

THE IMPACT OF RATOON STUNTING DISEASE AT RAMU SUGAR, PAPUA NEW GUINEA

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Abstract

Ratoon stunting disease (RSD) is caused by the bacterium, *Leifsonia xyli* subsp *xyli* (Davis *et al*, 1984) and the disease has been recorded worldwide in most sugar industries. RSD was first recorded at Ramu Sugar, Papua New Guinea (PNG), in 2002. A total of 78 samples taken from commercial cane were assayed by SASRI; and about 40% of these samples tested positive to RSD. A further 700 samples were taken from commercial cane in 2004; more than 85% of these samples proved positive. Also in 2004, over 100 samples were taken from *Saccharum officinarum* and *S. edule* in village gardens and wild cane (*S. robustum*) with 16% of samples infested by *Leifsonia xyli* subsp. *xyli*. In the 2004 season, a 16% reduction in cane yields was observed and it is likely that a significant part of this reduction was due to RSD; dry weather conditions exacerbated the losses.

Keywords: ratoon stunting disease, *Leifsonia xyli*, *Saccharum* spp, crop losses, Papua New Guinea

Introduction

New Guinea is the centre of origin for several *Saccharum* species, including the 'original' sugarcanes belonging to *S. officinarum* (noble cane), the domesticated vegetable sugarcane 'pit pit' (*S. edule*) and the 'wild' canes belonging to *S. robustum*. Extensive stands of wild canes can be seen growing along river banks and other disturbed areas such as roadsides. Chewing and vegetable canes (use of aborted inflorescence) are cultivated in village gardens. Pests and diseases are common as a result of the widespread occurrence of *Saccharum* species, and these present high disease pressure to the commercial sugar industry in Papua New Guinea (PNG).

Commercial hybrid varieties were introduced to PNG between 1960-1980 with a view to establishing a PNG sugar industry. The planting of commercial fields began in 1980 in the Ramu Valley with the first commercial harvests made in 1982. Ramu Sugar Limited operates the commercial estate located at Gusap in the Madang Province. Over 8500 ha under sugarcane produces around 500 000 tons cane to make 48 000 to 50 000 tons of sugar. About 2.5 million litres of ethanol is also produced, mainly for export.

With the monoculture of hybrid sugarcane over an extensive area, the Estate has predictably had problems with outbreaks of endemic pests and diseases. The import of sugarcane from other cane growing countries has also led to the introduction of several major 'exotic' diseases. In the early 1990s, Ramu Sugar initiated a breeding programme to develop local varieties with a higher level of resistance to diseases endemic in the area. These varieties are prefixed 'PN'.

Endemic diseases have had a significant impact on commercial production at Ramu. In 1985-86, an unknown endemic disease, Ramu stunt, severely affected the widely grown variety Ragnar, causing heavy yield losses and the near collapse of the PNG sugar industry (Eastwood, 1990). Downy mildew, caused by *Peronosclerospora sacchari*, has caused ongoing yield losses and led to the discard of a number of high yielding varieties. Since production first began, leaf scald (*Xanthomonas albilineans*) and ratoon stunting disease (*Leifsonia xyli* subsp *xyli*) have been introduced and are also affecting sugarcane production. This paper provides details of an epidemic of ratoon stunting disease (RSD) at Ramu Sugar, and its impact on sugar production.

Materials and methods

RSD status of Ramu crops

This paper reports on studies conducted between 2002 and 2004 at Ramu Sugar estate, Madang Province, Papua New Guinea. Selective sampling of crops enabled the collection of sugarcane xylem sap for RSD assay. Weak sugarcane stools were selected and within these stools a healthy, actively growing stalk was sampled for sap extraction. The selected stalk was then cut at both ends to give at least 30-40 cm length. Vascular extract (sap) was collected from each stalk by the positive air pressure extraction method (Croft *et al*, 1994). A total of five samples were collected for each sugarcane block. About 1-2 ml of sap was collected, with one to two drops placed in wells on glass slides and air dried before dispatching to the South African Sugarcane Research Institute (SASRI) for assay. In the village and wild canes, stalks were randomly collected within a stool for sap extraction.

