Single and Combined Effects of Nematode Communities and Pythium Arrhenomanes on the Growth and Yield of Sugarcane in Louisiana.

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SINGLE AND COMBINED EFFECTS OF NEMATODE COMMUNITIES AND PYTHIUM ARRHEHOMANES ON THE GROWTH AND YIELD OF SUGARCANE IN LOUISIANA

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

in

The Department of Plant Pathology and Crop Physiology

by

Jason P. Bond
B.S., Southeastern Louisiana University, 1990
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ABSTRACT

A survey conducted from May 1995 through August 1998 revealed diverse nematode communities in sugarcane fields in Louisiana. High populations of Mesocriczonem, Paratrichodorus, Pratylenchus, and Tylenchorhynchus were widespread in nine sugarcane production parishes. Comparisons of plant cane and ratoon sugarcane crops indicated that nematode community levels increase significantly in successive ratoon crops.

Greenhouse experiments evaluated the susceptibility of sugarcane cultivars to a nematode community comprised of Mesocriczonem xenoplax, Paratrichodorus minor, and Tylenchorhynchus annulatus. Across years (1995 and 1996) and cultivars (CP 65-357, CP 70-321, LCP 82-89, HoCP 85-845, and LCP 86-454), plant height, shoot length, top and root dry weight, and the number of tillers per plant were reduced by nematodes. Growth parameters of the LCP cultivars were most affected by the nematodes, and those of cultivars HoCP 85-845 and CP 65-357 were least affected.

The susceptibility of cultivars to nematodes also was evaluated in microplot experiments. Across years (1995, 1996, and 1997) and cultivars (CP 70-321 and LCP 82-89), nematodes reduced top and root dry weight and number of tillers per plant. LCP 82-89 supported higher nematode community levels and sustained the greatest amount of root damage.

Nematicide trials evaluated the efficacy of aldicarb, ethoprop, and phorate against indigenous nematode populations. Aldicarb consistently increased the number of millable stalks, cane tonnage, and the yield of sucrose in soils with a high sand content. Yield increases were concomitant with reductions in the density of the nematode community shortly after planting and at harvest. In soils with a higher clay...
content, the chemicals were less effective in controlling nematode populations, and as a result, yield increases were minimal.

Greenhouse experiments conducted in 1996, 1997, and 1998 evaluated the single and combined effects of nematodes and the sugarcane root-rot pathogen, Pythium arrhenomanes. Individually, P. arrhenomanes and nematodes reduced top and root dry weight. Temperature had a significant influence on nematode reproduction and Pythium colonization. Interactions between P. arrhenomanes and nematodes were antagonistic with regard to root dry weight and nematode reproduction.
CHAPTER 1

INTRODUCTION
Sugarcane (Saccharum officinarum L.) was first introduced into Louisiana in the late 1600s by Pierre LeMoyne Sieur d'Iberville. It was not until 1751 that sugarcane was successfully produced in what is now downtown New Orleans. In 1797, the first sugarcane cultivar, "Creole", was replaced with Otaheite, which had increased frost tolerance and was less susceptible to pests. When Etienne de Bore coupled his improved extraction methodology with this new cultivar, he was the first to demonstrate the profitability of producing granulated sugar. The sugar industry blossomed in Louisiana throughout the 1800s during the Civil War Era, with innovations, such as the development of steam power, the availability of new frost resistant varieties, and new methodologies for sugar extraction (Richard, 1995).

During the 1920s, the Louisiana sugarcane industry almost collapsed (Rands and Dopp, 1938). This disaster was due mainly to a combination of mosaic, red rot, and root rot diseases. The importation and distribution of interspecific hybrids with improved vigor and disease resistance restored yields and profitability to the industry. Mechanization of the sugarcane industry occurred in the 1940s and 1950s with the development and widespread use of mechanical harvesters and planters. In the 1990s sugarcane production in Louisiana reached an all-time high. In 1998, over 170,000 hectares of sugarcane were produced in 23 parishes (Anonymous, 1998).

In Louisiana, sugarcane is vegetatively propagated by planting stalks in August and September. The following year, the initial plant cane crop is harvested in November and December. Successive annual harvests are obtained from ratoon crops that develop from buds on the stubble remaining after harvest. In Louisiana, the crop cycle is limited to a plant cane and two or three ratoon crops due to incremental reductions in the germination of basal buds and crop vigor caused by a syndrome now referred to as "stubble decline" (Edgerton et al., 1934; Edgerton, 1939). Under optimal
growing conditions, up to 20 ratoon or stubble crops may be obtained from the initial planting material (Blackburn, 1984).

Factors thought to contribute to stubble decline include winter severity, cultivar hardiness, soil aeration and drainage, date of harvest (Hoy and Schneider, 1988b), and diseases. Evidence indicates that the ratoon stunting disease agent, *Clavibacter xyli* subsp. *xyli* (Davis, et al., 1980) and an interaction between this bacterium and sugarcane mosaic virus can play an important role in stubble decline (Steib and Chilton, 1967; Koike, 1974 and 1977). Soilborne pathogens also are factors contributing to the severity of stubble decline.

*Pythium arrhenomanes* Drechs., is the primary casual agent of sugarcane root rot disease in Louisiana (Edgerton et al., 1929; Rands, 1929; Hoy and Schneider, 1988b). This pathogen was one of the major biotic factors involved in the near collapse of the sugarcane industry in Louisiana during the 1920s (Rands and Dopp, 1938). Improving soil drainage and the adoption of interspecific hybrids which were more tolerant of *Pythium* spp. subsequently reduced disease severity. (Rands and Dopp, 1938). *Pythium arrhenomanes* invades young, immature tissues of sugarcane roots following direct infection of root tissue by hyphae, zoospores, or oospores. Additionally, infected roots of alternative hosts can serve as inoculum reservoirs (Dissanayake et al., 1997). Infected primary roots have reddish-brown infection zones and water-soaked, rotted tips (Magarey, 1984). Obvious above ground symptoms are usually not observed; however, damage to primary roots and fine feeder roots can result in reductions in tillering and stalk weight (Rands and Dopp, 1938; Croft and Magarey, 1984; Hoy and Schneider, 1988b). Reductions in sugarcane yield caused by *P. arrhenomanes* are erratic, but can be as high as 20% (Hoy and Schneider, 1988a). In Louisiana, this pathogen flourishes during fall, winter, and spring when soil is moist.
and temperatures are moderate (Flor, 1930; Rands and Dopp, 1938; Hoy and Schneider, 1988b). Numerous other Pythium species have been isolated from the roots of sugarcane, with many of these being pathogenic (Rands and Dopp, 1938; Hoy and Schneider, 1988b). Symptoms caused by other Pythium species are mild when compared to those caused by P. arrhenomanes. While their effect on plant growth in the field is unknown, they do not cause appreciable root rot in greenhouse pathogenicity tests (Hoy and Schneider, 1988b).

Treib’s (1885) discovery of the root-knot nematode (Meloidogyne spp.) association with sugarcane roots was the first of many reports of nematodes parasitic on sugarcane. Since then, over 275 species in 48 genera have been found associated with either the roots or the rhizosphere of sugarcane (Birchfield, 1984; Spaull and Cadet, 1990). Among these, species of Meloidogyne and Pratylenchus, the lesion nematode, are the most pathogenic and economically important. Annual sugarcane yield losses due to nematodes have been estimated at 6% in the United States (C. Overstreet, pers. comm.) and 15% worldwide (Sasser and Freckman, 1987).

A recent survey of phytoparasitic nematodes species and their abundance in 12 sugarcane producing parishes in Louisiana indicated that Mesocriconema spp., Paratrichodorus spp., Pratylenchus spp., and Tylenchorhynchus spp. are most common (Bond et al., 1997). Foliar symptoms of nematode damage include stunted shoots, inhibited leaf production, and leaf chlorosis (Birchfield, 1984).

Damage to sugarcane roots caused by Tylenchorhynchus annulatus (Cassidy) Golden, the stunt nematode, can result in sparse root systems, stunted or irregular lateral roots, and reductions in yield (Birchfield and Martin, 1956; Roman, 1968; Gargantiel and Davide, 1973). Similar yield reductions also are known to be caused by Paratrichodorus minor Colbran (Siddiqui), the stubby-root nematode, and result from
roots that are stubby, coarse and lack fine feeder roots (Apt and Koike, 1962). Pathogenicity of Mesocricotoma spp. to sugarcane has not been documented.

Individually, nematodes (Birchfield and Martin, 1956; Apt and Koike, 1962; Roman, 1968; Spaull and Cadet, 1990) and P. arrhenomanes (Rands, 1961; Hoy and Schneider, 1988a and 1988b; and Croft and Magarey, 1984) have been shown to be limiting agents in sugarcane production. In spite of the fact that the two types of pathogens are perennial sugarcane rhizosphere inhabitants, few investigators have attempted to evaluate their combined influence on growth and yield.

In Louisiana, the potential for nematodes to be a factor in stubble decline warrants investigation. Therefore, objectives of this research were to: (i) determine the frequency and distribution of nematode genera and species in sugarcane soil of Louisiana, (ii) compare nematode population densities in plant and ratoon sugarcane crops, (iii) evaluate the damage potential of nematode communities to current sugarcane cultivars in Louisiana, (iv) evaluate the efficacy of current labeled nematicides, and (v) evaluate the interrelationship between nematodes and P. arrhenomanes.

**Literature Cited**


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CHAPTER 2

SUGARCANE GROWTH AS INFLUENCED BY SINGLE AND CONCOMITANT INFECTIONS BY NEMATODES AND PYTHIUM ARRHENOMANES IN LOUISIANA
Introduction

Sugarcane, interspecific hybrids of *Saccharum* L., is a major agricultural crop that has been produced for over 200 years in Louisiana. Each year, approximately 170,000 hectares are planted to sugarcane producing a crop with a total value in excess of 500 million dollars (Anonymous, 1998).

The ring nematode, *Mesocrictonema xenoplax* Raski, the stunt nematode *Tylenchorhynchus annulatus* (Cassidy) Golden, and the stubby-root nematode *Paratrichodorus minor* (Colbran) Siddiqui, are found with great frequency in sugarcane soil in Louisiana (Bond et al., 1997). Both *T. annulatus* (Birchfield and Martin, 1956; Roman, 1968; Gargantiel and Davide, 1973) and *P. minor* (Apt and Koike, 1962) have been previously shown to be pathogenic to sugarcane. Both of these nematodes cause similar damage to sugarcane roots which results in a stubby and stunted appearance with a lack of fine feeder roots. Such damage to the root system can cause significant reductions in plant weight (Birchfield and Martin 1956; Apt and Koike, 1962).

Nationwide, nematodes reduce annual sugarcane yield by 6% (C. Overstreet, pers. comm.), and worldwide, the annual loss estimate is 15% (Sasser and Freckman, 1987).

In Louisiana, the causal agent of sugarcane root-rot is *Pythium arrhenomanes* Drechs., (Rands, 1929; Hoy and Schneider, 1988b). Following infection, mycelium of the pathogen grows inter- and intra-cellularly in young root tissue. Distinct above-ground symptoms of sugarcane root rot are usually not observed. Damage to the root system can result in reduced tillering and stalk weight. Root damage includes reddish-brown tissue at the infection zone, root tips with flaccid and water-soaked appearances, and lesions on the primary roots. Infected primary roots often exhibit reddish-black discolorations, and may have rotted root tips. Lateral roots, which are critical for water and nutrient transport, are destroyed by *Pythium*. Disease severity is intensified by
moderate temperatures and wet conditions which favor growth and sporulation of the pathogen (Flor, 1930; Rands and Dopp, 1938; Hoy and Schneider, 1988b). Yield reductions caused by *P. arrhenomanes* can be as high as 20% (Hoy and Schneider, 1988a).

