SUSCEPTIBILITY OF SUGARCANE VARIETIES TO TWO SPECIES OF ROOT-KNOT NEMATODE (*MELOIDOGYNE JAVANICA* AND *M. INCOGNITA*), AND IMPLICATIONS FOR CROPS GROWN IN ROTATION WITH SUGARCANE

By

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Abstract

THE MULTIPLICATION of two species of root-knot nematode (*Meloidogyne javanica* and *M. incognita*) on tomato and 13 varieties of sugarcane was assessed by inoculating potted plants with 4000 nematode eggs and later measuring the number of nematodes present on roots and in soil. Fifty days after inoculation with *M. javanica*, there were 970 000 nematodes/pot on tomato and only 81 850 nematodes/pot on sugarcane (averaged across all varieties). The corresponding figures with *M. incognita* were 1 340 000 for tomato and 7720 for sugarcane. This result indicates that sugarcane is much less susceptible to root-knot nematode than tomato, a highly susceptible host. Ninety days after inoculation, nematode population densities on most sugarcane varieties had increased 80–126 times for *M. javanica* and only 1–10 times for *M. incognita*, indicating that sugarcane is more susceptible to the former species. Varieties varied considerably in their capacity to host both nematode species, as there was almost a 10-fold difference in final population densities between the most susceptible and resistant varieties. No variety was resistant to *M. javanica*, but Q152 and Q158 supported much lower population densities than other varieties. Q138 and Q196$^{\phi}$ were relatively resistant to *M. incognita*. The implications of these findings for crops that are currently grown in rotation with sugarcane (e.g. vegetable crops, legumes and pineapples) are discussed.

Introduction

Root-knot nematode (*Meloidogyne* spp.) is widely distributed in tropical, sub-tropical and warm temperate regions of the world, and is a serious pest of a broad range of food and fibre crops, including cotton, soybean, cowpea, mung bean, peanut, tomato, potato, capsicum, cucurbits, tobacco, pineapple, banana and papaya (Luc *et al*., 1990). Sugarcane is also a good host of root-knot nematode and high nematode population densities are usually found when crops are grown in light-textured soils, as these soils are ideally suited to nematode reproduction. In Australia, the nematode is common in sand, sandy loam and well-structured clay loam soils that are used for sugar production, but is rarely found in heavy-textured soils

(Blair *et al*., 1999a, b). *M. javanica* is the dominant species of root-knot nematode, but *M. incognita* and *M. arenaria* have also been reported (Blair *et al.,* 1999a, b).

Damage caused by root-knot nematode on sugarcane results in reduced primary and secondary tillering, shorter stalks and lower yields (Spaull and Cadet, 1990). In Australia, significant yield losses are observed in situations where obvious galling is apparent on the roots of newly-planted crops (Bull, 1979, 1981).

However, these situations are confined to relatively infertile sandy soils with a clay content of less than about 8%, where *Meloidgyne* tends to be the dominant plant-parasitic nematode. Since these soils comprise a relatively small proportion of the area planted to sugarcane in Australia, root-knot nematode is sometimes locally important but is not considered an industry-wide problem (Blair and Stirling, 2006).

In recent years, the Australian sugar industry has begun to move away from monoculture towards a farming system that includes a rotation crop in the interval between sugarcane cycles.

This change has been driven by observations that the impact of yield decline can be reduced by crop rotation (Garside *et al.,* 1999; Stirling *et al.,* 2001), and by the desire of sugarcane growers to supplement their income with crops other than sugarcane.

Since root-knot nematode can cause problems on many of the rotation crops being considered by growers and some potentially useful crops are damaged by relatively low root-knot nematode population densities, sugarcane varieties that are poor hosts of root-knot nematode are likely to be advantageous in such farming systems.

The objective of this work was to assess the capacity of two common species of root-knot nematode to multiply on various sugarcane varieties.

Materials and methods

Single eye setts of 13 sugarcane varieties were germinated in seedling trays for 10 days and then setts with emerging shoots were transplanted into 1.5 L pots containing pasteurised washed river sand.

Two days later, inoculum of *Meloidogyne javanica* and *M. incognita* was prepared by soaking nematode-infested tomato roots in NaOCl (1% available chlorine) for 5 minutes and retrieving root-knot nematode eggs on a 38 µm sieve (McLure *et al.,* 1973).

