Geographic Distribution of *Heterodera schachtii* in the Imperial Valley of California from 1961 to 1983

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ABSTRACT

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The geographic distribution of the sugar beet cyst nematode (*Heterodera schachtii*) in the Imperial Valley of California was determined for the years 1961–1983 by computer mapping. Results show that the nematode has had a wide geographic distribution since 1961, with only the intensity of infestation increasing. During these years, an average of 20% of the fields planted each year were infested. Seven hundred twenty-five fields have been found to be infested, representing about 20,235 ha, or 11% of the total cultivated acreage in the Imperial Valley.

The first successful beet sugar factory in the United States was established in Alvarado (Alameda County), CA, in 1870 (7,8). In the United States, the sugar beet cyst nematode (*Heterodera schachtii* (Schm.)) was first detected in Utah and California in 1907 in areas of intense sugar beet cultivation (1,7). In California, the nematode was first detected in the counties of Alameda (Alvarado), Los Angeles, Ventura (Oxnard), and Salinas (Monterey) (7,8).

The Imperial Valley is in the south central desert of California and contains 176,851 ha of cultivated land of which 16,000–20,000 ha are planted annually to sugar beets. This acreage accounts for about 20% of California's annual sugar beet production (6).

Sugar beets were first grown in the Imperial Valley in 1938, and the sugar beet cyst nematode was first detected there in 1957 (2). By 1959, the nematode had been recovered from 15 fields (3) and has since been found in many fields. The nematode was probably introduced on contaminated farm machinery brought in from nematode-infested areas in northern California (3). Sugar beets are planted in September and harvested in May, June, and July, and because of suitable soil temperatures, the nematode can complete up to five generations per year (10).

After the nematode was detected, the potential problem was of concern to sugar beet growers and the sugar companies. A dump-sampling program was begun in 1960 to check sugar beet fields for the presence of the cyst nematode. This consisted of collecting tare soil samples from truckloads of beets

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delivered to the sugar factories or to railroad loading points. All soil samples acquired were analyzed for the presence of cysts at the Holly Sugar Company laboratory in Brawley, CA. Records of the dump-sampling process have been maintained by the sugar company and specify whether a field was infested or not infested for each year from 1961 to 1983. The geographic location of each field can be determined using irrigation system canal names and gate numbers assigned by the Valley Irrigation District.

The complete geographic distribution and the specifics of dissemination of the nematode in the valley have not been analyzed during the 23 yr of dump sampling. This study reports results of a computer analysis of the data from the dump-sampling records. These records represent an epidemiological data base, which can be analyzed with computers. It was thought that a central focus, or several foci, of initial cyst nematode infestation could be recognized and the dissemination of the nematode followed from these point sources. Similar types of analyses have been performed on the geographic distribution of the sugar beet cyst nematode in England (11) and a tobacco cyst nematode in Virginia (4).

MATERIALS AND METHODS

Records from the sampling process were obtained from the Brawley factory office. An X-Y coordinate system was superimposed over Platt book maps of the Imperial Valley Irrigation District. Individual fields were assigned an X-Y coordinate, and for each year of data, this information was entered into a computer data base together with the infested or uninfested status of the field. The data base was constructed such that once a field was designated infested, it was henceforth considered infested. Additional information available in some of the records, such as the number of acres planted in a field, was also entered into the data base.

Maps were generated with a plotter to illustrate the geographic locations of infested and uninfested fields yearly from 1961 to 1983. The resolution of the maps produced was 10.2 ha. The data base was also analyzed to determine numbers of fields planted to sugar beets per year and the percentage of planted fields that were infested.

RESULTS AND DISCUSSION

In 1961 and 1962, the sampling program did not include all fields planted. From 1964 onward, the dump-sampling process included all infested and uninfested fields with a few exceptions.

Results from 1961 and 1962 revealed infested fields distributed throughout the valley. The cumulative distribution of infested and uninfested fields for 1961–1983 are depicted in Figures 1 and 2. A pattern in the geographic distribution of the nematode was not discerned when maps were analyzed on a year-by-year basis from 1961 to 1983. According to visual inspection of the cumulative geographic distribution of the nematode from 1961 to 1983, the density of nematode-infested fields was greater in the southern end of the valley, whereas a higher density of uninfested fields occurred in the northern end of the valley. Our analysis shows that the nematode continues to be disseminated to new fields over time.

It has been suggested that when this nematode establishes itself in a geographic location, it takes several years for populations to increase to levels where damage is apparent (9). By the time the presence of the nematode is suspected and confirmed by sampling, there is a high probability that it has already been disseminated to other locations. Our results confirm this hypothesis. That is, after 20 yr of sugar beet production, the nematode when first observed was found to be widely distributed. In the Imperial Valley, where there may be three to five generations of the nematode per year (10), the time required to reach damaging population densities may be shorter than in temperate regions. This rapid reproductive rate does ensure a large pool of dispersive propagules.