The individual effects of *P. arrhenomanes* (Rands, 1961; Hoy and Schneider, 1988a and 1988b; Croft and Magarey, 1984) and nematodes (Birchfield and Martin, 1956; Apt and Koike, 1962; Roman, 1968; Gargantiel and Davide, 1973, Spaull and Cadet, 1990) on sugarcane have been investigated previously. However, information on the effect of a community of nematode species and the combined effect of nematodes and *Pythium* on sugarcane is lacking in spite of the fact that they occur together in nature. Therefore, the objectives of this research were to evaluate: (i) the effects of a community of nematode species and *P. arrhenomanes* on sugarcane and (ii) the interrelationship between nematodes and *P. arrhenomanes*.

**Materials and Methods**

**General Procedures.**

Plants were obtained by excising single-bud cuttings from the middle portion of sugarcane stalks. Cuttings were trimmed to 1-2-cm of internode tissue on either side of the node. Prior to planting, eye pieces were selected for uniformity and subjected to a hot water treatment at 50 °C for 50 minutes, to eliminate minor fungal pathogen populations. Heat-treated cuttings were germinated in fumigated (67% methyl bromide : 33% chloropicrin at the rate of 0.91 kg per 1.42 m^3 soil) Convent silt loam soil (Aeric Fluvaquent, coarse-silty, mixed, nonacid, thermic) in styrofoam trays (Speedling, Inc., Sun City, FL) with 7.5-cm by 7.5-cm cells. After three weeks, plants were selected for uniformity and transplanted.
Populations of *Mesocriconema* spp., *Tylenchorhynchus* spp., and *Paratrichodorus* spp. were derived from communities obtained from the Cinclare Sugarcane Plantation in West Baton Rouge Parish. Populations of *Mesocriconema xenoplax* (Raski), *Tylenchorhynchus annulatus* (Cassidy) Golden, and *Paratrichodorus minor* (Colbran) Siddiqui were propagated in axenic culture on the sugarcane cultivars CP 70-321 and LCP 82-89. Inoculum for all tests consisted of juveniles and adults extracted from greenhouse cultures by wet-sieving through nested 250-μm-pore and 38-μm-pore sieves followed by sugar flotation and centrifugation (Jenkins, 1964). Five days after transplanting, soil was infested by pipetting suspensions containing known numbers of nematodes into depressions (1.5-cm-diam. by 3- and 6-cm deep) around the base of the sugarcane cutting. Controls contained suspending fluids minus nematodes. Following soil infestation, depressions were filled with fumigated soil. At harvest, for all experiments, 3 g subsamples from each root system were placed on a Baerman funnel apparatus for evaluation of endoparasitic nematodes.

At two-week intervals throughout the growing season, plant height and shoot length were measured and the number of tillers recorded. Plant height was obtained by measuring the distance from the soil line to the tip of the longest leaf. Shoot length was obtained by measuring the distance from the soil line to the highest ligule. Dry weights for shoot and root systems were obtained by placing samples in a forage drier for approximately two weeks at 70 °C.

**Experiments with only Nematodes.**

**Greenhouse.** Experiments were conducted under conditions where air temperature ranged from 25-33 °C. Three-week-old cuttings were transplanted to the center of 20-cm-diam. clay pots, each containing 4 kg of a soil mixture composed of three parts fumigated Convent silt loam and one part steam-treated sand. Soil fertility
analysis indicated that pots should receive 120 ml of 23-19-17 N-P-K fertilizer solution (RapidGro; Chevron, San Ramon, CA) every 14 days until harvest.

Five sugarcane cultivars currently planted in Louisiana (CP 65-357, CP 70-321, LCP 82-89, HoCP 85-845, and CP 86-454) were evaluated in two experiments. Planting and harvest dates were 21 February and 1 June 1995 and 24 November and 11 March 1996. Treatments were arranged in a randomized complete block design with a factorial treatment structure. Treatments included three levels of nematodes (0, 1x, or 4x) and five cultivars in all possible combinations for a total of 15 treatments with six replications. Nematode inoculum at the 1x level contained 925 (32% Stunt, 61% Ring, and 7% Stubby-Root) and 911 (43% Stunt, 46% Ring, and 11% Stubby-Root) nematodes per pot in 1995 and 1996, respectively. Infestation levels and community composition were selected to reflect nematode community structure and density commonly encountered in sugarcane fields in Louisiana at planting time (Bond et al., 1997).

At harvest, each pot and its entire contents were placed into a 19 liter plastic bucket containing 6 liters of water. After soaking for 5 minutes, the empty pot was removed and rinsed with an additional 2 liters of water. The root system was then agitated to dislodge soil particles and an additional 2 liters of water were employed to rinse the root system, making the final soil:water slurry to a volume of 10 liters. The slurry was stirred vigorously for 10 seconds and a 500-ml subsample was removed and subjected to the extraction procedure described above. Immature and mature vermiform life-stages of each nematode species were enumerated at 50x with an Olympus CK-2 inverted microscope. Total population density per pot (Pf) and the reproductive values (R, where $R = \frac{Pf}{Pi}$ and Pf = the final population level and Pi = infestation level) were determined for each nematode species and for the total nematode community.
Microplots. Each microplot consisted of a 40.6-cm-diam. clay pot that contained 35 kg MeBr-treated Commerce silt loam soil obtained from the Sugar Research Station of the Louisiana Agricultural Experiment Station at St. Gabriel, LA. Soil fertility analysis indicated that microplots receive 3.5 g of 33-0-0 (N-P-K) every four weeks. Each microplot was placed into a preformed depression in the soil with only the rim of the pot exposed. The 42 microplots were spaced 1 m apart in a 5-by-9 pattern. The entire area was covered with a 14-m-long by 6.5-m-wide aluminum quonset hut frame, open at both ends, and covered with 4 ml polyethylene plastic. Reflective shade cloth was placed over the plastic cover so that soil and air temperatures in microplots were within 2-3 °C of those in the field. Light intensity under the reflective cloth was measured at 512 µE • s⁻¹ • m⁻² of light, which is approximately 30% of full sunlight.

Planting and harvest dates were 4 April and 10 October, 12 April and 27 October, 7 May and 17 November for 1995, 1996, and 1997, respectively. Treatments were arranged in a randomized complete block design with a factorial treatment structure. Treatments included three levels of nematodes (0, 1x, or 10x) and two cultivars (CP 70-321 and LCP 82-89) in all possible combinations for a total of six treatments with seven replications. Nematode inoculum at the 1x level contained 1,256 (30% Stunt, 30% Ring, and 40% Stubby-Root), 1,247 (32% Stunt, 29% Ring, and 39% Stubby-Root) and 1,200 (44% Stunt, 50% Ring, and 6% Stubby-Root) nematodes per pot for 1995, 1996, and 1997, respectively.

At harvest, six soil cores (2.5-cm-diam. by 30-cm deep) were collected from each microplot, bulked, and a 150 g subsample collected. Nematodes were then extracted, counted, and reproductive values determined as in greenhouse experiments.
Experiments with Nematodes and Pythium arrhenomanes.

*Pythium arrhenomanes* isolate ATCC 96526 was obtained from the collection of J.W. Hoy (Department of Plant Pathology and Crop Physiology, Louisiana State University) and used for all experiments. Agar discs (3 mm) containing *P. arrhenomanes* were revived from sterile water storage by plating on V8 medium (200 ml of V8 vegetable juice, 2 g of CaCO₃, 17 g of Bacto agar, 800 ml of distilled water (dH₂O)). Inoculum was produced following a method described by Mircetich and Matheron (1976). Canning jars (473 ml) that contained 450 ml of medium grade vermiculite, 300 ml of V8 vegetable juice broth (200 ml of V8 juice, 800 ml dH₂O, and 2 g CaCO₃), and 20 ml of oat seeds were autoclaved on two consecutive days. Four agar discs containing *P. arrhenomanes* were added to each jar and incubated four weeks at room temperature (24-26 °C). Prior to incorporation into soil, the mixture was placed in cheese-cloth and thoroughly washed to remove excess nutrients. Inoculum from all jars was bulked, mixed, and added to the soil at the appropriate levels.

In three greenhouse tests, the interrelationship between the nematodes and *P. arrhenomanes* was evaluated on the cultivar LCP 82-89. Planting and harvest dates for 1996, 1997, and 1998 were 8 January and 16 April, 1 March and 10 June, 9 May and 7 July, respectively. Experiments were arranged in a randomized complete block design with a factorial treatment structure. Treatments included three levels of nematodes (0, 1x, or 10x) and three levels of *Pythium* (0, 22, or 220 g of inoculum mixture) in all possible combinations for a total of nine treatments with six replications. Nematode inoculum at the 1x level contained 491 (35% Stunt, 58% Ring, 6% Stubby-Root), 495 (28% Stunt, 69% Ring, and 3% Stubby-Root), and 495 (42% Stunt, 46% Ring, and 12% Stubby-Root) nematodes per pot in 1996, 1997, and 1998, respectively. In 1998, temperature was included as a main effect in addition to the levels of *P. arrhenomanes*.
and nematodes described for 1996 and 1997. Two temperatures (20 and 30 °C) were selected to simulate spring and summer conditions, respectively. This 3 x 3 x 2 factorial design was replicated six times.

At the highest Pythium infestation level, pots received 220 g of the inoculum mixture. To maintain the same soil consistency in all pots, all treatments received similar levels of growth medium minus P. arrhenomanes. The inoculum was thoroughly mixed with three parts steamed (100 °C for 12 hours) field soil (same source as in microplot tests) and one part steamed-treated sand and placed in 20-cm-diam. clay pots.

At harvest, nematode reproduction and plant growth were determined as in other greenhouse tests. Root colonization by P. arrhenomanes was determined by evaluating a total of 180 cm of root length for each treatment. Six 5-cm root segments were selected randomly from each root system. Root pieces for each treatment were combined and placed into a 250-ml Erlenmeyer flask and agitated in dH2O for 12 hours. Roots were then rinsed, blotted dry, and placed in 100 x 15-mm plastic petri plates. Three root segments per plate were covered with molten pimaricin-vancomycin-pentachloronitrobenzene-spectinomycin (PVPS) medium (Dissanayake et al., 1998), a modified Pythium-selective medium (Mircetich and Matherson, 1976). To prepare PVPS, 10 g each of Difco cornmeal agar and Bacto agar were autoclaved in 1 liter of dH2O. The medium was allowed to cool (40-45 °C) and was amended with 300 mg of vancomycin dissolved in 10 ml of sterile dH2O, 300 mg of spectinomycin dissolved in 10 ml of sterile dH2O, 0.4 ml of pimaricin (10 mg a.i./liter), and 15 mg of pentachloronitrobenzene dissolved in 2 ml of 95% ethyl alcohol. Roots were fully covered with the medium and incubated at room temperature (24-26 °C). After 24 and 48 hours, quantitative estimates of root segments from which Pythium growth emanated
were recorded. A subset of four *Pythium* colonies were removed from the leading edge of randomly selected colonies from each plate (eight isolates for each plant), and transferred to V8 medium and incubated for 24 hours. After incubation, five, 3-mm-agar disks were transferred to 60 x 15-mm petri plates, covered with 5-ml filter-sterilized soil extract (10 g of soil/liter of dH2O, agitated for 24 hours), and incubated at 20-24 °C. Sexual and asexual structures were produced within 48 hours. Isolates were verified as *P. arrhenomanes* by comparing reproductive structures to species descriptions in a monograph on the genus *Pythium* (Van der Platts-Niterink, 1981).

