Available online at www.sciencedirect.com
SCIENCE DIRECT®
Applied Soil Ecology 28 (2005) 271–282
Applied Soil Ecology
www.elsevier.com/locate/apsoil

Effect of rotation breaks and organic matter amendments on the capacity of soils to develop biological suppression towards soil organisms associated with yield decline of sugarcane

C.E. Pankhurst[a], B.L. Blair[b], R.C. Magarey[c], G.R. Stirling[d], M.J. Bell[e], A.L Garside[f,*]

Sugarcane Yield Decline Joint Venture

[a]*CSIRO Land and Water, PMB, PO Aitkenvale, Qld 4814, Australia*
[b]*Agency for Food and Fibre Science, QDPI, C/-BSES Limited, Tully, Qld 4854, Australia*
[c]*BSES Limited, Tully, Qld 4854, Australia*
[d]*Biological Crop Protection, 3601 Moggill Road, Moggill, Qld 4070, Australia*
[e]*Agency for Food and Fibre Sciences, QDPI, Kingaroy, Qld 4610, Australia*
[f]*BSES Limited, C/-CSIRO Land and Water, PMB, PO Aitkenvale, Qld 4814, Australia*

Accepted 21 July 2004

Abstract

A plant bioassay was developed to test the capacity of soil to suppress the activity of detrimental soil organisms associated with yield decline (YD) of sugarcane. The bioassay utilised the diseased roots of sugarcane plants growing in soil that had been under continuous sugarcane monoculture for more than 20 years, as the source of soil organisms associated with YD. Single-eye sugarcane setts were planted into pots of fumigated sand containing 2% (w/w) diseased roots and 10% (w/w) of the test soil. Suppression was measured as the capacity of the added test soil to block the detrimental effect of soil organisms associated with YD on plant growth. The bioassay indicated that a soil that had been under a pasture break for 7 years had increased biological suppression towards soil organisms associated with YD compared to a soil that had been under continuous sugarcane. There was little difference in suppression between sugarcane soils that had been under a soybean break for 1 year, a cropped soil that had never grown sugarcane and the soil that had been under continuous sugarcane. In contrast, a rainforest soil was found to have less suppression than the continuous sugarcane soil. Incorporation of organic amendments into a sugarcane soil (including sawdust, cane trash, grass hay, lucerne hay, feedlot manure, poultry manure, chitin and mill mud) initially increased fungal and bacterial populations, microbial activity (FDA hydrolysis) and microbial biomass. Plant bioassay tests of the amended soils 1, 7 and 12 months after the incorporation of the amendments indicated that the amendments generally had only a minor effect on the soils capacity to suppress soil organisms associated with YD.

Keywords: Sugarcane; Yield decline; Plant bioassay; Soil organisms; Suppression; Organic amendments

* Corresponding author. Tel.: +61 7 4753 8588; fax: +61 7 4753 8600.
E-mail address: alan.garside@csiro.au (A.L. Garside).

0929-1393/$ – see front matter.
doi:10.1016/j.apsoil.2004.07.010

1. Introduction

Yield decline (YD) in sugarcane, defined as the loss of productive capacity of sugarcane soils under long-term monoculture, is a widespread problem throughout the Australian sugar industry (Garside et al., 1997a). It is believed to be caused by a combination of factors associated with the current sugarcane management system, including the growth of sugarcane as a monoculture, the frequent aggressive tillage of the soil between crop cycles and the use of heavy harvesting machinery. These practices have resulted in sugarcane soils becoming physically, chemically and biologically degraded and as a consequence, conducive to the growth and survival of a suite of different soil organisms detrimental to the growth of sugarcane (Magarey, 1996; Garside et al., 1997b; Stirling et al., 1999; Pankhurst et al., 2003).

The introduction of rotation breaks, notably an alternate crop such as soybeans or a sown pasture has been shown to be effective in improving sugarcane yields (Bell et al., 1998; Garside et al., 1999) and soil health generally (Pankhurst et al., 2003). A major factor associated with the yield responses following the different rotation breaks was rotation-induced changes in the composition of the soil biota. These changes included a reduction in the populations of root pathogens known to be associated with YD (e.g. the root rot fungus *Pachymetra chaunorhiza*, and the lesion nematode, *Pratylenchus zeae*) (Pankhurst et al., 1999, 2003; Stirling et al., 2001). In addition, it was speculated that other changes associated with an increase in beneficial organisms in the soil also contributed to the improved cane yields, particularly after a pasture break. These beneficial soil organisms were thought to include those with a capacity to suppress the growth and activity of YD pathogens (Pankhurst et al., 2000, 2003; Stirling et al., 2001).

Suppression of root disease causing soil organisms by other soil organisms (bacteria, fungi and nematodes) is a well-documented phenomenon (Hoitink and Boehm, 1999; Whipps, 2001). Populations of soil organisms suppressive towards specific root disease causing organisms may build up following crop rotations, particularly where green manure crops are used, and also following incorporation of organic amendments or composts into the soil (Bailey and Lazarovits, 2003; Hoitink and Boehm, 1999; Peters et al., 2003; Stirling et al., 2003). Mechanisms of suppression include competition for food resources, antibiosis, predation, parasitism and induced host resistance to the pathogen (Whipps, 2001; Mazzola, 2002).

Whilst it is relatively straight forward to demonstrate the presence of soil organisms that are suppressive towards specific pathogens in a soil (Hoitink and Boehm, 1999; Stirling et al., 2003), it is more difficult to demonstrate this for a complex of soil organisms that are associated with a problem such as YD of sugarcane. We have approached this problem by developing a plant bioassay system which (a) uses the diseased roots of sugarcane grown in continuous monoculture as a source of detrimental soil organisms associated with YD and (b) tests the capacity of a test soil to block (or suppress) the transfer of detrimental soil organisms from these diseased roots to the roots of a healthy pre-germinated sugarcane plant. In this paper, we present the results of experiments using the plant bioassay to test a range of soils, including a sugarcane soil that was amended with different organic substrates, for their capacity to suppress the growth and activity of soil organisms associated with YD.

2. Materials and methods

2.1. Field soils from north Queensland

The following field soils were tested for their capacity to suppress soil organisms associated with YD: (1) a sugarcane soil that had been under continuous sugarcane monoculture for more than 20 years and the same soil that had been under a sown legume/grass pasture break for 7 years at a site near Tully (17°59′S, 145°55′E), north Queensland; (2) a sugarcane soil under a 12-month rotation break of soybeans at the BSES station at Tully, and at a farmers property near, Abergowrie (100 km south of Tully); (3) a cropping soil that had never grown sugarcane, near Atherton (120 km to the northwest of Tully); and (4) a rainforest soil on the BSES station at Tully. Soil samples (0–10 cm deep) were collected using a spade from 10 randomly selected areas at each site. With the two sugarcane soils under the soybean break, samples