Survey of Nematodes Associated with Almond Production in California

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ABSTRACT

McKenry, M. V., and Kretsch, J. 1987. Survey of nematodes associated with almond production in California. Plant Disease 71: 71-73.

Soil samples (350) from 14 of 17 almond-producing counties of California were analyzed for presence of plant-parasitic nematodes. The presence of *Criconemella xenoplax* is associated with bacterial canker complex and sandy soils. *Pratylenchus vulnus* was detected in one-fourth of the almond production region. *Xiphinema americanum* was most prevalent in the cooler Sacramento Valley region. *Paratylenchus hamatus* was most common, and *Meloidogyne* spp. were among the rarest parasitic taxa detected. *Gracilacus epacris* is reported for the first time on *Prunus* spp. in California.

Additional key words: fumigation, peach

Half of the world's almond (*Prunus amygdalus*) crop emanates from within the Sacramento and San Joaquin valleys of California. Production occurs along a 500-mi. corridor of varied soil, temperature, and rainfall gradients. Diverse cultural practices are used within this region to protect the crop from maladies of soil and weather conditions.

In 1984–1985, we conducted a survey of the nematodes associated with almond production. The goal was to identify the extent of nematode problems. We also attempted to identify associations of specific nematodes with specific rootstocks, soils, climate, or cultural practices. Of various *Prunus* spp. grown in California, almond is grown under the greatest diversity of conditions. There were no previous local studies of the nematodes of almond, although nematodes of other *Prunus* spp. including *P. persica* have been evaluated. It is well known that *P. amygdalus* is highly susceptible to *Meloidogyne* spp. (1) and that half of the region within the central valley is commonly affected with this parasite (5). The early recognition of root-knot prevalence in California prompted a heavy reliance on the use of *P. persica* cv. Nemaguard as a favored rootstock. Much of the almond crop has been established in the last three decades.

MATERIALS AND METHODS

The California Crop and Livestock Reporting Service provides information on almond acreage throughout the state. Cooperative extension farm advisors in each almond-producing county were asked to provide sampling sites that would be representative of the production in their area. They were asked to provide sites with a known history relative to planting dates, prior cropping, fumigation experiences, rootstocks, and disease incidence.

Selected growers or ranch managers were questioned to obtain background information on fields sampled; 350 soil samples were collected, nematodes extracted, and plant-parasitic nematodes identified. Sampling sites were rated for vigor and general health on a scale of 1–10, where 1 = dead trees and 10 = the most healthy, vigorous trees. Subsamples of soil were collected from the surface 60 cm at the canopy edge of each of three trees. Presence of diseases, particularly bacterial canker complex (BCC), was noted at the time of sample collection. When possible, samples were collected from poor and better growing trees of each orchard so that we could assess relative nematode damage if any. Soil samples were protected from sunlight and stored at 10 C for no more than 20 days before extraction.

Nematodes were extracted using either a modified sieve-mist or sieve-centrifuge procedure (3). Samples collected from known BCC sites were processed using both techniques to maximize extraction of *Criconemella xenoplax* (Raski) Luc & Raski, which has been found associated with a similar malady, peach tree short life (4).

RESULTS

Over a period of 1 yr, 14 of 17 almond-producing counties were sampled (6). Eighty-two samples were from Butte, Sutter, Yuba, Colusa, Glenn, and Tehama counties (Sacramento Valley region); 131 samples were from San Joaquin, Stanislaus, and Merced counties (northern San Joaquin region); and 120 samples were from Fresno, Kings, Tulare, and Kern counties (southern San Joaquin region). Eighteen samples were also collected from a coastal region of nonirrigated hillside near Paso Robles, CA. The regions are referred to for convenience; however, they also provided four distinct nematode situations. The incidence of nematodes in the three major regions is indicated in Figure 1. The average population levels are indicated in Table 1.

Sacramento Valley region. *Xiphinema* spp., locally referred to as *X. americanum* Cobb, was found to dominate this region. The second most common nematode was *Paratylenchus hamatus* Thorne & Allen, the pin nematode, which was also the most common parasitic species of the survey. The most common root-lesion nematode, *Pratylenchus vulnus* Allen & Jensen, was found in 32% of the samples, but other species of this genus were not commonly found. Species of *Tylenchorhynchus* and *Merlinius* nematodes were more common in this region, which also has the greatest frequency of natural vegetation. *Helicotylenchus dihystera* (Cobb) Sher was found associated with the soils of finest texture that are relatively common to the region. *Criconemella xenoplax* was only occasionally found. Roughly, 32% of the samples in this region, which represents 30,000 ha, had no dominant nematode present. The predominant rootstock is Lovell Seedling, *P. persica* cv. Lovell. *P. amygdalus* seedling, *P. domestica* cv. Marianna 2624, and *P. persica* cv. Nemaguard were grown in 23, 12, and 11% of the sampled areas, respectively. None of the orchards we sampled had received a preplant fumigation. The average age of the orchards was 20 yr. Where *Meloidogyne* spp. galls were detected in sandiest soils, the gall frequency was relatively less than that for the San Joaquin Valley, and there was no apparent tree damage even in replant situations.

