Controlled traffic and wider row spacing reduces the incidence of Chlorotic Streak Disease (CSD) in sugarcane seedbeds in subtropical Australia

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Abstract

Chlorotic streak disease (CSD) is one of the most destructive sugarcane (*Saccharum* interspecific hybrids) diseases worldwide. However, as the causal agent of CSD, *Phytocercomonas venanatans*, was only recently discovered, its ecology is largely unknown. The impact of different agronomic practices on CSD incidence was examined using field data collected over three growing seasons from the Harwood production area, NSW, Australia. Sugarcane is vegetatively propagated from existing crops called 'seedbeds', which are inspected prior to use in annual Plant Source Inspections (PSI). Variety, crop class (plant, 1st ratoon *etc.*) and row spacing were recorded for each seedbed, while CSD incidence was recorded on a 0-3 scale, with 0 meaning no evidence of CSD, and 3 meaning widespread disease incidence. A total of 1,105 prospective sugarcane seedbeds comprising 20 sugarcane varieties were assessed over a three-year period, and it was found that there was less CSD in production systems using dual-row configuration and controlled traffic than conventional single-row systems without traffic control. This was observed for both plant and ratoon crops. In addition, varieties with fewer than 10 years of production history showed significantly lower CSD rates than older varieties. These findings may help sugarcane growers in choosing appropriate varieties and row configurations in areas prone to CSD to minimise losses.

Keywords

Phytocercomonas venanatans, sugarcane agronomy, incidence rate.

Introduction

Chlorotic streak disease (CSD) is one of the most destructive sugarcane diseases worldwide (Magarey and Neilsen, 2002). Economic losses from CSD in the Australian sugarcane industry reached $8-10 million per year with concomitant yield reductions of up to 40% in susceptible varieties in the early 2000s (Magarey and Neilsen 2002). CSD was first identified in sugarcane (*Saccharum* interspecific hybrids) in Australia and the US in 1929 and was likely present in Indonesia at the same time (Martin 1930). Later research found that CSD was originally identified in Australia in Cardwell, north Queensland (Bell 1933), but is now widespread across the rest of Australia's sugarcane production areas.

Figure 1. Symptoms of chlorotic streak disease (CSD) on a sugarcane leaf of variety Q241 growing in a waterlogged situation at Tully, Queensland.

The main visible symptom of CSD is the presence of pale-yellow irregular long streaks of 3-10 mm width occurring on the leaves and sometimes extending from the base to the tip (Fig 1). However, these external symptoms are only temporarily visible and the symptomatic period can be affected by several environmental factors, especially soil temperature (Sturgess 1962). The internal symptom of CSD is the presence of red streaks visible on the nodes when sliced vertically, which may extend to the internodal regions (Martin 1935). Generally, CSD infected sugarcane shows reduced stalk number and weight, associated with lower germination rate of planted stalks and ratoons (Magarey and Neilsen 2002).

The causal agent of CSD remained a mystery for over 90 years, despite early identification of the disease and its impacts. The use of next generation DNA sequencing on heavily infected stalks from Harwood, NSW helped identify the protist pathogen, which was confirmed as a new Cercozoan and named *Phytocercomonas venanatans* (Braithwaite et al. 2018; Ngo et al. 2018). However, well before the pathogen was identified it was established that wet and warm soil conditions favoured disease development (Sturgess 1962; Sturgess1963; Egan 1961; Egan 1963). Young and Ensbey (2016) compared the incidence rate of CSD in Harwood, NSW, in three consecutive years and found that the prevalence of this disease was highest in the two La Niña-defined years and gradually decreased in the subsequent year. Sturgess (1962) found that 30°C was the optimal temperature for CSD transmission. Higher temperatures can suppress transmission of CSD, with hot water treatment (52°C) for at least 20 minutes eliminating the causal agent in seedcane (Bell 1933). However, Sturgess (1964) found that CSD could be transmitted after a nine-month fallow, thus the risk of secondary infection remains high even when using disease free seedcane (Sturgess 1963).