Most of the samples were sent to SASRI for assay, where the dried xylem sap slides were first processed with an antiserum specific to *Leifsonia xyli* subsp *xyli*. The processed slides were then examined using an immunofluorescence microscopy technique to determine the presence and density of RSD infection in the sample (¹personal communication).

Crop losses

Estimation of crop losses in the 2004 season was based on crop estimates obtained by subjective assessment from field managers (based on experience) and actual cane yields for the 2002 and 2003 seasons. These estimates provide a guide only as to the losses caused by the disease. There were about 100 blocks with no RSD detected in the 5-stalk samples, but yield data in these blocks were very variable and there were no trends in crop losses. The weather data from Ramu Sugar estate were used to determine any relationships (regression analysis) between rain days, evaporation and cane yield.

Results

RSD status at Ramu Sugar

RSD assays

Prior to 2002, a limited number of samples was taken from cane in village gardens and from commercial cane at Ramu Sugar, and the results of RSD assays were negative. A report in the literature of RSD in PNG (Davis and Bailey, 2000) could not be confirmed. It was only in 2002 that selective sampling of the commercial estate suggested that RSD was in commercial crops at Ramu (²unpublished data). Out of the 78 samples tested, 40% of these tested

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positive. This was the first record of RSD in PNG. Further samples were taken in 2003 and the samples were split and tested by the Bureau of Sugar Experiment Stations (BSES) in Australia and SASRI in South Africa. The results from both laboratories confirmed the presence of the causal organism.

A follow-up comprehensive sampling programme was carried out in 2004, with a total of 692 samples taken from commercial cane on the sugar estate, and 140 samples from wild and village garden canes. The results suggested that 85% of these samples were infected by the RSD bacterium (²unpublished data). Apart from the commercial cane on the sugar estate, 20% of the wild and village garden canes sampled also tested positive (Table 1). Although village and wild canes at other locations within PNG have not yet been intensively tested for RSD, samples collected at Kerevat and Rabaul, East New Britain Province, all tested negative. This confirms the results reported by Magarey *et al.* (2002) on the RSD status of sugarcane in other areas of PNG.

Table 1. Summary of RSD infections in commercial, wild and village garden canes from the 2004 survey.

Location	<i>Sacharum</i> spp	Samples tested	Number of wells tested positive to RSD				RSD positive %
			Nil	Low	Moderate	High	
Ramu Sugar estate, Madang Prov.	Hybrids	692	106	48	158	380	85
	<i>S. robustum</i>	8	8				0
	<i>S. officinarum</i>	31	24		5	2	23
Sausi/Kesowai, Madang Prov.	<i>S. robustum</i>	4	2	2			50
	<i>S. officinarum</i>	3	1	2			67
Kainantu, Eastern High. Prov.	<i>S. robustum</i>	15	12	1	1	1	20
	<i>S. officinarum</i>	12	9	3			25
Watarias-Lae, Morobe Prov.	<i>S. robustum</i>	23	20	2	1		13
	<i>S. officinarum</i>	25	18	7			28
Keravat-Tavilo, ENB Prov.	<i>S. officinarum</i>	2	2				0
	<i>S. edule</i>	11	11				0
	<i>S. robustum</i>	2	2				0
Rabaul, ENB Prov.	Hybrids	2	2				0
	<i>S. edule</i>	1	1				0
	<i>S. officinarum</i>	1	1				0

Nil, tested negative; low, moderate and high means 1, 2-3, 4-5 wells positive, respectively.

The incidence of RSD was generally high in commercial crops, where rapid disease spread is likely as a result of transmission by mechanical harvesting and other agricultural equipment. In the village and wild canes, the incidence of *Leifsonia xyli* subsp *xyli* was generally low. The spread of the disease in wild and village garden canes may be through planting of infected material, or the use of contaminated bush knives.

