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Review of the RSD situation in the South Johnstone Mill Area

Commissioned by: Innisfail-Babinda Cane Productivity Service Board

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By

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1.0
EXECUTIVE SUMMARY

1. **RSD review background**: High incidence of RSD in both nursery cane and in commercial fields led to the IBCPS Board requesting a review of the RSD situation in the Innisfail-Babinda area.
2. **Review**: extensive consultations were held in early October 2018 with IBCPS staff and several other key industry players to find out the reasons for the current RSD incidence in the region.

3. **Management history**: a consideration of RSD management over the last 20 years led to the following conclusions: -
    - Extension of RSD management solutions in the region has been inconsistent and lacking, especially over the last 15 years.
        - A significant reduction in IBCPS staff numbers, and experience, over this time was a very significant contributing factor.
    - Farmers are failing to consistently apply known RSD management strategies, including obtaining Approved seed plot cane, sterilising all cutting surfaces on planting equipment, planting their nursery cane into fallow nursery plots and ensuring harvesting equipment is sterilised.
    - The situation has been exacerbated by two severe cyclones in the period which destroyed nursery plots, the return of 'tree farm' lands to cane without sufficient clean nursery material, a very big emphasis on smut management during the smut epidemic – while tending to ignore RSD, and application of inappropriate assays in RSD testing of nursery cane.

4. **Key recommendations**: for reducing the impact of RSD are: -
    - **Staff resources**: significantly increase IBCPS staff numbers and resources to provide for better IBCPS RSD services to the area.
    - **Assay methods**: adopt the best RSD assay procedures – with discard (generally) of slicing, phase contrast microscopy (PCM) and EB-EIA.
    - **Approved seed plots**: a review of the placement and number of Approved seed plots for the Babinda-South Johnstone area be undertaken to ensure farmers can easily access large quantities of quality planting material.
    - **Commercial crop survey**: a survey of commercial crops be undertaken, using the best assay technology, to determine the extent of the RSD problem. This will allow a calculation of the monetary cost to the area so that local industry can better prioritise RSD amongst the factors affecting profitability.
    - **Software capability**: adoption of better software for recording RSD incidence data and for mapping its occurrence through the area.
        - Staff training to equip them for various software will be required.
    - **RSD extension package**: a well-designed and considered RSD extension strategy to promote an excellent Integrated Disease Management (IDM) approach – this will be needed long-term to reduce RSD incidence.
    - Other minor recommendations are located in the text of the review.

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2.0 INTRODUCTION

Ratoon stunting disease (RSD) is an insidious, bacterial, systemic disease of sugarcane that has no external symptoms; the disease is caused by *Leifsonia xyli* sub.sp. *xyli (Lxx)*. The bacterium is very readily transmitted by any equipment that cuts sugarcane vascular tissues (including cane knives, planters and harvesters) and is also spread via infected planting material. It limits yield through several mechanisms; the principal one is the restriction of water movement through the xylem (water-conducting) tissues. Growth slows as a result, with drought stress exacerbating the effect and leading to yield losses upward of 50% in dry areas or during drier seasons in wetter areas. Diagnosis is difficult; the most sensitive techniques rely on a molecular assay (qPCR) of xylem extracts; a current research project is seeking to make commercially available a leaf sheath biopsy (LSB-qPCR). Further research is needed in defining the RSD industry incidence.

The sugarcane industry in Australia has long been aware of the cause and effects of RSD; an issue has been maintaining focus on the disease, and the application of the management strategies needed to minimise incidence. Recently, RSD incidence reached undesirable levels in the South Johnstone mill area of far-north Queensland. The Board of the Innisfail-Babinda Cane Productivity Services (IBCPS) sought guidance on whether increasing its efforts in RSD management would provide an economic return for its miller and grower investors, and if so, what strategies would provide the best economic returns. A review of the RSD situation was needed in order to identify the causes of the disease outbreak and to make recommendations for remedial actions to reduce the extent of the problem.

Along with Dr Anthony Young (The University of Queensland), I was asked to explore the situation. I spent time on 2-3 October 2018 discussing the problem with industry staff (initially Mick Ward (MSF), Bianca Spannagle (IBCPS staff member), Joe Morano, (CANGROWERS and contractor / farmer), Stephen Calcagno, Chairman, Babinda CANEGROWERS and contractor / farmer, Michael Porta, (MSF Agronomist) to determine the specifics of what happened with RSD management in the past and the current approach adopted by local industry. With experience in the local area covering the last 34 years, I also drew on my past knowledge of RSD management within the region. The report below outlines an assessment of the current situation along with draft recommendations for actions to reduce disease incidence.

3.0 PAST RECOMMNEDED INDUSTRY MANAGEMENT STRATEGY

Before outlining past recommended management strategies, a brief description of the disease provides some important background information.

3.1 **Disease characteristics**

Causal agent: is a very small coryneform bacterium (around 1µm) that is difficult to visualise except under phase contrast microscopy; even then it is not easy to see.

Transmission: the bacterium is very easily transmitted on cutting surfaces, via all knives, blades and machinery that cuts cane. It is documented that a single diseased stalk passing through a whole-stick planter may infect the next 100 stools established from healthy cane passing immediately afterwards through the same planter. The bacterium may survive for up to 12+ days on cutting surfaces.

Planting material: the disease also spreads through diseased planting material; as a vegetatively propagated crop, this is an important spread mechanism.

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- The bacterium can be eliminated by hot water treating (HWT) the diseased cane at 50^0C for 3 hours. This treatment is not 100% effective (3% escapes) and two consecutive HWT treatments are recommended to be confident of *Lxx* elimination.
    - Best practice involves only heat treating the cleanest material to ensure the cane is indeed free from *Lxx*.

Volunteers
The presence of surviving, diseased plants from terminated crops is a significant source of the causal agent, both for newly established commercial crops and especially for farmer nursery cane. The presence of even a few volunteer, diseased plants means that as these plants are cut (either when harvesting a commercial crop or when a farmer cuts nursery material), the bacterium will be present on cutting blades and transferred to the healthy cane that is cut immediately afterwards. Volunteers are thus an immediate threat to the health of nursery material and new commercial crops.

