Effect of ratoon stunting disease (RSD) on sugarcane yield in Fiji

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Abstract

Sugarcane (Saccharum officinarum) ratoon stunting disease (RSD) caused by bacterium Leifsonia xyli subsp. xyli causes huge (29% or more) damage in sugarcane ratoon crops. It cost farmers thousands of dollars. A study was conducted to minimize these losses using various hot-water treatments to sugarcane sets before sowing in the field. The differences in cane yield were recorded with all the treatments in the cane yield loss experiment but the differences were not statistically significant. It was observed that the only notable effect of the disease was on the cane yield but very little effect on the sugar and percent of pure obtainable cane sugar (% POCS). The cane yield for the plant (first crop) and subsequent ratoon crops (third year, fourth year, etc.) differed with an average reduction of 37% but the average loss caused by RSD was 29%. Out of the two hot water treatments the best duration of hot water treatment was identified as 2 hours at 50ºC because it gave a higher average yield compared to the control (untreated) and 3 hours at 50ºC. Three hour duration seems to affect germination of sets and thus total plant population which eventually results in low yield of sugarcane and thus total pure obtainable cane sugar (POAC).

Keywords: Ratoon stunting, hot water treatment, cane yield, sugar yield

1. Introduction

Sugarcane is an important cash crop in Fiji Islands. Its production is declining over years due to various reasons including infection by pathogens such as bacterium Leifsonia xyli subsp. xyli which causes sugarcane stunting disease particularly sugarcane ratoon crops. Due this reason this disease is called ratoon stunting disease (RSD). Ratoon stunting disease (RSD) was first identified in Fiji in 1953 at Nausori, Rawawai and Lautoka sugarcane growing areas (Anonymous, 1953). Since its identification it has been recorded that it causes wide spread damages to sugarcane ratoon crop. The preferred control method for RDS in Fiji was heat treatment of sugarcane sets before sowing (planting). Hot water treatment kills the bacteria present in sugarcane sets but overexposure to heat sugarcane planting sets are prone to heat damage and thus results in reduced germination. Hot water treatment tanks were erected at Rawawai and Lautoka mills for establishing disease-free seedbeds of the major varieties with the intention of supplying sugarcane growers with disease-free material (Anonymous, 1957).

Research on RSD in Fiji was limited until the South African Sugar Experiment Station confirmed its presence in Fiji in 1994 after sap samples from suspected RSD stalks were sent for analysis. Sap samples were identified positive (Tamankiyaroici and Johnson, 1995) for the bacterium Leifsonia xyli subspecies xyli, using phase contrast microscopy and immunofluorescence microscopy.

Ratoon stunting disease (RSD) is one of the most devastating diseases of sugarcane in the world causing losses up to 30% per year (Hughes, 1974). It costs $10 million loss in the Australian sugar industry annually and if no control measures are practiced, losses could reach as high as $200 million (Croft et al., 1993). Ratoon stunting disease has always been managed by heat therapy of planting material, combined with well-organized multiplication nurseries (Walker, 1987).

The epidemiology of the ratoon stunting disease in the Fiji sugar industry showed that the disease is widespread in all the sugarcane growing sectors of Fiji with varying degrees of infection. The incidence of RSD in Fiji is 27% in all the thirty eight sugar cane sectors with different levels of infection (Johnson et al., 2006). Therefore the present study was undertaken with the main objective to assess the effect or RSD and record the recovery with various hot water treatments of sugarcane planting material (stem cuttings).

2. Materials and Methods

Primarily the most important commercially grown (80-90%) but highly RSD susceptible sugarcane (Saccharum officinarum) variety Mana was selected for this experimental treatment. Diseased canes of this variety were obtained from sectors where ratoon crop was being grown. A seedbed of diseased cane was established at the ratoon stunting disease nursery at Nausori Highland in Nadi. Diseased sugarcane sets were planted in 5-pint polythene pots to multiply the RSD infected sugarcane material. The prepared seedbed was used for planting RSD infected sugarcane sets to use as seed material for planting a trial to determine the loss caused by RSD. Once the seed cane was 9 months old, were harvested and planted in trial to assess RSD infection losses at the Sugar Research Institute of Fiji, Lautoka.