Northern San Joaquin region. Soils from this region are among the sandiest in the state. The dominant nematode was *C. xenoplax*. The region showed the greatest incidence of BCC, and of 31 orchards with BCC incidence, 28 had this nematode with an average population level of 456/250 cm^3 of soil. Forty-seven percent of the orchards sampled had received preplant or postplant fumigation.

Accepted for publication 11 June 1986.

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Nemaguard was the rootstock in 73% of our sampled sites, and Lovell Seedling was the rootstock in 18%. The remaining orchards are either on *P. amygdalus* seedling, *P. domestica* cv. Marianna 2624, or hybrids of Nemaguard and almond. Many orchards from this region of 80,000 ha had a cropping history of two or three generations of *Prunus* spp. The average orchard age was 9.6 yr. The survey provided an indication that there is antagonism between pin nematode and ring nematode. Where the *P. hamatus* population is 100 nematodes or fewer per 250-cm^3 sample, 69% of the samples also have *C. xenoplax* (72 of 104 samples). Where *P. hamatus* nematode population is greater than 100, only 13% of the samples have ring nematode (9 of 72 samples).

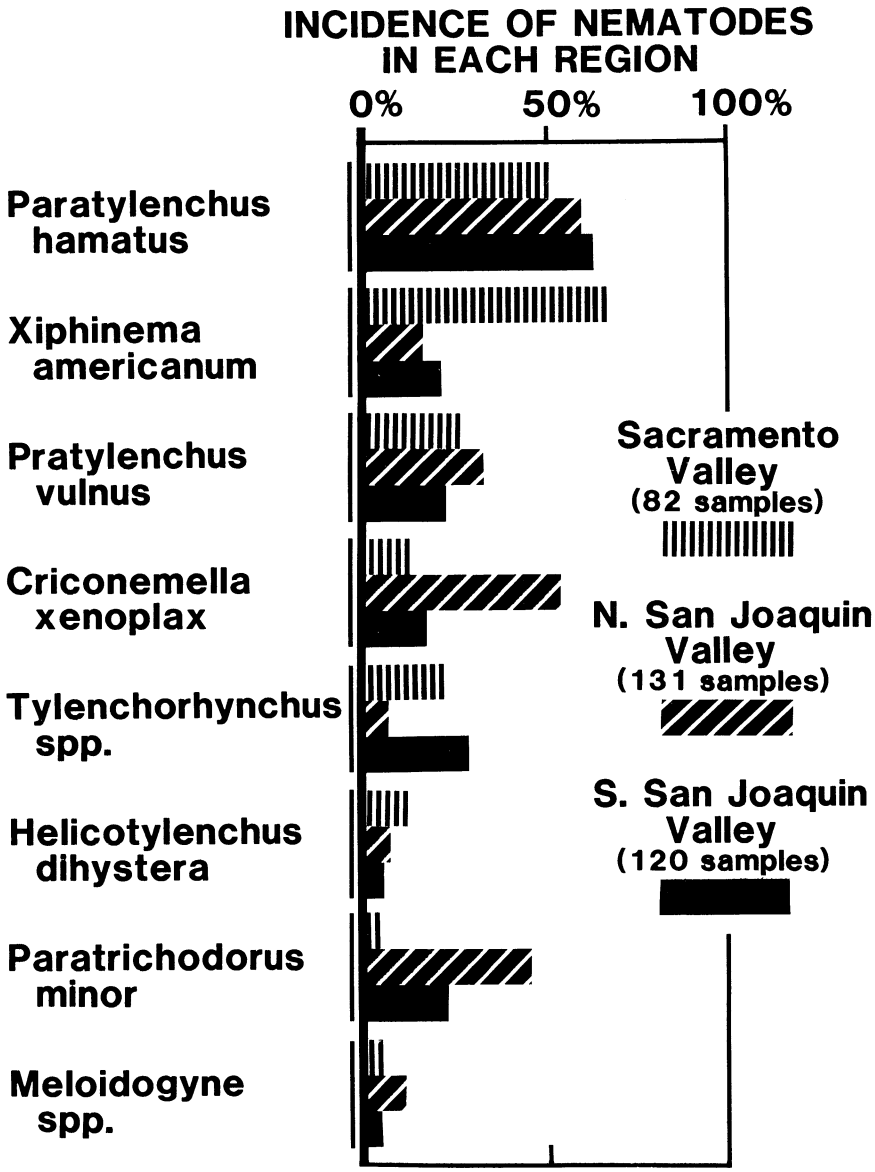

Fig. 1. Incidence of the common plant-parasitic nematodes associated with almond production in three regions.

Southern San Joaquin region. The dominant soil in this region is sandy loam, but there are streaks of sand present. The newest almond plantings were in this region, with first-generation trees most common. *P. hamatus* was present throughout the area at an average population level of 367 per 250-cm^3 soil sample.

Tylenchorhynchus spp. was present in 28% of the sites. *Meloidogyne* spp. nematodes were found in two sample sites near DiGiorgio, CA, on Nemaguard rootstock, but galls were not apparent on the roots. Nemaguard was the dominant rootstock, with 97% incidence. Ring nematode was present in sandy soils and was commonly associated with the root-lesion nematode. BCC incidence was relatively low but was commonly associated with *C. xenoplax*. A single sample from the southern tip of the valley contained *Gracilacus epacris* (Allen & Jensen) Raski at 629/250 cm^3. This nematode had previously been found on *Juglans hindsii* 100 mi. north and from higher elevations surrounding the valley floor (2). One-third of the orchards had no dominant plant-parasitic nematode, and only 10% had received preplant fumigation. This region encompasses 70,000 ha, and orchards averaged 10.8 yr old in our sampling.