Six replicate pots of each variety were then inoculated with 4000 eggs of each nematode species, with six additional control pots being left uninoculated. To check the viability of the inoculum, three replicate pots containing seedlings of tomato (cv. Tiny Tim) were also inoculated in the same way.

Plants were grown in a glasshouse at temperatures ranging from 22–28˚C and, after 50 days, three replicate pots were harvested. The dry weight of above-ground material was measured, a soil sample was collected for nematode analysis, and then roots were washed free of soil. A 200 mL sample of the soil was placed on a Whitehead tray for 2 days and second-stage juveniles were recovered by sieving twice on a 38 µm sieve (Whitehead and Hemming, 1965), while eggs were removed from roots with NaOCl as described above.

The remaining three replicate pots were harvested in the same way 90 days after plants were inoculated. To calculate the total number of root-knot nematodes in each 1.5 L pot, the number of nematodes/200 mL soil was multiplied by 7.5 and added to the number of eggs extracted from the root system.

Statistical analyses

Top dry weights and nematode numbers ($\log_{10}$ transformed) for both harvests were analysed by a repeated measures ANOVA using Genstat for Windows 7th Edition (VSN International).

Results

Analysis of the dry weight data indicated that there were significant effects ($p < 0.001$) of variety, time, variety × nematode and variety × time. When data were averaged over the two harvest dates, some sugarcane varieties produced more biomass than others (Table 1), but inoculation with root-knot nematode did not significantly reduce the dry weight of any variety relative to its non-inoculated control (data not shown).

Table 1—Population densities of two species of root-knot nematode (*Meloidogyne incognita* and *M. javanica*) 50 and 90 days after planting (DAP) 13 sugarcane varieties in soil inoculated with 4000 nematode eggs.

Variety	Dry weight tops (g)	Log no. root-knot nematodes/pot				No. root-knot nematodes/pot[A]			
		M. incognita		*M. javanica*		*M. incognita*		*M. javanica*	
		50 DAP	90 DAP	50 DAP	90 DAP	50 DAP	90 DAP	50 DAP	90 DAP
Q138	11.5	3.256	4.625	3.923	5.353	1 800	8 380	42 170	225 420
Q151	10.4	4.042	4.790	4.395	5.480	11 002	24 830	61 660	302 000
Q152	12.3	3.381	4.057	4.253	4.741	2 400	17 910	11 400	55 080
Q158	10.6	3.655	4.755	4.633	4.892	4 520	42 950	56 885	77 980
Q170$^{\phi}$	9.8	3.852	4.612	4.471	5.070	2 410	29 580	40 930	117 490
Q183$^{\phi}$	13.0	3.860	5.090	4.427	5.059	7 240	26 730	123 030	114 550
Q186$^{\phi}$	10.2	3.702	5.032	4.631	5.461	5 040	42 760	107 650	289 070
Q190$^{\phi}$	11.1	4.012	5.004	4.300	5.512	10 280	19 953	100 930	325 090
Q196$^{\phi}$	12.6	3.689	4.452	3.720	5.409	4 890	5 250	28 310	256 450
Q200$^{\phi}$	11.3	3.952	4.968	4.608	5.514	8 950	40 550	92 900	326 590
Q205$^{\phi}$	11.5	4.469	5.444	4.585	5.701	29 440	38 460	277 931	502 340
Q208$^{\phi}$	10.3	3.919	4.940	4.337	5.387	8 300	21 730	87 100	243 780
Q209$^{\phi}$	7.9	3.610	4.521	4.044	5.327	4 070	11 070	33 190	212 320
LSD (P=0.05)	1.15	0.4051							

[A] Back-transformed means.

M. javanica multiplied readily on sugarcane as there was a 14 to 126-fold increase in nematode populations across all varieties in 90 days. The multiplication rate for *M. incognita* was much lower, ranging from 1.3 to 10.7 during the same period (Table 1). Both root-knot nematode species reproduced on all varieties, but multiplication was much lower on sugarcane than on tomato.

After 50 days, the population densities for *M. javanica* and *M. incognita* (averaged across all sugarcane varieties) were 81 850 and 7720 nematodes/pot, respectively, whereas the corresponding numbers for tomato were 970 000 and 1 340 000 nematodes/pot.

A range of reactions to root-knot nematode was observed within sugarcane varieties (Table 1). Some varieties (e.g. Q205$^{\phi}$) were susceptible to both *M. javanica* and *M. incognita*, whereas other varieties were relatively resistant to one species and susceptible to the other (e.g. Q158).