Sterilisation: there are chemicals available to industry that kill the bacterium on pre-cleaned, cutting surfaces (for instance, 'Sterimax', a quaternary ammonium compound). Such chemicals should be applied routinely to all machinery cutting surfaces before cutting plant sources and commercial crops.

Diagnosis: molecular assay of xylem extract provides the most sensitive test for the bacterium. Historically, diagnostics progressed from unreliable observation of internal stalk symptoms (slicing), to phase contrast microscopy (PCM), to serological assays (EB-EIA) and currently to molecular technologies (qPCR). Molecular assays provide much improved sensitivity, 1000+x more sensitive than EB-EIA or PCM.

3.2 **Recommended management strategies**
A brief description of the current recommendations therefore, are the following: -

1. **Disease-free planting material**: it is imperative to obtain disease-free planting material by regularly accessing '*approved seed*' (HWT cane) from Productivity Service Approved seed plots. This is a critical part of the strategy.
    - *Nursery plots*: the disease-free cane should be planted into fallow ground (to avoid infection via diseased volunteer plants) using sterilised planting equipment
    - *Diagnosis*: before cane is used to plant new commercial crops, the material should be re-assayed for *Lxx*, using the most up-to-date diagnostic test.

2. **Sterilisation of cutting equipment:** all equipment used to cut planting material, to plant new crops and to harvest these crops, should be cleaned and sterilised to prevent infection of the healthy cane.
3. **Termination of diseased crops**: when commercial crops have tested positive for *Lxx*, then plans should be made to: -
    - Ensure no spread of the disease to other cane on the farm (through vigilant sterilisation of equipment)
    - Terminate the crop, as soon as financially practical.

As the bacterium is so easily transmitted, any deficiencies in the application of these management strategies will inevitably lead to a disease outbreak.

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4.0 **RSD INCIDENCE**

4.1 **Incidence pre-2003**

Introduction: Previous to 2003, Cane Productivity Service (CPS) supervisors were required to report pest and disease data to BSES on an annual basis. For RSD, this included details on plant source inspections, tonnage of cane supplied from Approved seed plots, hot water treatment information, a summary of the diagnostic techniques used by the Boards plus other information. Individual reports from Mourilyan, South Johnstone and Babinda staff for the period are maintained at SRA Tully. Example data are included in Table 1 (1998 information) and provide RSD incidence data typical for the late 1990s-early 2000s.

Table 1: Example data on RSD inspections and incidence for Babinda, Mourilyan and South Johnstone Mill areas (1998).

Mill area	No. assignments inspected (%)	Plant source blocks with RSD	Assignments with RSD	No. assignments receiving cane ex-Board plots	Diagnostic techniques used			Known area RSD (ha)	Estimated area RSD (ha)
					Slicing	PCM	EB-EIA		
Babinda	239 (98%)	15	9	85 (31%)	+	+	+ (ASP only)	282	500
Mourilyan	125 (38%)	46	19	145 (48%)	+	+	+	246	1200
South Johnstone	212 (64%)	8	7	116 (?)	+	+	+	105	500

These data suggest RSD incidence varied between mill areas and was significant even in these times. Estimated diseased cropping areas, expressed as a percentage of the total area for 1998 in each mill area, were: -

i. Babinda: 4.1%
ii. Mourilyan: 8.8%
iii. South Johnstone: 3.1%.

4.2 **Incidence 2003-2016**

Introduction: There are no SRA-held records of RSD incidence in the three mill areas for the 2004-2016 period, and there are only a relatively few records held in CPS files (Bianca, personal communication). The most significant RSD incidence date comes from a survey initiated by Michael Porta (IBCPS co-ordinator for 2013-2014). These data reflect incidence in plant source inspections (PSI) and some commercial crops across the Mourilyan-South Johnstone areas. Two hundred crops were sampled across the region, south of the North Johnstone River. Samples were collected and dispatched to the SRA RSD assay lab for EB-EIA assay. The results are summarised below.

4.2.1 ***Overall RSD incidence***:

- Samples positive for RSD: 16%
- Farms positive for RSD: 17%

4.2.2 ***Crop cycle influences:*** when the data were analysed by crop cycle stage, there appeared to be differences (Figure 1).

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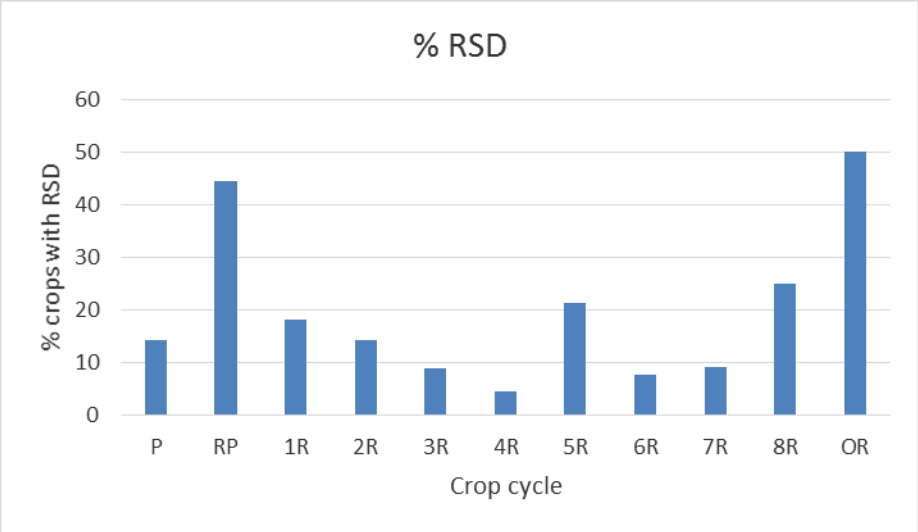
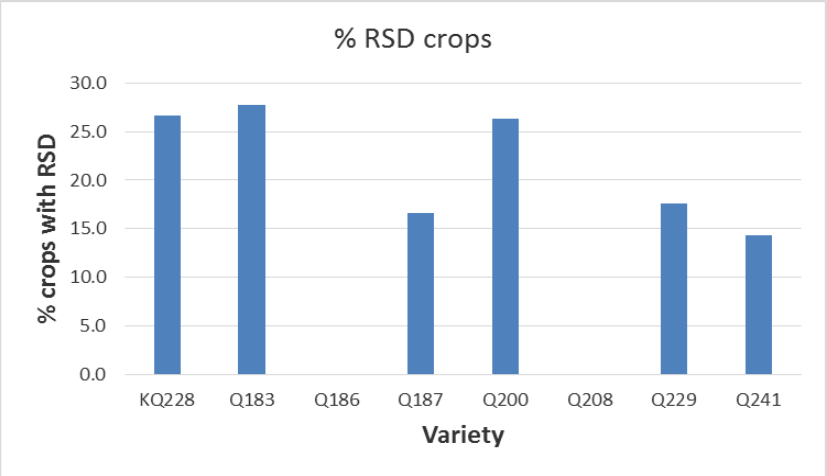