Contract tillage and harvesting operations and movement of equipment and associated soil is common in the valley. After harvest, cattle are often allowed to graze on the remaining beet tops. The cattle are moved from field to field, and viable cysts will pass through their digestive tracts (5). These represent means for dissemination of the nematode.

Across the years surveyed, an average of 20% of the fields planted to sugar beets each year were nematode-infested (Fig. 3). The short, dashed lines in Figure 3 are based on alternative data (I. J. Thomason,

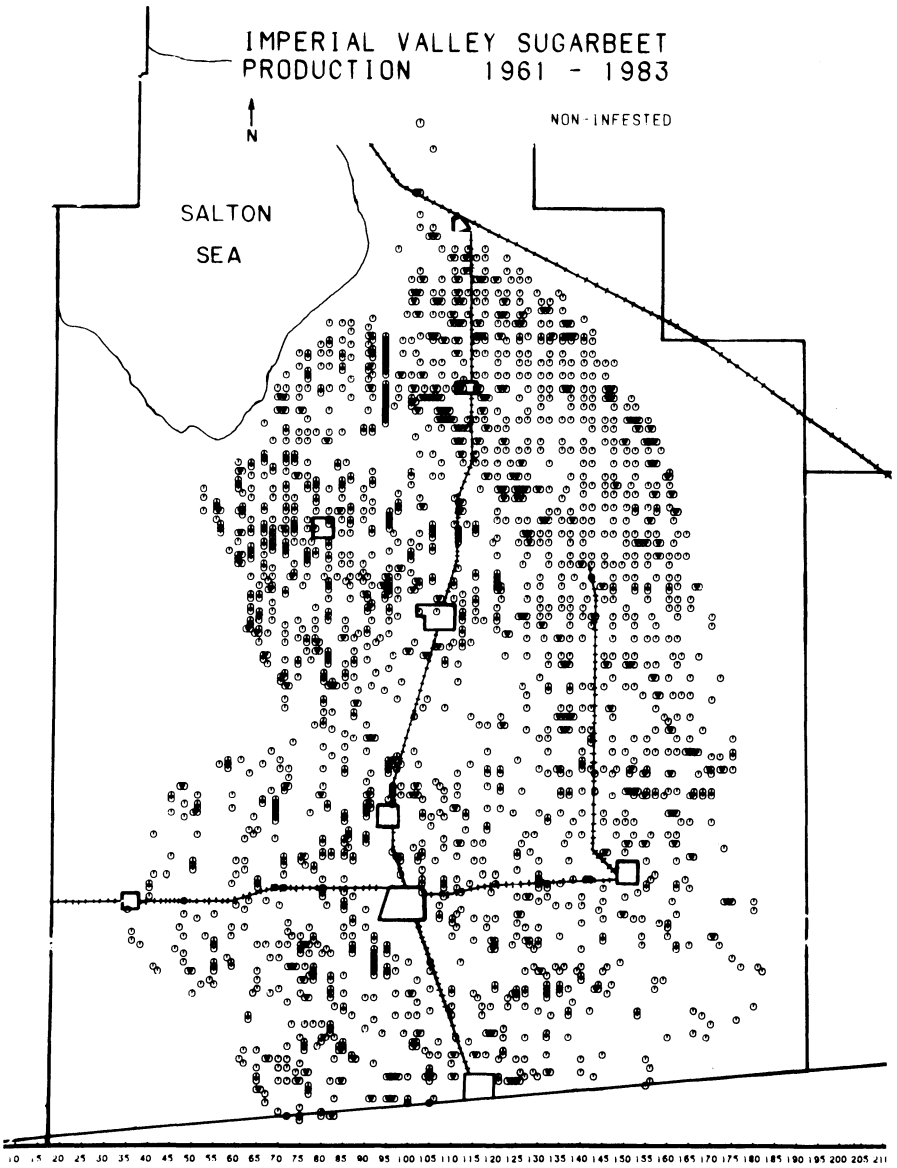

Fig. 1. Cumulative geographic distribution of sugar beet fields in the Imperial Valley of California that have not been found to be infested with the sugar beet cyst nematode during 1961–1983. Major cities and railroad lines are indicated.

