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OCCURRENCE OF PEST NEMATODES IN BURDEKIN AND CENTRAL QUEENSLAND SUGARCANE FIELDS

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Abstract

Five pest nematode species were widespread on sugarcane in central Queensland and the Burdekin region, namely *Pratylenchus zeae, Meloidogyne javanica, Paratrichodorus minor, Helicotylenchus dihystera* and *Tylenchorhynchus annulatus*. However, the Burdekin had a more diverse nematode fauna than central Queensland, as *Pratylenchus coffeae, Tylenchorhynchus claytoni, Achlysiella williamsi* and *Paralongidorus* spp. also occurred in more than 10% of the sites sampled. The most important pests were considered to be *P. zeae* and *M. javanica*, as they were often found at high densities and their pathogenicity on sugarcane is established. High populations of the common species were found in most soil types, apart from *Meloidogyne* spp. which tended to be more common in the sandiest soils. In the Burdekin region, *P. zeae* and *Meloidogyne* spp. tended to be equally as widespread in soils recently developed for sugarcane as in soils of a similar texture under long term sugarcane production.

Introduction

In the Australian sugar industry, sugarcane has been intensively cultivated as a monoculture for more than 80 years in most districts. This production system has contributed to 'yield decline', defined as 'the loss of productive capacity of sugarcane growing soils under long term monoculture' (Garside *et al.*, 1997). Sugarcane planted into 'yield decline' soils typically develops a poor root system, with lesions and rotted roots being apparent (Lawrence, 1984). Following fumigation of these soils, sugarcane yield is improved by 30% or more, due to restored root health and increased root length, thereby implicating soil pathogens as major contributors to the reduced productivity (Magarey and Croft, 1995; Magarey and Grace, 1998). Nematodes are one of the pathogens involved, as yield responses were obtained with soil fumigants that controlled nematodes but not fungal root rots (Chandler, 1984).

The detailed distribution of nematode pests in sugarcane soils is unknown, but there is a general perception within the sugar industry that nematode problems are confined to south Queensland. This perception is based on nematicide use, which has found a commercial niche only in sandy soils in the Bundaberg district (Bull, 1981). However, nematode problems are likely to be much more widely distributed, as crop losses due to nematodes in South Africa are not confined to sands (Spaull, 1995), and surveys in south Queensland have shown that plant-parasitic nematodes are common in all soil types (Blair *et al.*, 1999).

The authors present a survey for nematodes in the Plane Creek, Mackay, Proserpine and Burdekin sugar growing districts of central and north Queensland, where 47% of Queensland's sugarcane is grown. Pest nematodes were quantified and nematode densities compared in different soil types and locations.

Materials and methods

Nematodes were identified and counted in root and soil samples from 307 randomly selected sugarcane fields. In each field, 10 subsamples of soil and roots were collected 0–30 cm from the stool to a depth of about 30 cm over an

KEYWORDS: Nematodes, *Meloidogyne javanica*, *Pratylenchus zeae*, Soil Texture, Sugarcane, Survey.

area of 0.2 hectares. Samples were collected from central Queensland in April and May 1996, and from the Burdekin district in January and February 1997, when plant or ratoon crops were 6 to 12 months old.

From composite samples, nematodes were extracted from 200 mL of soil using a Baermann tray (Whitehead and Hemming, 1965) and from approximately 100 grams of fresh roots using a misting cabinet (Seinhorst, 1950). Nematodes were collected after four days, concentrated by sieving twice through a 38 μm sieve, and counted by species or by genus, except for some groups (e.g., ring nematodes) that were difficult to distinguish at the counting magnification used (× 50). Representative specimens were mounted on slides for confirmation of identity.

To detect root-knot nematode at low densities and provide mature females for identification, 34 randomly selected soils were bioassayed by adding 700 mL of the test soil and 700 mL of pasteurised coarse sand to a 15 cm pot. Tomato (*Lycopersicon esculentum* cv Tiny Tim) was grown for five weeks and then roots were examined for galls produced by root-knot nematode. Ten mature females were dissected from the galls and identified to species using a PCR-based diagnosis of mtDNA (Stanton *et al.*, 1997).

