MANAGEMENT STRATEGIES FOR RATOON STUNTING DISEASE IN SUGARCANE AT RAMU SUGAR

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ABSTRACT

Ratoon stunting disease (RSD) of sugarcane is caused by the bacterium, Leifsonia xyli *Davis and it is a major problem in many sugar industries worldwide. Recently, this disease was detected in commercial crops at Ramu Sugar. Data from estate wide survey indicated up to 84% of the samples taken were tested positive to RSD. In 2004, crop losses are estimated to be at least 15%, this is worth up to K14.2million. Management strategies have been developed and these would take up to 5 years to be fully implemented. This program would cost up to K0.5million in the first year and in subsequent years, this will be around K300-400,000 per year.*

Keywords: *ratoon stunting disease,* Leifsonia xyli, *Sacharum, sugarcane, disease management*

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* and *S. spontaneum*. Extensive stands of wild canes grow along rivers and roadsides as well as domesticated chewing and vegetable canes in village gardens. Up in the Highlands of PNG, both *Miscanthus floridulus* and *Erianthus* sp which are related to *Sacharum* are common. Pests and diseases of sugarcane are common and these present a high disease pressure resulting from the widespread occurrence of *Saccharum* species.

Commercial hybrid varieties were introduced into PNG since 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 8,500 ha is under sugarcane to produce around 500,000 tonnes cane to make 48-50,000 tonnes of sugar. About 2.5 million litres of ethanol is also produced mainly for export [Ramu Sugar Ltd unpublished Annual Reports].

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 program to develop local varieties with a higher level of resistance to diseases endemic in the area. These varieties are pre-fixed 'PN'.

Endemic diseases have had significant impact on commercial production at Ramu. In 1985-86, the then unknown endemic disease, Ramu stunt, severely affected the widely grown variety Ragnar, causing heavy yield losses and near collapse of the sugar industry in PNG (Eastwood 1990). Downy mildew, caused by *Peronosclerospora sacchari*, has caused on-going 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 s.sp. xyli*) have appeared and are also affecting sugarcane production. This paper gives details of ratoon stunting disease (RSD) epidemic at Ramu Sugar and its impact on sugar production. Implementation of management strategies for RSD have started and these are also discussed here.

RATOON STUNTING DISEASE

Causal organism

The causal organism of RSD is a small, slender, usually bent or Y-shaped bacterium called *Leifsonia*

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xyli subsp. *xyli* Davis *et al* which can be grown on complex artificial media.

Distribution

The disease occurs in all cane-growing areas of the world including Australia. The disease was recently detected in commercial cane at Ramu Sugar, Papua New Guinea. The disease is spread mainly by the use of diseased planting material and subsequently by cutting implements such as; mechanical harvesters, bush knives and stool splitters. Volunteers from the previous crop may harbour the disease and may cause scattered distribution in the newly planted crops. Harvesters also may spread the disease throughout the ratoon crops.

Symptoms and identification

The external symptoms of RSD are a general stunting and un-thriftiness in diseased plants, similar to that caused by poor cultural practices such as, inadequate moisture, poor soils, fertilizer or other stresses. Variation in growth between healthy and diseased stools in partly diseased fields, or between badly stunted and less affected stools where there is 100% infection, frequently gives a characteristic, irregular 'up and down' appearance to infected crops. Two types of internal stalk symptoms may be found associated with the disease; one is a discolouration (which varies through yellow, orange, pink, red and reddish brown) of individual vascular bundles in the nodes of mature cane, and the other a general pink colour or 'pink blush' throughout the nodes of very young cane.

The dis-coloured vascular bundles can be seen at the base of the nodal tissue when a reasonably mature diseased stalk is sliced longitudinally with a sharp knife. They are first seen just below the rind as small dots. As slices are made more deeply into the stalk, they appear in the shape of dots, commas and various forms of straight or bent lines up to 3mm long, depending on the angle at which the vascular bundles are cut. In transverse sections made at about the level of the wax band, the dis-coloured bundles are seen as small spots throughout the node with streaks in the leaf traces radiating from near the centre of the stem. For a diagnosis to be reasonably reliable, the dis-coloured vascular bundles should occur throughout the node and in virtually all the fully developed nodes of a stalk. Symptoms are generally better developed at the base of stalks.

