VISUAL DETECTION OF SWEETPOTATO WEEVIL
BY NON INVASIVE METHODS

JAMES D. HANSEN1, CAROL L. EMERSON2, AND DARLEEN A. SIGNOROTTI3

1Subtropical Horticulture Research Station, USDA-ARS,
13601 Old Cutler Road, Miami, FL 33158

2Division of Veterinary Resources, University of Miami,
P. O. Box 016960, Miami, FL 33101

3Department of Radiology, Baptist Hospital of Miami,
8900 N. Kendall Dr., Miami, FL 33176

ABSTRACT

Sweet potatoes, *Ipomoea batatas* (L.), infested with the sweetpotato weevil, *Cylas formicarius elegans* (Summers), were examined by radiography and ultrasound. No weevil life stage was clearly detected by radiographic methods. However, uninfested sweet potatoes and feeding tunnels in infested tuberous roots were clearly distinguishable. Thus, radiography could assist in the development of quarantine treatments. Ultrasound could not penetrate the root surface and did not produce an image.
RESUMEN

Batatas, *Ipomoea batatas* (L.), que han sido infestadas con el gorgojo de la batata, *Cylas formicarius elegantulus* (Summers), fueron examinadas por radiografía y ultrasonido. Ningun estado de desarrollo del gorgojo fue detectado claramente por métodos de radiografía, no obstante la sensibilidad de la película. Sin embargo, batatas no infestadas y túneles de alimentación en batatas infestadas fueron reconocidos claramente. Así, la radiografía pudo asistir en el desarrollo de tratamientos cuarentenarios. El ultrasonido no pudo penetrar la superficie de la batata y no presentó una imagen.

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The sweetpotato weevil, *Cylas formicarius elegantulus* (Summers) (Coleoptera: Curculionidae) is the most important pest of the sweet potato, *Ipomoea batatas* (L.) Lam. (Convolvulaceae), in the southern United States and throughout the tropics and subtropics (Talekar 1982, Sutherland 1986). This weevil damages the tuberous roots and vines of the sweet potato and other *Ipomoea* spp. To prevent the weevil from spreading, quarantine regulations prohibit the importation of any untreated commodity that may have this pest. The treatment (APHIS 1985, Fiskaal 1989) is limited because it involves methyl bromide fumigation that may cause phytotoxicity, is restricted to only cured sweet potatoes, and has temperature, time and facility constraints.

The development of improved treatments is hampered because the immature life stages of the weevil are unobservable. Eggs (0.7 × 0.4 mm) are laid in cavities just below the skin of the root (Sutherland 1986). The larvae are vermiform and the number of instars ranges from 3 to 5 (Sutherland 1986). Typically, the early instars feed near the surface, but burrow into the interior as they mature; the larval stadium varies according to temperature (Mullen 1981, Sutherland 1986). After pupation (4 to 15 days) within the larval chamber, the adult remains within the root for 1 to 9 days, then exits by tunneling to the surface (Mullen 1981, Sutherland 1986). The life cycle takes from 30 to 85 days depending on temperature (Sutherland 1986).

Radiography may be a promising method for detecting weevils in the root. Radiographs have been used to detect insects in solid media such as bark (Berryman 1964, Wickman 1966), wood slabs (Johnson & Molatore 1961), and grain (Mills & Wilber 1967) without causing apparent injury. Furthermore, radiographs have been precise enough to identify the endoparasite *Mesopolobus verditer* (Norton) (Hymenoptera: Pteromalidae) in the larch casebearer, *Coleophora laricella* (Hübner) (Lepidoptera: Coleophoridae), (Hansen 1981) and the ectoparasite *Choetospila elegans* Westwood (Hymenoptera: Pteromalidae) on the maize weevil, *Sitophilus zeamaize* (L.) (Coleoptera: Curculionidae) (Sharifi 1972).

Another technique, the use of ultrasound, differs from the previous method in that it is suitable for soft tissue. Hence, it is used extensively by the medical services to detect tumors and to observe fetal development. Yet, the application of ultrasound to identify pests in infested commodities has been poorly understood.

Here we report on the value of these technologies in identifying the presence of the sweetpotato weevil and the damage it causes to its host.

MATERIALS AND METHODS

Radiography

Radiographs were produced using a Philips Super 80 CP Digital Radiography Machine on a Diagnostic 92 Remote Control Table. The exposures were at 40-70 KVP
and 55-60 MAS. Radiographs were produced either digitally or directly on radiographic film.

In the digital method, the radiographic image was shown on a cathode-ray-tube (CRT) monitor. Because each radiograph was electronically stored, the contrast and brightness was adjustable on a monitor as well as the choice of a positive or negative image. The final image was fixed on Kodak Ektascan Radiographic Film using a Kodak M-6 Processor and a Kodak Ektascan Laserprinter.