In general, *M. javanica* multiplied well on most varieties, although Q152 and Q158 were less susceptible than the others. Q138 and Q196$^{\phi}$ were relatively resistant to *M. incognita*.

Discussion

In this paper, the term 'susceptible' is used to describe varieties that are capable of supporting nematode reproduction, whereas the term 'resistance' describes varieties where multiplication is limited. It is important to recognise that the results provide no information on the capacity of the tested varieties to withstand attack from the nematodes in the field, a property that is usually referred to as 'tolerance'.

The fact that sugarcane varieties differ in their susceptibility to a particular nematode species does not mean that they also differ in their capacity to tolerate nematode attack. Information on the relative tolerance of varieties to nematodes can only be obtained by comparing yields in the presence and absence of nematodes (i.e. by measuring responses to nematicides or soil fumigants in the field).

My data on nematode reproduction clearly show that the sugarcane varieties currently used in Queensland are much more susceptible to *M. javanica* than *M. incognita*. Since both nematode species are well adapted to the tropical and sub-tropical climate of the region, the higher reproductive potential of *M. javanica* on sugarcane probably explains why State-wide surveys have previously shown that it is the dominant species of root-knot nematode in Queensland sugarcane fields (Blair *et al.,* 1999 a, b).

This observation has implications for crops currently grown in rotation with sugarcane. *M. javanica* is the most common root-knot nematode on soybean and most other fallow legumes (Stirling, unpublished data), and is the dominant species on most vegetable and horticultural crops (McLeod *et al.,* 1994). In light-textured soils, there is therefore considerable potential for damage from root-knot nematodes whenever a rotation crop is grown following sugarcane.

Although every effort was made to achieve even establishment of the sugarcane varieties used in the experiment, it is possible that variability in the quality of the planting material was responsible for some of the differences in nematode multiplication rates.

Some varieties (e.g. Q209$^{\phi}$) were slow to establish and since this is likely to have impacted on root growth, limitations in the number of feeding sites may have affected the reproductive capacity of the nematode on such varieties. Inherent differences in rooting habits possibly explain the temporal changes in susceptibility that were observed with some varieties.

Nematodes recovered at 50 days were produced by females in sett roots whereas those recovered after 90 days would have been mainly second generation nematodes from shoot roots, so apparent increases in the susceptibility of some varieties with time (e.g. Q196$^{\phi}$ with *M. javanica* and Q158 with *M. incognita*) may have been associated with varietal differences in the relative importance of sett and shoot roots. If this is the case, the results from the second harvest are likely to provide a better indication of the susceptibility of a variety to root-knot nematode than results obtained from the first harvest.

The nematode data from this experiment suggest that varietal selection may be helpful in limiting damage caused by root-knot nematodes on crops that are grown in rotation with sugarcane. Varietal differences in the susceptibility of sugarcane varieties to both *M. javanica* and *M. incognita* were relatively large, with an 8 to 9-fold difference in final nematode populations being observed between the most resistant and the most susceptible varieties. Since differences of this magnitude are also likely to occur on mature crops in the field, choice of sugarcane variety is likely to have a major impact on the number of root-knot nematodes present in soil at the time a rotation crop is planted.

Of all the crops currently grown in rotation with sugarcane, capsicum (*Capsicum annuum*) is unusual in that it is resistant to *M. javanica* and susceptible to *M. incognita* (Hartman and Sasser, 1985). Sugarcane, which is relatively resistant to *M. incognita*, is

therefore an excellent rotation crop for capsicum and varieties with the highest levels of resistance (e.g. Q138 and Q196[ϕ]) are likely to be particularly useful.

The situation with regard to other rotation crops is not as clear because *M. javanica* is the dominant root-knot nematode pest on most potentially useful crops, and it is able to reproduce to some extent on all sugarcane varieties.

There may be advantages in growing some of the more resistant varieties (i.e. Q152 and Q158) prior to planting a rotation crop that is reasonably tolerant (i.e. can withstand relatively high nematode population densities), but this approach is unlikely to be useful in very sandy soils or on vegetable crops such as tomato, potato and cucurbits, which have relatively low damage thresholds (Stirling, 2000).

One possible solution to this problem is to select or breed sugarcane varieties with better resistance to *M. javanica*. Such an objective is likely to be technically achievable because my data show that within commercial varieties that have been developed from a relatively narrow range of sugarcane germplasm, final population densities of *M. javanica* can vary considerably.

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