Nematodes in Plant Quarantine

detection of plant parasitic nematode infestations difficult because of complexity of possible causes of visible symptoms

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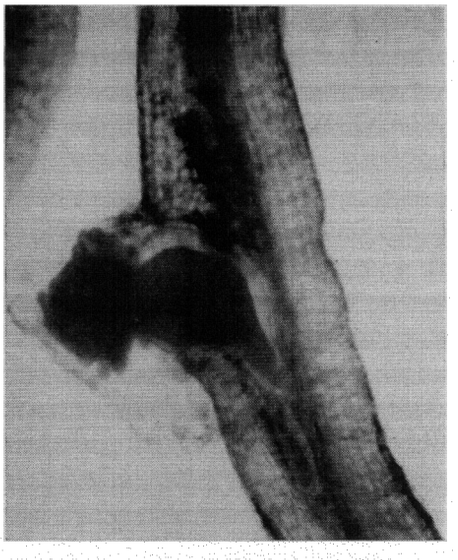
Nearly all the major crop pests in California—including plant parasitic nematodes—have been introduced on or in host plants or as contaminants on articles of commerce. There are, however, a number of nematode species of serious economic importance in other parts of the world which are not known to occur in California. The golden nematode is a serious pest of potato in Europe and on Long Island, New York; the sting nematode injures many crops in the southeastern states; the soybean cyst nematode, in the Mississippi Valley and other southeastern states, attacks soybean, snapbean, and other plants of the bean family; and the burrowing nematode, reported to be the cause of spreading decline of citrus in Florida, are some of the nematode species not yet established in California.

Opportunities for the introduction of new species of nematodes have been numerous but introduction of a pest organism does not necessarily mean its establishment as a pest. Often a complicated set of conditions and events must be present before an organism can survive in a new environment. Frequent introductions, particularly of large numbers of the pest organism, increase that organism's chance of becoming established in a new area. Once a nematode is introduced and established, it may be years before numbers sufficient to cause severe crop injury are produced.

Ordinary plant quarantine regulatory action is not well adapted to the detection of plant parasitic nematodes. Most quarantine action utilizes visual inspection—supplemented by a hand lens or low power microscope—to detect parasitic organisms themselves or to check symptoms of infection. Symptoms of nematode injury usually are not diagnostic, because they are largely such plant reactions as poor growth, chlorosis and other symptoms equally indicative of root injury from many other causes. Specific symptoms also may vary with the reaction of different plants. Large obvious lesions are formed on the roots of certain plants attacked by root-lesion nematodes, while such lesions are not found on the roots of many other kinds of plants attacked by the same nematode, although serious injury may be caused on both. Root-knot nematodes, which stimulate numerous or massive swollen roots on certain plants, may produce little or no galling on other kinds of plants. Nematodes also may enter and be carried in roots of plants which are not preferred hosts. These nematodes later may prove to be of importance on other crops in the area or to subsequent crops on the same land. Careful separation and identification must be made of

Adult root-knot female in root, showing eggs deposited outside of root tissues.



nematodes present in planting stock or in established crops, to determine whether the species found are potentially injurious, are the cause of an existing disease problem, or are non-injurious.

Examination for nematodes is usually valueless unless laboratory extraction procedures are used and careful identifications are made under high magnification by experienced nematologists.

Restrictive actions against nematodes have been attempted many times in the United States. Quarantines against the bulb or stem nematode in narcissus by the United States Department of Agriculture and by California against the root-knot nematode in potato were once attempted and later abandoned. Federal quarantines now in existence include those for the golden nematode of potato and the soybean cyst nematode of soybean.

California has a quarantine against the burrowing nematode of citrus which was found entering the state on certain subtropical and tropical ornamental plants.

There is no general agreement on the effectiveness of quarantine restrictions and containment programs for nematodes. The golden nematode of potato, found on Long Island in 1941, is believed to have been established there as early as 1934. Soon after the nematode was detected, an intensive control and containment program was started. Surveys for the golden nematode, made several times throughout the major potato-producing areas of the United States including California, produced no evidence of wider occurrence. European workers familiar with this species estimate that a population level of about one million per acre in the top foot of soil would probably not be detected by usual survey methods. On Long Island the nematode has been found, by its injury to potato plants, in fields previously surveyed and believed not to be infested.

In California, the state and county departments of agriculture have recently intensified efforts to further explore the seriousness of plant parasitic nematodes as agricultural pests and to resolve the possibilities of control or containment by practical and economic regulatory measures.

The California Agricultural Code defines an agricultural pest, in terms that clearly include plant parasitic nematodes. However, evaluation of the pest potential of nematodes and action to restrict or prohibit their further dissemination is more difficult than with many other organisms. Information concerning pathogenicity of many nematodes is incomplete. Adequate knowledge of nematode distribution within the state is not available. Investigation into all phases involves time consuming laboratory and greenhouse work. Techniques for eliminating nematodes from infected planting stock without injury to or death of plants are very limited.