**Data Analysis.**

Data were subjected to analysis of variance using the General Linear Models procedure of the Statistical Analysis System version 6.12 for Macintosh (SAS Institute Inc., Cary, NC). Unless otherwise stated all experiments were repeated at least once and differences noted are significant at $P \leq 0.05$. For treatments with three or more levels, means were separated with Tukey’s HSD test. Coefficients for orthogonal polynomial contrasts were derived according to Gomez and Gomez (1984) and used to determine relationships between inoculum levels and plant parameters. Interactions that were significant in two or more years are presented, those that occurred in only one year are described only in the text. When test by treatment interactions were detected in the initial analysis, data for each test were analyzed and presented separately.

**Results**

**Experiments with only Nematodes.**

*Greenhouse.* All five cultivars were susceptible to nematodes (Table 2.1). At both low and high infestation levels, plant height, stalk length, top and root weight, and the number of tillers per plant were reduced. Stalk length and top weight were reduced in a stepwise manner as nematode infestation level increased. Orthogonal polynomial
Table 2.1. Sugarcane growth parameters as influenced by nematode infestation levels and sugarcane genotype in greenhouse experiments during 1995 and 1996 combined.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Level</th>
<th>Height / (cm)(^a)</th>
<th>Dry weight (g)(^b)</th>
<th>Tillers per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plant</td>
<td>Shoot</td>
<td>Top</td>
</tr>
<tr>
<td>Nematode(^c)</td>
<td>0</td>
<td>147.2 a</td>
<td>36.1 a</td>
<td>31.8 a</td>
</tr>
<tr>
<td></td>
<td>1x</td>
<td>138.7 b</td>
<td>32.1 b</td>
<td>25.6 b</td>
</tr>
<tr>
<td></td>
<td>4x</td>
<td>135.2 b</td>
<td>30.0 c</td>
<td>22.5 c</td>
</tr>
<tr>
<td>P &gt; F</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Cultivar</td>
<td>CP 65-357</td>
<td>154.9 a</td>
<td>35.4 b</td>
<td>26.9 b</td>
</tr>
<tr>
<td></td>
<td>CP 70-321</td>
<td>139.6 b</td>
<td>29.9 cd</td>
<td>25.3 bc</td>
</tr>
<tr>
<td></td>
<td>LCP 82-89</td>
<td>130.9 c</td>
<td>27.1 d</td>
<td>23.3 c</td>
</tr>
<tr>
<td></td>
<td>HoCP 85-845</td>
<td>153.4 a</td>
<td>39.0 a</td>
<td>33.9 a</td>
</tr>
<tr>
<td></td>
<td>LCP 86-454</td>
<td>123.4 d</td>
<td>32.2 c</td>
<td>23.7 bc</td>
</tr>
<tr>
<td>P &gt; F</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>N x C</td>
<td>P &gt; F</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

Data are means of 12 replicates. For each factor and column, ** and *** indicate differences at P ≤ 0.01, and 0.001, respectively; NS indicates that means are not significantly different. For treatments with three or more levels, means followed by the same letter are not different (P ≤ 0.05), according to Tukey's HSD test.

\(^a\) Plant height is the distance from the soil line to the tip of the longest leaf; shoot height is the distance from the soil line to the highest ligule.

\(^b\) Weight after drying for 2 weeks at 70 °C.

\(^c\) Infestation levels for 1995 and 1996 were: (1x) 925 and 911 nematodes per pot; (10x) 3,700 and 3,644 nematodes per pot, respectively. Ratios of *Tylenchorhynchus annulatus* : *Mesocriconema xenoplax* : *Paratrichodorus minor* in inocula were 32:61:7 in 1995 and 43:46:11 in 1996.
contrasts (Fig 2.1A and 2.1B) revealed that top weight \( t = -9.17, P > |t| = < .0001 \),
root weight \( t = -13.84, P > |t| = < .0001 \), plant height \( t = -5.38, P > |t| = < .0001 \),
and shoot length \( t = -6.68, P > |t| = .0006 \), decreased in a linear fashion as nematode
infestation level increased. Since there were no significant differences among the non-
inoculated controls for each of the five cultivars, it can be concluded that nematodes
were most damaging to LCP 82-89 and LCP 86-454 (Table 2.1). Heights of LCP 86-
454, LCP 82-89, and CP 70-321 were reduced more than those of CP 65-357 and
HoCP 85-845. Shoot lengths for LCP 82-89, CP 70-321, and LCP 86-454 were most
affected by nematodes. Differences in top and root weights were observed among the
five cultivars at harvest. Top weight and number of tillers per plant for HoCP 85-845
were least affected by nematodes.

There was abundant nematode reproduction on all cultivars as evidenced by
reproductive values which ranged from a low of 10 for M. xenoplax at the high
infestation level to a high of 305 for P. minor at the low infestation level (Table 2.2).
Final density for each of the three nematode populations and the community reflected
greater nematode reproduction at low than at high infestation levels. At the low
infestation level, population totals ranged from a low of 13.2 thousand M. xenoplax per
pot to a high of 21.2 thousand P. minor per pot. Similarly at the highest infestation
level, population totals ranged from 17.4 thousand T. annulatus per pot to a high of
18.8 thousand M. xenoplax per pot. Population totals for the entire nematode
community at the conclusion of the test (approximately four months after inoculation),
averaged 55.1 thousand individuals at the low and 54.8 thousand at the high infestation
level. Generally, based on the extent of reproduction and final densities, CP 65-357
was the most suitable host for the nematode community. Final community density for
CP 65-357 averaged 75.9 thousand nematodes per pot while that of the next most
Fig. 2.1. Relationships between plant parameters and nematode infestation levels in greenhouse and microplot experiments. The type of relationship, and $P > 0.05$ are noted where significant. A) Dry weights (g) in greenhouse environment. B) Plant height and stalk length (cm) in greenhouse environment. C) Dry weights (g) in microplot environment. D) Plant height and stalk length (cm) in microplot environment.
Table 2.2. Individual population densities and reproductive values for *Tylenchorhynchus annulatus*, *Mesocricicema xenoplax*, and *Paratrichodorus minor*, and community totals as influenced by infestation level and sugarcane genotype in greenhouse experiments during 1995 and 1996 combined.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Level</th>
<th>T. annulatus</th>
<th>M. xenoplax</th>
<th>P. minor</th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pf&lt;sup&gt;a&lt;/sup&gt;</td>
<td>R&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Pf</td>
<td>R</td>
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<tr>
<td>Nematode&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>1x</td>
<td>20.7</td>
<td>61</td>
<td>13.2</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>4x</td>
<td>17.4</td>
<td>12</td>
<td>18.8</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>P &gt; F</td>
<td>ns</td>
<td>***</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>Cultivar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CP 65-357</td>
<td>21.0 a</td>
<td>37 ab</td>
<td>28.7 a</td>
<td>32 a</td>
</tr>
<tr>
<td></td>
<td>CP 70-321</td>
<td>12.9 b</td>
<td>26 b</td>
<td>15.9 b</td>
<td>20 b</td>
</tr>
<tr>
<td></td>
<td>LCP 82-89</td>
<td>19.5 ab</td>
<td>37 ab</td>
<td>11.0 b</td>
<td>13 c</td>
</tr>
<tr>
<td></td>
<td>HoCP 85-845</td>
<td>21.5 a</td>
<td>42 a</td>
<td>11.7 b</td>
<td>13 c</td>
</tr>
<tr>
<td></td>
<td>LCP 86-454</td>
<td>20.2 ab</td>
<td>40 ab</td>
<td>12.8 b</td>
<td>12 c</td>
</tr>
<tr>
<td></td>
<td>P &gt; F</td>
<td>*</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>N x C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P &gt; F</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
<td>***</td>
</tr>
</tbody>
</table>

Data are means of 12 replicates. For each factor and column, *, **, and *** indicate differences at $P \leq 0.05$, 0.01, and 0.001, respectively; NS indicates that means are not significantly different. For treatments with three or more levels, means followed by the same letter are not different ($P \leq 0.05$), according to Tukey’s HSD test.

<sup>a</sup> Pf = final population density in 1000s per 20-cm-diam. clay pot containing 4 kg of MeBr treated soil.
<sup>b</sup> R (reproductive value) = Pf/Pi, where Pf = final population density and Pi = infestation level.
<sup>c</sup> No nematodes were recovered from controls.
<sup>d</sup> Infestation levels for 1995 and 1996 were: (1x) 925 and 911 nematodes per pot; (10x) 3,700 and 3,644 nematodes per pot, respectively. Ratios of *Tylenchorhynchus annulatus : Mesocricicema xenoplax : Paratrichodorus minor* in inocula were 32:61:7 in 1995 and 43:46:11 in 1996.
suitable host, HoCP 85-845, averaged 30% less. Only for *M. xenoplax* were nematode by cultivar interactions detected which influenced population density and reproduction. Inspection of individual treatments means revealed that population density was approximately the same at low and high infestation levels on LCP 82-89, CP 70-321 and HoCP 85-845. However, both CP 65-357 and LCP 86-454 supported greater densities of *M. xenoplax* at the higher infestation level.

**Microplots.** The absence of year by treatment interactions allowed data for all microplot tests to be combined for analysis and presentation. As in greenhouse experiments, the cultivars CP 70-321 and LCP 82-89 were both susceptible to nematodes (Table 2.3). Across both cultivars, there were numerical but non-significant reductions in both plant height and stalk length. Top and root weight were reduced by nematodes at both infestation levels, and the number of tillers per plant was reduced at the highest nematode infestation level. Individually, susceptibility to nematodes differed between the two cultivars. Reductions in root weight were greater for LCP 82-89 than CP 70-321; however, the number of tillers per plant was greater for LCP 82-89. Orthogonal polynomial contrasts revealed that top weight (*t* = -2.47, *P* > |t| = .015) and root weight (*t* = -4.02, *P* > |t| = < .0001) decreased in a linear fashion as nematode infestation level increased (Fig. 2.1C). However, plant height and stalk length were not affected by nematode infestation level (Fig. 2.1D).

As in greenhouse tests, both cultivars proved to be good hosts for each of the three nematode species under microplot conditions (Table 2.4). In greenhouse tests, the final community contained approximately equivalent numbers of each of the three nematode species. However, in the microplot environment there was an overwhelming dominance by *T. annulatus* with final communities containing 93 to 96% of this species. Of the two sugarcane cultivars, LCP 82-89 was a better host than CP 70-321. The
Table 2.3. Sugarcane growth parameters as influenced by nematode infestation levels and sugarcane genotype in microplot experiments during 1995-97 combined.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Level</th>
<th>Height / Length (cm)&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Dry weight (g)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Tillers per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plant</td>
<td>Stalk</td>
<td>Top</td>
</tr>
<tr>
<td>Nematode&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0</td>
<td>222.3</td>
<td>93.3</td>
<td>687.6</td>
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<tr>
<td></td>
<td>1x</td>
<td>215.7</td>
<td>86.5</td>
<td>616.6</td>
</tr>
<tr>
<td></td>
<td>10x</td>
<td>219.6</td>
<td>89.1</td>
<td>608.9</td>
</tr>
<tr>
<td>P &gt; F</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>Cultivar</td>
<td>CP 70-321</td>
<td>220.0</td>
<td>88.8</td>
<td>652.0</td>
</tr>
<tr>
<td></td>
<td>LCP 82-89</td>
<td>218.0</td>
<td>90.4</td>
<td>623.4</td>
</tr>
<tr>
<td>P &gt; F</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>*</td>
</tr>
<tr>
<td>N x C</td>
<td>P &gt; F</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

Data are means of 21 replicates. For each factor and column, *, and ** indicate differences at P < 0.05, and 0.01, respectively; NS indicates that means are not significantly different. For treatments with three levels, means followed by the same letter are not different (P < 0.05), according to Tukey’s HSD test.

<sup>a</sup> Plant height is the distance from the soil line to the tip of the longest leaf; stalk length is the distance from the soil line to the highest ligule.

<sup>b</sup> Weight after drying for 2 weeks at 70 °C.

