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Resistance of Australian sugarcane clones to moth and weevil borers in Papua New Guinea

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A B S T R A C T

Papua New Guinea (PNG) has several moth borers (Lepidoptera) that damage commercial crops of sugarcane in the Ramu Valley. These borers are not present in Australia but would almost certainly cause very serious losses if introduced. To prepare for a possible incursion, Australian cultivars and promising clones were tested for their susceptibility to these borers in field trials at Ramu Agri-Industries, PNG. Three field trials were planted, one in each of 2010 (32 clones), 2011 (33 clones) and 2013 (32 clones), and sampled for borers in the plant and first ratoon crops. There were significant differences among clones for internode damage from *Sesamia grisescens* Warren (Noctuidae) and *Chilo terrenellus* Pagenstecher (Crambidae) and meristem damage from *Scirpophaga excerptalis* (Walker) (Pyralidae), as well as internode damage from the weevil borer *Rhabdoscelus obscurus* (Boisduval) (Coleoptera: Curculionidae). Generally, the range of damage among clones in each trial was less for *C. terrenellus* than for the other borers. The proportion of damaged internodes was strongly correlated with the proportion of damaged stalks for all borers and so the proportion of damaged stalks could be used as a surrogate estimate of internal stalk damage for rapid sampling. Levels of damage were correlated, positively or negatively, between species of borers in some trials. Damage from *R. obscurus* was positively correlated with damage from the two stalk borers, *S. grisescens* and *C. terrenellus*, which agrees with its status as a mainly secondary pest; its damage was not correlated with damage from *Sc. excerptalis* which affects only the stalk tops and the apical meristem. Damage correlations among the moth borers could reflect similarities or differences between resistance profiles of clones against different species, or could be due to direct or indirect interactions among species. Thirteen standard clones were included in all three trials. Among data sets, results for the standard clones were least consistent for *C. terrenellus* and most consistent for *Sc. excerptalis*. Some evidence was obtained that antixenosis may play a role in influencing resistance of clones to *Sc. excerptalis* and, perhaps, *S. grisescens*, but more research would be needed to confirm this.

1. Introduction

Moth borers (Lepidoptera) are the most serious pests of sugarcane, *Saccharum* spp. hybrids, in most sugarcane-growing countries (Goebel and Sallam, 2011). Australia is currently free of damaging species. However, Papua New Guinea (PNG), which is about 150 km north of mainland Australia at its closest point, has several: the stalk borers *Sesamia grisescens* Warren (large pink stalk borer; Noctuidae) and *Chilo terrenellus* Pagenstecher (internode borer; Crambidae) and the top borer *Scirpophaga excerptalis* (Walker) (top shoot borer; Pyralidae). *Sesamia grisescens* and *C. terrenellus* are restricted to the island of New Guinea whereas *Sc. excerptalis* is widespread through Asia (Sallam and Allsopp, 2005). These borers damage commercial crops of sugarcane grown in the Ramu Valley in the north of PNG, and are also found in *Saccharum* spp. (*S. officinarum*, *S. edule*, *S. robustum* and *S. spontaneum*, as well as commercial hybrids) growing in home gardens and in the wild. Potential losses vary depending on borer species and sugarcane variety, but Kuniata (1998) estimated that *S. grisescens* has the potential to cause cane losses of more than 32 t/ha, with additional industry costs due to increased cost of harvesting and milling the damaged cane.

S. grisescens lays eggs behind the leaf sheaths. First instars feed

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on the inner surfaces of leaf sheaths for several days and then bore into the stalk, where they feed gregariously in the upper internodes and usually damage the meristem. Maturing larvae then migrate to nearby stalks, causing extensive tunnelling damage to the stalks and sometimes damaging the meristem (Young and Kuniata, 1992; Kuniata and Sweet, 1994; Kuniata, 1998). *Chilo terrenellus* and *Sc. excerptalis* both oviposit on the unfolded leaves. Larvae of *C. terrenellus* tunnel inside semi-mature and mature stalks (Kuniata et al., 2001). Larvae of *Sc. excerptalis* feed within the very top of each stalk and damage the meristem, with only one larva surviving in each stalk (Mukunthan, 1985). Meristem damage from *S. grisescens* and *Sc. excerptalis* causes a 'dead heart' and stops the stalk from growing, leading to side shooting and reduced stalk weight, while internode damage from *S. grisescens* and *C. terrenellus* reduces stalk weight and sugar content and quality.

Exotic moth borers are a biosecurity risk to the Australian sugar industry. In order to prepare for a possible incursion, Sugar Research Australia Limited, in partnership with Ramu Agri-Industries, commenced field trials in 2010 to assess the resistance of Australian clones to moth borers in PNG. Varietal resistance is a common component of management programs for borers in sugarcane (Goebel and Sallam, 2011) and would certainly be employed in Australia in the event of an incursion. We aimed not only to determine resistance ratings for Australian clones, but also to investigate consistency of ratings between trials and relationships of resistance levels among borer species. Some Australian commercial cultivars and advanced clones (not commercially released) were already being propagated in PNG while others were shipped to allow screening for borers and diseases. *Sesamia grisescens* was the main target of the trials, as it is judged the most damaging pest at Ramu Agri-Industries (Kuniata, 2000), but the other moth borers were also recorded during sampling. The sugarcane weevil borer, *Rhabdoscelus obscurus* (Boisduval) (Coleoptera: Curculionidae), which occurs in both PNG and Australia and which tunnels within cane stalks in the larval stage (Robertson and Webster, 1995), was also recorded in trials.

