Status of ten quarantine "A" nematode pests in California

Prepared by J. Chitambar

The Nematode Pest Rating system was established in the 1950s by the State Department of Food and Agriculture (then known as the State Department of Agriculture, Bureau of Entomology and Bureau of Plant Pathology) in response to an increase of nematode related agricultural problems made known by the Department of Agriculture and the University of California. It was also at this time that both agencies produced the first distribution records of plant parasitic nematodes in California. As a result, the pest rating system was developed primarily as a guideline for evaluating the statewide importance of particular pest species, including nematodes, so that subsequent action could be administered. Hence, it was called the "Action Oriented Rating System" and represented the State Department's view and policy on the importance of a pest to California agriculture and public health, and necessary actions required to deal with a potential pest-related problem. The rating for nematodes was first revised in the mid 1960s, and since then periodically revised according to set protocol by the Division of Plant Health and Pest Prevention Services' Pest Study Team.

According to the current nematode pest rating list, there are fourteen nematode species with an "A" rating. The history of detection, current status and biological feasibility for establishment in California of ten "A" pests are discussed in this article. By definition an "A" rating is "assigned to an organism of known economic importance subject to state (or commissioner when acting as a state agent) enforced action involving: eradication, quarantine regulation, containment, rejection, or other holding action."

Aphelenchoides besseyi Christie

White tip of rice nematode

Detection history: In California, *A. besseyi*, was first detected in 1959 in a quarantine strawberry sample that originated in Canby, Oregon and sent to a nursery in Modesto, Stanislaus County. State action would have resulted in the rejection and/or destruction of the shipment. However, the detection that documented the possible presence of *A. besseyi* in California was in 1963 when the species was found in a *Sclerotium oryzae* fungal culture (Chitambar, 1999). The fungus had been collected from a rice field in Butte County. The rice field was used by a research facility that exchanged seed with regions in southeastern United States where *A. besseyi* was parasitizing rice.

The development of trade agreements with Turkey's Ministry of Agriculture for the export of paddy rice led to more determined attempts to confirm the assumed absence of the White-tip of rice nematode in California's paddy rice. However, after intensive survey of rice seed in county driers representing13 rice producing counties in 1997, one confirmed and three suspected detections of *A. besseyi* were made in 4 samples from Butte and Sutter counties. Since then, and after the establishment of specific sampling protocol agreed upon by Turkey's Ministry of Agriculture, United States Department of Agriculture –APHIS and California Department of Food and Agriculture, the White-tip of rice nematode was detected in paddy rice seed shipments in 1999, 2001, 2002, 2005 and 2008 in Sutter and Yolo County.

Current Status: Aphelenchoides besseyi remains very limited in its distribution and occurrence within rice fields of Butte, Sutter and Yolo Counties. Export shipments of paddy rice are handled on a per shipment basis and disqualify for phytosanitary certification if found contaminated with the White-tip of rice nematode.

White leaf tips of paddy rice cause by *Aphelenchoides besseyi* (photo by E. McGawley)

Biological feasibility for establishment: It is not known how long the nematode species has been present in California. If it was introduced historically, then its low rate of detection in cultivated rice clearly indicates its inability to become established to damaging levels in cultivated fields over time. The nematode survives in unhulled rice grains for months to up to 8 years. Certain biological and ecological factors working against the nematode's ability for increase would include, 1) Insufficient moisture: a continuous supply of moisture with at least 70% atmospheric humidity is necessary for nematode development. While California rice is grown under low relative humidity from April to October, the relative humidity within dense crop growth may reach required levels to spurt sporadic nematode increases, as detected; 2) Flooding: California rice is planted, by airplane, directly into flooded fields. Paddy fields flooded before sowing rice are less susceptible to *A. besseyi* than those flooded at sprouting or later; 3) Resistant varieties may be present; 4) High temperature: in USA, activity of the species was greatest at 25-28 C, inactivity at 35-37 C and 47.5 C was the thermal death point.