<sup>c</sup> Infestation levels for 1995, 1996, and 1997 were: (1x) 1,256, 1,247, and 1,200 nematodes per pot; (10x) 12,560, 12,470, and 12,000 nematodes per pot, respectively. Ratios of *Tylenchorhynchus annulatus* : *Mesocriconema xenoplax* : *Paratrichodorus minor* in inocula were 30:30:40 in 1995, 32:29:39 in 1996, and 44:50:6 in 1997.
Table 2.4. Individual population densities and reproductive values for *Tylenchorhynchus annulatus*, *Mesocricicronema xenoplax*, *Paratrichodorus minor*, and community totals as influenced by infestation level and sugarcane genotype in microplot experiments during 1995-97 combined.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Level</th>
<th><em>T. annulatus</em></th>
<th><em>M. xenoplax</em></th>
<th><em>P. minor</em></th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pf&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Pf</td>
<td>Pf</td>
<td>Pf</td>
</tr>
<tr>
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<td>1x</td>
<td>398</td>
<td>919</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>10x</td>
<td>443</td>
<td>103</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>P &gt; F</td>
<td>ns</td>
<td>***</td>
<td>**</td>
<td>***</td>
<td>ns</td>
</tr>
<tr>
<td>Cultivar</td>
<td>CP70-321</td>
<td>340</td>
<td>389</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>LCP82-89</td>
<td>500</td>
<td>634</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>P &gt; F</td>
<td>**</td>
<td>***</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>N x C</td>
<td>P &gt; F</td>
<td>ns</td>
<td>***</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

Data are means of 21 replicates. For each column and factor, ** and *** indicate differences at *P* ≤ 0.01 and 0.001, respectively; NS indicates that means are not significantly different.

<sup>a</sup> Pf = final population density in 1000s per 40.6-cm-diam. clay pot containing 35 kg of MeBr treated soil.

<sup>b</sup> R (reproductive value) = Pf/Pi, where Pf = final population density and Pi = infestation level.

<sup>c</sup> No nematodes were recovered from controls.

<sup>d</sup> Infestation levels for 1995, 1996, and 1997 were: (1x) 1,256, 1,247; and 1,200 nematodes per pot; (10x) 12,560, 12,470, and 12,000 nematodes per pot, respectively. Ratios of *Tylenchorhynchus annulatus*: *Mesocricicronema xenoplax*: *Paratrichodorus minor* in inocula were 30:30:40 in 1995, 32:29:39 in 1996, and 44:50:6 in 1997.
cultivar LCP 82-89 supported greater reproduction by *T. annulatus* which averaged 500 thousand individuals per microplot compared to 340 thousand individuals on CP 70-321. Nematode by cultivar interactions were detected which influenced reproductive values for both *T. annulatus* and the community. These interactions are accounted for in that means for each of these two parameters were greater at the low infestation level on LCP 82-89 than on CP 70-321, but not at the high infestation level.

**Experiments with Nematodes and *Pythium arrhenomanes***.

In each of the three years, there were nematode effects which reduced sugarcane plant weights (Table 2.5). In 1996, nematodes reduced top weights at the highest level and root weights at both infestation levels. In 1997, nematodes reduced top and root weights only at the high infestation level. In 1998, both top and root weights were reduced by nematodes at both infestation levels. Across all three trials of this experiment, reductions in root weight averaged 22% and 30%, respectively, at low and high nematode levels.

Both levels of *P. arrhenomanes* reduced top and root weights in 1996 and 1998 (Table 2.5). Only root weights were reduced in 1997. In 1996 and 1998, reductions in top weights averaged 47% and 56% at low and high *Pythium* levels, respectively. Across the three trials, reductions in root weight were 48% and 58% at low and high *Pythium* levels, respectively. In 1998, there was a temperature effect which influenced top weight.

Nematode by *Pythium* interactions occurred in each year and consistently impacted root weight. Examination of individual treatment means for root weights in each year showed that the interactions were similar. The nematode by *Pythium* interaction for root weight in 1997 is presented as an example (Fig. 2.2). In the absence of *Pythium*, nematodes reduced root weight at both infestation levels. When *Pythium*
Table 2.5. Sugarcane dry weights as influenced by nematode (N) and *Pythium* arrhenomanes (P) infestation levels and temperature (T) in greenhouse experiments during 1996-98.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>Nematode</td>
<td>0a</td>
<td>19.1 a</td>
<td>18.5 a</td>
<td>37.3 a</td>
<td>30.3 a</td>
<td>24.6 a</td>
<td>30.2 a</td>
</tr>
<tr>
<td></td>
<td>1x</td>
<td>17.0 ab</td>
<td>13.7 b</td>
<td>31.8 b</td>
<td>27.3 ab</td>
<td>21.7 b</td>
<td>22.9 b</td>
</tr>
<tr>
<td></td>
<td>10x</td>
<td>13.3 b</td>
<td>13.0 b</td>
<td>26.9 b</td>
<td>23.5 b</td>
<td>20.6 b</td>
<td>18.3 b</td>
</tr>
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<td>P &gt; F</td>
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<td>**</td>
<td>**</td>
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<td>Pythium</td>
<td>0b</td>
<td>31.1 a</td>
<td>33.7 a</td>
<td>37.5</td>
<td>33.0 a</td>
<td>31.8 a</td>
<td>41.6 a</td>
</tr>
<tr>
<td></td>
<td>22</td>
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Data are means of six replications. For each factor and column, *, **, and *** indicate differences at P ≤ 0.05, 0.01, 0.001 respectively; NS indicates that means are not significantly different. For treatments with three levels, means followed by the same letter are not different (P ≤ 0.05), according to Tukey’s HSD test.

* Infestation levels for 1996, 1997, and 1998 were: (1x) 491, 495, and 495 nematodes per pot; (10x) 4,910, 4,950, and 4,950 nematodes per pot, respectively. Ratios of *Tylenchorhynchus annulatus*: *Mesocriconema xenoplax*: *Paratrichodorus minor* in inocula were 35:58:6 in 1996, 28:69:3 in 1997, and 42:46:12 in 1998.

* b 0, 22, or 220 g of inoculum mixture containing *Pythium arrhenomanes.*
Fig. 2.2. Sugarcane root dry weight as influenced by nematode and *Pythium arrhenomanes* infestation levels in the 1997 experiment. Nematode infestation levels were 495 (1x) and 4,950 (10x) nematodes per pot (inoculum was 27% *Tylenchorhynchus annulatus*, 69% *Mesocricnema xenoplax* and 3% *Paratrichodorus minor*), and *Pythium arrhenomanes* infestation levels were 22 or 220 g of inoculum mixture per pot. Within each *Pythium* level, bars with the same letter indicate means that do not differ significantly (*P* ≤ 0.05) according to Tukey’s HSD test.
was present at low levels, root weight was reduced at the highest nematode infestation level when compared to the low nematode infestation level. At the highest Pythium level, differences in root weight were not observed.

Nematode data collected for each of the three nematode and P. arrhenomanes greenhouse studies are presented in Table 2.6. Final population density of T. annulatus was greater at the low nematode infestation level only in 1998. Final population density of M. xenoplax was significantly greater at the high nematode level in 1997 and 1998. In 1997, the population density of P. minor was greater at the highest infestation level. Greater reproductive values were observed at the low infestation level for each of the three nematodes in each of three years.

The presence of P. arrhenomanes reduced population densities and reproductive values of T. annulatus and M. xenoplax in all three trials of this experiment (Table 2.6). In 1996 and 1998, similar reductions in population densities and reproductive values of T. annulatus occurred at both Pythium infestation levels. In 1997, the population density decreased in a stepwise manner as Pythium level increased, and reproductive values were reduced only at the high Pythium infestation level. Overall, reductions in population densities of T. annulatus of 58% and 71% resulted from low and high levels of Pythium, respectively. With the exception of reproductive values obtained for 1996, reproductive values and population densities of M. xenoplax were reduced similarly at both Pythium infestation levels in all three tests. Overall, population densities of M. xenoplax were reduced by 48% and 72% at low and high levels of Pythium, respectively. The population density of P. minor was increased at the low Pythium level in 1996, reduced to a similar extent at both Pythium levels in 1997, and not affected in 1998. With the exception of 1997, where the reproductive values were reduced, reproductive values of P. minor were not affected by Pythium.
Table 2.6. Individual population densities for *Tylenchorhynchus annulatus* (Ta), *Mesocricotomina xenoplax* (Mx), and *Paratrichodorus minor* (Pm), as influenced by nematode (N) and *Pythium arrhenomanes* (P) infestation levels and temperature (T) in greenhouse experiments during 1996-98.

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Data are means of six replicates. For each factor and column, *, **, and *** indicate differences at P ≤ 0.05, 0.01, 0.001, respectively; NS indicates that means are not significantly different. For treatments with three levels, means followed by the same letter are not different (P < 0.05), according to Tukey's HSD test.

a Infestation levels for 1996, 1997, and 1998 were: (1x) 491, 495, and 495 nematodes per pot; (10x) 4,910, 4,950, and 4,950 nematodes per pot, respectively. Ratios of *Tylenchorhynchus annulatus* : *Mesocricotomina xenoplax* : *Paratrichodorus minor* in inocula were 35:58:6 in 1996, 28:69:3 in 1997, and 42:46:12 in 1998. 0, 22, or 220 g of inoculum mixture containing *Pythium arrhenomanes*.

b Pf = final population density in 1000s per 20-cm-diam. clay pot containing 4 kg of steamed soil, no nematodes were recovered from controls.

c R (reproductive value) = Pf/PI, where Pf = final population density and PI = infestation level.
Temperature influenced both nematode and *P. arrhenomanes* populations (Table 2.6). In 1998, population density and the reproductive value for *T. annulatus* were greater at 30 °C than at 20 °C. Temperature did not affect the final population density of *M. xenoplax*; however, the reproductive value was reduced at 30 °C. Both population density and reproductive value for *P. minor* were greater at 20 °C than at 30 °C.

Consistent nematode by *Pythium* interactions influenced the population densities of all three nematode species, with the exception of that for *T. annulatus* in 1998. Examination of individual treatment means for each year indicated that within each nematode species interactions were similar. Therefore, data from 1997 will be used for illustrative purposes (Fig 2.3). At the low nematode infestation level, population density of *T. annulatus* was reduced only at the high *Pythium* level. At the high nematode level, however, population density was reduced to a similar extent at both *Pythium* levels. Treatment means for *M. xenoplax* and *P. minor* at the low nematode infestation level showed that population densities in the presence and absence of *Pythium* were similar. However, at the high nematode infestation level, *P. arrhenomanes* caused marked reductions in population densities.

Nematode by *Pythium* interactions which affected reproductive values of *T. annulatus* were consistent across all three trials. Data from 1997 are presented as an example (Fig 2.4). At the low nematode infestation level, reproductive values were reduced only at the highest *Pythium* infestation level. However, at the high nematode level, reproductive values were not influenced by either low or high levels of *Pythium*.