Soil samples were typed by soil texture grade (Northcote, 1971), soil particle size as % coarse sand, % fine sand, % silt and % clay (Australian Standard AS 1289.3.6.3) and by location using descriptions on soil identification maps (Smith and McShane, 1981; Holz and Shields, 1985; McClurg *et al.*, 1988). Soils similar in their texture, origin and general location were then grouped to produce nine soil categories in each of the central Queensland and Burdekin regions, as described in Tables 2 and 4.

Populations of the most abundant nematode species were compared in different soil categories using one-way analysis of variance (ANOVA). Where the F-Test found significant differences at the 5% level, means were compared via least significant difference (LSD). To normalise the nematode counts, a cube root transformation of $\sqrt[3]{x + 0.5}$ was applied to nematodes in 200 mL of soil or per gram of dried roots. Nematode densities were deemed to be adequately normalised for ANOVA comparisons when Bartlett's test of equal variance was non-significant at the 1% level. Where *Meloidogyne* spp. and *Paratrichodorus minor* were absent from a significant proportion of samples, their densities were not adequately normalised and comparisons were conducted using Kruskal-Wallis one-way ANOVAs (data ranked irrespective of soil category and a one-way ANOVA applied to the ranks).

Results and discussion

Occurrence

Pratylenchus zeae was ubiquitous and *Meloidogyne* spp. were found in a high percentage of fields, and the densities of both groups in soil were higher than for other species (Table 1). Their incidence inside roots was also high, as mean population densities of 1002 and 1225 *Pratylenchus*/gram dry weight of root and 692 and 1349 *Meloidogyne*/gram dry weight of root were recorded in the central Queensland and Burdekin regions respectively. *M. javanica* was identified in 76% of the bioassays, while *M. incognita* (12%) and *M. arenaria* (12%) comprised the rest. *P. zeae* and *M. javanica* are widespread on sugarcane globally (Spaull and Cadet, 1990), and their pathogenicity to the crop has been well demonstrated in microplots (Sundararaj and Mehta, 1993) and by association when nematicides have improved crop yields in Australia (Chandler, 1978; Bull, 1981) and elsewhere (Handojo *et al.*, 1980; Cadet and Spaull, 1985). Since these two species are also widespread in southern districts (Blair *et al.*, 1999), they must be considered the most important nematode pests of sugarcane in Queensland.

Paratrichodorus minor, *Tylenchorhynchus annulatus* and *Helicotylenchus dihystera* were the most commonly detected ectoparasites (Table 1). These nematodes were also widespread in south Queensland cane fields (Blair *et al.*, 1999). The pathogenicity of these species to sugarcane has been demonstrated in glasshouse pot experiments (Spaull and Cadet, 1990). However, their effect on crop yields is unclear as they are usually found in association with the more dominant endoparasitic nematodes. *Xiphinema elongatum* was common in central Queensland, while *Macroposthonia xenoplax* was common in the Burdekin (Table 1). Actual population densities of these ectoparasites were probably higher than stated because the detection of these genera using Baermann techniques is poor (Harris and Braithwaite, 1976). Damaged shoot roots and reduced yield were in part attributed to *X. elongatum* on plant crops in South Africa (Cadet and Spaull, 1985).

The nematode species detected in central Queensland were similar to those found in southern districts by Blair *et al.* (1999). However, a more diverse range of species occurred in the

Table 1—Nematodes detected in soil samples from 307 sites in the Burdekin and central Queensland sugarcane growing regions.