***Belonolaimus longicaudatus* Rau**

Sting nematode

Detection history: The CDFA Nematology Laboratory detected the sting nematode in incoming quarantine shipments of Bermuda grass from Georgia in 1962, roses from Texas and coconut palm from Mexico in 1967, and plant-associated soil from Florida in 1983 and 1987. *Belonolaimus longicaudatus* was detected for the first time in California soil in 1992 on Bermuda turfgrass at a golf course near Rancho Mirage, Riverside County. Consequently, intensive and delimiting surveys in the Coachella Valley were conducted by CDFA and the Riverside County Department of

Agriculture and by late 1993, the Sting nematode was detected on Bermuda and rye turfgrass in eight golf courses: four in Rancho Mirage, two in Palm Desert, and one each in Palm Springs and Bermuda Dunes. Following its detection, quarantine restrictions were imposed by State and County in order to contain or suppress the nematode within the Coachella Valley. Eradication was not deemed a practical alternative, due to high cost of operations, extensive sampling required and nature of dissemination of the nematode. Restrictions were placed on movement and disposal of mowed grass clippings from sting nematode-infested properties to non-infested properties or agricultural lands. Composting with sewer sludge was chosen as control of potentially infested grass clippings or thatch. Compliance agreements were established with golf course superintendents accordingly.

Current Status: Restrictions continue to keep the sting nematode under suppression in the Coachella Valley. To date, the nematode species is limited to 8 golf courses around Rancho Mirage. No further surveys for the nematode within the restricted region have been conducted since 1993.

Figures. Left – Turfgrass damage caused by *Belonolaimus longicaudatus* (W. Crow).
Right – Turfgrass roots on left damaged by *Belonolaimus longicaudatus* (photo by B. Dunn)

Biological feasibility for establishment: The detection of the nematode species in Riverside County marked its feasibility for establishment within California. Although a major parasite of grasses, the sting nematode is capable of parasitizing a wide range of plants that include grapes, citrus, cantaloupes, lettuce, tomatoes, beans, onions, corn, wheat, barley, oats, forage crops, cotton, ornamentals and weeds. The nematode has not been found in grapes, citrus and other agricultural plants grown in the Coachella Valley. The distribution of the nematode is restricted to sandy soils (>80% sand). Heavier, fine textured soils may actually inhibit nematode movement and increase. Soil temperature is another limiting factor in the reproduction and distribution of the nematode. In Florida, reproduction was greater at 29.4 C than at 26.7 C and greatly reduced at 35 C (Perry, 1964). In their study on population dynamics of the sting nematode monitored at monthly intervals at three golf courses in Rancho Mirage, Coachella Valley, Bekal and Ole Becker (2000) demonstrated that soil temperature and fluctuation of nematode densities were significantly correlated. Significant increases in nematode populations did not occur until the soil temperature reached 20 C or late spring, and distribution was greatest in the top 15 cm of soil except during the hottest summer months, when the population was higher at depths of 15-30 cm.

Dolichodorus heterocephalus Cobb
Cobb's awl nematode

Detection history: Cobb's awl nematode was first detected in quarantine shipments of aquatic plants from Ohio in 1966. Since then the nematode was detected in soils associated with ornamental plants from Florida: Australian umbrella tree (*Brassaia actinophyla*) in 1985, 1987, 1993, 2000, 2006, and palm (*Chamedorea elegans*) in 1985.

Current Status: Dolichodorus heterocephalus has not been detected in California soil and is most likely not established within the State.

Damage to celery (left) caused by *Dolichodorus heterocephalus* (photo by S. Ayoub)

Biological feasibility for establishment: The nematode species is naturally found in water or wet soil around edges of lakes, streams and ponds. Water hazards in golf courses and flooded soils are good habitats for the nematode, however, it has also been found in areas remote from bodies of freshwater. A range of plant hosts include annual and perennial ornamentals, grasses, bulrush, blueberry, cranberry, citrus, cabbage, celery, corn, cotton, potato, bell pepper, bean and tomato. The nematode is capable of causing as much damage to plants as the sting nematode, however, unlike the latter, distribution of *D. heterocephalus* is generally limited to wet habitats. A number of hosts are present in California that may allow populations of the nematode species to establish and increase in numbers. Plant damage similar to the sting nematode is produced however, information on crop loss due to Cobb's awl nematode is still wanting. Severe root injury and stunting in celery resulted in 50% crop loss (Perry, 1953), while 81% loss in root weight was observed in corn (Paracer *et al.*, 1967).