Apparently healthy cane can also show discoloured vascular bundles closely resembling those of ratoon stunting and some varieties will show no nodal symptoms even when they are diseased. Thus, a positive identification of the disease can be made by examining a vascular extract with an electron or phase-contrast microscope for the presence of the small bacteria which cause the disease.

The standard procedure for examination for bacteria with the phase-contrast microscope involves:

(i) Collect the vascular extract by exerting a positive air pressure to one end of a piece of stalk and collect by sucking up the extract with a Pasteur pipette. Stalk pieces should be from the base of the stalk and pipes in the stalk must be plugged with plasticine or a pencil.

(ii) Place as small drop of the extract on a clean slide and cover with a coverslip.

(iii) Place a drop of microscope immersion oil on the coverslip and examine for RSD bacteria at 1000x magnification or greater with phase-contrast illumination.

The RSD bacteria are thin rods (0.25-0.5 x 1-4 *m*m) which are often bent and occasionally Y shaped (Davis and Bailey 2000). The detection of RSD in a field depends on the number of stalks examined and the sensitivity of the diagnostic technique. Slicing stalks by experienced people can be quite accurate; however, varieties which show no nodal markings or false positive markings cannot be accurately diagnosed by this technique. Phase-contrast microscopy is currently the most sensitive technique for routine diagnosis. The greater the number of stalks examined by phase contrast microscopy the greater the probability of detecting the disease in a field that is not 100% diseased. This probability of detecting the disease can be increased by selecting the largest stalk in poorly grown stools (possibly poorly grown because of RSD), volunteer cane or canes showing possible nodal markings. At least 10-20 stalks need to be examined to have a reasonable chance of detecting RSD in a field with 10% diseased stools.

Transmission

Diseased planting material is an important means of spreading RSD. The base-cutter and the spray of juice from the chopper box and extractor fan of harvesters can spread the disease to cut stubble. They can carry it into clean blocks if not adequately sterilised beforehand, and they increase the amount of infection in blocks that already have some disease.

Harvesters used to cut plants for billet planters, plant cutting machines, and cane knives can all transmit the RSD bacterium to healthy cane.

The disease is readily transmitted artificially by dipping the freshly cut ends of setts into juice extracted from diseased plants, or by applying this juice to the cut surface of a stalk decapitated above the growing point as for leaf scald. The disease does not appear to spread readily in the field by any natural means.

Economic importance

The effects of ratoon stunting are a general reduction in yield, the extent of which depends on the variety and weather conditions. Losses can be very severe during droughts, but they can be reduced considerably by regular irrigation. Sugar content is usually not affected unless death occurs. The slow ratooning of infected crops, particularly during dry weather, allows weeds to become established. Some varieties may fail to ratoon with the disease, but this is not usual (Davis and Bailey 2000).

Control

RSD infected planting material can be effectively controlled by the treatment of stalks at 50°C for three hours. Clean seed plots are a good way of providing disease-free planting material but extra care is needed to ensure the clean seed plot never becomes infected. The sterilization of all cutting implements which are likely to infect healthy planting material, or carry infection into healthy fields is essential.

The recommended method for disinfecting machinery is to thoroughly clean off all dirt and organic material, spray with the recommended rate of benzalkonium chloride (Cane Knife Steriliser) and leave for 5 minutes (Davis and Bailey 2000). In harvesters the base-cutter, throat, chopper box, extractor fans and toppers should all be sterilized. This is important when using a harvester for cutting billet plants. Once a field is infected the prevention of spread within that field is virtually impossible. Tolerant varieties can play some part in reducing losses, but they are only a few.