Root colonization by *P. arrhenomanes* was influenced by nematode infestation only in 1996 (Table 2.7). When compared to the low nematode infestation level, a 22% reduction in colonization by *P. arrhenomanes* was observed at the high nematode level.
Fig. 2.3. Population densities of Tylenchorhynchus annulatus, Mesocriconema xenoplax and Paratrichodorus minor as influenced by nematode and Pythium arrhenomanes infestation levels in the 1997 experiment. Nematode infestation levels were 495 (1x) and 4,950 (10x) nematodes per pot (inoculum was 27% Tylenchorhynchus annulatus, 69% Mesocriconema xenoplax and 3% Paratrichodorus minor), and Pythium arrhenomanes infestation levels were 22 or 220 g of inoculum mixture per pot. Within each Pythium level, bars with the same letter indicate means that do not differ significantly ($P \leq 0.05$) according to Tukey's HSD test.
Fig. 2.4. Reproduction of Tylenchorhynchus annulatus, as influenced by nematode and Pythium arrhenomanes infestation levels in the 1997 experiment. Nematode infestation levels were 495 (1x) and 4,950 (10x) nematodes per pot (inoculum was 27% Tylenchorhynchus annulatus, 69% Mesocriconema xenoplax and 3% Paratrichodorus minor), and Pythium arrhenomanes infestation levels were 22 or 220 g of inoculum mixture per pot. Within each Pythium level, bars with the same letter indicate means that do not differ significantly ($P \leq 0.05$) according to Tukey's HSD test.
Table 2.7. Colonization of sugarcane roots by *Pythium arrhenomanes* as influenced by nematode (N) and *P. arrhenomanes* (P) infestation levels and temperature (T) in greenhouse experiments, 1996-98.

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Data are means of six replicates. For each factor and column, * and ** indicate differences at P < 0.05 and 0.01, respectively; NS indicates that means are not significantly different. For treatments with three levels, means followed by the same letter are not different (P < 0.05), according to Tukey’s HSD test.

<sup>a</sup> Infestation levels for 1996, 1997, and 1998 were: (1x) 491, 495, and 495 nematodes per pot; (10x) 4,910, 4,950, and 4,950 nematodes per pot, respectively. Ratios of *Tylenchorynchus annulatus* : *Mesocricicnema xenoplax* : *Paratrichodorus minor* in inocula were 35:58:6 in 1996, 28:69:3 in 1997, and 42:46:12 in 1998.

<sup>b</sup> 22 and 220 g of inoculum mixture containing *Pythium arrhenomanes*. 

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As was the case for nematodes, colonization of sugarcane roots by *P. arrhenomanes* was greater at the low *Pythium* infestation level in 1996 and 1998. Additionally, colonization was greater at 20 °C than at 30 °C.

**Discussion**

*Tylenchorhynchus annulatus* (Birchfield and Martin, 1956; Roman, 1968; Gargantiel and Davide 1973) and *P. minor* (Apt and Koike, 1962) have both been shown to be pathogenic to sugarcane. However, research evaluating the impact of polyspecific nematode communities on the growth and yield of sugarcane has not been documented even though sugarcane soil virtually always contains multiple nematode species (Muir and Henderson, 1926; Fielding and Hollis, 1956; Roman, 1968; Spaull, 1981; Hall and Irey, 1990). During the course of these studies, eight individual experiments evaluating the damage potential of this combination of nematodes were conducted. In every case, nematodes were shown to cause significant injury to sugarcane. In the greenhouse environment, damage caused by nematodes was most severe, and reductions averaged 50 - 60% across experiments and cultivars. In microplots, nematodes reduced top and root weights by 12% and 20%, respectively. Since experiments evaluating the individual damage potential of the three nematodes were not conducted, the relative damage caused by each species cannot be accurately assessed.

In greenhouse studies, all five cultivars were shown to be susceptible to nematode damage. The degree of susceptibility differed among the five cultivars with the LCP cultivars being most affected by nematodes. In these studies, the nematode community at harvest contained populations of the three nematodes in approximately equal densities. In microplots, the final nematode community was almost 95% *T. annulatus*. Differences in the magnitude of damage and the nematode community...
structure between the two environments were probably most closely related to
differences in soil type and growing conditions. The soil used in the microplot tests
was a Commerce silt loam, that is typical for sugarcane production. Soil used in the
greenhouse environment was three parts Convent silt loam and one part sand, a mixture
which optimizes nematode reproduction. The latter soil type favors reproduction of all
three nematodes. However, trichodorids (Winfield and Cooke, 1975; Hall and Irey,
1990) are more prevalent in sandier soils than finer texture soils, and Tylenchorhynchus
spp. generally are numerous in loam and clay soils (Hu et al., 1968; Hall and Irey,
1990). Mesocrictonema spp. generally are widespread regardless of soil type (Hall and

Results from microplot experiments suggest that the pathogenic effect on
sugarcane growth due to T. annulatus alone is not as great as that caused by the
complete nematode community. When the three nematode species that comprise most of
the naturally occurring community in sugarcane soils were present at approximately
equal levels, their combined effect on plant growth was much greater. In one
greenhouse trial currently in progress, top growth of plants grown in soil infested with
T. annulatus are not significantly different from those of non-inoculated controls (Bond,
unpubl.).

In nematological research, there is not always a direct correlation between host
suitability and host sensitivity (Rhode, 1965; Ostenbrink, 1966). In greenhouse
studies, greater sensitivity to nematode damage did not reflect greater host suitability.
The cultivar CP 65-357 supported higher community levels than all other cultivars.
However, it was this cultivar that was one of the least damaged by the nematodes. In
the microplot environment, the cultivar which supported the highest nematode
community level, sustained the greatest amount of root damage.
Pythium arrhenomanes is a production constraint in subtropical sugarcane areas such as the Mississippi delta, which experience winter conditions (Matherne et al., 1977). In Louisiana, root rot caused by P. arrhenomanes has been shown to be both temperature and moisture dependent. Research indicates that when temperatures are between 15-20 °C root rot is more severe. At higher temperatures, symptoms are less severe (Flor, 1930, Rands and Dopp, 1938; and Hoy and Schneider, 1988b). Results from studies detailed herein are in agreement with these findings. In the present study, the greatest reductions in root weight caused by P. arrhenomanes occurred in 1996 and averaged 83% across both Pythium infestation levels. The 1996 test was initiated in January and the 1997 and 1998 tests were initiated in March and May, respectively. Reductions in root weight in 1997 and 1998 averaged 27% and 64%, respectively.

Research evaluating the influence of nematodes on the severity of root rot caused by P. arrhenomanes on sugarcane or on any other crop is lacking. However, interactions between other Pythium species and nematodes that influence plant growth have been documented as additive, synergistic, and antagonistic. Root rot on sugar-beet caused by Pythium ultimum Trow. was more severe in the presence of Heterodera schachtii Schmidt. However, in these same studies, the interaction of this nematode and another species of Pythium, P. aphanidermatum (Eds.) Fitz., was shown to be additive (Whitney, 1974). Colonization of chilli roots by P. aphanidermatum was shown to be increased by prior infection with Meloidogyne incognita (Kofoid & White) Chitwood. Additionally, root colonization by P. aphanidermatum reduced resistance of chilli to M. incognita (Hasan, 1985). However, infection of ginger roots by M. incognita prevented P. aphanidermatum from causing root rot (Doshi and Mathur, 1987). Meloidogyne hapla (Kofoid & White) Chitwood exacerbated the loss of alfalfa seedlings to P. ultimum (Townshend, 1984) and increased root rot severity on peanut when together with Pythium myriotylum Drechs. (Garcia and Mitchell, 1975).
On sugarcane, interactions between nematodes and *Pythium graminicola* Subr. have been demonstrated. Valle-Lamboy and Ayala (1980) indicated that *M. incognita*, *Pratylenchus zeae* Graham, and *P. graminicola* separately reduced the growth of sugarcane. However, when soil was infested with either nematode species and *Pythium* in combination, the effect on plant growth was less than additive. The species *P. arrhenomanes* and *P. graminicola* are so similar in morphology and ecology (Van der Platts-Niterink, 1981) that it is possible some confusion in identification has occurred in the literature. Birchfield and Martin (1956) indicated that the pathogenicities of *T. annulatus* and *P. arrhenomanes* were independent of one another on sugarcane, although no data were presented to support this contention. Results of this study are in contrast to this report. In the present study, interactions between the nematode community and *P. arrhenomanes* were antagonistic. The sum of damage caused separately by the nematodes and *P. arrhenomanes* was greater than damage caused when both organisms were together.

Antagonistic interactions such as those observed between *P. arrhenomanes* and nematodes in this work, can be explained by destruction or competition for available root space, or by fungal production of nematicidal or nematistatic metabolites (Evans and Haydock, 1993). *Tylenchorhynchus annulatus* (Johnson, 1970), *P. minor* (Apt and Koike, 1962) and *P. arrhenomanes* (Hendrix and Campbell, 1973) all parasitize young root tissue and therefore may compete for the same feeding sites. In all trials of this experiment, *P. arrhenomanes* was added to the soil just prior to the addition of the sugarcane cuttings, and nematodes were added 72 hours after transplanting. It is possible that this sequence of infestation provided *P. arrhenomanes* with a competitive advantage over the nematodes. Research indicating the rate at which *P. arrhenomanes*
infects and successfully colonizes host tissue is lacking. However, in the present study, *P. arrhenomanes* inoculum contained actively growing mycelium capable of immediate direct infection or developing sporangia within 24 hours. All three of the nematodes included in this study require at least 72 hours to establish a parasitic relationship on sugarcane (E. C. McGawley, pers. comm.). Therefore, the antagonistic interaction that was detected could have resulted from *Pythium* destroying or altering root tissue rendering it less suitable for the nematodes. A final possible factor affecting the interactions between *P. arrhenomanes*, nematodes, and sugarcane would be limitations imposed by the experimental system. Substantial damage to the plant root systems occurs in greenhouse pathogenicity tests. In order for the effects of *P. arrhenomanes* and nematodes to be additive, nearly the entire root system would have to be destroyed, and given the characteristics of infection of both pathogens, this would be unlikely.

This work constitutes the first report that *P. arrhenomanes* influences nematodes on sugarcane or any other crop. Nematode reproduction has been shown to be either reduced (Santo and Holtzman, 1970; Lanjewar and Shukla, 1985; Hasan, 1985) or unaffected (Valle Lamboy and Ayala, 1980) by several other *Pythium* species. In the present study, reproduction and final densities of the *T. annulatus* and *M. xenoplax* were consistently reduced by *P. arrhenomanes*. However, *Pythium* had variable effects on population densities of *P. minor*; in the presence of *P. arrhenomanes*, *P. minor* populations were greater in 1996, reduced in 1997, and unaffected in 1998. Interactions that were antagonistic to nematode reproduction in 1996 appear to be directly related to the lack of available substrate caused by *P. arrhenomanes* related root damage. In 1997, and to a lesser extent in 1998, root weights were reduced by *P. arrhenomanes*, but the amount of visible discoloration and root system destruction were less than that observed in 1996. In these two years, reductions in nematode populations
may have resulted not only from competition with *P. arrhenomanes* for feeding sites but also from alteration of the nutritional substrate. Toxic metabolites are known to be produced by this fungus (Mojdhi et. al., 1990). Whether or not *P. arrhenomanes* directly or indirectly effects nematode reproduction is a topic currently under investigation.

The effects of nematodes on root colonization by *P. arrhenomanes* have not been investigated. Brodie and Cooper (1964) indicated that sporangial production and root colonization of *Pythium debaryanum* Hesse in cotton were enhanced by the presence of *M. incognita*. Conversely, Valle-Lamboy and Ayala (1980) indicated that as a result of root damage caused by *M. incognita*, colonization by *P. graminicola* was inhibited. The data from the 1996 trial is in agreement with the work of Valle-Lamboy and Ayala. In this study, reduced colonization by *P. arrhenomanes* was observed only at the high nematode infestation level suggesting a high level of nematode infection is necessary to inhibit *Pythium*.

As evidenced by all studies represented herein, nematodes are significant constraints to the production of sugarcane in Louisiana. Previously, it has been assumed that the 14 year duration breeding program in Louisiana would eliminate cultivars highly susceptible to unknown soil factors, biotic and abiotic. This may not be the case, especially with nematodes. Greenhouse and microplot tests highlight the need to incorporate nematode screening activities into sugarcane cultivar selection in Louisiana. Most of the current cultivars used in sugarcane production in Louisiana are susceptible to nematodes. Currently, the best nematode management strategy available is to incorporate a fallow season in the crop cycle. Even though this tactic is currently employed by many producers, it is not uncommon to find fields in the fallow cycle that are infested with numerous weed species. Many of these weed species are excellent
hosts for the nematodes and provide a means of bridging the fallow period during spring and summer. Research conducted by Birchfield and Martin (1956) showed that many weeds in sugarcane fields, especially johnsongrass (Sorghum halepense L. Pers.), are excellent hosts for nematodes.