Globodera pallida (Stone) Behrens & *Globodera rostochiensis* (Wollenweber) Skarbilovich

Potato cyst nematodes: Pale potato cyst nematode & Golden nematode

Detection history: The potato cyst nematode (PCN) comprises two species nether of which have been detected in California soil. Both species are under Federal Quarantine. After the discovery of the Golden nematode in New York State, national surveys have been conducted by the United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS) to monitor the pest prior 1982. CDFA and California's agricultural counties have coordinated efforts and sampled select potato producing areas from 1958-81. In 1965, 14 interceptions of *G. rostochiensis* were made at California's ports of entry by USDA-APHIS. Federal action would have resulted in the rejection and/or destruction of the shipment. In 2006, *Globodera pallida* was detected in Idaho thereby, marking the first detection of the species in the United States. The State Department participated in USDA's national survey plan for the detection of potato cyst nematodes in California's potato production acreage. During 2006-2007, a total of 1,531 soil samples examined represented certified seed and production (commercial and organic) potato fields in 14 counties, namely, Fresno, Kern, Los Angeles, Madera, Marin, Modoc, Monterey, Riverside, San Benito, San Joaquin, Siskiyou, Sonoma, Yolo and Yuba. No potato cyst nematodes were found.

Current Status: Potato cyst nematodes continue to be restricted under Federal Quarantine. The recent detection of the Golden nematode in Alberta, Canada has led to the development of USDA-APHIS sponsored "Golden Nematode Trace-forward Survey" of US states that received seed and/or production potatoes from Alberta, possibly traceable from 1998 and forward, or at least, three years back for seed and one year back for commercial production. Details of California fields that were planted to Alberta seed potato, year and number of potato shipments from Alberta, field acreage, number of fields, receiving counties and growers in California, and disposition of shipments are currently being worked out by USDA-Surveillance and Internal Trade Compliance (SITC). Protocol for full-field sampling has been developed with a greater soil collection per acre scheme for seed potato fields than production fields. The objective is to determine whether or not potato cyst nematodes have spread from Alberta, Canada to California soils (and other US states). California Department of Food and Agriculture is expected to commence survey of targeted California potato fields by late spring 2008.

Figures. Left – Potato cultivation damaged by *Globodera rostochiensis* (photo by B. Hammeraas).

Right – Damage to potato on right caused by *Globodera rostochiensis* (photo by U. Zunke)
Biological feasibility for establishment: There is every possibility for the nematode to enter California through checked and non-checked cyst-infested soil accompanying plants or farm equipment and through infested seed potato. This possibility exists as populations of PCN below 200,000 cysts per acre cannot be detected reliably. This low population level allows for the slow build up in numbers while remaining undetected, as evidenced in New York where the golden nematode was detected 15 years after its introduction. Furthermore, the nematodes are able to spread from an infested area to a non infested area at a population level of 10,000 cysts per acre.

Once entered, the possibility for PCN to establish and increase in California soils is dependent mainly on presence and cultivation of a host plant for 20 to 30 years, and suitable soil temperatures. Primary hosts for the nematodes include potato, tomato and eggplant all of which are grown in California. In addition there are several solanaceous weed hosts of which some such as, Jimson weed, hairy nightshade, black nightshade, and heartleaf horsenettle are present in California. Some of these have grown resistant to herbicides and act as reservoirs of PCN. The pale potato cyst nematode is a cool temperature pest and is better adapted to temperatures below 20 C than the golden nematode at 25 C. At 20 C both species are equally active neither species can last at 30 C for lengthy periods. In general, PCN will survive in environments where potatoes can grow. Cooler areas in California are expected to favor PCN.