Figure 1: RSD incidence as detected in crops through the crop cycle.

4.2.3 ***Variety influences***: Previous research suggests there are differences in the propensity of different varieties to host the bacterium. This is illustrated in the survey data (Figure 2).



Data for Q186[A] and Q208[A] reflect their known more resistant reaction to RSD, with no detected *Lxx* infection (47 out of 200 sampled crops). The lack of disease in these crops is in contrast to the relatively high levels of disease in canes such as KQ228[A], Q183[A] and Q200[A].

4.3 Current incidence

Introduction: some data are available on RSD incidence within the area, principally from records from mid-2017 and 2018. These are now held electronically by IBCPS and are fully-searchable.

4.3.1 *IBCPS Approved seed plot:* an Approved seed plot (Martyville) south of the North Johnstone River contained RSD-diseased plots in 2017, but the infection has now been eliminated.

4.3.2 *Farmer nurseries:* the following percentage of plant sources were found diseased in each of the two years

- 2017: 16%

- 2018: 20%
  - Higher disease levels in 2018 may reflect SRA assay lab adoption of the more sensitive qPCR assay of xylem extracts in 2018 (vs 2017).

4.3.3 *Commercial crops:* no representative data are available on the current RSD incidence in commercial crops. Some crops were sampled as part of plant source inspections, but the information could not be construed to accurately reflect actual field incidence.

4.4 *Economic cost to industry:* because of the lack of recent commercial incidence data, no accurate estimate of lost industry revenue can be provided. However, if the disease incidence in plant sources is any guide, then the likely commercial crop incidence could be very high (may be >30% crops). This figure can be used to calculate potential losses to South Johnstone mill; in this case the following data / assumptions have been adopted: -

South Johnstone milling data (2017)

- Ha harvested: 22,708
- Mean cane yield: 79.4 tonnes / ha

The disease would have the following economic implications for the South Johnstone mill area, based on assumed losses of 10, 15 and 20% tonnes cane / ha, with a value of $30 / tonne cane (Table 2)

Table 2: Estimated economic losses from RSD in the South Johnstone mill area (2017), with assumed yield losses of 10, 15 and 20% (t/ha).

Assumed losses	Ha affected	Lost tonnes/ha	Lost tonnes	Lost income ($)
10% loss	6812.4	7.94	54,090	1,622,713
15% loss	6812.4	11.91	81,135	2,434,070
20% loss	6812.4	15.88	108,180	3,245,427

This suggests current losses to RSD could be in the order of $1-3m.

4.5 *General application of management strategies*

4.5.1 *Accessing Approved seed plot material:* 400-500 tonnes of material was sourced from the IBCPS plots in 2018. This compares with around 600 tonnes of material collected from Babinda, South Johnstone and Mourilyan CPPB plots in 1998.

4.5.2 *Planting into fallow ground:* there is no information available on the percentage of nursery cane planted into fallow ground (vs land containing volunteer cane).

4.5.3 *Plant source inspection:* 48.5% of farmers requested plant source inspections in 2018.

4.5.4 *Sterilisation of cutting equipment:* there is no information on the extent to which this practice is followed.

4.5.5 *Contractors:* again, there is no information available on how contractors address RSD management.

4.6 *Unknown causes for disease incidence:* in a review such as this, it is important to determine if unknown reasons exist for the RSD detected in recent years. Three cases were identified where the disease occurred unexpectedly on farms where standard recommended RSD management practices are followed. There is no general feeling amongst industry staff that RSD is spreading via unknown mechanisms. It would be worth following up, however, on the three crops where incidence cannot be explained.

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5.0 PRE-DISPOSING FACTORS FOR RSD IN INNISFAIL-BABINDA

Introduction: As sugarcane is grown over a crop cycle, generally lasting 4-7 years, the incidence of the disease depends on the management history over a much longer period. Factors affecting RSD management in the Innisfail-Babinda area are therefore considered over the last 15-20 years.

5.1 IBCPS services: Cane Productivity Service (CPS) staff offer a strategic and important service to the local sugarcane industry. They provide the original source of disease-free planting material through their Approved seed plots. They are also agents for the most sensitive RSD assay of planting material (as provided by SRA). IBCPS staff also provide one-to-one advice on other management strategies, such as sterilisation of farm machinery, general knowledge of the disease, and extension advice concerning the specifics of the disease on an individual farm basis. The diligence, accessibility, and then provision of the diversity of services is a critical aspect to RSD control within the district and a key part of IBCPS staff duties.

The success of RSD management applied by industry depends to no small extent therefore on the services provided by the local Cane Productivity Service (CPS). In assessing factors leading to RSD incidence within a region, a major consideration is how the service provided by IBCPS has varied over an extended period. IBCPS activities are considered therefore over three time periods (>15 years, 2-15 years ago, the last 2 years).