Based on evidence from this and previous studies, there is a very strong indication that nematodes are a factor in sugarcane stubble decline in Louisiana. Research evaluating sugarcane growth parameters as influenced individually by T. annulatus, M. xenoplax, and P. minor is currently in progress.

**Literature Cited**


CHAPTER 3

DISTRIBUTION OF PLANT PARASITIC NEMATODES
ON SUGARCANE IN LOUISIANA AND
EFFICACY OF NEMATICIDES

43
Introduction

Sugarcane, interspecific hybrids of *Saccharum* L., is a major agricultural crop that is produced worldwide in tropical and subtropical climates. In Louisiana, over 170,000 hectares in 23 parishes are cropped to sugarcane each year. In 1998, sugarcane was the most valuable row crop in Louisiana with an estimated value of 500 million dollars (Anonymous, 1998).

In Louisiana, sugarcane crops are planted in August and September by vegetative propagation. Initial shoot growth is terminated by winter conditions. However, growth resumes in the spring, and the crop is harvested in November and December. From initial plantings, two or three ratoon crops may be obtained in successive years. A disease complex, known as stubble decline, is responsible for reductions in the ratooning ability of the crop (Edgerton et al., 1934; Edgerton, 1939). Major biotic and abiotic factors involved in this complex include: winter stress, physiological status of the plant at harvest, cultivar genotype, weed competition, and diseases, such as Pythium root rot (Edgerton et al., 1929), caused by *Pythium arrhenomanes* Drechs. (Rands and Dopp, 1938; Hoy and Schneider, 1988), and ratoon stunting disease, caused by *Clavibacter xyli* subsp. *xyli* (Davis et al., 1980). Recent evidence indicates that nematodes also play a role in this decline (Bond et al., unpubl.).

Numerous nematode genera have been shown to be pathogenic to sugarcane with *Meloidogyne* and *Pratylenchus* being the most important worldwide (Birchfield, 1984; Spaull and Cadet, 1990). Many researchers have demonstrated that nematode communities in sugarcane fields generally are comprised of numerous endoparasitic and ectoparasitic species (Muir and Henderson, 1926; Fielding and Hollis, 1956; Spaull, 1981; Hall and Irey, 1990). Population dynamics studies have characterized nematode populations in sugarcane soil and have demonstrated that monoculturing of sugarcane
can foster the accumulation of diverse nematode communities (Spaull and Cadet, 1990; Hall and Irey, 1990). In Louisiana, recent greenhouse and microplot studies have demonstrated that most sugarcane cultivars are susceptible to nematode communities found in sugarcane soil (Bond et al., 1997).

Management of phytoparasitic nematodes with nematicides is common in many sugarcane production areas of the world. In South Africa, nematicide applications in sandy soil provide significant increases in yield, which justify their use (Spaull et al., 1990; Spaull and Cadet, 1991). However, Spaull and Cadet (1990) state that nematodes reduce the yield of sugarcane across a variety of soil types and that more research is needed to evaluate nematicide efficacy in heavier soils. Currently, chemicals are not intentionally used for control of nematodes in sugarcane in Louisiana. However, several pesticides used for insect control such as carbofuran and phorate have nematicidal activity.

The objectives of this work were to: (i) determine the frequency and distribution of nematode genera and species in sugarcane soils of Louisiana, (ii) compare nematode population densities in plant and ratoon sugarcane crops, and (iii) evaluate the efficacy of current nematicides labeled for use on sugarcane.

Materials and Methods

Nematode Survey.

Sugarcane fields were sampled from May 1995 through August 1998. Nine parishes were selected to represent the sugarcane production region of Louisiana. All fields from which a sample was collected have a long history of sugarcane production. A total of 93 samples were collected. Additional criteria for site selection included cultivar and crop cycle year. Each sample was a composite of 45 soil cores (2.5-cm-diam. x 30-cm-deep) collected from a 2.0 ha subsection of the field. Nematodes were
extracted from 150 g of soil by wet-sieving through nested 250 μm-pore and 38 μm-pore sieves followed by sugar flotation and centrifugation (Jenkins, 1964). Root pieces collected on the 250 μm-pore sieve were placed on a Baerman funnel for extraction of endoparasitic nematodes.

Nematicide Trials.

Nematicide trials were conducted at two sites in 1995 and 1997. In 1995, sites in St. James and Ascension Parishes were selected to represent light sandy and heavier clay loam soils, respectively. In 1997, a site in St. James Parish with a sandy soil and a site in Iberville Parish with a heavy clay soil were employed for the nematicide studies. In each year, trials were initiated in September and harvested 15 months later in December. At all sites, plots consisted of six 1.8-m-wide x 22.9-m-long rows. Chemical treatments were applied individually to each row. Data were collected from the center 15.2 m of each of the four center rows.

Treatments were arranged in a randomized complete block design with five replications. Treatments consisted of the nematicides aldicarb (Temik 15 G, Rhone-Poulenc, Research Triangle Park, NC) applied at 4.21 kg a.i./ha and ethoprop (Mocap 20 G, Rhone-Poulenc, Research Triangle Park, NC) applied at 4.71 kg a.i./ha, and the insecticide phorate (Thimet 20 G, American Cyanamid, Parsippany, NJ) at 4.09 kg a.i./ha, and a nontreated control. Granular chemicals were applied at planting in a 18-cm band directly over the cane stalks in open rows. Tractor mounted chisels covered the rows and incorporated the chemicals to a depth of 25 to 30 cm. Following chemical application, all trials were managed and harvested according to conventional sugarcane production methods. Cultivar LCP 82-89 was used in all trials except in the St. James Parish trial in 1997 where LCP 85-384 was employed.

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At harvest, the number of millable stalks was counted in each plot. Additionally, 15 stalks were harvested from each plot and weighed to estimate stalk weight. The stalk weight and the number of stalks were then used to estimate cane tonnage per hectare. The stalk bundles were then transported to the Sucrose Lab at the Sugar Research Station of the Louisiana Agricultural Experiment Station to determine the percentage of sucrose per stalk. The sucrose content and tonnage estimates were then used to calculate the yield of sucrose per hectare. To estimate nematode populations, a composite of 30 soil cores (2.5-cm-diam. x 30-cm-deep) were collected from each plot, and a 150 g subsample was processed as described for the field survey. In trials initiated in 1995, soils samples were collected to estimate nematode populations two months after planting and again at harvest. In the 1997 trials, nematode populations were estimated only at two months after planting.

Data Analysis.

Since there were year by treatment and site by treatment interactions, data for each test and year are presented separately. Data were subjected to analysis of variance using the General Linear Models procedure of the Statistical Analysis System version 6.12 for Macintosh (SAS Institute Inc., Cary, NC). Means were separated with Duncan's Multiple-Range Test, and all differences noted are significant at $P \leq 0.05$.

Results

Nematode Survey.

Nematode species in six genera were found with varying frequencies in the nine parishes included in the survey (Fig. 3.1; Table 3.1). Across parishes, Helicotylenchus spp., spiral nematodes, were found in 30% of the samples and detection ranged from a low of 11% in St. John Parish to a high of 80% in Point Coupee Parish. Of the six genera, Meloidogyne spp., root-knot nematodes, were detected with the least frequency...
Fig. 3.1. Sugarcane production in Louisiana. Highlighted are the twenty-three parishes of Louisiana which produce sugarcane. Parishes which contain a dot were included in the nematode survey during the period 1995-98.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascension</td>
<td>46.0</td>
<td>7.6</td>
<td>76.9</td>
<td>38.4</td>
<td>76.9</td>
<td>92.3</td>
</tr>
<tr>
<td>Assumption</td>
<td>0.0</td>
<td>0.0</td>
<td>62.5</td>
<td>25.0</td>
<td>87.5</td>
<td>75.0</td>
</tr>
<tr>
<td>Iberville</td>
<td>37.5</td>
<td>0.0</td>
<td>100.0</td>
<td>58.3</td>
<td>91.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Point Coupee</td>
<td>80.0</td>
<td>40.0</td>
<td>100.0</td>
<td>100.0</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>St. James</td>
<td>12.5</td>
<td>12.5</td>
<td>100.0</td>
<td>68.8</td>
<td>50.0</td>
<td>100.0</td>
</tr>
<tr>
<td>St. John</td>
<td>11.1</td>
<td>33.3</td>
<td>100.0</td>
<td>88.8</td>
<td>66.6</td>
<td>100.0</td>
</tr>
<tr>
<td>St. Mary</td>
<td>0.0</td>
<td>0.0</td>
<td>100.0</td>
<td>0.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Terrebone</td>
<td>40.0</td>
<td>0.0</td>
<td>80.0</td>
<td>40.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>West Baton Rouge</td>
<td>41.6</td>
<td>0.0</td>
<td>91.6</td>
<td>33.3</td>
<td>83.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Average</td>
<td>29.6</td>
<td>7.1</td>
<td>87.7</td>
<td>57.1</td>
<td>75.5</td>
<td>91.2</td>
</tr>
</tbody>
</table>

* Ninety-three samples were collected from nine parishes, and each county or parish was represented by approximately 10 samples.
occurring in only four of the nine parishes. In samples collected, detection of root-knot nematode varied from 13% in St. James Parish to 40% in Point Coupee Parish. Mesocriconema spp., ring nematodes, were detected with great frequency and occurred in 88% of the samples across all parishes. In 57% of the samples collected, Paratrichodorus spp., stubby-root nematodes, were detected. Among the nine parishes, detection ranged from 25% in Assumption Parish to 100% in Point Coupee Parish. Seventy-five percent of the samples contained Pratylenchus spp., lesion nematodes. Samples from St. James Parish had the lowest incidence, 50%, while 100% of the samples collected in St. Mary Parish and Terrebonne Parish contained Pratylenchus spp. Tylenchorhynychus spp., stunt nematodes, were found with the greatest frequency. In six of the nine parishes, this nematode was present in 100% of the samples collected.

Across all four stages of the crop cycle, species in the genera Mesocriconema and Tylenchorhynychus were most abundant (Table 3.2). Individually, totals for Mesocriconema spp. and the nematode community were greater in second and third ratoon crops as compared with plant cane and first ratoon crops. Additionally, densities of Tylenchorhynychus spp. were higher in third ratoon as compared with the plant cane crop.

Nematicide Trials.