Nursery stock is a common means of disseminating plant parasitic nematodes, either as parasites of nursery plants involved or as contaminants in or on these plants. Regulations established by the California Department of Agriculture require that locations, where nursery stock is grown or sold, be inspected for plant

Nematode Structure and Life

wide range of life habits requires combination of characters for identification of parasites classified among nematodes

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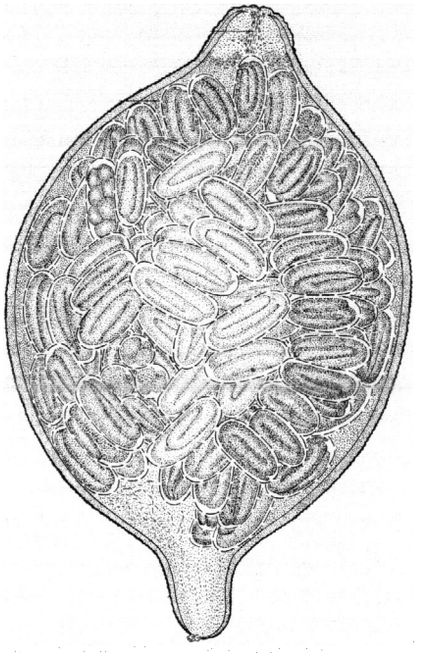
The many thousands of species of nematodes in the phylum Nemata are a group of animals commonly placed into four categories: parasites of man and animals; parasites of plants; species living in marine and brackish water; and free-living soil and fresh-water species. No single character or criterion can be used to distinguish nematodes from other similar animals, although one feature—not structural—sets nematodes apart, and that is the tremendous variation in size. Nematodes vary in length from the 1/125″ ectoparasites of plants to the 25′ long parasite of whales.

Nematodes are generally elongate cylindrical and taper at both ends. Deviations in shape occur mainly in the animal and plant parasitic forms. In some forms the adult females may be obese, saccate, spherical or kidney-shaped. In addition to differences in size and shape, all nematodes have certain features in common regardless of whether marine, soil or fresh-water, animal or plant parasites. The alimentary canal begins with the oral opening which is anterior, terminal and usually surrounded by lips which bear the cephalic sensory structures: papillae, setae, amphids, and so forth. Following the oral opening is the buccal cavity or stoma which may or may not be armed by teeth, jaws or a stylet—spear. The esophagus, sometimes called the pharynx, is formed of one, two or three distinct parts in which a variety of valves and glands may be located. Anteriorly the tubular intestine is separated from the esophagus by the esophagointestinal valve; posteriorly the intestine joins the rectum which ends in a terminal or subterminal anus in the female and a cloaca in the male. Externally nematodes are covered by a resistant cuticle which may or may not exhibit surface modifications. Internally nematodes are not segmented and the somatic musculature is limited to longitudinal fibers. As a result of this almost unique musculature nematodes move mainly in a dorsoventral plane.

Sugar-beet nematode cyst containing eggs.



The excretory system in its simplest form can be described as consisting of collecting tubules located in or near the lateral hypodermal chords. The collecting tubules connect anteriorly with a renette cell which excretes its contents to the enviroment by way of an excretory duct. The system undergoes many variations. In some groups of nematodes there lated animals. The female genital opening is separate from the posterior opening—rectum and anus—of the alimentary canal but in the male the reproductive system and the alimentary canal join posteriorly to form a cloaca. Although is no evidence of the presence of an excretory system, in other groups there is only a single collecting tubule and in still others only the renette cell and excretory duct remain.

There are also features of the reproductive system of nematodes that can be utilized to separate them from other re-

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pests at least once in every 12-month period. Growers and sellers of nursery stock are required to maintain effective control over all plant pests. When a pest is found that is of limited distribution or is not known to be established in California the pest must be eradicated in a way satisfactory to the authorities.

To comply with the regulations, an infestation of a nematode—of known economic importance—must be determined to be under effective control, but there are no known practical and reliable methods of measuring nematode populations which may be present in nursery stock but not showing evidences of infection. Furthermore, there are no methods available to significantly reduce or to eliminate a nematode infestation in most nursery stock other than by destroying the stock itself.

In California, efforts are being directed toward resolving some of the problems presented by the growth and sale of nursery stock. If an effective pre-planting treatment of nursery growing grounds followed by protection of the plantings against further infection during growth can be accomplished, certification of California-grown nursery stock at origin should be possible.

To obtain a more accurate and complete picture of nematode distribution in California, records of the University and of the California Department of Agriculture are being compiled and coordinated. When complete the distribution patterns demonstrated should provide a firm basis for practical quarantine regulations affecting both California growers and importers of agricultural products.

A program of collection and collation of additional knowledge of nematodes established, and of those entering and moving within the state, is being attempted. In the program, a portion of the necessary laboratory work has been delegated to personnel of the County Agricultural Commissioners' offices. The California Department of Agriculture has prepared instructions for use by the counties in certain standardized methods to extract nematodes from plant tissue and from soil. Specimens of the nematodes are preserved and sent to Sacramento for identification.

The county laboratory program has shown promise of adding materially to the knowledge necessary for practical quarantine actions.

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