Effect on 2004 crop

The 2004 crop started very well with the cane yields in the first two months of harvest (late April-June) giving over 17% higher yields than the estimates (Figure 1a). As the dry season progressed, cane yields rapidly declined and were lower than earlier estimates in crops harvested from July through to the last week of harvest. In the final weeks of harvest, most crops were yielding less than 50 tons cane per ha, 36% below estimate. This reduction in cane yield represented more than 72 000 tons of cane (15% of the crop) equivalent to 7100 tons of

sugar, valued at more than US\$3.5 million. A similar estimate of 17% crop loss was made when the average cane yields from 2002 and 2003 crops were used (Figure 1b). Unlike the cane yield trends observed for the 2002 and 2003 crop (which held up for most of the harvesting period), the yields in the 2004 crop declined significantly starting in July, most likely from the combined effect of RSD and the dry weather. The additional costs of harvesting a low yielding crop, and under-utilised fertilisers and pesticides, could not be estimated here but these costs are additional to the value of direct crop losses from RSD.

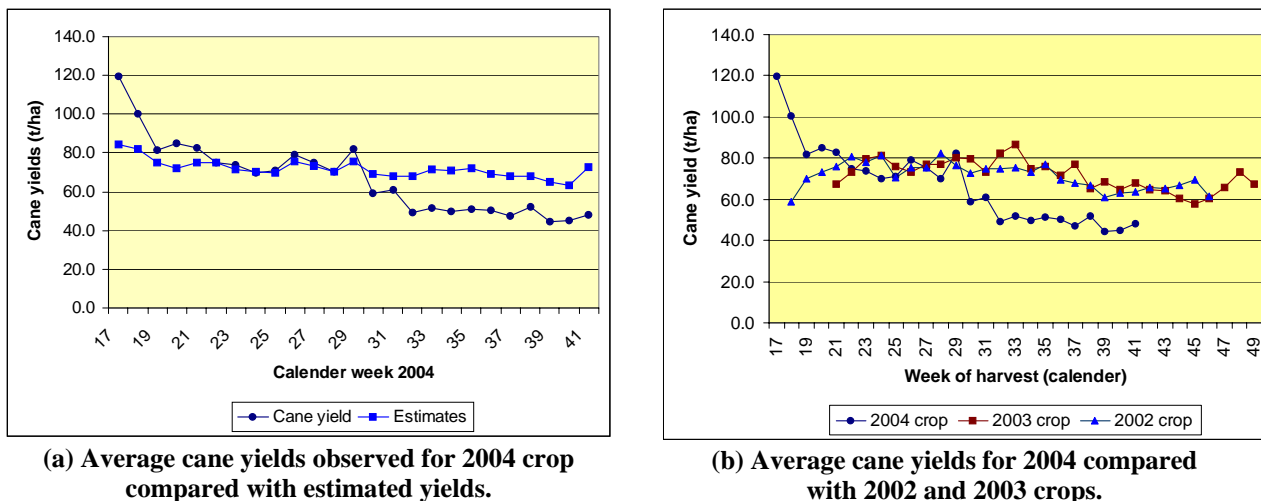


Figure 1. Summary of cane yields.

Total rainfall received during harvest seasons (April-October) of 2002 and 2003 were 95 and 34% higher than in 2004 (Figure 2). The impact of RSD on cane yields is severe during a dry year and this proved to be the case during 2004. Rainfall received from June to September was 40% below the long-term average. Severe moisture stress was widespread in 2004 crops and this resulted in minimal cane growth and consequent lower yields. Regrowth crops from cane harvested in 2004 were greatly affected, leading to shoot death; lower yields are anticipated in the 2005 crop.