Paso Robles region. Pin nematode was present in each of the 18 soil samples from this region. *X. americanum* and *Tylenchorhynchus* spp. nematode also had a high incidence. *Pratylenchus neglectus* (Filipjev & Schuurmans) Stekhoven is common in grasslands of the area and in this survey was commonly found with *P. vulnus*. None of the sites had received preplant fumigation, and all the orchards were on almond rootstock, which is most suitable to the dryland production conditions. The soil is medium-textured and calcareous. *Meloidogyne* spp. did not occur, although heat accumulation throughout the year is adequate for its development. This production region only represents 2,500 ha but is uniquely different from the production areas of the three central valley regions. The average orchard age was 30.5 yr.

Table 1. Average population levels of selected nematodes in the four regions of the survey

Region	Average population level per 250-cm^3 soil sample[a]								
	Paratylenchus hamatus	*Xiphinema americanum*	*Pratylenchus vulnus*	*Criconemella xenoplax*	*Tylenchorhynchus*	*Helicotylenchus dihystera*	*Paratrichodorus minor*	*Meloidogyne* spp.	Other
Sacramento Valley	115	15	57	4	13	36	6	9	*Pratylenchus thornei* (280)
N. San Joaquin Valley	313	19	43	325	4	131	13	21	*P. neglectus* (2)
S. San Joaquin Valley	367	19	40	173	19	3	23	37	*Gracilacus epacris* (629)
Paso Robles	290	11	5	10	83	···	1	13	*P. neglectus* (2)

[a] All samples extracted by modified sieve-mist technique. Samples positive for *C. xenoplax* were extracted by sieve centrifugation. The extraction efficiency for each life stage of each species is unknown but is between 25 and 50% for root-lesion and root-knot and 50% for *C. xenoplax*.

DISCUSSION

Within the San Joaquin Valley, the most common plant-parasitic nematodes are *Meloidogyne* spp.; however, in this survey, they were not detected in more than 10% of the samples. Among almond orchards, root-knot nematode is in low numbers because 1) Nemaguard rootstock is in common use in the warmest production areas, 2) there are cooler and less sandy soils in the Sacramento Valley region, and 3) the finer textured, unirrigated orchards of the Paso Robles area were not conducive to root-knot development.

Because of the associated BCC, the *C. xenoplax* currently appears to be the most damaging nematode of almond production. This nematode is commonly associated with the sandiest soils and orchards with a replant history. In Table 2, the incidence of three nematodes with BCC is compared. These data indicate that where BCC was identified in an orchard, the single soil samplings from good and poor trees revealed the presence of *C. xenoplax* nematode 86% of the time. Furthermore, the population levels of *P. hamatus* nematode were not as high where BCC occurred.