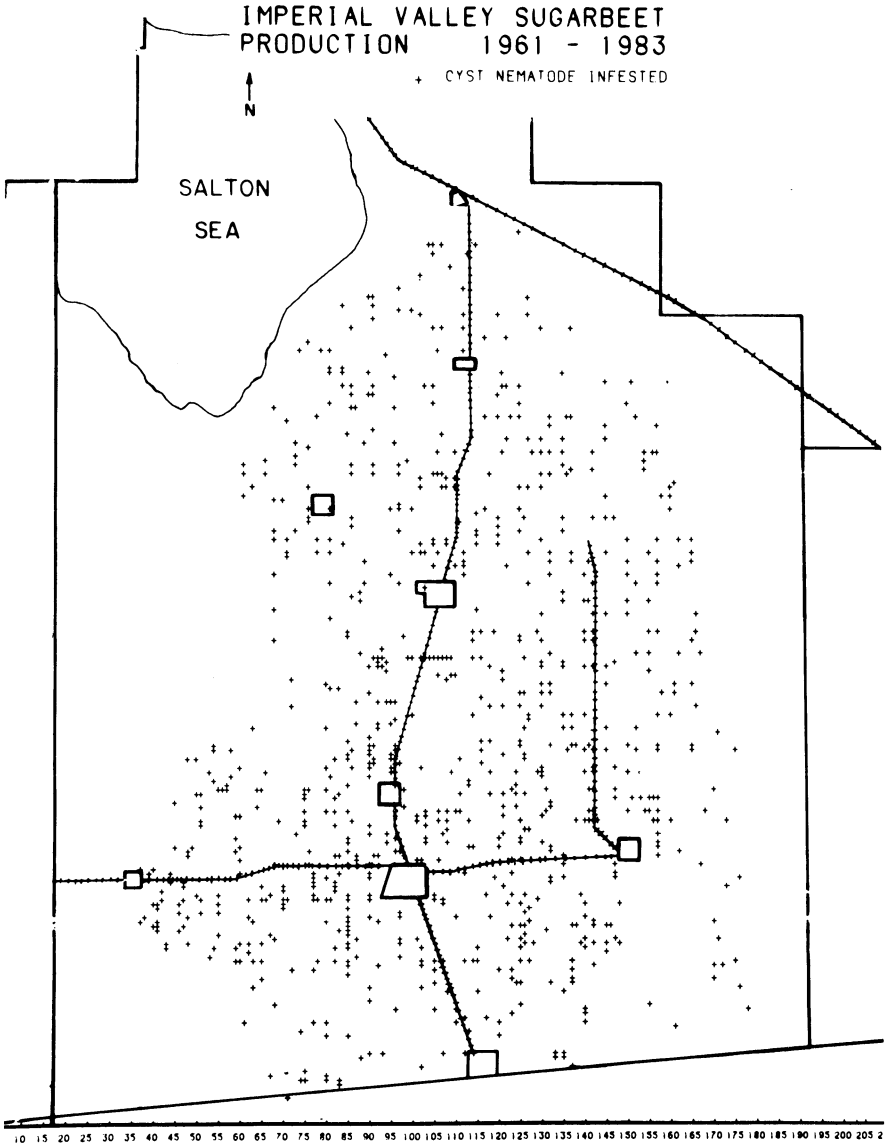

Fig. 2. Cumulative geographic distribution of sugar beet fields in the Imperial Valley of California that have been found to be infested with the sugar beet cyst nematode during 1961–1983. Major cities and railroad lines are indicated.

unpublished) for the percentage of infested fields in the years 1960–1964. This information is in contrast to the Holly Sugar Company data for those years but agrees more closely with the trend established for subsequent years by the Holly Sugar Company data. A linear regression of years (X variable is years as consecutive integers: 1960 = 1, 1961 = 2, etc.) versus percentage of planted fields infested (Y) (using the alternate data for the years 1960–1964) is $Y = 13.12 + 0.583X$ ($r^2 = 0.42$) (Fig. 3). The regression shows that the percentage of fields planted each year that are infested is slowly increasing. The regression does not fit the data well because of data for 1979 and 1980. However, it is interesting that the X-intercept (0% of planted fields infested) of the regression corresponds to about 1938, the year sugar beets were first grown in the valley.

A total of about 725 fields have been found to be infested. This represents about 20,235 ha, or 11% of the total cultivated acreage in the valley. Despite the fact that the percentage of planted fields that are infested with the sugar beet cyst nematode is (on average) increasing, sugar beet yields have continued to increase over the years.

Our study demonstrates the rapidity with which the sugar beet cyst nematode may be disseminated through a region.

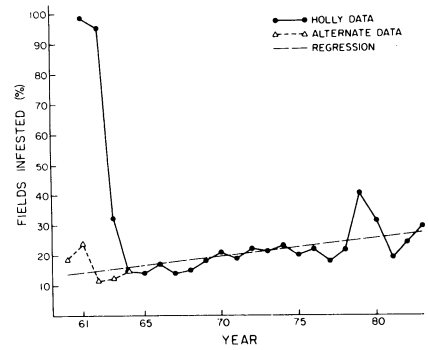

Fig. 3. Percentage of sugar beet fields planted each year in the Imperial Valley of California that are infested with the sugar beet cyst nematode. Solid line represents data from the Holly Sugar Company, short-dashed lines represent data from I. J. Thomason (*unpublished*), and the long-dashed line represents a regression of years (X variable, as consecutive integers; 1960 = 1, 1961 = 2, etc.) versus percentage of planted fields infested (Y). Regression equation is $Y = 13.12 + 0.583X$ ($r^2 = 0.42$).

This recognition may be important with respect to effective quarantine of other cyst nematodes, such as *H. zeae* and *Globodera rostochiensis*.

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