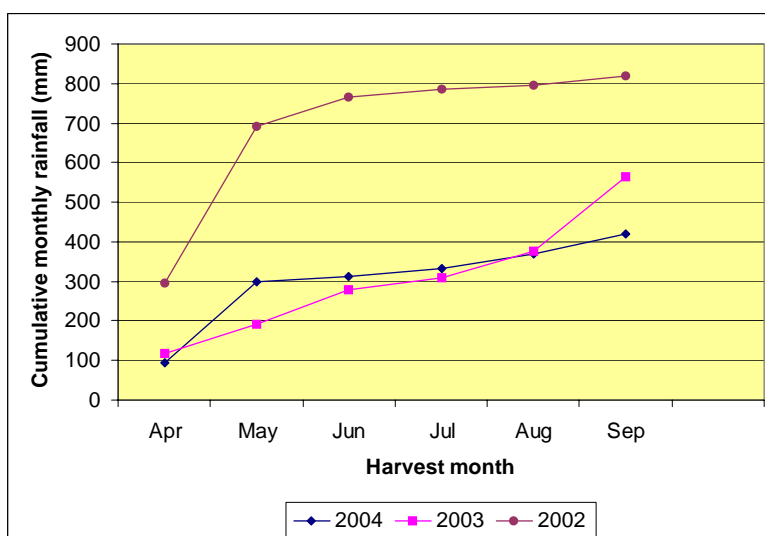


Figure 2. Cumulative monthly rainfall received during harvest for the 2002-2004 seasons.

Analysis of weather data on the estate showed that the cumulative number of zero rain days was significantly ($p < 0.001$) negatively correlated with weekly average cane yields in the 2004 season (Figure 3a). The effect of zero rain days in the 2003 and 2002 crops were also significantly correlated with weekly average cane yields, but the impact was not as severe as seen in the 2004 crop (Figure 3b,c). Similarly, class A pan evaporation was significantly ($p < 0.001$) negatively correlated with average weekly cane yields in the 2004 crop (Figure 4a). It was likely that the impact of RSD on cane yields in the 2004 crop became severe as cumulative pan evaporation reached over 450 mm. In the 2002 and 2003 crops, the impact of RSD was minimal and it was not until more than 800 mm of pan evaporation was reached that cane yields start showing a decline (Figure 4b,c).

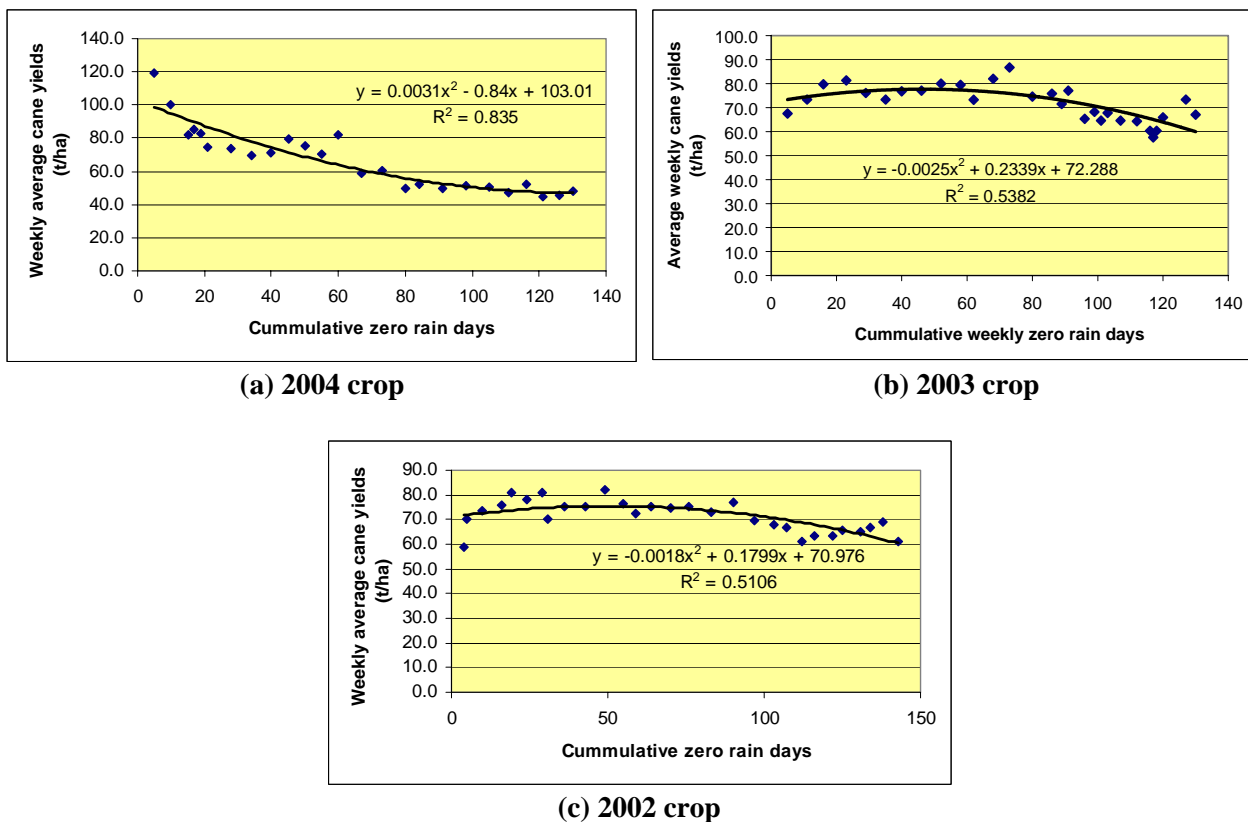
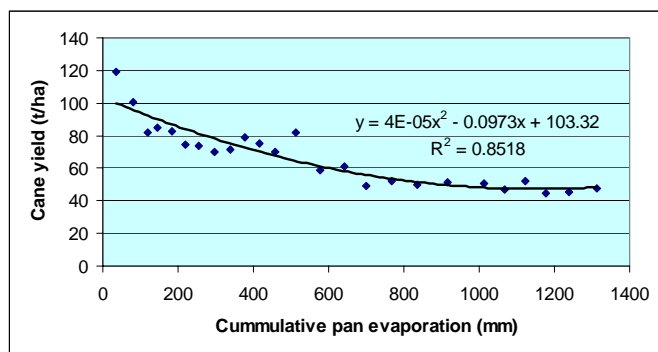
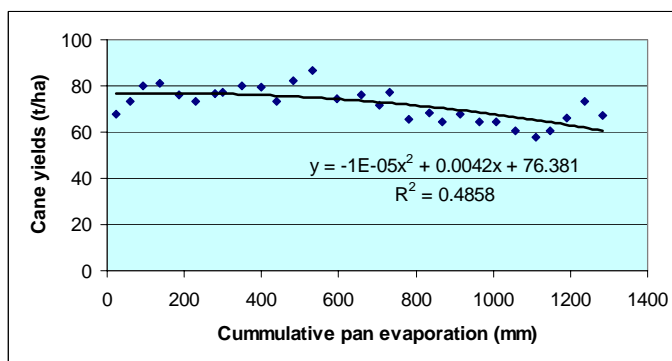