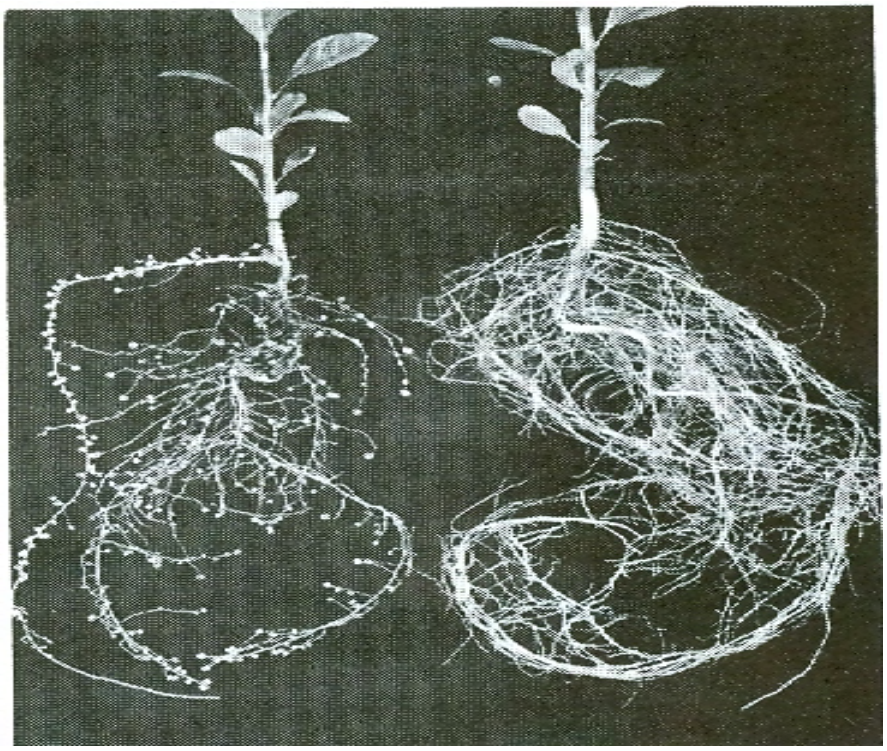
***Hemicycliophora arenaria* Raski**
Sheath nematode

Detection history: The nematode was first found and reported in 1957, parasitizing rough lemon roots in a grower's nursery in the Coachella Valley, near Mecca (McElroy and Van Gundy, 1967). Soon after, the nematode was found about two miles from the original finding and also in citrus soil in Imperial County. All the properties apparently were planted with citrus trees from a commercial nursery located near Niland. This nursery had been planted on virgin desert soil and subsequently failed due to lack of moisture and was eventually abandoned. Surveys were conducted by the State at that time to determine the extent of spread of the nematode. In October 1965, the nematode was found in a number of soil samples taken from Cheese bush (*Hymenoclea* sp.) growing in a virgin desert area about one mile north of the original abandoned nursery. At about the same time, the nematode was also found on Cheese bush near Palm Springs, about 30 miles northwest from the infestation in Mecca. According to CDFA-Nematology records, the species has a recorded limited distribution within California and has been detected in the 1960s – 1970s in Imperial, Riverside and San Diego Counties. In Riverside it was detected in citrus, lemon, orange, tomato and weed plant soils in Niland, Brock Ranch and Holtville. In Riverside it was detected in grapefruit and citrus soils in Mecca, and in San Diego it was found in Cheese bush soil near the Borrego State Park campground. During recent Cooperative Agricultural Pest Surveys in 2006, the nematode was detected once again in lemon and grapefruit soils in Imperial County.

Hemicycliophora arenaria was rated by CDFA an "A" pest and placed under "hold-order" quarantine. Under this action, the nematode was contained within the restricted areas. The movement of all soil, bare-rooted plants and equipment with soil was restricted. Furthermore, *H. arenaria* has only been found in California, and thus far only within the contained areas. At that time, the discovery of the pest was of great concern to other states in trade agreement with

California, especially Florida. Quarantine action was necessary and justified based on the extreme limited distribution, economic crop damage potential, and California trade agreements.

Current Status: To date, *H. arenaria* remains confined to the restricted regions within California and has not been reported from anywhere else in the world.



Root galls on Rough lemon seedling (left) caused by *Hemicycliophora arenaria*
(photo from McElroy & Van Gundy, 1967)

Biological feasibility for spread: H. arenaria is indigenous to California and is a serious potential pathogen of many citrus varieties. Cheese bush and coyote melon are indigenous host plants commonly found in the sandy washes and stream beds in the Coachella and Imperial Valleys and may provide reservoirs of nematodes for infesting future plantings on virgin soil. Greenhouse trials have shown that tomato, pepper, blackeye bean, celery, squash and Tokay grapes are good hosts for the nematode species. Sandy soils favor the nematode. Reproduction is optimum in 90% sand, 5% silt and 5% clay at 30-32 C. Therefore, the potential for spread and establishment is great in hot and sandy environments of California. Regulatory restrictive action is necessary to prevent the interstate and intrastate spread of the nematode.