THE SITUATION AT RAMU SUGAR

Monitoring

A limited number of samples were taken from cane in village gardens and the commercial cane at Ramu Sugar but the results of the diagnosis were negative. The record of the presence of the RSD in PNG by Davis and Bailey (2000) could not be proven. It was only in 2002 that selective sampling was carried out that RSD was detected in commercial cane at Ramu (Ramu Sugar Limited, internal reports). Out of the 78 samples tested for RSD in South Africa, 40% of these tested positive. This was the first record of RSD in PNG. Further samples were taken in 2003 and the samples were split and got tested by BSES in Australia and South Africa. The results received for these samples from both laboratories confirmed the presence of the causal organism.

A comprehensive sampling program was carried out covering over 700 samples taken from commercial cane on the sugar estate and 120 samples from wild and village garden canes. The results from these samples showed up to 84% of the samples tested positive to RSD (Ramu Sugar Limited, internal reports). Apart from the commercial cane on the sugar estate, up to 20% of the wild and village garden canes sampled also tested positive (Table 1). The concentration of RSD was generally high in the commercial cane most likely effectively spread by mechanical harvesting and other agricultural equipment used. In the village and wild canes, the concentration of the bacteria was generally low. The spread of the disease in the wild and village garden canes may be through planting of infected material or use of contaminated bush knives.

Effect on 2004 crop

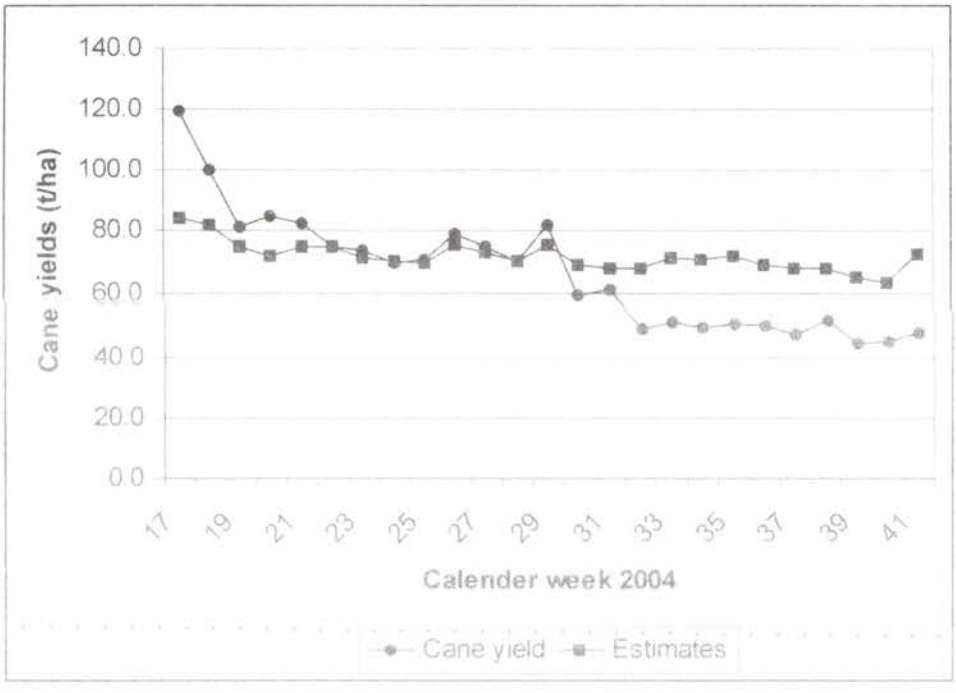
The 2004 crop started very well with the cane yields in the first 2 months of harvest (late April-June) giving over 17% higher yields than the estimates (Figure 1). As the dry season progress the cane yields rapidly declined and this was lower than the estimates for July through to the last week of harvest. By the end of the harvest, most of the blocks harvested were yielding less than 50 tonnes cane per ha [36% below the estimates]. This reduction in cane yield represented more than 72,000 tonnes of cane (15%), which is equivalent to 7,100 tonnes of sugar [valued over K14.2 million]. The cost of

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

Location	Nil	Low	moderate	high	RSD positive %
Commercial (692)	106	48	158	380	85
Ramu Estate wild cane (8)	8				0
Ramu Estate, backyard plots (31)	24		5	2	23
Sausi/Kesowai wildcane (4)	2	2			50
Sausi/Kesowai gardencanes (3)	1	2			67
Kainatu wild cane (15)	12	1	1	1	20
Kainatu village garden canes (12)	9	3			25
Watarias-Lae wild cane (23)	20	2	1		13
Watarias-Lae garden cane (25)	18	7			28

Nil, tested negative; low, moderate and high means 1, 2-3, 4-5 wells positive, respectively.
Numbers in brackets show total number of samples taken.