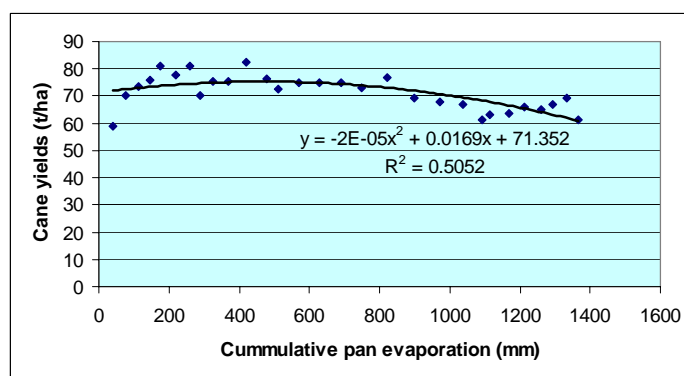
Figure 3. Relationships observed between average cane yields and cumulative number of zero rain days for the 2002-2004 crops. The impact of RSD on cane yield in the 2004 crop was highly correlated with cumulative zero rain days compared with the previous two crops.



(a) 2004 crop



(b) 2003 crop



(c) 2002 crop

Figure 4. Summary of relationships between average cane yields and cumulative class A pan evaporation during April to October.

Strategies for RSD management

The most effective RSD control method is the use of disease-free (hot water-treated) seed cane. Hot water treatment (HWT) involves placing stalks in a hot water bath at 50°C for three hours, and this can lead to 98% of stalks being RSD-free (Davis and Bailey, 2000). A second HWT of the nursery material produced (next round of planting) can lead to 100% disease-free seedcane.