Despite increased scientific interest in recent decades, the impact of agronomic practices on CSD incidence is still not well understood. Young and Ensbey (2016) classified their data based on fallow history, seedcane type and farming system, and examined the relationship of these factors with CSD rate. However, they erroneously employed parametric analyses on rank data, so there is scope to re-evaluate their findings using the same data. They reported no significant relationship between CSD rate and fallow history or seedcane type (eg. plant cane planted into fallow, replant crops, first ratoon, second ratoon etc.), but found that dual-row configured seedbeds had lower incidences than conventional seedbeds. This study aimed to further analyse the impacts of additional independent variables and the cross impact of different variable pairs on CSD rate, including fallow history, seedcane type, farm system, variety age and ratoon age.

Methods

Data were collected from Plant Source Inspections (PSI) of prospective sugarcane seedbeds in the Harwood (NSW, Australia) production area in 2012, 2013 and 2014. Total rainfall in these years was 1411, 1390 and 740 mm, respectively, while average daily solar exposure was 18, 17 and 17 MJ m^{-2}, respectively (BOM 2020). The average temperature recorded by the nearest bureau stations (11 km from the study site) of the three years were 24, 24 and 25°C, respectively (BOM 2020). The elevation of the study site was ~2 m above sea level, and five significant flooding events between 2011-2013 provided ideal conditions for CSD transmission (BOM 2020; Young et al. 2013).

The PSI team made a CSD rating based on symptom incidence with a rank from 0 to 3 according to the number of CSD-affected plants (0 = no infection; 1 = some symptoms present; 2 = significant symptoms present; 3 = most plants showing symptoms). Before sampling, the criteria for each CSD grade was explained and demonstrated with examples by the supervisor to each PSI team member.

In each prospective seedbed, the sugarcane variety, fallow history (planted after one-year fallow vs. replanted after plough-out that season) and crop class (P = plant, RP = replant, 1R = 1st ratoon following plant crop, 1RR = 1st ratoon following replant crop, 2R = second ratoon from a plant crop following a fallow etc.) were recorded. In addition, two types of row configuration were recorded: conventional single-row (1.50 m–1.70 m row space with or without controlled traffic) and dual-row configurations (1.80 m–1.83 m centres, typically with 400 mm separation between dual rows, with controlled traffic).

In total, 1105 sugarcane seedbeds were assessed, comprising 20 sugarcane varieties. These included older varieties with over 10 years of production history as well as more recently released varieties which were only commercially planted within the previous 10 years. Seedbeds were classified in four different ways to examine the cross impact of different agronomic factor combinations: fallow × row configuration; variety age × crop class; crop class × row configuration; fallow history × ratoon number. In each classification, CSD rate of the seedbed groups was compared to determine the impact of different agronomic practices on CSD incidence.

The data collected was qualitative in nature, i.e. based on visual rating of CSD incidence into discrete ranks of 0-3. Consequently, the data did not conform to the assumptions of standard parametric analyses. As such, the difference in CSD rate between different seedbed categories was analyzed using the non-parametric Kruskal-Wallis test followed by a *post hoc* Dunn test for pairwise comparisons in R (Version 1.1.463, McKight and Najab 2010).

Results and Discussion

CSD incidences were significantly different among seedbeds with older versus newer varieties, and crop classes (Fig. 2A). The *post hoc* Dunn test showed that, among all ratoon grown seedbeds, the CSD rank of older varieties was significantly higher than that of new varieties ($z=6.1$, $p<0.001$, Fig. 2A). A similar trend was found in plant seedbeds ($z=9.47$, $p<0.001$, Fig. 2A). Young et al. (2013) had previously established no inherent CSD-susceptibility among newer and older varieties, so the higher incidence in older varieties can be interpreted by vegetative transmission associated with increased infection opportunities. That is, newer varieties are hot water treated prior to release, while older varieties are typically propagated from the growers' stock, which in the absence of hot water treatment allows incremental build up of the pathogen in the stock of that variety over seasons. When seedbeds were classified by seedcane type and farming system, the CSD rate was also significantly different. Among all plant seedbeds, the CSD rank of the seedbeds with conventional single-row configuration was significantly higher than those with dual-row configuration ($z=3.38$, $p<0.01$, Fig. 2B).