***Figure 1*:** Summary of actual cane yields observed during 2004 crop compared to the crop estimates (budget).



harvesting a low yielding crop, fertilizers and pesticides used could not be estimated here but these costs are additional to the value of crop losses from RSD.

The effect of RSD on cane yields is severe during a dry year and this proved to be the case in 2004. Rainfall received from June to September was 40% below the long term average. Severe moisture stress was widespread in the crops; resulting in no growth and lower yields. Re-growth from cane harvested was greatly affected leading to shoot death with lower yields anticipated in the future crop.

STRATEGIES FOR RSD MANAGEMENT

The effective control method of RSD is the use of disease-free seed cane at planting, usually obtained from use of hot water treated cane. Cane used for planting is placed in a hot water bath at 50°C for three hours can lead to 98% control of RSD bacteria

in the planting material. Repeat treatment in the next round of planting (double treatment) could produce almost 100% RSD-free seed cane.

A hot water treatment (WHT) facility was built in 2004 at a cost of K150,000. This facility has been established and is now in operation. As this is a new problem, more that K350,000 will be spent this year to purchase various laboratory equipment and other operating costs/ consumables to get the control program started. The cost of the program will be K300-400,000 annually, an expenditure previously not necessary.

One of the most important factors in the control of ratoon stunting disease is the education of growers and harvesting contractors to adhere strictly to the recommendations for disease control. If these procedures are followed the disease can be kept under control with potential crop losses minimized.

The main challenge after the introduction of disease-free seed cane in to production, will be to minimize the spread of the disease in to clean cane blocks. This will require constant awareness of the potential risks to production and getting all crop production staff to follow strict hygiene procedures now being implemented. Sterilizing of all harvesting and fertilizer application equipment, bush knives and minimizing volunteer cane in fallow blocks will be very 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 trained in the diagnosis of the RSD bacteria. An ELISA equipment has been purchased with funding from the Australian Centre for International Agricultural Research project on sugarcane and this will be used for rapid testing of RSD. Linkages between the BSES Ltd (Australia) and the South African Sugarcane Research Institute laboratories will be maintained for collaborative research on this disease.

DISCUSSION

The RSD epidemic at Ramu Sugar has caused severe production losses valued at more than K14.2 million. The management of the RSD will be very important economic consideration and the company has invested up to K0.5 million to set up HWT plant and develop strategies for the control of this disease. Use of disease-free planting material and keeping clean sugarcane will be very critical to minimize its impact on sugar production and maximizing potential profits. Monitoring disease levels in the crops and seed cane will enable effective implementation of the control program. The establishment of a diagnostic laboratory at Ramu Sugar is essential to achieve this.

The selection of resistant varieties will provide long term solutions but this is an expensive process. 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* extracted from PNG village gardens that has proved successful in inhibiting the growth of *Clavibacter michiganensis*, a close relative to RSD. It is possible that this bacterium is providing some form of suppression on RSD in village and wild canes in PNG. It may be possible that RSD got in to the commercial cane through contaminated bush knives (commonly used by local workers) and rapidly spread through the commercial cane by mechanical harvesting.

CONCLUSION

The impact of RSD in the 2004 crop was severe with crop losses estimated to be 14% valued at more than K14million. This loss is already significant for a small sugar industry. The cost of implementing management strategies will also be significant. Given the ease in the transmission of the disease through contaminated machinery and implements, it will be necessary to educate all workers about the importance of RSD and its management strategies adopted.

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