A HWT facility was built in 2004 and is now in operation at Ramu. As RSD is new to Ramu Sugar, over US\$90 000 was spent in 2004 on laboratory equipment and other operating costs and consumables to initiate the RSD management programme. The on-going routine costs of the programme are expected to be US\$50 000-80 000 annually, an expenditure that was previously not necessary.

Another important component of the control programme is sanitation of machinery; educating growers and harvesting contractors to ensure they strictly adhere to the disease control recommendations is essential if RSD is to be controlled at Ramu Sugar.

Establishment of RSD-free seedcane plots began in late 2004, with about 15 ha planted to HW-treated cane. Planting material from these plots will be given a second HWT in May-June 2005 to establish disease-free seedcane plots. A total of 60 ha will be planted and seedcane will be available to plant more than 300 ha of commercial nurseries in 2006. In

2007, all the commercial plantings (up to 1800 ha) will be done with RSD-free seedcane. This process will continue in subsequent years as disease blocks get ploughed out and replanted to disease-free seedcane.

Discussion

The detection of RSD at Ramu Sugar estate in the past three years has added further constraints to sugar production. The RSD epidemic at Ramu Sugar has caused severe production losses valued at more than US\$3.5 million. The management of RSD will be a very important economic consideration, and the company invested US\$90 000 in 2004 to set up a HWT plant and develop strategies for the control of this disease. Use of disease-free planting material and keeping crops disease-free will be critical to minimise the impact of RSD on sugar production and maximise potential profits. Monitoring disease levels in commercial crops and seedcane will be an essential part of the control programme. The establishment of a diagnostic laboratory at Ramu Sugar is essential to achieve this.

The impact of the prolonged dry seasons during the harvest period will have a significant impact on cane yields. High cumulative zero rain days and evaporation (as measured by class A pan evaporation) has exacerbated the RSD impact on the 2004 crop. Since the dry weather is necessary for natural ripening, minimising RSD disease levels in the crop will be important to maintaining productivity and profitability.

It is anticipated that up to 98% of cane blocks will be infected with RSD by the end of 2006, and this should decline when disease-free cane is used for planting starting in 2007, and diseased crops begin to be ploughed out. It will not be until 2011 that the high RSD disease level will be brought down to less than 5%.

Maintaining machinery sanitation, especially when a high percentage of crops are diseased, will be a major challenge at Ramu. This will be important to minimise the spread of the disease to disease-free crops. This will require constant extension of the sanitation message to raise awareness of the potential risks, so that all crop production staff strictly adhere to the strict hygiene procedures now being implemented. Sterilising of all harvesting and fertiliser application equipment, including bush knives, and minimising volunteer cane in fallow blocks, will be critical in reducing the spread of the disease.

Monitoring of disease levels on the estate will greatly facilitate the management of RSD. A laboratory has been established and personnel have been trained in the diagnosis of the RSD bacteria. ELISA assay equipment will be purchased shortly under an Australian Centre for International Agricultural Research (ACIAR) project on sugarcane and this will be used for rapid testing of RSD. Linkages between the BSES Limited (Australia) and the South African Sugarcane Research Institute laboratories will be maintained for collaborative research on this disease.

Resistant varieties provide a second possible long term control strategy, but this is an expensive process and would lead to the loss of susceptible, but high yielding germplasm. It is anticipated that this will only be considered if machinery sanitation (including bush knives) proves impossible because of the high usage of knives by indigenous communities around the sugar estate.

The low concentration of RSD in village gardens and wild canes suggests that these canes may be tolerant to the disease. Recently, Omarjee *et al.* (2004) found a number of bacteria

from the genus *Burkholderia* in sap extracted from PNG village garden canes, and these have inhibited the growth of cultures of *Clavibacter michiganensis*, a close relative to *Leifsonia xyli* subsp. *xyli*. It is possible that this bacterium is providing some form of suppression of RSD in PNG village and wild canes. It may be possible that commercial cane was infected with RSD through contaminated bush knives (commonly used by local workers), and the disease was rapidly spread through the commercial cane by mechanical harvesting. However, there is a need for further research to determine whether this mechanism is likely.

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