5.1.1 **Pre-2003 (>15 years ago)**

In previous times (>15 years ago), three CPS groups were present in the region: i. Mourilyan Cane Protection & Productivity Board (MCPPB), ii. South Johnstone CPPB and iii. Babinda CPPB. This inevitably led to a more locally-focussed and executed RSD program.

5.1.1.1 *Industry staffing*: Around six, full-time, experienced staff members were present on the ground to service the area.

5.1.1.2 *Disease diagnosis*: There was very significant emphasis during this period on RSD, with diligent collection of samples for RSD assay; Mourilyan and South Johnstone samples were generally sent for EB-EIA assay to the SRA RSD assay lab (the best available assay service at the time). Some slicing was used by Mourilyan staff but not by South Johnstone personnel. Babinda plant sources were first assayed via slicing (to view internal stalk symptoms) and, when doubt existed, via PCM. It is estimated (from CPPB reporting to BSES at the time) that a very high percentage of Babinda plant sources were inspected, with lower percentages in the Mourilyan and South Johnstone mill areas.

5.1.1.3 *Operation of Approved seed plots:* Approved seed plots were operated in each local area (Babinda, South Johnstone, Mourilyan) and were available for local farmers to access. It is not clear how many plots were in each mill area but the operation ran smoothly and successfully. Three hot water treatment tanks were available to treat farmer nursery cane for most of this period – tanks were located at each of Mourilyan, South Johnstone and Babinda mills, with close attention paid to water temperatures and treatment times.

5.1.1.4 *Grower awareness of RSD*: because of the emphasis placed on RSD management, grower awareness of the issue was good. Several extension strategies, such as demonstration of RSD yield losses in three varieties at Martyville in the 1990s, is still remembered by local growers. Personal interactions with the CPPB staff at the time suggested that each CPPB

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were diligent in extending their RSD knowledge to growers. Michael Porta, Joe Morano and Bianca Spannagle all confirmed this perception.

5.1.1.5 *Grower relations with Board staff:* generally good grower relations were maintained via long-term, knowledgeable and experienced staff (George Bugeja, Dave Collinson (Mourilyan) / Neil Clark, Kim Bodka (South Johnstone) / Mike Goodson, Bill Brand (Babinda)).

5.1.1.6 *Disease records*: most record keeping was paper-based – but thorough records were maintained. Prior to 2003, CPPB supervisors reported to BSES each year on their RSD management activities. This included the following data: i. plant sources inspected, ii. number of RSD-positive, iii. estimated area diseased, iv. tonnes cane HWT, v. tonnes distributed from Board approved seed plots to growers plus several other parameters.

There was definite emphasis placed on RSD management; long-term staff, with very significant experience in RSD and good connections with the growing sector, were actively extending RSD management advice to the farming community.

5.1.2 **2003-2016 (2-15 years ago)**
With the combining of the CPPBs (into the Innisfail-Babinda Cane Productivity Service) in 2006 and some change in their function, staff numbers were significantly reduced with only around 3 in-field permanent staff employed. Previous CPPB long-term staff had mostly resigned at this point to take up other positions; very significant RSD experience was thus lost to the local industry.

5.1.2.1 *Diagnostic testing*:
5.1.2.1.1 *Babinda*: staff continued to use slicing / PCM as their diagnostic assays of choice, even though assay technology had improved. If a positive sample was detected, then close attention continued to be paid to the issue and farmers were advised to obtain a disease-free source – assistance was offered with how to access this. The sensitivity / accuracy of the slicing assay remained questionable, given the improvements in assay technology.
5.1.2.1.2 *Innisfail-based staff*: new Innisfail staff continued to utilise the SRA assay lab, but in more recent times, the quality of samples sent for assay was at times poor. For instance, in early 2017, 11 boxes of samples were sent for EB-EIA assay without clear records and without proper cooling (to maintain juice quality for assay). These samples were rejected by the SRA assay lab. There is significant doubt about the methods / quality of samples sent for RSD assay during this period. A IBCPS staff member also utilised slicing as an assay procedure but the method used was questionable; it was noted that slicing of the upper portions of stalks was undertaken, rather than the slicing of lower sections (the recommended position).

5.1.2.2 *Operation of Approved seed plots:* as staff turnover continued during the period, knowledge and attention paid to the operation of Approved seed plots in the Innisfail area was somewhat deficient. This was epitomised by the planting of RSD-diseased cane into the Martyville Mother plot in 2016 (detected in early 2017).

5.1.2.2.1 *Babinda*: good standards appear to have been maintained in Babinda plots located at Bartle Frere and Babinda.

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5.1.2.2.2 *Innisfail:* four plots were initially present in the mid-2000s – in the southern and northern parts of the area (Silkwood-Mourilyan). Any lapse in seed cane quality at these plots is extremely significant.

5.1.2.3 *Grower awareness of RSD*:
5.1.2.3.1 *Babinda*: with Bill Brand operating consistently in the Babinda mill area, a strong emphasis remained on RSD management through this period.

5.1.2.3.2 *Innisfail:* Some questions have been raised about the emphasis placed by IBCPS staff on RSD management in the South Johnstone / Mourilyan area during this period. One reason noted was a possible lack of mentoring of new recruits by long-term Productivity Service officers with significant RSD experience. Such mentoring would have emphasised both the significant disease priority and the need for the application of management strategies. This is likely to have contributed to a lack of active extension on RSD to local farmers, including details related productivity and yield constraints.

5.1.2.4 *Grower relations with Board staff*: it was noted in discussions that some grower relations with Innisfail-based IBCPS staff were not optimal over this period; this contributed to some difficulty in extension of information to growers. Bill Brand at times had to cover some extension activities in the South Johnstone area to cover for poor grower relations.

It should also be noted that previous long-term BSES extension staff, again with good knowledge of RSD, were replaced by less-experienced and transient BSES extension officers in this period. In 2013, extension was completely eliminated from this industry research body. This also led to a decreased emphasis on RSD management during this period.

