Effect of Pachymetra Root Rot on Sugarcane Yield

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ABSTRACT

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The effect of Pachymetra root rot on yield of sugarcane was assessed through a correlation of soil inoculum density with yield in the susceptible cultivar Q90. Variation in plot inoculum density was created by growing cultivars of varied resistance in the previous crop. Yield loss in the plant crop was estimated at 33% and in the first ratoon at 37%. Pachymetra root rot significantly reduced stalk number and stalk weight in both the plant and first ratoon crops but not stalk sugar content. Pachymetra root rot is probably a significant component in northern poor root syndrome of sugarcane.

Northern poor root syndrome of sugarcane (*Saccharum officinarum* L.) was first identified in northern Queensland in the late 1970s and characterized by poorly developed and rotted roots in the widely grown cultivar Q90. Aboveground symptoms include loss of crop vigor, poor stooling, and thin stalks (6). Croft (3) isolated a previously undescribed Oomycete, which was shown to cause the rotted primary root symptoms. Dick et al (5) described the pathogen as *Pachymetra chaunorhiza* Croft & Dick and called the root condition it caused Pachymetra root rot. General field observations suggested that Pachymetra root rot could be responsible for a significant proportion of the yield loss associated with northern poor root syndrome.

The failure of fungicides to adequately control Pachymetra root rot (4; and *unpublished*) has hindered yield loss assessment studies. However, the development of an assay to measure inoculum density (9,10) and the presence of resistant cultivars in the Australian sugarcane germ plasm (2) have established a means of assessing yield loss through a correlation of *P. chaunorhiza* inoculum density with yield.

There are very few known hosts for *P. chaunorhiza* (12), and none of these occur in sugarcane fields. *P. chaunorhiza* does not have a saprophytic growth stage. Oospores are the only known propagule, and these are only produced in rotted roots (8). Inoculum density measurements therefore reflect previous disease levels.

The Bureau of Sugar Experiment Stations regularly conducts yield trials for cultivars throughout Queensland, including areas affected by Pachymetra root rot. The yield trials are maintained at least until harvest of the second ratoon crop, that is, until the harvest of the third annual crop from the same planting.

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Previous work (11) showed that cultivar resistance has a substantial influence on the inoculum density of *P. chaunorhiza*, and the cultivars included in these yield trials vary considerably in resistance to *P. chaunorhiza* (B. J. Croft, *personal communication*). This suggests that large differences in inoculum density may occur among plots in these trials.

This paper reports on the relationship between *P. chaunorhiza* inoculum density and yield when a cultivar yield trial site in northern Queensland was replanted with the *P. chaunorhiza*-susceptible cultivar Q90.

MATERIALS AND METHODS

A cultivar yield experiment containing 20 cultivars and two replicates was planted on 14 August 1984 at Miriwinni in northern Queensland in a randomized complete block design. Each plot was four rows (1.47-m row spacing) 8.5 m long. The experiment was maintained according to practices commonly employed in the district.

In early September 1988, after the growth of a plant and three ratoon crops, the crop was destroyed by rotary hoeing the site parallel to row direction. Two passes of the rotary hoe were made at a cultivation depth of approximately 25 cm. On 14 September, the former plots were marked, and soil samples were collected from each plot.

Soil samples were taken with a soil corer (40-mm diameter) to a depth of 45 cm. A stratified random sampling strategy was used with four cores taken from the planting line of the central two rows in each plot. Cores from an individual plot were bulked, sieved (0.5-cm aperture sieve), and mixed thoroughly by hand before subsampling for determining the number of *P. chaunorhiza* oospores (9).

Disease-free planting material of the *P. chaunorhiza*-susceptible cultivar Q90 was used to replant the site on 14 and 15 September 1988. Care was taken to ensure that the planting line of the replanted crop was coincident with that of the previous crop. Planting was done with a whole-stalk trash planter, and the crop was fertilized according to commercial practice.

On 2 June 1989, stalk counts were made in the central 6 m of row in the middle two rows of each plot. On 25 and 26 September 1989, the experimental crop was harvested by hand, and yields were estimated by a sampling method. Sixty stalks were cut from each plot and weighed. Six stalk samples were collected from each plot for analysis of sugar content (commercial cane sugar) (1).