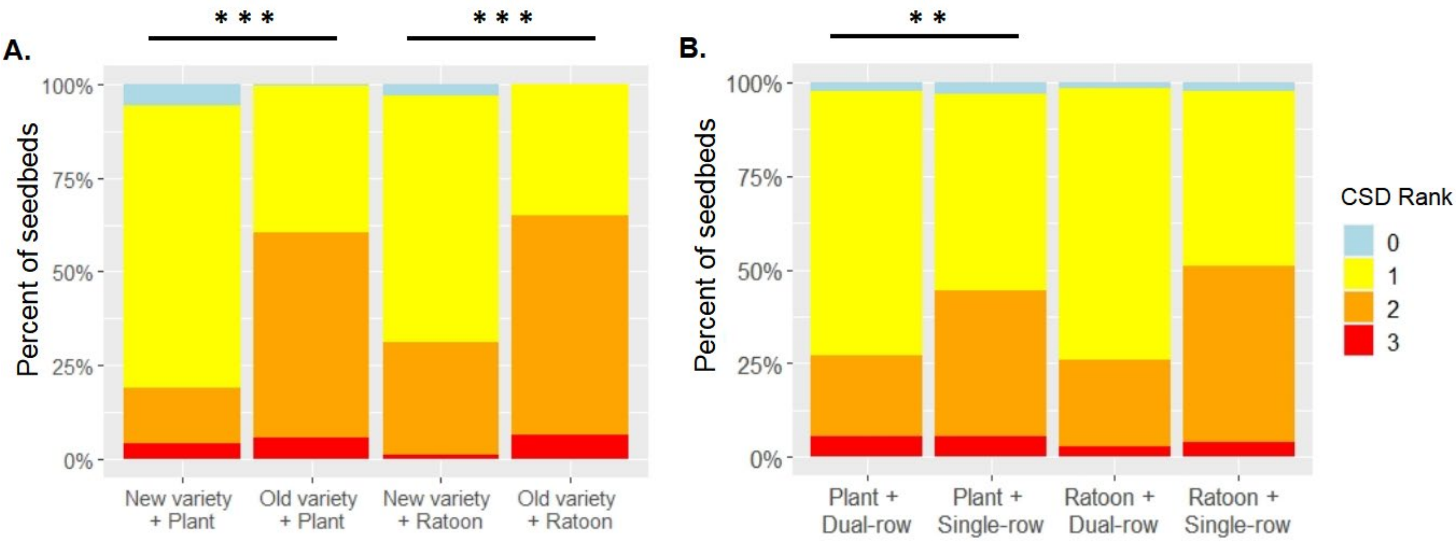

Figure 2. The percentage distribution of each CSD rank within fields classified based on: A. variety age and seedcane type; and B. seedcane type and row configuration. The seedbed groups with significant difference in CSD rank distribution (determined by Dunn tests) are highlighted with asterisks, where * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

These results indicate that controlled traffic dual-row systems tend to lower CSD infection rates. In addition, seedbeds with newer sugarcane varieties showed significantly lower CSD rate than those with older varieties, which is consistent with the findings of Young et al. (2013).

The high correlation between CSD infection and field soil moisture may explain the findings of this study. Compared with the single-row system, dual-row sugarcane systems can effectively reduce machinery traffic compaction. Therefore, the lower CSD rate found may be due to better drainage and higher evaporation rates in dual-row fields. Ratoon crops followed the same pattern, albeit with higher CSD incidence levels. That is, although the CSD incidence of ratoon crops was higher than plant crops under dual row propagation, it was still significantly lower than the CSD incidence of ratoon crops under conventional single-row configurations. This is likely explained by the increased opportunity of CSD infection experienced by ratoon crops, as they have been in the ground for longer.

Conclusion

This study demonstrated that dual-row configurations led to reduced CSD incidence in sugarcane seedbeds at Harwood. Due to the lack of effective chemical and biological control measures, choosing appropriate agronomic practices may be an alternative way to reduce CSD incidence and transmission. These findings help identify appropriate combinations of agronomy and germplasm to minimise disease incidence in areas prone to CSD.

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