5.1.2.5 *Disease records*: it appears that data recording was lacking in more recent times, at both Babinda and in the Innisfail area. As a result, there are few records available on RSD incidence (for instance, plant source inspection information), of HWT data, and of other aspects of RSD management. Much of the IBCPS activities relied on the memory of the local staff; there are few data from the period which were able to be reviewed at this time, particularly for the 2003-2016 period.

5.1.3 **2016-present (0-2 years ago)**
Things have changed significantly at IBCPS with the employment of more enthusiastic staff; however staff numbers remain critically low. In 2017, Bill Brand retired leading to a loss of another experienced IBCPS staff member. Significant changes to RSD management within IBCPS, and RSD extension to the local industry, have occurred in 2017-2018. These changes are reflected in some of the data presented below; flow-on effects to industry RSD incidence will take some time to effect, as will outcomes from recommendations made as a result of this review.

5.1.3.1 *Diagnostic testing*: IBCPS staff in 2018 now utilise the best available RSD molecular tests; Bill's retirement means that slicing for RSD diagnosis has now ceased. Previous to 2017, around 220 samples were collected annually for RSD assay in the South Johnstone-Mourilyan areas (south of the North Johnstone River). New staff now test 700-800 blocks each year, using the SRA RSD assay lab facilities (2017 and 2018). This represents 131 of 270 growers (48.5%), a figure approaching the extent of plant source inspections in the same two mill areas in the pre-2003 period. It is estimated that only around 10% of farmers utilised the service 2003-2016.

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5.1.3.2 *Operation of Approved seed plots:* in the years previous to 2016, only about 100 tonnes of cane was distributed from IBCPS ASPs to growers; in 2018, this increased to approximately 400-500 tonnes. The provision of disease-free planting material is a major component of a successful RSD integrated disease management (IDM) strategy. Around 600 tonnes of cane were distributed from Approved seed plots in 1998.

5.1.3.3 *Grower awareness of RSD:* RSD awareness is increasing with the employment of new IBCPS staff. In late 2017, a series of extension meetings was organised through the Innisfail-Babinda region; the meetings highlighted both the importance of RSD and the strategies needed to reduce the extent and effect of the disease. These meetings, plus other extension strategies has significantly raised the awareness of the issue (as evidenced by improved uptake of disease-free planting material). However, IBCPS staff perceive there remains a lack of understanding amongst some growers of the recommended RSD management strategies.

5.1.3.4 *Grower relations with Board staff:* grower relations with Board staff have improved significantly over the last 2 years; it should be noted that Bill Brand maintained good relations with his growers during his working life. Improved relations south of the North Johnstone River is an important development that will assist with disease control into the future.

5.1.3.5 *Disease records:* data are being recorded more methodically than in previous times, with electronic records now available on an on-going basis. This will be the case in Babinda now too, with Bill Brand's retirement. There is little doubt Bill had a very good understanding of his growers and the state of their crops, but this was not in an easily-transferable form.

5.2 VARIETAL SUSCEPTIBILITY

The industry's ability to accurately assess varietal resistance to *Lxx* is limited and requires further research. However, based on current data in SPIDNet, the estimated resistance of the commercial crop (as in proportion of tonnes supplied to the mill) over the last five years has hovered around 3 (resistant-intermediate). This compares to around 5 (intermediate) in 2003. The greater RSD resistance of $Q208^{A}$ (rated '1' (resistant); 22% of the 2017 crop) has no doubt made a contribution to the trend to greater resistance. It appears that varietal susceptibility cannot explain the increase in RSD incidence.

5.3 CYCLONES

Two intense cyclones passed through the Innisfail area; Cyclone Larry in 2006 and Cyclone Yasi in 2011. With cyclones comes lodging and general trashing of potential seedcane sources. With Cyclone Larry particularly, this effect was extreme making many designated plant sources unsuitable. As a result, farmers resorted to a whole range of planting material to plant their crops. This is not an ideal situation and is likely to have resulted in the planting of significant quantities of RSD-infected cane, both in 2006 and 2011. It takes time for diseased crops to be replaced and the planting of such material may still be affecting disease incidence, especially if these crops led to RSD transmission to other, more recently-planted, healthy crops.

5.4 SMUT EPIDEMIC

In 2006, the Queensland smut outbreak caused significant emphasis to be placed on smut management. Feedback from local staff suggested this contributed to less emphasis on RSD

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in the following few years. With the smut incursion, the highest priority was replacing smut-susceptible varieties with more resistant canes. There were a number of smut-susceptible, high-yielding varieties (Q158, Q166, Q186^{A}, Q187^{A} for instance) that needed to be eliminated; most extension activities were therefore directed at smut incidence, spread and management. There were few extension meetings in this period that even mentioned RSD. Once the urgency of the smut situation dissipated, an ongoing lack of emphasis on RSD management appears to have continued.

5.5 TREE FARM RETURN TO SUGARCANE PRODUCTION

One of the outcomes resulting from the two cyclones was the economic effect on the local 'tree farms' and their subsequent return to sugarcane production. The purchase of these farms led to the rapid replanting of around 3,000 ha to sugarcane; this created the urgent need for planting material. With a strong business motivation, questionable planting material was used (older ratoon plant sources / non-dedicated clean plant nurseries) and significant areas of RSD-infected crops resulted. The area planted on these farms constitutes around 16% of the South Johnstone mill area.

5.6 INNISFAIL EXTENSION STAFF

There is no doubt that a reduction in extension staff numbers since 2003 (both CPS staff and ultimately BSES extension), coupled with a reduction in RSD experience, has contributed to poor industry RSD management. Poorer quality planting material, inferior disease assay technology and poor management advice was prevalent in the 2003-2016 period.

6.0 CONCLUSION ON FACTORS LEADING TO HIGH RSD INCIDENCE

Key issues leading to high RSD incidence are: -

Key issues

1. Diseased planting material
2. Diseased volunteers in nursery areas and commercial fields
3. Poor sanitation practices
4. Lack of extension emphasis on RSD; a lack of RSD experience in extension staff
5. Lack of grower awareness / motivation to implement adequate management practices

A summary of the factors contributing to each of these issues is presented below.