The three treatments were (i) diseased cane (control with no hot water treatment), (ii) diseased cane - treated with hot water for 2 hours and (iii) diseased cane - treated with hot water for 3 hours. Once the plants in the pot were about one and half months old, they were transplanted in the field using random complete block design (RCBD) with a plot size of 10m X 1.37m X 2 rows or an area of 27.4m² (Figure 1).

At harvest time (9 months after planting), all the rows in each plot were harvested for the plant crop (first planting) and the ratoon crop (crop regenerated from regrowth) and manually weighed. Total amount of cane weight per plot was used to determine the yield per unit area. Cane samples consisting of nine stalk samples were taken at random from each plot for cane juice analysis. The Amount of Cane Juice (POL), Sugar Percentage
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### Figure 1.
Trial design (RCBD) for RSD Yield – loss trial.

(BRIX) and Remnant Solid Material (FIBRE) values were used to determine the % Pure Obtainable Cane Sugar (% POCS). The sugarcane yield in tonnes per hectare (TC/HA) was analyzed and compared in three treatments. The product of cane yield per unit area and % POCS gave total tones sugar per hectare.

### 3. Results
Hot water treatment used in this study did not affect percent of pure obtainable cane sugar (POCS) and showed no significant difference in the sugar yield between the three treatments for variety Mana in the plant crop as shown in Table 1. However, cane treated at 50°C for 2 hours produced higher cane and sugar yield compared to other treatments investigated in the study.

Cane harvested from the untreated plot had the lowest cane yield (tcha⁻¹) and sucrose content (tsha⁻¹). The total rain days for the year were 142 days with a total rainfall of 2044.2mm. The high yield for the plant crop was expected as a good amount of rainfall was experienced during the growing period from planting to the sixth month (Table 1).

Table 2 shows that planting cane treated with hot water did not significantly increase cane and sugar yield in the first ratoon crop. However, cane treated at 50°C for 2 hours produced higher cane and sugar yield compared to cane treated at 50°C for 3 hours as observed in plant crop.

The total rain days for the year were 144 days with a total rainfall of 1704.4 mm. Overall cane yield declined in first ratoon crop due mainly to RSD infection and the lower amount of rainfall in growing months of the ratoon crop. The effect of ratoon stunting disease infection was become visible as the lower cane yield as compared to plant crop.

There was a sharp decline in cane yield compared to plant and first ratoon crops as shown in Table 3. The total average reduction in cane yield from plant to ratoon was 36.6%. However, cane treated at 50°C for 2 hours produced higher cane and sugar yield than untreated and cane treated at 50°C for 3 hours.

The total rain days for the year were 109 days with a total rainfall of 11459.3 mm. The significant decline shown was attributed not only to dry conditions, which affected vegetative growth during active growth period from May to November but also due the effect of ratoon stunting disease and its spread from infected plots. The average difference of cane yield (tcha⁻¹) between the plant and the two ratoon crops was 28.7% thus establishing that the average loss caused by ratoon stunting disease in this trial was 28.7%.

### Table 1. Sugarcane yield (plant crop) of ratoon stunting disease infected cane with three different duration of hot water treatment from a RCBD experiment with four reps.

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant date/ Date harvest</th>
<th>Variety &amp; Crop</th>
<th>Treatment (Hot water treatment at 50°C for different amount of time - hours)</th>
<th>Cane Yield (tons cane ha⁻¹)</th>
<th>POCS (%)</th>
<th>Sugar Yield (tons sugar ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lautoka</td>
<td>June 2001, July 2002</td>
<td>Mana Plant</td>
<td>A. Cane untreated</td>
<td>119</td>
<td>10.43</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B. Cane treated in hot water at 50°C for 2 hours</td>
<td>134</td>
<td>10.93</td>
<td>14.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C. Cane treated in hot water at 50°C for 3 hours</td>
<td>149</td>
<td>10.90</td>
<td>16.1</td>
</tr>
<tr>
<td>LSD 5%</td>
<td></td>
<td></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td></td>
<td>14.35</td>
<td>4.52</td>
<td>15.47</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Sugarcane yield (first ratoon crop) of ratoon stunting disease infected cane with three different duration of hot water treatment from a RCBD experiment with four replications.