***Heterodera glycines* Ichinohe**

Soybean cyst nematode

Detection History: The soybean cyst nematode (SCN) has not been detected in California either in imported quarantine plant shipments or in the state's agricultural production sites. The reason for this may be contributed at least, in part, to a history of national and state quarantines imposed against the nematode. It appears that SCN came from Japan where it was first reported more than 75

years ago. The nematode was first detected in North Carolina in 1954 and thereafter, in 25 more states in southeastern and central United States (Riggs, *et al*., 1988). During November 8, 1966 to September 30, 1972, USDA maintained and enforced Federal Domestic Quarantine 79 against SCN. Under this federal quarantine, California was protected from the entrance of SCN into the State. When the federal quarantine was rescinded, there was no known commercial acreage cultivated to soybean in California and subsequently, CDFA decided that quarantine would not be needed. However, in 1972, 1978 and 1979 soybean was cultivated on 5, 22,000 and 10,000 acres respectively, while cultivation was expected to continue and increase in future years. In 1980 CDFA took protective action and prepared the Soybean Cyst Nematode Exterior Quarantine. Under this quarantine all states and districts of the United States were under quarantine for SCN and restriction was placed on entry into California of hosts and possible carriers of the pest from areas under quarantine. Since the quarantine was adopted, commercial soybean production was discontinued in California, and in 1992 there was no reported acreage or value associated with commercial production of soybean. Based on this fact and the misinformation that soybean is the only host of SCN, CDFA found it inappropriate to restrict entrance of plant hosts and carriers of the nematode into California and in 1994, repealed the Soybean Cyst Nematode Exterior Quarantine, while maintaining its "A" rating.

Current Status: The nematode continues its rank as a quarantine pest that is not known to occur in California.

Figures. Left – Soybean cultivation damage caused by *Heterodera glycines* (phot by J. Eisenback)
Right – *Heterodera glycines* on soybean roots (photo, Michigan State University)

Biological feasibility for establishment: The lack of soybean production in California definitely decreases the potential incidence of the pest, however, SCN has a broad host range, especially among legumes including beans (green, snap, dry, red, lima, mung, bush and Adzuki), garden peas and cowpeas, and also attacks many non-legumes, including ornamentals and weeds. Some of these "other hosts" especially snap, dry, red and lima beans, are economically important crops cultivated in the State and may present possible reservoirs for establishment and increase of SCN. At the same time, biological races of SCN exist that vary in their parasitic ability of different hosts. The nematode is able to develop within a range of 10-34 C. Climatic conditions favorable for the growth of host plants in California would also be conducive for SCN development.

Radopholus similis (Cobb) Thorne
Burrowing nematode

Detection History: In 1953 the burrowing nematode was recognized as the cause for spreading decline in Florida, thereby, giving CDFA sufficient cause to protect California against this devastating pest. The next year *R. similis* was found in banana in a Los Angeles nursery. In the years to follow, a series of actions occurred within California, the highlights of which are chronicled below:

- In 1954-56, a state-county survey revealed several ornamental host plants in nurseries to be infested with *Radopholus similis*. Eradicative measures were pursued.
- In 1956, the Burrowing Nematode Exterior Quarantine was established by CDFA to restrict the entrance of the pest from infested areas.
- In 1956, a nationwide survey of citrus-producing areas was organized by USDA. In California, surveys were conducted through the cooperative efforts of federal, state and county agricultural commissioners. Citrus and avocado orchards, as well as, citrus, avocado and ornamental nursery stock comprising 630 properties from 14 counties were surveyed over 2 months. No *R. similis* was found in this survey.
- From 1956 to 1963 no organized surveys were conducted for detecting *R. similis*. Some counties conducted their own sampling schemes during this time. Random sampling of indoor decorative plants was encouraged by the State.
- In February 1963, an established burrowing nematode infestation of 3,000 *Anthurium* spp. plants was discovered in San Mateo County during a routine nursery inspection. Based on this occurrence, CDFA initiated a state-wide survey of *Anthurium* spp. Also, CDFA in conjunction with federal and county officials developed a survey for the detection of the burrowing nematode in California. The survey lasted till 1964, and comprised three main inspections.
    - Inspection of all *Anthurium* spp. plants grown by cut-flower growers, nurseries and hobbyists. Samples were collected at 100 locations in 18 counties. 15,000 plants were included from 67 nurseries, 7 commercial florists and 26 hobbyists. *Radopholus similis* was found in 7 locations in 4 counties: San Mateo, Contra Costa, Santa Barbara and Orange counties.
    - Inspection of citrus and avocado orchards and nursery stock, as well as, residential/dooryard plants of subtropical host plants adjacent to orchards. More than 4,300 individual properties comprising 150,000 acres of orchards were surveyed. No *R. similis* was found in the 6,842 samples, and it was firmly believed that the nematode was not established in California orchards. No *R. similis* was found in the 178 citrus nurseries and 27 avocado nurseries surveyed.
    - Inspection of nurseries engaged in wholesale production of indoor decorative plants. 214 nurseries in 19 counties were surveyed. Burrowing nematode was detected in 29 locations in ten counties. The most extensive infestations were in Los Angeles, Orange, San Mateo and San Diego counties.
- The survey resulted in no indication "that *Radopholus similis* is an established resident of the natural environment of the State."