- **RSD-diseased planting material**:
    - Insufficient numbers of farmers have had their plant sources checked for RSD. The disease status of their cane was therefore unknown, with a high probability of *Lxx* infection. Farmers are planting diseased cane.
    - Farmer nursery cane (obtained from Board plots) has often been planted into replant land, meaning that re-infection from diseased volunteer cane has been highly likely. This is a very significant issue.
    - Poor assay technology (slicing) has been used to diagnose RSD in seedcane material, meaning that some farmers have unwittingly planted with diseased cane.
    - Poor application of assay techniques has also been a factor in diagnosing diseased planting material, leading to poor assay results and use of diseased planting material.
    - Some farmers have knowingly planted RSD-infected cane, because they don't perceive the issue is important (extension issue).

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- Questionable plant sources have been utilised at times when original plant sources have been destroyed by weather events or when smut eliminated other sources.
- RSD has been detected in Board plots, which questions the quality of the material distributed to growers in past years. It is likely this has had a limited direct effect on disease incidence. It has also had indirect effects via reduced confidence of farmers in IBCPS plots, who otherwise may have accessed approved seed cane for their nursery material – but instead used their own questionable material.
- Some planting contractors have not adequately paid attention to machinery sanitation, leading to infection of otherwise healthy planting material – but it should be noted that others pay strict attention to proper sanitation.
- Fewer hot water treatment tanks are now operating in the area, meaning that there is less opportunity for farmers to treat their cane. This is not necessarily an issue if approved seed plots are operated efficiently and well.

- **RSD diseased crops**
  - Many farmers replant their crops, rather than incorporating a fallow with good volunteer weed control; this has led to infection of their disease-free planting material from diseased volunteers when the crop is harvested.
  - Poor harvester sanitation practices have been followed leading to infection of some healthy crops. This is likely to be a smaller issue than the status of planting material and the issue of volunteers in plant nurseries and commercial fields.

- **Lack of grower awareness / motivation**
  - **Reduced staff numbers**: less CPS staff have been on the ground since the early 2000s to actively work on / engage with / and apply a focus on RSD management with industry.
  - **Less experience**: the short longevity of IBCPS staff in recent years has reduced the RSD experience drawn on in providing grower advice. Rapid turnover has been an issue (coupled with lower staff numbers).
  - **Reduced extension focus**: less emphasis has been placed on RSD in recent years, with (until recently) very few extension meetings addressing the issue.

7.0 STRATEGY FOR REDUCING RSD IN SOUTH JOHNSTONE

7.1 Prioritising the issue

The first key issue to address is the economic consequences of the RSD outbreak in the Innisfail-Babinda area. Quantification of the current commercial crop losses will provide IBCPS, MSF and the farming community with the necessary economic data to decide how much funding to invest in reducing disease levels. A method for undertaking this task is outlined below.

7.1.1 *Quantifying the economic cost of RSD:* it is most important that any disease management strategies are prioritised in terms of relative economic return on investment.

7.2.1.1 *Commercial crop survey:* few CPS Boards have recently undertaken a representative commercial crop RSD survey. Such a survey will provide commercial data on disease incidence, and with it, the ability to estimate commercial economic losses. A survey of approximately 30% of farms, with sampling in 2-3 selected crops on each of these farms, would provide a very good assessment of disease incidence in the local area. Factors such as varietal susceptibility to the disease, geographic

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location within the mill area, harvesting and planting contractor, soil type, crop cycle stage and other such factors should be taken into account when selecting farms and crops. The most sensitive diagnostic assay should be utilised in this survey.

7.2.1.2 *Sub-survey objectives:* in undertaking such a survey, opportunity will arise to explore other related questions; for instance, '*Is RSD incidence influenced by certain contractors"*? '*Is the disease influenced by whether farmers obtained approved seed regularly*? These, and other, questions should be considered carefully, in consultation with other industry staff before a survey goes ahead. Specific details related to the survey should remain confidential in order to protect the commercial interests of the involved parties; however, the general outcomes from the survey should be broadly extended to industry.

This should be a high priority issue for the local industry. The current distribution and incidence of RSD is unclear; a previous survey conducted in 2013-2014 suggested a relatively high incidence even then – it is likely that the disease has spread much further now. Better assays are now available and a survey strategy should be discussed with industry experts before it is initiated.

7.2 Key management issues to address

The most important management issues which will lead to reduced levels of the disease are outlined below. A consideration of breeding for RSD resistance is also presented.

- **Finalise and implement the RSD IDM extension strategy:** to ensure as many farmers as possible are aware of the disease and the most effective management strategies. This should also include extension to contract planter and harvester groups.
- **Provide adequate resources for IBCPS staff:** ensure there are sufficient numbers on the ground, with sufficient funding / training, to undertake the required activities.
- **Focus on the provision of an abundance, and high-uptake, of disease-free planting material**: RSD won't ever be controlled adequately without providing large quantities of disease-free material. Farmers need to be able to readily access such material as conveniently as possible; extra resources may be needed for IBCPS staff to achieve this.
- **Plant source inspections**: increase the level of uptake of PSIs; undertaking these provides good opportunity to discuss with growers a range of other RSD management strategies and will also lead to the identification of additional diseased nursery material. With 20% of plant sources diseased in 2018, a significant number of RSD-infected plant sources can be expected in 2019.
- **Commercial crop survey:** it will be most important to quantify both the RSD incidence, and value of lost production caused by RSD, across the IBCPS area. This will provide a starting point for measuring the success or otherwise of the developed RSD IDM. Of utmost importance will be the magnitude of the lost profit ($s); this will provide the IBCPS Board and other industry organisations, the opportunity to prioritise RSD in terms of its importance as a yield-limiting constraint. The value of committing extra resources to the RSD IDM program will then be better understood, leading to a better-informed strategy.

These issues are further explored below.