Nematodes			Occurrence (% of fields)		Mean nematodes/200 mL soil[1]	
Common name	Genus	Species	Burdekin	Central Queensland	Burdekin	Central Queensland
Lesion	*Pratylenchus*				512	1323
		P. zeae	100	100		
		P. coffeae	18	0		
		P. teres	5	0		
		P. brachyurus	2	1		
		P. penetrans	1	0		
Root-knot	*Meloidogyne*		63	77	756	928
		M. javanica				
		M. incognita				
		M. arenaria				
Stunt	*Tylenchorhynchus*				440	113
		T. annulatus	94	81		
		T. claytoni	28	0		
Stubby-root	*Paratrichodorus*				68	141
		P. minor	68	95		
		P. lobatus	0	1		
Spiral	*Helicotylenchus*				192	147
		H. dihystera	57	85		
		H. multicinctus	3	0		
Ring	*Macroposthonia*		53	0	60	0
		M. xenoplax				
		M. caelata				
	Criconemella	*C. curvata*	0	17	0	28
Burrowing			25	2	70	343
	Achlysiella	*A. williamsi*				
	Radopholus	*R. inanus*				
Dagger	*Xiphinema*	*X. elongatum*	20	66	39	51
Needle	*Paralongidorus*	—	11	0	17	0
Sheath	*Hemicycliophora*	*H. labiata*	5	0	71	0
Pin	*Paratylenchus*	*P. colbrani*	5	0	31	0
Spiral	*Hoplolaimus*	*H. seinhorsti*	1	0	<10	0
	Scutellonema	—	1	0	<10	0
Reniform	*Rotylenchulus*	*R. parvus*	1	1	<10	145

[1]Means were calculated only from the samples in which nematodes were detected in Baermann tray or root misting extractions

Burdekin region. *Pratylenchus teres*, *P. penetrans*, *P. coffeae*, *Macroposthonia xenoplax*, *M. caelata*, *Paratylenchus colbrani*, *Helicotylenchus multicinctus* and *Hoplolaimus seinhorsti* had not previously been recorded on sugarcane in Australia, as they were not listed by McLeod *et al.* (1994) or detected in previous surveys. In contrast to previous records, *P. coffeae* and *Tylenchorhynchus claytoni* were common in the lower delta of the Burdekin River. *Achlysiella williamsi*, a species related to burrowing nematodes of the genus *Radopholus*, was also common in the Burdekin River delta (Table 1). It has been associated with badly damaged sugarcane in far north Queensland (Chandler, 1978). The Burdekin valley may be the southern limit of its common range, as the nematode is rare on sugarcane in central and southern Queensland.

Soil texture and location

In central Queensland, *P. zeae* occurred in all soils and mean densities of this nematode in roots were similar across most categories (Table 3). However, mean soil densities of *P. zeae* were higher ($P<0.05$) in Plane Creek soils (category 5, 9) than many of the other categories (Table 3). In the Burdekin, *P. zeae* also occurred in all soils. It was well established in 'new land' sugarcane, to the extent that category 5 fine sandy loams had significantly higher ($P<0.05$) mean soil and root

Table 2—Soil type categories used to describe soils in the central Queensland sugarcane growing region.

Soil category number	Description (Holz and Shields, 1985)	Mill area	Mean particle size distribution[A]	Survey sites in the category
1	Beach ridge sands. Coarse loamy sands on upland slopes in the Farleigh Mill district.	Farleigh, Racecourse	30:60:5:5	10
2	Loamy sands to coarse sandy loams on alluvial plains and upland slopes in upriver sections of the Proserpine and Pioneer Rivers and Cattle Creek.	Proserpine, Marian, Pleystowe	42:40:10:8	18
3	Sandy loams to sandy clay loams on upper alluvial plains and upland slopes in the Marian Mill area.	Marian	30:37:15:18	16
4	Sandy loams to sandy clay loams on alluvial plains and terraces in the Pioneer River and Sandy Creek valleys.	Racecourse, Farleigh, Pleystowe	22:38:20:20	33
5	Sandy loams to sandy clay loams on alluvial plains in the Plane Creek Mill area.	Plane Creek	25:35:20:20	11
6	Fine sandy loams on alluvial plains in the Proserpine region.	Proserpine	5:60:17:18	19
7	Clay loams to clays in the Proserpine region.	Proserpine	12:30:32:26	17
8	Clay loams to clays on upland slopes and alluvial plains of the Pioneer River, its catchments and Black Mountain catchments.	Farleigh, Pleystowe, Marian	10:30:25:35	27
9	Loams to clay loams and clays on plains and hillslopes in the Plane Creek Mill area.	Plane Creek	10:25:35:30	5

[A]Particle size distributions are expressed as % coarse sand : fine sand : silt : clay

Table 3—Nematodes in 200 mL of soil, or per gram of dry root, transformed[1] or ranked[2] and compared in different soil categories in central Queensland cane fields.