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant date/ Date harvest</th>
<th>Variety &amp; Crop</th>
<th>Treatments</th>
<th>Cane Yield (tons cane ha⁻¹)</th>
<th>POCS (%)</th>
<th>Sugar Yield (tons sugar ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ratoon</td>
<td>Ratoon</td>
<td>Ratoon</td>
<td></td>
</tr>
<tr>
<td>Lautoka</td>
<td>June 2001</td>
<td>Mana</td>
<td>A. Cane untreated</td>
<td>98</td>
<td>12.88</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>October 2004</td>
<td>1st ratoon</td>
<td>B. Cane treated in hot water at 50°C for 2 hours</td>
<td>133</td>
<td>12.73</td>
<td>16.9</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>C. Cane treated in hot water at 50°C for 3 hours</td>
<td>124</td>
<td>12.45</td>
<td>15.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant date/ Date harvest</th>
<th>Variety &amp; Crop</th>
<th>Treatments</th>
<th>Cane Yield (tons cane ha⁻¹)</th>
<th>POCS (%)</th>
<th>Sugar Yield (tons sugar ha⁻¹)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ratoon</td>
<td>Ratoon</td>
<td>Ratoon</td>
<td></td>
</tr>
<tr>
<td>Lautoka</td>
<td>June 2001</td>
<td>Mana</td>
<td>Other ratoon</td>
<td>47</td>
<td>12.93</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>July 2005</td>
<td>Other ratoon</td>
<td>A. Cane untreated</td>
<td>58</td>
<td>12.83</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B. Cane treated in hot water at 50°C for 2 hours</td>
<td>49</td>
<td>12.30</td>
<td>6.1</td>
</tr>
</tbody>
</table>

Table 3. Sugarcane yield (other ratoon crop) of ratoon stunting disease infected cane with three different duration of hot water treatment from a RCBD experiment with four reps.

<table>
<thead>
<tr>
<th>Location</th>
<th>Plant date/ Date harvest</th>
<th>Variety &amp; Crop</th>
<th>Treatments</th>
<th>Cane Yield (tons cane ha⁻¹)</th>
<th>POCS (%)</th>
<th>Sugar Yield (tons sugar ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>Other Ratoon Crop</td>
<td>Other Ratoon Crop</td>
<td>Other Ratoon Crop</td>
<td></td>
</tr>
<tr>
<td>Lautoka</td>
<td>June 2001</td>
<td>Mana</td>
<td>A. Cane untreated</td>
<td>47</td>
<td>12.93</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>July 2005</td>
<td>Other ratoon</td>
<td>B. Cane treated in hot water at 50°C for 2 hours</td>
<td>58</td>
<td>12.83</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C. Cane treated in hot water at 50°C for 3 hours</td>
<td>49</td>
<td>12.30</td>
<td>6.1</td>
</tr>
</tbody>
</table>

4. Discussion

The difference in cane yield due to RSD was recorded in both hot water treatments as compared to untreated cane in this experiment however the difference was not statistically significant which can easily be attributed to RSD alone. This could be due to several reasons particularly variety Mana used for hot water treatment showed that it was more tolerant to hot water treatment compared to other commercial varieties such as Kaba and Aiwa. Losses in resistant clones may not be significant, whereas losses in the highly susceptible clones, in both yield of cane and sugar per unit area, may approach 50% (Gillaspie and Teakle, 1989). It was seen that the only notable effect of the disease was on the cane yield but very little effect on the sugar yield as evident from percent POCS. The disease has little effect on plant crop cane quality and stalk population, and losses in yield were almost entirely due to decreases in stalk mass in ratoon crop (Bailey and Bechet, 1986).