7.2.2 *Prioritising IBCPS activities:* the outbreak of a disease generally implies significant lost profitability to an area, and on the flip-side, the immediate value from investing in disease-mitigation activities. It is likely that there will be very significant economic drivers for

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IBCPS to commit extra disease management resources to RSD over the next few years. An important aspect of the recent RSD outbreak has been the evident lack of staff, with sufficient training, on the ground in the local area. In the 2003-2016 period, there was a lack in both experience and in staff numbers to undertake the required RSD activities. In 2018, approved seed plot opening hours were restricted simply due to the limited number of staff in each local area. The same applied to plant source inspections; adequate staff resources will be essential to the extension of the refined RSD IDM. Without significant further resources, it will be difficult for the Innisfail-Babinda industry to get on top of the problem.

It could be worthwhile considering scaling down other activities, such as chemical sales, in order to minimise overall Board spending. The economic returns on investment are likely to favour RSD management in this case.

7.2.3 *Application of best diagnostics:* the opportunity now arises to fully and permanently transition to the most accurate, easily-applied diagnostic technology available. In 2019, the SRA RSD laboratory will be providing qPCR assay of xylem extracts only; an RSD research project currently in progress may make further recommended improvements to the RSD assay procedure (LSB-qPCR for instance) in mid-2019. Industry will be made aware of this in due course. Some preliminary surveys of South Johnstone may occur in 2019 research, to compare the diagnostic protocols developed in the research project. Slicing, EB-EIA and PCM microscopy should cease, unless urgent circumstances prevail; PCM will be the only local assay able to be applied (EB-EIA won't be offered; slicing should now be eliminated).

7.2.4 *Approved seed plots:* Once additional resource allocation decisions have been made by the IBCPS Board, I suggest that the number of Approved seed plots across the Babinda-Innisfail area should be reviewed, with due consideration given to ease of grower access to the released cane. An overall plan for the whole area should be developed, taking into account: i. number of farmers within the local area, ii. ease of securing the site / farmer access, iii. history of disease within the area, and iv. availability of land at the site, to ensure best management practices can be readily effected (fallow plots between planting years).

7.2.5 *Farmer nursery plots:* three big issues for farmer nurseries are: i. using IBCPS approved seed cane to establish the plots, ii. planting the cane into fallow (vs replant land with volunteer cane), and iii. requesting a plant source inspection to ensure freedom from RSD. Of course other management strategies are also needed – sterilisation of cutting and planting equipment etc. Significant extension emphasis is needed to ensure a maximum percentage of farmers apply these principles.

7.2.6 *Contractors:* both planting and to a lesser degree, harvesting contractors also provide a significant potential threat to the RSD status of commercial crops. It is important therefore that any progress made by individual farmers in RSD management is not compromised by poor protocols applied by these industry players

7.2.6.1 *Assisting planting contractors*: emphasis on a RSD IDM extension program should also include this industry group. Specific meetings should be organised to provide the necessary information to enable contractors to judge and see for themselves the RSD implications for crops they plant. Every effort should be made by IBCPS staff to equip, train and inform them in relation to RSD. Farmers also need to be made aware of their rights as the 'employer' - what they have a right to expect from their local contractor. The RSD IDM should clearly indicate how this issue will be addressed. There was

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some suggestion during the review of a financial incentive for those who plant into fallow ground, rather than replant land; this of course would be aimed at the farmers themselves – but contractors should also be educated on this topic. Other issues contractors need to be aware of are: i. sterilising all cutting surfaces between crops / farms, ii. avoiding the carry-over of planting material from one farm to another, iii. ensuring all possible thought is given to selecting known disease-free plant sources.

7.2.6.2 *Harvesting contractors:* similarly, harvester contractors should also be included in the RSD IDM extension program. It will be easier for a contract planter to sterilise their equipment (but this depends on planting method); however, harvester operators should be made aware of the highest priority surfaces to treat. It will be impossible to ensure commercial harvesters, under significant pressure to cut bin allocations, can be completely sterilised between each crop. However, by treating high-probability areas, the chances of transmission may be drastically reduced. Some CPS services supply harvester contractors with farm maps (farms they harvest) to show where RSD occurs; this should also be considered.

7.2.7 *IT issues:* this issue may be a little sensitive to MSF management. Current IBCPS staff have little capability in GIS systems and no direct access to the appropriate GIS data. GIS systems are increasingly a standard professional '*tool-of-trade*'. Many CPS Boards are adept at using this technology and utilise it for recording / visualising pest and disease records. The technology offers several distinct advantages: i. provides easy visual feedback on disease incidence – allowing for a much improved interpretation of the reasons for disease spatial patterns, ii. provides for the production of maps –which are very easily interpreted by farmers, whether they are educated or not. Maps could be produced for effective communication of relevant information to individual farmers and the industry as a whole.

The introduction and use of GIS is a completely separate issue to the protection of commercial interests and privacy considerations. The latter issues can be addressed by the application of appropriate administrative rules. To deny the introduction of GIS systems is to reduce the technological assets of IBCPS staff and to hinder their activities in disease management.

It would also be useful to better record crop cycle status by noting in the records whether a crop is fallow plant (P) or plough-out / re-plant (RP) – and continuing this record through the crop cycle (P1R, P2R, P3R etc). This will provide a way to gauge how many farmers are following recommended RSD fallow management protocols.

7.2.7.1 *RSD / disease fully searchable database (and apps):* disease records, and the ability to fully search these records at a moment's notice, are essential in the work of CPS staff. The ability to do this enables such things as the history of a disease, either on an individual farm or across a district, to be fully understood. This in turn leads to the best recommendations with regard to disease management.

A hindrance to the RSD review has been the lack of available, thorough, fully-searchable RSD data from recent years. Older data (pre-2003) are paper-based and only available because SRA staff happened to have a copy. Electronic data storage within IBCPS, data which is automatically 'on-saved' as new software is adopted, will ensure the valuable history of pests and diseases within the district is preserved for later analysis and interpretation.

7.2.8 *IBCPS staff management / training:* depending on the review outcomes and the allocation of resources, significant staff training will be needed. This could include: i.

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disease training for new staff, ii. software training for more experienced staff (GIS / databases), iii. management training for a more experienced staff member.