Soil category number—Table 2	*Pratylenchus zeae* in soil[1]	*Pratylenchus zeae* in roots[1]	*Paratrichodorus minor* in soil[1]	*Meloidogyne* spp. in soil[2]	*Meloidogyne* spp. In roots[2]
1	8.46^{e} (606)	10.14^{abc} (1043)	5.14^{ab} (136)	144^{a} (4360)	142^{a} (3573)
2	11.07^{bcd} (1357)	11.94^{a} (1702)	5.13^{ab} (135)	109^{ab} (1766)	115^{ab} (1057)
3	9.77^{cde} (933)	7.94^{cd} (501)	4.85^{bc} (114)	75^{bcd} (176)	69^{bcd} (52)
4	9.66^{de} (901)	8.52^{bcd} (618)	4.25^{bc} (77)	90^{bc} (223)	90^{abc} (310)
5	12.25^{ab} (1838)	10.86^{ab} (1281)	4.26^{bc} (77)	64^{bcd} (80)	72^{bcd} (68)
6	11.16^{bc} (1390)	8.81^{bcd} (684)	5.01^{ab} (126)	47^{d} (39)	44^{d} (25)
7	10.30^{cde} (1093)	7.49^{d} (420)	4.38^{bc} (84)	77^{bcd} (222)	71^{bcd} (100)
8	9.58^{e} (879)	7.23^{d} (377)	3.91^{c} (60)	53^{cd} (40)	54^{cd} (35)
9	14.42^{a} (2998)	10.94^{ab} (1309)	6.49^{a} (273)	45^{bcd} (12)	70^{abcd} (31)
Average LSD[3] ($P = 0.05$)	1.90	2.25	1.25	45	45

Values in the same column followed by the same letter are not significantly different ($P < 0.05$).
[1]Transformed to $\sqrt[3]{x+0.5}$. Values in parentheses are back-transformed means.
[2]Mean ranks from Kruskal-Wallis ANOVA. Values in parentheses are arithmetic means of the raw data.
[3]Average LSD is shown, but exact LSD values were used for pairwise testing.

densities than some other soil categories (Table 5). Grasses such as *Sorghum nitidum* and *Heteropogon* spp. that dominate undeveloped savanna (Fleming *et al.*, 1981) probably host *P. zeae* prior to development of the land for sugarcane. In the Burdekin, the mean density of *P. zeae* in roots was significantly lower (P<0.05) in heavy textured soils with more than 50% clay (category 9). Similarly in south Queensland, fewer *P. zeae* were found in cane fields with a clay content above about 40% (Blair *et al.*, 1999).

In central Queensland, mean densities of *Meloidogyne* spp. in soil and roots were significantly higher (P<0.05) in sands and coarse loamy sands (category 1) than most other soil types (Table 3). In the Burdekin, sugarcane soils with less than 10% clay are rare, and significant differences (P<0.05) were observed only between some sandy soils and the highest clay soils (Table 5). *Meloidogyne* spp. damage was previously recognised only on very sandy soils in south Queensland (Bull, 1979). The occurrence of high *Meloidogyne* spp. populations in loams and clay loams in these surveys suggests that damage may be occurring in a wider range of soils in all districts.

P. minor, *H. dihystera* and *T. annulatus* occurred at a wide range of densities in the soil. Mean densities of these nematodes were similar (P<0.05) across different soil categories (Table 3 and 5). An exception was the sandiest soil (category 1) in central Queensland, where the mean soil populations of *T. annulatus* and *H. dihystera* were lower (P<0.05) than in most other soil categories (ANOVA and rank tests for *T. annulatus* and *H. dihystera* are not shown).

These surveys have shown that pest nematodes are numerous and widespread in central

Table 4—Soil type categories used to describe soils in the Burdekin sugarcane growing region.