Generally, the use of only one cane variety may be biased in drawing such conclusions but it is important for the Fiji sugar industry because farmers prefer growing the variety Mana, which accounts for almost eighty percent of all varieties planted (Anonymous, 2002). The plant crop yields were less affected by ratoon stunting disease than were the ratoons and there were indications that further reductions in cane yields could be expected in subsequent ratoon crops. The disease seems to be more prominent in the ratoon crop compared to the plant crop (Koike, 1980), that is why this disease is called Ratoon Stunting Disease (RSD). The decrease in yield in other ratoon was more obvious as shown in Table 3, which could also be due to the disease spreading to other plots during harvesting as studied by Bailey and Tough (1992). Highly susceptible varieties may die as a result of infection by the bacterium; however, RSD does not have any consistent effects on cane juice quality (James, 2005). The present average yield of 45-70 tonnes/ha (Anonymous, 2003) in the Fiji
sugar industry is similar to those shown in Table 3, but on the lower range of the average. It is likely that the declining cane yield in the Fiji sugar industry may be partly due to the infection by ratoon stunting disease. Stalk populations may be affected when the disease is severe and RSD-infected ratoon crops grow more slowly and the yield losses are larger (James, 2005).

The use of hot water treatment in assessing the loss in yield is relevant because hot water treatment (HWT) has been known to control ratoon stunting disease. As clearly shown in Tables 2 and 3, the cane and sugar yield for the HWT at 50°C for 2 hours was higher as compared to the control and HWT at 50°C for 3 hours. The optimum temperature for hot water treatment has been found to be at 50°C for 2 hours (Steindl, 1961). The difference between yields of sugarcane treated for 3 hours as compared to 2 hours may be due to the prolonged heat on the cane which may have killed some of the buds in sets thus resulting low germination and low yield (Johnson et al., 2006). Therefore the best hot water treatment was identified as 2 hours at 50°C.

Hot water treatment does not totally eliminate the infection of RSD but merely diminishes it to a level to enable the grower to establish a nursery with a very low level of infection (James, 2005). Roach et al. (1992) recommended that to control RSD, there was a need to increase grower awareness of the disease; screen potential new varieties for RSD susceptibility; minimise planting of RSD infected cane using heat treatment for RSD-free plant sources; and increase effectiveness of farm sanitary measures.

Low rain (drought) or excessive rain (water logging) can contribute to yield losses due to the disease manifestation (Davis and Bailey, 2000). During the second (2002) and third ratoon (2003), the weather conditions were relatively dry than usual as seen in Table 3 where all the treatments had an average reduction of 36.6% loss in cane yield (tcha⁻¹). The effect on sugarcane growth with RSD tends to increase when crops are stressed, losses are greatest when the precipitation is erratic under rain fed conditions or when irrigation management is poor (James, 2005). The high concentration of the bacteria in the vascular bundle in susceptible varieties causes blockage that ultimately leads to the poor and stunted growth of the sugar cane plant.

The effect of RSD on %POCS was non-significant but the loss caused by RSD to the cane yield was 28.7% which falls under the range found by Hughes (1974) making RSD as one of the most devastating disease of sugarcane in the world causing losses up to 30% per year. The disease has little effect on cane quality and stalk population, and losses in yield were almost entirely due to decreases in stalk mass (Bailey and Bechet, 1986). As shown in Tables 1, 2 and 3, the % POCS increased from the plant to subsequent ratoon crops. Cane quality may slightly decrease by the presence of RSD when the crop receives the adequate water but quality might slightly change when subjected to moisture stress (Rossler, 1974).

5. Conclusions

Experiment findings have clearly established the effect of RSD particularly first, second and subsequent ratoon crops. The other ratoon crops figures obtained in this study were similar to the average yield currently observed in the Fiji sugar industry of 45-70 tonnes/ha. The plant crop figures showed that the disease was not so widespread in the plots to show any significant difference between treated and untreated plots. After the plant crop, in ratoon crops there was clear decline in cane and total sugar yield. It is also observed in this study that the effect of RSD when compounded with dry conditions resulted in an average reduction of 36.6%. The average losses due to RSD in this trial in two ratoon crops were 28.7% in cane yield but cane quality and percent POCS remained somewhat constant. The decline in the yield was attributed to the effect of the ratoon stunting disease in ratoon crops. Therefore farmers should be made aware of build up of RDS in subsequent ratoon crops and thus should be advised to avoid ratoon crops beyond a maximum or two or at the most three ratoon crops only to obtain higher yield of sugarcane and total sugar tons per hectare.

References


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