It will also be important for IBCPS to retain staff, providing them with sufficient incentive to remain. A big issue for IBCPS has been the loss of experienced staff, followed by the temporary retention of personnel who never really took the needed RSD extension messages to industry in the way it was needed.

7.3 **Breeding for RSD resistance**

Introduction: Current evidence suggests that some varieties limit the titre (concentration) of *Lxx* within the cane plant and also limit spread of the disease (for instance, $Q186^{A}$ and $Q208^{A}$). Plant resistance is a management strategy that could pay dividends for the industry. A plant breeder was consulted to consider the requirements for a breeding approach and other relevant implications. Some important considerations were provided.

Issues to be considered:

7.3.1 *Effect of resistance*: the presence of true resistance in sugarcane varieties is likely to limit both *Lxx* populations within cane plants and also spread of the disease, as pointed out by Dr Anthony Young. These would be positive benefits.

7.3.2 *Current management strategies:* if high-yielding intermediate and susceptible varieties were to continue to be released, then the current suite of management strategies (approved seed plots / RSD assay of plant sources / sterilisation of cutting surfaces / elimination of volunteer cane) would remain essential. Infection pressure may be reduced by a breeding strategy, but an abandonment of these activities would lead to lower productivity in other high-yielding intermediate and susceptible varieties.

7.3.3 *Requirements for a breeding program:* the following issues would need to be researched before a breeding strategy was implemented: -

7.3.3.1 *Identification of resistance in parents:* the production of seedling populations possessing RSD resistance will require the identification of parents with an enhanced level of resistance. For other major diseases managed via plant resistance, the resistance of all parents is considered before crossing. Screening of the elite parent population would therefore be recommended so enabling RSD resistance to be taken into consideration. It is unclear at this point what proportion of the current elite parents possesses *Lxx* resistance. If few do, then the choice of parents will become limiting to the breeding program; if many do, then this will be less of an issue.

7.3.3.2 *Inheritance of resistance*: a further key issue to a plant breeding strategy is the heritability of RSD resistance – in other words, if resistance genes are in one or other of the parents, how likely are the progeny to also be resistant to RSD. This research has been conducted with many of the other major Australian diseases managed via resistance. A low inheritance will mean it is harder to breed for resistance; a high heritability makes the process more straight forward and more likely to produce adequate resistance in seedling populations.

7.3.3.3 *RSD resistance screening:* breeding for resistance will require routine resistance screening of clones coming through the plant breeding selection program. This is not impossible, but will add to core plant breeding / plant pathology activities. Suitable mass-screening techniques will need further research. True resistance screening (selecting for low populations of the organism within the plant), rather than selection for tolerance (the ability of the clone to continue to yield well, despite colonisation) should be the preferred option.

7.3.3.4 *Genetic gain:* selecting for another resistance character will undoubtedly slow the rate of genetic improvement in the plant breeding program.

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I recommend that if resistance is to be considered, a full economic analysis of both positive and negative consequences be undertaken and that both plant breeders and plant pathologists be involved in the analysis. This analysis should be an objective study and lead to a factual report easily understood by all industry participants. Unless such an analysis is undertaken, various opinions (for or against selecting for resistance) will be provided without adequate facts to support the conclusions drawn.

An economic analysis will naturally consider the extent of the RSD problem within industry and the limitations the disease imposes on productivity and profitability. This is currently unclear; the percentage of crops affected across each major cropping region remains uncertain. With the development of more sensitive assays, I suggest that industry surveys be conducted to determine the true extent of the RSD problem before a resistance solution is considered. High incidence of RSD within the industry would provide stronger justification for a resistance management approach and suggest that current management approaches are inadequate. If low RSD incidence prevailed in most regions, the justification for a resistance approach would not be sustainable, as the potential for a positive economic outcome from a breeding approach would be slim.

8.0 DISCUSSION

The RSD review provided me with an excellent opportunity to find out what has led to the poor RSD situation in the Babinda-South Johnstone area. It appears from the review that recommended best-practice RSD management has not been adequately applied for over 15 years. This could adequately explain the high disease incidence – there appear to be few unexplained reasons for disease escalation.

Key contributing factors are a loss of experienced IBCPS / BSES-SRA extension staff; IBCPS staff numbers have dropped very significantly over the period leading to reduced emphasis on RSD integrated disease management procedures, poor application of best-practice assay procedures and a lack of on-ground disease-management services for farmers. Other contributing factors to the situation include two severe cyclones destroying nursery cane, rapid return of tree farms to commercial production, the smut epidemic - which re-directed attention away from RSD, and lastly farmer apathy in the application of needed control measures.

It should be noted that the true extent of the RSD incidence in the region is yet to be adequately assessed; this needs to be undertaken quickly, and with high priority, to provide an economic guide to local industry on the way forward. A representative survey, using the best assay procedures, should be undertaken along with an economic analysis to quantify the economic effect of the disease on the region. Such a survey would allow better prioritisation of IBCPS staff activities to make maximum productivity gains for the area. With better assay technology, more (rather than less) RSD will be detected. A current very rough estimate of the economic cost of RSD in the South Johnstone mill area is $1-3m.

Investment in IBCPS staff will be needed, not only to improve and broaden their skills, but to help ensure skilled staff remain in the area to oversee the recovery from the disease outbreak. Equipping in better software skills and providing the necessary resources for them to undertake their tasks will be a high priority.

9.0 CONCLUSIONS

- RSD currently poses a significant economic constraint on productivity in the Innisfail-Babinda area

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- There are no current data on the extent of the constraint in the region; it is important that a survey of commercial crops be undertaken to provide incidence and economic data on the disease outbreak.
- A lack of application of recommended management strategies by industry appears to be the reason for the current incidence of RSD within the Innisfail-Babinda area. This includes lack of adoption of the best assay technology and less than optimal on-farm management.
- A comprehensive extension package needs to be developed and delivered, with adequate staff resources provided to ensure industry adoption of management practices.
- Recommendations with regard to a plant resistance management option are provided; significant research and associated analyses will be needed to determine the likely benefits of such an approach.

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