- Also in 1964, CDFA created the Burrowing Nematode Detection Program for California nurseries. The program was terminated in 1994 as the pest risk potential did not justify the economic costs and workload.
- On October 26-28, 1971, a survey of 65 lemon orchards in Ventura County failed to yield the Burrowing Nematode.
- In 2005-2007 CDFA, in collaboration with USDA-APHIS/CAPS conducted a statewide survey for several target nematode pests including *R. similis*. Burrowing nematode was not detected.
- From 1982 to February 2008, 157 burrowing nematode detections were made in external quarantine plant shipments. These interceptions led to eradicative measures.
- A noteworthy early detection of an established *R. similis* population occurred in 1996, in a residential property in Huntington Beach, southern California, in actively growing banana corms that had been imported from Louisiana. The nematode was eradicated from the area through the administration of excavation of soil, effective chemical, cultural and sanitary treatments. Thereafter, periodic sampling of the treated area failed to yield the nematode.

Current Status: Radopholus similis is not present in California and continues its rank as an important quarantine pest.

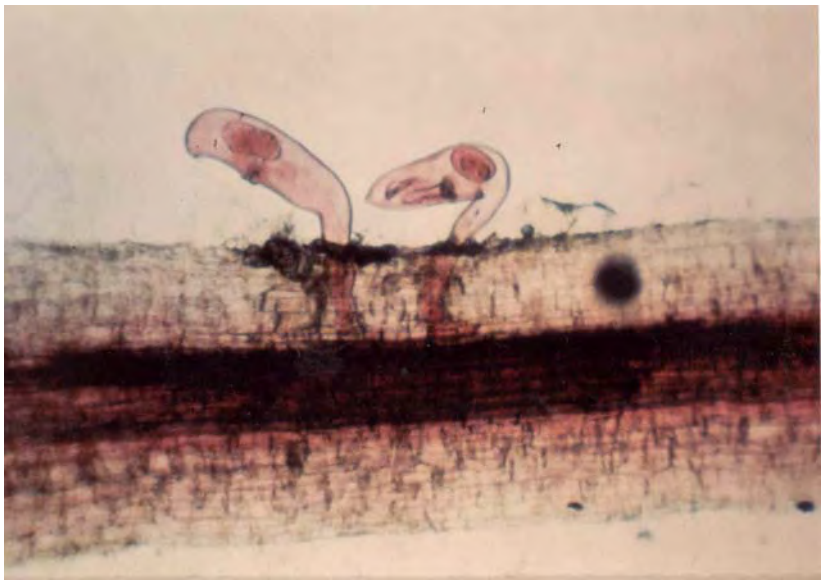
Figures. Left – Banana Plant damage caused by *Radopholus similis* (photo, Nemapix).
Right – Symptom on roots infested with *Radopholus similis* (photo by A. Mani)

Biological feasibility for establishment: California provides favorable climate and hosts for the establishment and increase of the burrowing nematode. There are over 350 host plants of which citrus, strawberry, carrots and ornamentals are examples of major hosts cultivated in California. The nematode prefers coarse, sandy soils which are present in the Coachella Valley, the Bard Valley near Blythe, the Edison-Arvin citrus district of Kern County, and in streaks throughout the state. Citrus and date palm, good hosts of the nematode, in the Coachella Valley are planted in soils subject to temperatures favorable to the development of the nematode. Host crops along the coastal areas, when planted in sandy soil, experience soil temperatures that can favor the development of the nematode if even for a few months (Ferris, *et al*, 2003).

