts again dilate.

Morphology of the dorsal gland cell. Study of thin sections through the oesophageal bulb with the electron microscope has shown that the ducts observed dilating and depleting are all part of the dorsal gland cell. This cell is the largest structure within the oesophageal bulb, extending along the entire length on the dorsal side and half-way along the ventral side. The two subventral gland cells are much smaller occupying only the posterior, ventral half of the bulb (Fig. 1).