Following harvest, soil samples were again taken from each plot as described previously, and inoculum levels were quantified. The leaf material remaining after harvest was maintained as a trash blanket with a minimum tillage cultivation strategy. The growing ratoon crop was fertilized according to district practices.

Stalk counts in the first ratoon crop were completed on 26 July 1990, and all plots were harvested by hand as for the plant crop on 17 September 1990. Soil samples were taken from each plot, as previously, and inoculum densities were quantified following the first ratoon crop harvest.

The relationships between *P. chaunorhiza* inoculum density and stalk population, stalk weight, and sugar content (commercial cane sugar) were analyzed by analysis of variance procedures and regression analysis.

RESULTS

P. chaunorhiza assays conducted on plots prior to replanting suggested that inoculum density varied markedly among plots, with levels ranging from 38 (standard deviation 10.62) to 370 (standard deviation 22.14) spores/g (dry weight) of soil. Visual differences in plant height were seen in the replanted Q90 crop as early as 14 wk after planting.

Analysis of the results obtained at the plant crop harvest indicated that there was a highly significant ($P < 0.005$) relationship between the weight of cane per plot and inoculum density (Fig. 1A). This response was largely due to the effect of *P. chaunorhiza* on stalk numbers (Fig. 2A). The relationship between stalk weight and inoculum density was also significant ($P < 0.05$) (Fig. 3A), but there was no significant effect of *P. chaunorhiza* on commercial cane sugar. These parameters were related by the following equations: yield (tonnes cane/ha) $= -0.03/\log_e$ spores $+ 6.88$; stalk number $= -0.04 \log_e$ spores $+ 7.09$; and

stalk weight = $-2.15 \log_e$ spores + 6.99. Using the equation relating yield to inoculum density, and without extrapolation, the estimated yield loss caused by *P. chaunorhiza* in the plant crop was 33%.

Assays conducted on plot soils following the plant and first ratoon crop harvests suggested that there had been an increase in inoculum density in almost all plots during each 12-mo period. Conditions were therefore suited to Pachymetra root rot during the trial period. Average plot inoculum densities

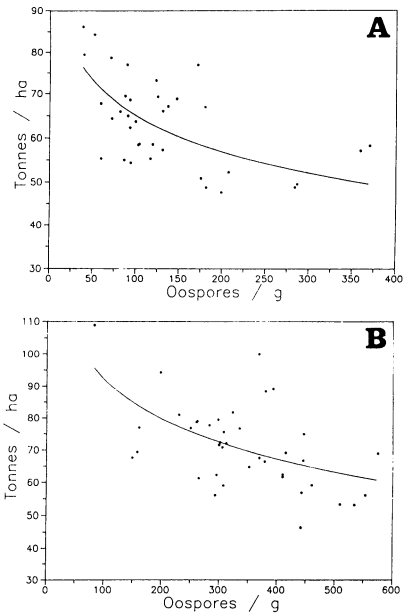

Fig. 1. Relationship between inoculum density of *Pachymetra chaunorhiza* in plots precrop and the yield of the susceptible sugarcane cultivar Q90 on the same plots after 12 months of growth. **(A)** Plant crop, **(B)** first ratoon.

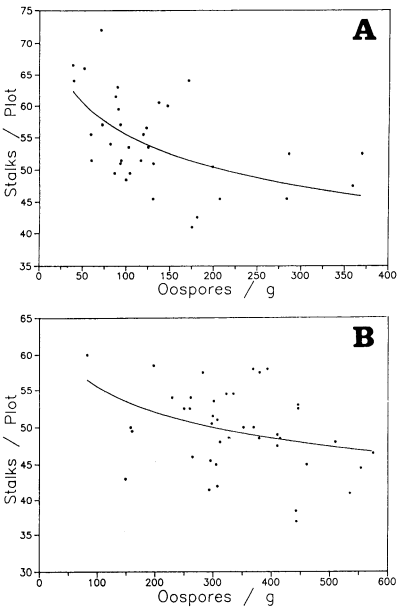

Fig. 2. Relationship between inoculum density of *Pachymetra chaunorhiza* in plots precrop and the stalk populations in the same plots after 12 months of growth. **(A)** Plant crop, **(B)** first ratoon.

preplant, postplant crop harvest, and postratoon crop harvest were 129.0, 238.8, and 622.5 spores/g (dry weight) of soil. Significant increases in spore count occurred even in those plots with the lowest inoculum densities (in both cropping years) (Table 1).