An 11-yr record of county almond production was obtained from the California Almond Board. The production records of five counties are depicted in Figure 2. Yield figures for San Joaquin, Merced, and to a lesser extent, Stanislaus County have tended to decline over the last decade but especially since 1977, when the postplant use of DBCP was banned. Comparable yield data from Butte County reflect the impact of wet and dry years, whereas data from Kern County show the yield improvement expected from a warmer, young production region.

In association with BCC, the *C. xenoplax* provides visible evidence of nematode damage including dead limbs and entire trees across irregularly shaped spots or streaks in the orchard. This survey indicates that about half of the orchards of the San Joaquin Valley with ring nematode also had BCC.

Damage caused by root-lesion nematode is visible in young replant situations, but in producing orchards, high populations of nematodes other than ring are not easily distinguished. A soil sample is necessary to determine that a nematode problem exists, and therefore, indications have been provided of the average populations detected in each region.

Thirty years of experience with Nemaguard rootstock has indicated its positive and negative attributes. Since 1977, however, growers have been without the use of DBCP, a postplant nematicide that was useful for control of *P. vulnus* and *C. xenoplax*. Based on this survey, we estimate that 40,000 ha of almond orchards are currently in need of some method to mitigate the effect of *P. vulnus* and *C. xenoplax* nematodes, and this need will increase as orchards are replanted.

This survey did not reveal any benefit of Lovell Seedling compared with Nemaguard as a rootstock to combat BCC. Both stocks were associated with BCC.

Much of the replanting that occurs in the northern San Joaquin Valley is accomplished with preplant fumigation of individual tree sites rather than with broadcast fumigation treatments. In view of the lack of postplant and genetic control of the two major nematode problems, we propose that the short-term nematode control provided by spot fumigation is inadequate to provide nematode protection, and other methods must be developed.

Table 2. Incidence and average population levels of three nematode species in San Joaquin Valley orchards damaged with bacterial canker complex

Sample location	Nematode incidence (%) and average population levels		
	Criconemella xenoplax	*Paratylenchus hamatus*	*Pratylenchus vulnus*
All sites (250 samples)	34[a] (295)[b]	61 (340)	26 (42)
All sites from BCC orchards (49 samples)	86 (381)	69 (95)	35 (20)

[a] Incidence expressed as a percentage of appropriate samples.
[b] Population levels are averaged from appropriate samples.

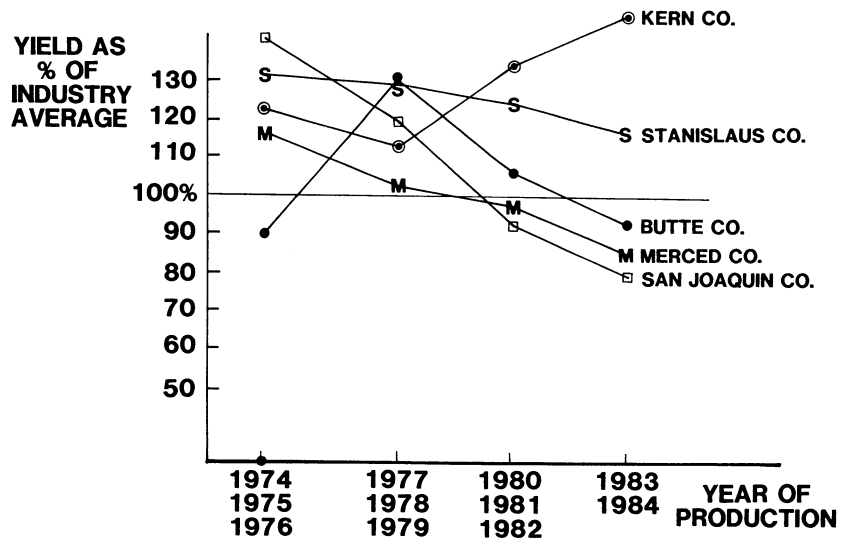

Fig. 2. Eleven-year trend of almond production from two counties without BCC and three counties with BCC in some of the orchards. Yields are expressed as a percentage of the industry-wide average and grouped into 3 yr to minimize annual variations. Use of postplant nematicide (DBCP) was banned in fall 1977.

ACKNOWLEDGMENTS

This project was partially supported by the California Almond Board. Contacts in each county would not have been possible without the cooperation and assistance of W. Asai, B. Beede, J. Connell, J. Edstrom, J. Foott, M. Freeman, J. Hasey, L. Hendricks, B. Krueger, J. Osgood, D. Rough, S. Sibbett, and M. Viveros.

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