In nematicide trials harvested in 1996, sugarcane yield was increased by the chemical treatments (Table 3.3). At the St. James site, the number of millable stalks was increased by each of the three chemicals. The magnitudes of the increase were similar for both aldicarb and phorate applications. The yield increase provided by aldicarb was greater than that for ethoprop. The only increase in cane tonnage at this site was the 13% observed for aldicarb. Both nematicides, aldicarb and ethoprop, increased the yield of sucrose by 15% and 12%, respectively. At the Ascension site,
Table 3.2. Phytoparasitic nematodes found in plant and ratoon sugarcane crops in Louisiana between May, 1995 and August, 1998.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Cane</td>
<td>10 a</td>
<td>126 b</td>
<td>20 a</td>
<td>60 a</td>
<td>129 b</td>
<td>345 b</td>
</tr>
<tr>
<td>1st Ratoon</td>
<td>17 a</td>
<td>208 b</td>
<td>19 a</td>
<td>44 a</td>
<td>153 bc</td>
<td>440 b</td>
</tr>
<tr>
<td>2nd Ratoon</td>
<td>10 a</td>
<td>323 a</td>
<td>47 a</td>
<td>62 a</td>
<td>221 ab</td>
<td>663 a</td>
</tr>
<tr>
<td>3rd Ratoon</td>
<td>15 a</td>
<td>414 a</td>
<td>36 a</td>
<td>52 a</td>
<td>249 ab</td>
<td>767 a</td>
</tr>
</tbody>
</table>

Ninety-three samples were collected from nine parishes and data are means per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan’s Multiple-Range Test.
Table 3.3. Sugarcane stalk population, tonnage, and sucrose yields as influenced by aldicarb, ethoprop, and phorate in St. James and Ascension Parishes, 1996.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>St. James&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Ascension&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Millable stalks/ha</td>
<td>Cane (tons/ha)</td>
</tr>
<tr>
<td>Control</td>
<td>94,738 c</td>
<td>111.0 b</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>103,351 a</td>
<td>127.7 a</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>100,115 b</td>
<td>118.1 b</td>
</tr>
<tr>
<td>Phorate</td>
<td>101,358 ab</td>
<td>116.4 b</td>
</tr>
</tbody>
</table>

|           | Millable stalks/ha     | Cane (tons/ha)          | Sucrose (kg/ha) |
| Control   | 83,603 b               | 81.3 a                  | 8,662 a         |
| Aldicarb  | 92,086 a               | 89.7 a                  | 9,155 a         |
| Ethoprop  | 87,917 ab              | 87.9 a                  | 9,227 a         |
| Phorate   | 94,720 a               | 91.2 a                  | 9,491 a         |

<sup>a</sup> Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

<sup>b</sup> Data are means of five replications. Within each site and parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan's Multiple-Range Test.
yield increases due to chemical treatments were less pronounced. Aldicarb and phorate increased the number of millable stalks by 9% and 11%, respectively, over that of controls. On average, all chemical treatments increased cane tonnage by 10% and yield of sucrose by 7%, however, these increases were not statistically significant.

Increases in sugarcane yield were concomitant with reductions in nematode populations. Two months after planting, the nematode community at the St. James site contained nematodes in five genera (Table 3.4). When compared with the control, aldicarb reduced levels of stunt nematodes. However, both aldicarb and ethoprop reduced population levels of ring nematodes as well as the total nematode community. Aldicarb and ethoprop reduced the nematode community level by an average of 34%. At harvest (Table 3.5), the total nematode community density in nontreated controls was approximately three times greater than that observed two months after planting (Table 3.4). The effects that the nematicides had on ring and stunt nematode populations two months after planting (Table 3.4) were not apparent at harvest, approximately one year later (Table 3.5). However, reductions in stubby-root nematode populations in aldicarb treated plots were apparent at harvest, and aldicarb effects on the density of the entire community were still detectable 15 months after planting. The density of the community in nontreated plots was 35% higher than those in plots treated with aldicarb.

Unlike the St. James site, the nematode community at the Ascension site did not contain root-knot or lesion nematodes (Table 3.6). In the heavier soil at this site, nematicides were not as effective in managing nematode populations. Population densities of ring, stubby-root, and stunt nematodes present in the soil in treated plots were not different from those of controls. Only the application of aldicarb reduced the community density two months after planting. At harvest, in the Ascension Parish test (Table 3.7), populations densities of ring, stubby-root, and stunt nematodes in treated
Table 3.4. Plant parasitic nematode populations as influenced by aldicarb, ethoprop, or phorate at the St. James site two months after planting, 1995.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lesion</th>
<th>Ring</th>
<th>Root-knot</th>
<th>Stunt</th>
<th>Stubby-root</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11 a</td>
<td>243 a</td>
<td>8 a</td>
<td>115 a</td>
<td>28 a</td>
<td>405 a</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>15 a</td>
<td>166 b</td>
<td>8 a</td>
<td>52 b</td>
<td>20 a</td>
<td>261 b</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>10 a</td>
<td>133 b</td>
<td>10 a</td>
<td>95 ab</td>
<td>26 a</td>
<td>274 b</td>
</tr>
<tr>
<td>Phorate</td>
<td>15 a</td>
<td>187 ab</td>
<td>8 a</td>
<td>67 ab</td>
<td>31 a</td>
<td>308 ab</td>
</tr>
</tbody>
</table>

* Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

*b Data are means of five replications. Nematodes per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan’s Multiple-Range Test.

Table 3.5. Plant parasitic nematode populations as influenced by aldicarb, ethoprop or phorate at the St. James site at harvest, 1996.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lesion</th>
<th>Ring</th>
<th>Root-knot</th>
<th>Stunt</th>
<th>Stubby-root</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>90 a</td>
<td>611 a</td>
<td>118 a</td>
<td>256 a</td>
<td>258 a</td>
<td>1332 a</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>62 a</td>
<td>381 a</td>
<td>79 a</td>
<td>165 a</td>
<td>167 b</td>
<td>854 b</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>67 a</td>
<td>453 a</td>
<td>96 a</td>
<td>271 a</td>
<td>210 b</td>
<td>1096 ab</td>
</tr>
<tr>
<td>Phorate</td>
<td>81 a</td>
<td>515 a</td>
<td>128 a</td>
<td>253 a</td>
<td>239 ab</td>
<td>1216 ab</td>
</tr>
</tbody>
</table>

* Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

*b Data are means of five replications. Nematodes per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan’s Multiple-Range Test.
Table 3.6. Plant parasitic nematode populations as influenced by aldicarb, ethoprop, or phorate at the Ascension site two months after planting, 1995.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ring&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stunt&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stubby-root&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Total&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>98 a</td>
<td>86 a</td>
<td>22 a</td>
<td>206 a</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>76 a</td>
<td>52 a</td>
<td>15 a</td>
<td>143 b</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>91 a</td>
<td>76 a</td>
<td>17 a</td>
<td>185 ab</td>
</tr>
<tr>
<td>Phorate</td>
<td>111 a</td>
<td>51 a</td>
<td>20 a</td>
<td>182 ab</td>
</tr>
</tbody>
</table>

<sup>a</sup> Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

<sup>b</sup> Data are means of five replications. Nematodes per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan's Multiple-Range Test.

Table 3.7. Plant parasitic nematode populations as influenced by aldicarb, ethoprop, or phorate, at the Ascension site at harvest, 1996.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lesion&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Ring&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stunt&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stubby-root&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Total&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>67 a</td>
<td>481 a</td>
<td>238 a</td>
<td>62 a</td>
<td>849 a</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>81 a</td>
<td>434 a</td>
<td>143 a</td>
<td>47 a</td>
<td>706 a</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>72 a</td>
<td>420 a</td>
<td>281 a</td>
<td>81 a</td>
<td>854 a</td>
</tr>
<tr>
<td>Phorate</td>
<td>82 a</td>
<td>376 a</td>
<td>305 a</td>
<td>52 a</td>
<td>815 a</td>
</tr>
</tbody>
</table>

<sup>a</sup> Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

<sup>b</sup> Data are means of five replications. Nematodes per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan's Multiple-Range Test.
plots were not different from those in the control plots. At this interval, lesion nematodes were detected, but densities in treated and nontreated plots also did not differ significantly.

In 1998, yield increases (Table 3.8) were similar to those observed in 1996 (Table 3.3). At the St. James site, when compared with the control, aldicarb increased the number of millable stalks, cane tonnage, and the yield of sucrose by 11%, 12%, and 18%, respectively. In the heavier soil of Iberville Parish, yield increases were similar to those observed at the Ascension site in 1996, in which only the number of millable stalks was increased. The number of millable stalks was numerically greater in the aldicarb treated plots. However, this number was not different from those estimated from control or ethoprop treated plots. Both cane tonnage and yield of sucrose were apparently unaffected by chemical treatments.

Increases in sugarcane yield at the St. James site in 1998 also were concomitant with reductions in nematode populations (Table 3.9). The nematode community was comprised primarily of ring and stunt nematodes. When compared to the nontreated control, population densities of stunt nematodes and the community density were reduced in aldicarb treated plots by 45% and 26%, respectively. At the Iberville site, the chemical treatments did not have significant effects on the individual populations of lesion, ring, or stunt nematodes or the total nematode community (Table 3.10).

**Discussion**

Results from the survey demonstrate the diversity of nematode communities in the sugarcane soils of Louisiana. Samples were obtained from fields that differed with regard to cultivar and weed spectrum; however, variation in the detection of the nematode species was apparently most closely related to differences in soil types. *Meloidogyne* spp. (Williams, 1963, Hu and Chu, 1964, and Roman 1968) and
Table 3.8. Sugarcane stalk population, tonnage, and sucrose yields as influenced by aldicarb, ethoprop, and phorate in St. James and Iberville Parishes, 1998.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>St. James $^b$</th>
<th></th>
<th>Iberville $^b$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Millable stalks/ha</td>
<td>Cane (tons/ha)</td>
<td>Sucrose (kg/ha)</td>
<td>Millable stalks/ha</td>
</tr>
<tr>
<td>Control</td>
<td>117,822 b</td>
<td>130.2 b</td>
<td>13,562 b</td>
<td>74,796 ab</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>133,111 a</td>
<td>149.3 a</td>
<td>16,568 a</td>
<td>79,227 a</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>123,318 ab</td>
<td>139.6 ab</td>
<td>15,415 ab</td>
<td>73,205 ab</td>
</tr>
<tr>
<td>Phorate</td>
<td>124,630 ab</td>
<td>131.7 ab</td>
<td>15,297 ab</td>
<td>71,213 b</td>
</tr>
</tbody>
</table>

$^a$ Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

$^b$ Data are means of five replications. Within each site and parameter, means followed by the same letter are not different ($P \leq 0.05$), according to Duncan’s Multiple-Range Test.
Table 3.9. Plant parasitic nematode populations as influenced by aldicarb, ethoprop or phorate at the St. James site two months after planting, 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ring&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stunt&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stubby-root&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Total&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>209 a</td>
<td>136 a</td>
<td>38 a</td>
<td>384 b</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>185 a</td>
<td>74 b</td>
<td>24 a</td>
<td>283 a</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>206 a</td>
<td>92 ab</td>
<td>28 a</td>
<td>326 ab</td>
</tr>
<tr>
<td>Phorate</td>
<td>221 a</td>
<td>118 ab</td>
<td>30 a</td>
<td>369 ab</td>
</tr>
</tbody>
</table>

<sup>a</sup> Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

<sup>b</sup> Data are means of five replications. Nematodes per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan's Multiple-Range Test.

Table 3.10. Plant parasitic nematode populations as influenced by aldicarb, ethoprop, or phorate at the Iberville site two months after planting, 1997.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lesion&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Ring&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stunt&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Total&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>57 a</td>
<td>162 a</td>
<td>108 a</td>
<td>327 a</td>
</tr>
<tr>
<td>Aldicarb</td>
<td>51 a</td>
<td>133 a</td>
<td>100 a</td>
<td>284 a</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>59 a</td>
<td>138 a</td>
<td>108 a</td>
<td>305 a</td>
</tr>
<tr>
<td>Phorate</td>
<td>60 a</td>
<td>156 a</td>
<td>120 a</td>
<td>336 a</td>
</tr>
</tbody>
</table>

<sup>a</sup> Aldicarb 15 G, ethoprop 20 G, and phorate 20 G were applied at planting in a 18-cm band directly over stalks at rates of 4.21, 4.71, and 4.09 kg a.i./ha, respectively. Each chemical was incorporated with tractor mounted chisels to a depth of 24 to 30 cm.