Rotylenchulus reniformis Linford & Oliveira
Reniform nematode

Detection History: In 1960, an established population of reniform nematode infested pygmy date palms and bread palms was detected in a residential property in San Diego. The plants had entered the state in a quarantine shipment and were planted prior to the confirmed diagnosis of the nematode pest. Subsequently, the plants were removed, destroyed and the infested site was treated with methyl bromide. In 1967, another established infestation was detected on *Yucca gloriosa* grown in 13 residential properties in San Bernardino County. The areas were treated with Nemagon®, however, in 1971 the nematode was detected again in the same properties. Despite continued treatments the nematode reappeared in 1973 and 1974. After intensive herbicide and fumigation trials the infested areas were declared eradicated on December 31, 1978. The nematode reappeared in 1980. No further treatment was pursued of the residential properties. The status of the nematode in those sites is not known nor has the nematode been detected in any agricultural production sites in San Bernardino or elsewhere in California. From 1982 to February 2008, eighty-eight detections of the reniform nematode have been made in imported quarantine plant shipments.

Current Status: Rotylenchulus reniformis is not present in California's agricultural crop production sites and continues its rank as an important quarantine pest. *[The Exterior Quarantine Burrowing Nematode Program was amended in 1997 to include the reniform nematode.]*



Adult female *Rotylenchulus reniformis* feeding on plant root

Biological feasibility for establishment: Similar to the burrowing nematode, California provides favorable climate and hosts for the establishment and increase of the reniform nematode. Reniform nematode populations were readily established in San Diego and San Bernardino before eradication. With a host range of over 140 plant species, the nematode poses serious threat especially to California's cotton and tomato production as well as the ornamental industry. Unlike the burrowing nematode, reproduction and development of the nematode is favored by fine-textured soils (Robinson et al., 1987). Temperatures that favor the development of the host plants also favor nematode development.

Xiphinema diversicaudatum (Micoletzky) Thorne
European dagger nematode

Detection History: X. diversicaudatum was found in two residential properties in San Diego County in 1970, during CDFA's Urban Detection Survey Program. The nematode was also found in a rose cut-flower greenhouse in Alameda County in 1975 (Siddiqui *et al.*, 1973). At that time, all three sites were treated with a soil sterilant and the nematode populations were believed to be suppressed below detectable level. The greenhouse site has since been replaced by residential property. In San Diego, despite soil treatment of the residential properties, the nematode continued to reappear in low numbers until 1983. Following intensive soil treatment, the site was declared eradicated of the nematode. However, in 1994, high populations of the nematode were again detected (Chitambar, 1997). The property is not close to any commercial agricultural production, nor has the nematode been detected elsewhere within the state.

Current Status: Xiphinema diveriscaudatum is not present in California's commercial agricultural production sites and continues its rank as a quarantine pest.

Rose plants parasitized by *Xiphinema diversicaudatum* (photo by J. Chitambar)

Biological feasibility for establishment: Although *X. diversicaudatum* is considered endemic to northern Europe (Boag, *et al*., 1983), it has become established in other parts of the world, e.g. Australia (Stubbs, 1971), Canada (Townshend, 1961) and New Zealand (Dale, 1971). In 1997, Boag *et al*. used a computer program to fit a model to the known European distribution of the European Dagger nematode and to predict its potential establishment globally. Temperature and precipitation were the main climate factors used in the prediction model. Their results indicated that the nematode could become established in North America, Australia, New Zealand and parts of Asia. The persistent resurgence of the species in a residential garden in San Diego, California despite treatment is evidence of the nematode's aggressive capability to establish itself in that region. The nematode

species parasitizes a range of agricultural crops and weeds. Those important to California include rose, grape, strawberry, raspberry, stone fruit, asparagus, celery, cucumber and cabbage. The nematode may take up to three years to complete a generation, from egg to egg. In the absence of its host, the nematode can survive in soil without multiplying for at least three years (Pitcher *et al.*, 1974). In a laboratory study, Brown and Coiro (1985) reported that the longevity and reproduction capacity of *X. diversicaudatum* was similar to the American Dagger Nematode, *X. index*, also present with limited distribution in California. The European Dagger Nematode is reported to occur in sandy textured soil with high silt content (Jiménez Guirado, *et al.*, 1995), as well as loam soil (Lišková et al., 1993). The San Diego site comprised a sandy loam soil. Given the opportunity to enter California's agricultural site, it is possible for the nematode to establish and increase in numbers causing detriment to crop production.
Xiphinema diversicaudatum is a NEPO virus vector.

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