P. chaunorhiza significantly ($P < 0.05$) reduced total yield, stalk number, and stalk weight in the first ratoon crop (Figs. 1B, 2B, and 3B), and sugar content again was unaffected. Without extrapolating the data, maximum yield loss caused by *P. chaunorhiza* in the first ratoon was estimated at 37%. Parameters in the first ratoon crop are related by the following equations: yield (tonnes of cane/ha) = $-17.85 \log_e$ spores + 174.03; stalk number = $-5.00 \log_e$ spores + 78.52; and stalk weight = $-0.19 \log_e$ spores + 2.37.

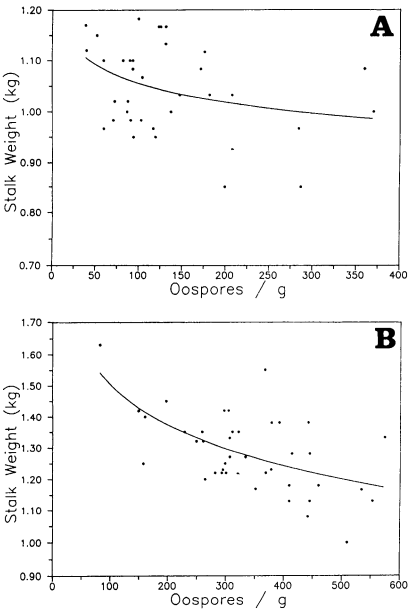

Fig. 3. Relationship between the inoculum density of *Pachymetra chaunorhiza* in plots precrop and the average stalk weight of the cultivar Q90 in each plot after 12 months of growth. **(A)** Plant crop, **(B)** first ratoon.

Table 1. Increase in *Pachymetra chaunorhiza* inoculum density in plots with the five lowest densities before the plant or first ratoon crops

Plot no.	Initial density[a] (oospores/g)	Postharvest density[a] (oospores/g)
Plant crop		
1	38.4	81.9
6	39.5	306.3
21	59.7	414.0
24	59.2	148.8
34	56.8	298.6
First ratoon crop		
1	81.9	708.0
8	196.8	556.2
20	157.3	311.2
24	148.8	466.7
30	160.0	631.7

[a] Oospores per gram (dry weight) of soil.

DISCUSSION

The results indicate that *P. chaunorhiza* may significantly reduce the yield of a susceptible sugarcane cultivar. Yield loss estimates of 33 and 37% probably underestimate potential yield losses. In the plots with the lowest inoculum densities, a significant amount of root rot occurred during growth of the two crops, because inoculum densities postharvest were considerably higher than those at the beginning of the growth period. A conservative yield loss estimate also is suggested by the curves relating inoculum density to yield. Extrapolation of these curves predicts a considerably higher yield at lower inoculum densities.

The magnitude of the yield losses attributed in this experiment to Pachymetra root rot is in accordance with field observations. A number of instances have been noted where farmers have planted *P. chaunorhiza*-resistant and susceptible cultivars adjacent to each other in the same field. After a crop cycle they destroyed the previous planting and replanted the entire field with a susceptible cultivar. A yield difference, consistent with the location of the previous cultivars, of up to 40% has been measured (*unpublished*).

Further field evidence comes from a consideration of the resistance of commercial cultivars. The most widely grown cultivars in the 1970s were susceptible to Pachymetra root rot. When the disease became prevalent from 1978 to 1980, high-yielding experimental cultivars selected by plant breeders for their commercial potential were almost all of intermediate or high resistance to Pachymetra root rot. Susceptible cultivars suffered a yield decline and were mostly discarded by farmers in favor of the new selections. In some districts where environmental conditions did not favor the disease, this natural selection and shift in resistance did not occur.

Yield loss associated with northern poor root syndrome has been related to a reduction in both stalk numbers and stalk weight (6). Such yield loss characteristics have been reported for Pythium root rot in the United States (7,13). Previous association of *P. chaunorhiza* with northern poor root syndrome (3,4,6) and the similar yield loss characteristics reported here suggest that Pachymetra root rot may be a significant component of northern poor root syndrome. Further research is required to determine the relative contribution of causal agents to the syndrome.

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