<sup>b</sup> Data are means of five replications. Nematodes per 150 g of soil. Within each parameter, means followed by the same letter are not different (P ≤ 0.05), according to Duncan's Multiple-Range Test.
**Paratrichodorus** spp. (Winfield and Cooke, 1975) have been found to occur most commonly in soils with a low clay content. In this survey, *Meloidogyne* spp. and *Paratrichodorus* spp. were found with the greatest frequency in samples collected from Point Coupee, St. James, and St. John Parishes. The majority of the samples obtained from these parishes had a high sand content. *Pratylenchus* spp. were found with the greatest frequency in heavy, muck soils (Hall and Irey, 1990). In this survey, the lowest detection of *Pratylenchus* spp. was in Point Coupee, St. James and St. John Parishes, and the highest detection was in St. Mary and Terrebonne parishes. Samples collected from St. Mary and Terrebonne Parishes had a higher clay content than did all other samples. *Tylenchorhynchus* spp. and *Mesocricicnema* spp. were reported to reproduce well across a variety of soil types (Hall and Irey, 1990). In this study, across all parishes and soil types, species in these two genera were found with great frequency and at high population levels.

In Florida, (Hall and Irey, 1990) nematode community levels were lower in younger plant cane crops when compared with ratoon crops. In older plant cane, however, population densities were similar to those found in ratoon crops. Additionally, nematode populations were much greater in sugarcane that was planted immediately after the harvest of the final ratoon crop as compared to that planted following a fallow season. In Barbados, monoculturing of sugarcane is known to lead to higher community densities in ratoon crops than in plant cane (Cadet and de Boer, 1990). In the present work, community densities were similar in the plant cane and first ratoon crops. However, both the second and third ratoon crops supported significantly higher community levels than either the plant cane or first ratoon crops.

In Louisiana, Birchfield (1969) was the first to report yield increases in sugarcane as a result of aldicarb and ethoprop applications. He demonstrated that
applying nematicides at planting would reduce nematode populations and increase the
yield of sucrose by 10-19%; however, the differences in yield were not significant. In
other sugarcane growing regions of the world, increases in sugarcane yield by aldicarb
have been demonstrated. In Australia, Bull (1981) demonstrated that cane tonnage
could be increased by 700% following application with aldicarb. In South Africa,
applying aldicarb at planting led to a 50% increase in cane tonnage (Donaldson, 1985).
In the present trials, soil at both sites in St. James consisted of a high sand content, and
aldicarb application increased cane tonnage and yield of sucrose by 13% and 17%,
respectively. Ethoprop increased the yield of sucrose in only the 1995 trial in St. James
parish.

Spaull and Cadet (1990) reported that in soils with a high clay content 7-15%,
yield increases as a result of aldicarb treatment were more variable. Research conducted
at the Sugar Research Station agreed with the report of Spaull and Cadet. Treatment
with aldicarb produced only slight increases in cane tonnage, however there were no
significant increases in the yield of sucrose (Dr. C. Overstreet, pers. comm.). In the
present studies, results obtained from the sites with the heavier soil type, were similar
with that of Spaull and Cadet, and Overstreet. At the Ascension site, the only parameter
that was increased in aldicarb-treated plots was the number of millable stalks.
However, at the Iberville site, sugarcane yield was not increased in aldicarb treatments
over that of the control.

The efficacy of nematicides as a management tool for nematodes in sugarcane
production systems has been well documented. The suppression of nematodes
populations can last only a few months (Birchfield, 1969; Showler et al., 1991) or can
persist until harvest (Chandler, 1980; Cadet, 1985). In the present trials, both types of
suppression were observed. In the 1995 and 1997 trials in St. James Parish, nematode
populations were reduced by the nematicides at two months after planting. In the 1995 trial, nematodes were assayed at harvest, and the suppression in nematode populations detected two months after planting were still apparent at harvest, 15 months later. At the Ascension site in 1995, the nematode community level was suppressed in the aldicarb treated plots two months after planting; however, community levels at harvest did not differ between treatments. At two months after planting, in the 1997 trial in Iberville Parish, nematode populations were not measurably impacted by the chemical treatments. Therefore, variability in the yield response in these two sites to chemical treatments is apparently related to a lack of nematode control.

Increases in the yield of sucrose averaged 17% at the two sites in St. James Parish. The magnitude of this increase would justify the use of aldicarb when considering the cost of the chemical, application costs, and the current value of United States sugar. Weighing these three factors and assuming an average sucrose yield of 7,846 kg/ha, a producer who owns the production land could expect a net profit of $175.00/ha. If the production land is rented, the producer could expect a net profit of $102.50/ha (Anonymous, 1998). The fact that nematicide efficacy is usually greater in soils with a high sand content than heavier soils is well documented (Donaldson, 1985; Spaull et al., 1990; Spaull and Cadet, 1990, 1991). Only 23% of the sugarcane acreage in Louisiana is planted in lighter soils where a yield increase could be expected. In heavier soils, consistent yield responses were not obtained when nematicides were applied.

Spaull and Cadet (1990) contend that even if increases in plant cane are not detected, the plants will develop a more extensive root system which can lead to yield increases in subsequent ratoon crops. Additionally, the number of ratoon crops might be increased by applying nematicides and reducing nematode populations. Currently,
information on nematicide effects on ratoon crops is lacking in Louisiana. However, due to the expenses involved in replanting after the third ratoon crop, the addition of a ratoon crop in the crop cycle would be a substantial benefit to sugarcane producers. Therefore, research is needed to address the effect of nematicides on ratoon crops and the potential to increase the number of ratoon crops.

At present, nematode resistant or tolerant cultivars and crop rotations are not viable nematode management strategies for sugarcane production in Louisiana. Nematode resistant cultivars are not available and the value of rotational crops, such as soybean and cotton, do not justify their incorporation into the sugarcane production system. Based on the results from these studies, aldicarb could be implemented into sugarcane production on a limited basis in Louisiana. Currently, the best available nematode management strategy is to incorporate a fallow season into the crop cycle. This fallow season which lasts about seven months is an important period in the producers weed management program. However, these data indicate that while nematode populations are significantly reduced following this fallow season, populations rebound and reach damaging levels shortly after planting. The nematode species common in sugarcane fields in Louisiana are not known to possess any resistant life stages. Undoubtedly, nematodes are surviving the fallow period by feeding and reproducing on indigenous weed species. Therefore, a diligent weed management program is the only strategy available to eliminate this “bridging” mechanism.

**Literature Cited**


CHAPTER 4

SUMMARY AND CONCLUSIONS
Extensive nematode sampling has revealed that sugarcane soils in Louisiana contain a complex nematode community comprised of multiple species in six genera. This community is favored by the ratooning process and multiple year crop cycle in sugarcane production. This nematode community usually reaches damaging levels shortly after planting and continues to increase throughout the crop production cycle.

The susceptibility of current sugarcane cultivars to the nematode community was consistently demonstrated in greenhouse, microplot, and field studies. In the greenhouse environment, all three nematodes species reproduced well regardless of cultivar genotype. The LCP cultivars were the most susceptible to nematodes. Cultivars HoCP 85-845 and CP 65-357 also were damaged, but to a lesser extent. In microplot conditions, LCP 82-89 supported greater nematode reproduction than CP 70-321 and was more sensitive to nematode damage.

All aspects of this research underscore the need to incorporate a nematode screening protocol into the Louisiana Sugarcane Breeding Program. Currently, outfield testing sites evaluate cultivar response to specific pathogens, such as: the sugarcane mosaic virus, the sugarcane smut fungus, and the sugarcane borer, across a variety of soil types. At each of these sites, the density and composition of the nematode community should be characterized with respect to nematode genera and density. If these sites do not provide a representative nematode community, it may be necessary to establish separate sites for evaluation of nematodes. Sugarcane is attacked by a multitude of nematode species and identifying cultivars with resistance to individual species is not feasible. However, data from this research demonstrates that there are distinct levels of sensitivity to nematodes among current sugarcane genotypes.

Nematicide trials demonstrated that suppression of nematode populations by chemical means can provide significant increases in sugarcane yield. Aldicarb, and to a
lesser extent, ethoprop reduced nematode populations shortly after planting, the most critical time for root establishment. In lighter soils, nematode suppression by aldicarb persisted until harvest in one trial; and in both trials the yield of sugar was increased an average of 17%. Nematicides were not as efficient in managing nematode populations in heavier soils, resulting in only minimal yield increases.

Research from other sugarcane growing regions indicate that increases in sugarcane yield in plant cane crops can be magnified in ratoon crops. This carry over effect is explained by the plant cane crop establishing a healthier root system and producing a greater number of stalks. Approximately, 20% of the land to which sugarcane is cropped would be considered a “sandy soil” and therefore, suitable for aldicarb application. However, the majority of sugarcane production takes place in heavier soils. Researchers in South Africa and Australia are currently addressing the problem of nematode management in heavier soils. Researchers in Louisiana should probably initiate similar studies.

Environmental conditions that favor reproduction of the nematodes and Pythium arrhenomanes occur at different times. Nematode feeding and reproduction is greatest in warmer temperatures and when the soil is moist but not waterlogged. Pythium arrhenomanes is favored by mild, damp conditions that are characteristic of late fall and portions of winter and early spring months. However, conditions which favor nematodes and Pythium do overlap in two important periods in early spring and late fall. These two periods are critical for early root establishment and recovery from harvesting injury. Results from greenhouse tests support the hypothesis that temperature significantly effects both nematode reproduction and Pythium colonization.

Across tests and temperatures, P. arrhenomanes and nematodes both reduced sugarcane yield. Significant Pythium by nematode interactions occurred in all three
greenhouse tests. These interactions were antagonistic with regards to root dry weight and nematode reproduction. For root dry weights, the sum of the damage caused individually by the nematodes and *P. arrhenomanes* was greater than the effect when both were together. *Pythium arrhenomanes* also consistently exerted an antagonistic influence on nematode reproduction. The nature of this antagonism by *P. arrhenomanes* against nematode is under investigation. Production of toxins by *P. arrhenomanes* during plant infection has been demonstrated. However, the effects of toxins or other metabolites produced by *Pythium* on nematode reproduction has not been evaluated.

In summary, these studies have demonstrated that nematodes are currently significant sugarcane production constraints in Louisiana. Management strategies currently available to reduce nematode populations and communities include the incorporation of a fallow season into the production cycle and the use of nematicides. The gradual, debilitating plant damage caused by nematodes and other soilborne pathogens is often ignored by producers. The sugarcane production cycle relies on monoculturing and fosters the accumulation of root pathogens in the soil. In order to maintain acceptable yields, producers must gain an increased awareness of the importance of soilborne pathogens, including nematodes. This awareness coupled with new sugarcane genotypes and harvesting technologies should strengthen sugar production in Louisiana.
VITA

Jason Payton Bond was born on September 17, 1972 in Hammond, Louisiana. He received his secondary education at Franklinton High School in Franklinton, Louisiana, graduating spring 1990. The following fall of 1990, he entered Southeastern Louisiana University in Hammond, Louisiana, majoring in general biology. He received his Bachelor of Science degree in the spring of 1994, graduating Cum Laude. In the fall of 1994, he entered Louisiana State University and began a masters program in Plant Pathology in the Department of Plant Pathology and Crop Physiology under the direction of Dr. E. C. McGawley. In the spring of 1995, he was awarded a research assistantship and in the fall of 1996, he switched to a doctoral program. He has served as the Vice-President of the Plant Pathology and Crop Physiology Graduate Student Association. Currently he is member of the American Society of Sugar Cane Technologists, American Phytopathological Society and the Society of Nematologists. He is now a candidate for the Doctor of Philosophy degree in Plant Health (Plant Pathology).
DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Jason P. Bond

Major Field: Plant Health

Title of Dissertation: Single and Combined Effects of Nematode Communities and Pythium Arrhenomanes on the Growth and Yield of Sugarcane in Louisiana

Approved:

[Signature]
Major Professor and Chairman

[Signature]
Dean of the Graduate School

EXAMINING COMMITTEE:

[Signature]

[Signature]

[Signature]

Date of Examination:

May 3, 1999