In the direct method, the image was exposed directly on Kodak T-Mat-G TMG-1 Radiographic Film (10 in × 12 in) and developed using either a Kodak Multiloader M-8 Processor or a Kodak RP X-Omat Processor. The film was held in a Kodak X-Omatic cassette with a Kodak Lanex screen. No adjustment was possible to the image before development and only the negative was produced. The grain size of the negative was controlled by using either a fast or fine screen.

Uninfested sweet potatoes served as controls. Others were infested in the laboratory by being placed in cages containing 100-300 adult weevils. All weevil life stages were obtained by dissecting sweet potatoes which were infested for different time periods. Individuals were located, life stage identified, and marked with metal insect pins. Sweet potatoes containing late instars, pupae, and adults had many feeding tunnels filled with frass. The tunnels of the early instars were intensified by injecting into them a radiographic opaque iodine-base liquid (Conray-43, meglumine, Mallinkrodt Inc., St. Louis, MO 63134). Tubers were dissected and life stages of the weevil were identified, then compared to the radiographs.

Ultrasound

Uninfested and weevil-infested sweet potatoes were examined by using a Diagnostic Ultrasound Machine, Model Classic Concept 2000 (Classic Medical Supply, Inc., Jupiter, Florida) with sector scanners in real time mode. The sweet potatoes were submerged in water and examined by sonography using 5.0 and 7.5 MHz transducers. The transducers were covered with a latex layer to protect them from water damage. Images were on a monitor where contrast and brightness were adjustable. No radiographs were produced although the equipment allowed for this.

RESULTS AND DISCUSSION

Radiography

Most of the radiographic investigations were done using the digital method because a minimum amount of film was needed to produce a high quality final image. Radiographs of uninfested potatoes were indistinguishable from those with eggs. The interior was uniform with the only variation in shading due to differences in root depth (Fig. 1). There were no apparent markings or other aberrations. Sweet potatoes heavily covered with feeding and oviposition sites showed no distinguishing marks. This technique could not discern surface disruptions or even the eggs embedded below the skin.

The early instars were also undetectable (Fig. 2). However, the radio-opaque material injected into the feeding tunnels clearly showed the irregular branching from a common source just below the surface. These branches were not caused by several larvae dispersing from a single point because eggs were laid singly and only one larva was located by dissection. Perhaps the opaque material entered several feeding tunnels.

The remaining life stages were unrecognizable (Fig. 1 & 3). Sclerotized parts, such as larval head capsules and the adult exoskeleton, were not dense enough to deflect X rays. However, without using the radio-opaque material, feeding tunnels of late instars
Fig. 1. Positive radiograph of sweet potato infested with the sweetpotato weevil; pins (3.8 cm length) indicate location of late instars and arrow points to uninfested area.
Fig. 2. Negative radiograph of sweet potato infested with the sweetpotato weevil; pins (3.8 cm length) indicate location of early instars and arrow point to feeding canal made evident by injection of radio-opaque material.
Fig. 3. Positive radiograph of sweet potato infested with the sweetpotato weevil; thick pin indicates location of pupa and thin pins (3.8 cm length) point to adults; mottled areas denote overlaying feeding canals.

appeared as mottled areas throughout the root. In Fig. 1, the root area with normal tissue has even shading, while that with feeding damage extends into the center of the root. Hence, radiography may be useful for determining commodity quality and detecting feeding.

The direct film method provided better resolution because the image was not based on monitor "pixels" (i.e., picture elements). However, the magnified image using the fast screen was too grainy to recognize detail. Magnification of the film with the fine screen also produced poor detail. The image was further confounded by superimposition of the surrounding feeding damage in the depth of view plane.

In summary, radiography is useful in determining the internal condition of the sweet potato. Efficacy in quarantine treatments can be evaluated by radiographing sweet potatoes before and a period of time after treatment, depending on the treated life
stage. The effect of feeding can be observed, providing indirect evidence of survival and failure of a particular treatment. Hence, treatment development can be improved by eliminating the unsuccessful treatments identified by radiographs. Individual insects are undetectable by radiography because the surrounding tissue of the sweet potato is very dense compared to the weevils.

Ultrasound

The internal structure of the sweet potato was unobservable at the frequencies used because the ultrasound could not penetrate the root surface. The only images were that of the skin and its reflection (echo). Eggs and feeding sites were too small to be shown on the monitor screen. Hence, vegetable materials with thick skin or dense tissues are not appropriate for ultrasound detection of internal insects.

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Reference to brand or firm name does not constitute endorsement by the U.S. Dept. of Agriculture or by the Univ. of Miami.

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