2. Materials and methods

Three field trials to assess clonal resistance to borers were conducted between 2010 and 2014 (Table 1). A set of 13 clones ('standard clones') was included in every trial to allow comparisons across trials. Twelve of them were chosen to represent a range of levels of susceptibility to *S. grisescens* as recorded in earlier trials in PNG (Korowi et al., 2011), while one more, Q219, was included after it showed a high level of damage from *Sc. excerptalis* in the first trial planted in 2010 (Korowi and Samson, 2013).

Each clone was planted in plots measuring 7.5 m or 8 m long by four rows wide at a 1.8 m row spacing, replicated four times in randomised complete-block designs. Clones believed to be susceptible to *S. grisescens* based on field observations, Cadmus or Q136, were planted in a 'spreader' or 'infestation' row between each four-row column of trial plots and also around the outside of each trial to increase the local population of borers. Each plot was separated from the next plot within the column by a 1 m gap, and an empty row was left between each column of plots and the spreader row on either side. Trials were mainly intended to evaluate clonal response to *S. grisescens*, so cane tops infested with this borer were distributed around the outside of the trial when infested material was available. Each plot row was planted by hand with 25 two-bud billets placed into pre-formed furrows. The fungicide Metalaxyl was sprayed over the billets at 1 kg product/ha for control of downy mildew disease, fertiliser was applied, and billets were then covered with soil.

Trials were destructively sampled for borers on the dates given in Table 1, at times when there was abundant damage from *S. grisescens* as evidenced by dead hearts. Ten stalks were randomly selected from each of the outside rows of each plot and any dead hearts were classified as being the result of infestation by *S. grisescens* or *Sc. excerptalis*. Stalks were then sliced open longitudinally and total internodes, internodes damaged by each borer species and numbers of larvae and pupae of each borer were counted. Classification of borer damage before and after slicing was based on previous experience of staff at Ramu Agri-Industries. Dead hearts from *Sc. excerptalis* occur higher in the stalk and are characterized by shortened internodes and stunted upper leaves, compared with dead hearts caused by *S. grisescens.* Tunnels of *C. terrenellus* could be distinguished from those of *S. grisescens* by their serrated margins and generally smaller diameter while tunnels of the weevil borer *R. obscurus* were packed with fibrous frass; damage from *Sc. excerptalis* was limited to a fine tunnel near the apical meristem. Each trial was harvested once by cutting all stalks at ground level using a cane harvester. Borer sampling was done at some time before the harvest, i.e. in the plant crop, and again in the first ratoon crop, i.e. in the crop that regrows from underground stubble after the first harvest.

Egg batches of two of the moth borers were counted in some trials. Egg batches of *S. grisescens* can be felt as a swelling beneath the young leaf sheaths, while egg batches of *Sc. excerptalis* can be counted on the lamina. Egg batches were counted in rows 1 and 4 of each 4-row plot for the whole plot length. In Trial 1, stalks and *S. grisescens* egg batches were counted in all plots in the plant crop on 25 May 2011, soon after a large moth flight as recorded in pheromone traps (data not presented). In the plant crop of Trial 2, stalks and egg batches of both species were counted on the standard clones only (due to labour constraints) on 24 February 2012 and again on 21 April 2012 (*S. grisescens* only, 12 standard clones with Q219 omitted); however, there were too few eggs of *S. grisescens* in February for statistical analysis. In the first ratoon of Trial 2, *S. grisescens* egg batches were counted on the standard clones on 23 May 2013, just after a large moth flight.

In each trial, damage to stalks and internodes recorded by destructive sampling was analysed by generalised linear mixed models in SAS (PROC MIXED) with clone and replicate as fixed and random effects, respectively, and with damage measurements as a proportion of total internodes or stalks transformed as logits. In addition, a pooled estimate of damage to the standard clones using all available data was obtained by a combined analysis across the six data sets from this study and three other data sets from two earlier trials in PNG (Korowi et al., 2011). Other measurements were analysed by generalised linear mixed models and relationships among damage measurements in each plot and among trials were

Table 1
Details of clonal resistance trials planted in Papua New Guinea.

Trial code	No. of clones (including standards)	Planting date	Destructive sample date, plant crop	Harvesting date	Destructive sample date, first ratoon crop
Trial 1	32	13 Dec 2010	20 Jun 2011	22 Oct 2011	30 Jul 2012
Trial 2	33	28 Nov 2011	5 Jun 2012	22 Sep 2012	30 Jul 2013
Trial 3	32	13 Mar 2013	27 Aug 2013	Nov 2013	23 Apr 2014