Soil category number	Description	Mill area	Mean particle size distribution[A]	Survey sites in the category
1	Loamy sands to fine sandy loams in the Burdekin River delta.	Pioneer	15:50:15:20	28
2	Loamy sands to fine sandy loams in the lower Burdekin River delta.	Kalamia	20:45:15:20	11
3	Fine sandy loams in the Burdekin River delta.	Inkerman	10:55:15:20	17
4	Fine sandy loams adjacent to the Burdekin River in upriver districts of Millaroo, Dalbeg and Clare.	Invicta	5:65:15:15	14
5	Fine sandy loams on 'new land'[B] plains and upriver sections of the Burdekin River.	Invicta, Inkerman	15:55:15:15	9
6	Clay loams in the Haughton River delta, in the south delta of the Burdekin River and along upriver sections of the Burdekin River.	Invicta Inkerman	3:45:26:26	23
7	Clay loams in the north delta of the Burdekin River.	Pioneer Kalamia	10:35:25:30	20
8	Clay loams on 'new land'[B] plains.	Invicta Inkerman	3:47:25:25	10
9	Clays on 'new land'[B] plains (main group) and in the Burdekin River delta (occasional group).	Invicta, Inkerman Kalamia	3:20:25:52	20

[A]Particle size distributions are expressed as % coarse sand : fine sand : silt : clay
[B]Land recently developed for sugarcane cultivation (<6 years)

Table 5—Nematodes in 200 mL of soil, or per gram of dry root, transformed[1] or ranked[2] and compared in different soil categories in Burdekin cane fields.

Soil category number—Table 4	*Pratylenchus zeae* in soil[1]		*Pratylenchus zeae* in roots[1]		*Paratrichodorus minor* in soil[2]		*Meloidogyne* spp. in soil[2]		*Meloidogyne* spp. in roots[2]	
1	7.39[bc]	(403)	11.22[a]	(1414)	90[ab]	(42)	90[ab]	(461)	93[ab]	(1057)
2	7.91[abc]	(494)	10.52[ab]	(1164)	73[abc]	(26)	115[a]	(768)	107[ab]	(2039)
3	7.06[bc]	(352)	8.09[bc]	(529)	83[abc]	(39)	70[ab]	(99)	73[abc]	(243)
4	6.68[c]	(297)	10.98[a]	(1324)	114[a]	(126)	106[a]	(933)	110[a]	(1741)
5 (new land)	8.93[a]	(713)	12.36[a]	(1890)	66[abc]	(113)	78[ab]	(709)	79[abc]	(1755)
6	7.72[abc]	(461)	8.36[bc]	(585)	80[abc]	(40)	74[ab]	(323)	78[abc]	(509)
7	8.13[ab]	(536)	7.11[cd]	(360)	79[abc]	(32)	63[ab]	(174)	59[bc]	(276)
8 (new land)	7.75[abc]	(466)	9.27[abc]	(796)	44[bc]	(9)	47[b]	(2)	39[c]	(2)
9 (new land)	6.43[c]	(266)	5.65[d]	(180)	41[c]	(10)	52[b]	(11)	49[c]	(6)
Average LSD[3] (P=0.05)	1.54		2.74		49		46		47	

Values in the same column followed by the same letter are not significantly different (P < 0.05).
[1]Transformed to $\sqrt[3]{x+0.5}$. Values in parentheses are back-transformed means.
[2]Mean ranks from Kruskal-Wallis ANOVA. Values in parentheses are arithmetic means of the raw data.
[3]Average LSD is shown, but exact LSD values were used for pairwise testing.

Queensland and the Burdekin. In fact, the results suggest that nematode densities may be higher in these regions than in south Queensland, where nematodes are known to cause significant crop losses on both sandy and clay soils (Bull, 1981; Stirling *et al.,* 1999). Since the relationship between nematode density and yield is influenced by factors such as soil type, moisture status and crop nutrition (Spaull and Cadet, 1990), the presence of these high nematode populations does not necessarily imply that crop losses are occurring. Nevertheless, there is a need to reassess the importance of nematodes in these two regions, as about half of Queensland's sugar is produced there.

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