

# Evaluation of Selected Sugarcane (*Saccharum* spp. Hybrid) Varieties for Smut Disease Reaction and its Effect on Cane- and Sugar- Yield Components

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## ABSTRACT

This study investigated smut disease reaction of locally-bred sugarcane varieties and its effect on cane- and sugar- yield components. Smut-inoculated (*Sporosorium scitamineum*) stem cuttings of six standard varieties with established ratings for disease reaction and 28 test varieties were planted in the field in one-meter long single row plots in three replicates using the randomized complete block design. The disease incidence was recorded at one-month intervals from 2 months after planting to 12 months. The regression equation derived from disease reactions of the standard varieties was used to assign resistance ratings to the test varieties. The ratings were based on the scale of 1 to 9, where 1 is highly-resistant and 9 is highly-susceptible. At harvest, five randomly-selected cane stalks per plot were used to measure hand refractometer brix, stalk diameter and stalk length. Cane yield (kg/plot) and number of millable stalks/plot were recorded at harvest. Out of the varieties tested, eight, ten and four varieties were grouped into highly-resistant, resistant and moderately-resistant categories, respectively. The results proved that smut reduces cane yield and sugar content in juice through significant negative correlations observed between disease incidence and cane yield, brix and number of millable stalks.

**Keywords:** *smut disease, Sporosorium scitamineum, standard varieties, sugarcane, yield components*

## INTRODUCTION

Sugarcane smut caused by the Basidiomycetes fungus *Sporosorium scitamineum* (Synonym *Ustilago scitaminea*) is one of the most conspicuous diseases of sugarcane. The disease has been reported in almost all sugarcane growing countries in the world and its characteristic symptom is the emergence of long, curved, whip-shaped sorus with melanised teliospores from apical region (Fig. 1) of the infected cane stalks (Comstock, 2000). The development and severity of this disease depend mainly on the

reaction of sugarcane varieties to the disease and on the environmental conditions (Ramesh Sundar *et al.*, 2012).

Smut reduces the yield and quality of sugarcane. Several countries have estimated possible cane- and sugar- yield losses due to smut disease (Bhuiyan *et al.*, 2010). Reduction in yield and quality varies widely among sugarcane-growing areas of the world and is mainly dependent on the races of pathogen, the sugarcane varieties and the prevailing environment conditions (Lemma *et al.*, 2015). Therefore, assessment of smut incidence in varieties and its effect on cane-

and sugar- yield at a regional scale is of paramount importance as no such study has been conducted in Sri Lanka to estimate yield losses due to smut disease.



**Fig. 1.** Smut whip in sugarcane

Since cultivation of resistant varieties is the most efficient and economical method for smut disease management in commercial sugarcane plantations (Phelps and Donelan, 1991), testing of smut disease reaction of locally-bred varieties is done in parallel to stage III of the varietal selection program of the Sugarcane Research Institute (SRI), Sri Lanka to find smut-resistant-high-yielding varieties. The planting materials of the test varieties are artificially-inoculated with smut pathogen and subsequently, the varieties are assessed for disease development in field conditions. In formal variety screening trials for smut disease, only the incidence of the disease of each variety was recorded at monthly intervals from 2 to 12 months after planting. During the variety screening trial of SL 2002 breeding series conducted for smut disease reaction, data related to yield components were also collected at harvest. The present study was, therefore, setup to investigate smut disease reaction of the

twenty nine varieties of SL 2002 series and to assess the effect of smut incidence on cane- and sugar- yield components.

## **MATERIALS AND METHODS**

A field experiment was carried out at the Research Farm of the Sugarcane Research Institute, Uda Walawe, where the annual average rainfall is 1450 mm during 2014-2015, using twenty-nine sugarcane varieties belonging to SL 2002 breeding series and six standard varieties with established smut disease ratings.

### **Preparation of smut teliospores**

Fresh smut whips were collected from different sugarcane-growing areas of Sri Lanka namely Uda Walawe, Sevanagala, Pelwatta and Hingurana. The whips were dried under shade for three days, scrubbed with hand covered with sterilized gloves and sieved using 53  $\mu\text{m}$  mesh to collect smut teliospores. The sieved teliospores were kept sealed in cellophane bags and stored under refrigeration for use in artificial inoculation (Dean, 1982).

### **Inoculation of planting material by smut pathogen and field establishment**

Three-budded setts (stem cuttings) of test varieties and standard varieties were artificially-inoculated with aqueous suspension of  $1 \times 10^6$  *Sporosorium scitamineum* spores per ml using standard vacuum inoculation technique. The inoculated-setts were kept in black-polythene bags at room temperature ( $28^{\circ}\text{C}$ - $31^{\circ}\text{C}$ ) for 12 hours for incubation of the pathogen before field establishment. The test varieties and the standard varieties were planted in the field using the randomized complete block design with three replicates. One-meter-long plots prepared with 1 m gap between two

plots within furrows and 3 m gap between furrows were used for planting the varieties in this field experiment. Five smut-disease-inoculated three-budded setts were used for planting canes in each plot. Twenty-eight most promising varieties of SL 2002 breeding series were tested for their reaction to smut disease with six standard varieties Co 740, Co 775, M 351 57, Co 997, Co 1001 and PH 56 226 in this experiment. Standard cultural operations for sugarcane were carried out at respective growth stages of the crop until harvest.

### Data collection

Number of smut-infected stalks in each plot was recorded at monthly intervals from 2 to 12 months after planting. Disease incidence in each variety was calculated at the end of the experiment *i.e.* after 12 months of planting using the formula;

$$\frac{n}{N} \times 100$$

where; n is the cumulative number of stalks affected by smut disease and N is the total number of stalks/plot.

At harvest, five randomly-selected cane stalks per plot were used to measure hand refractometer (model ATAGO N1 Japan) brix as a measure of total soluble solids (TSS) in cane juice, stalk diameter and stalk length. Cane yield (kg/plot) and number of millable stalks/plot were also recorded.

### Assignment of disease ratings to test varieties

Log incidences of smut disease of the standard varieties and their established ratings for the disease *viz.* Co 740 = 1, Co

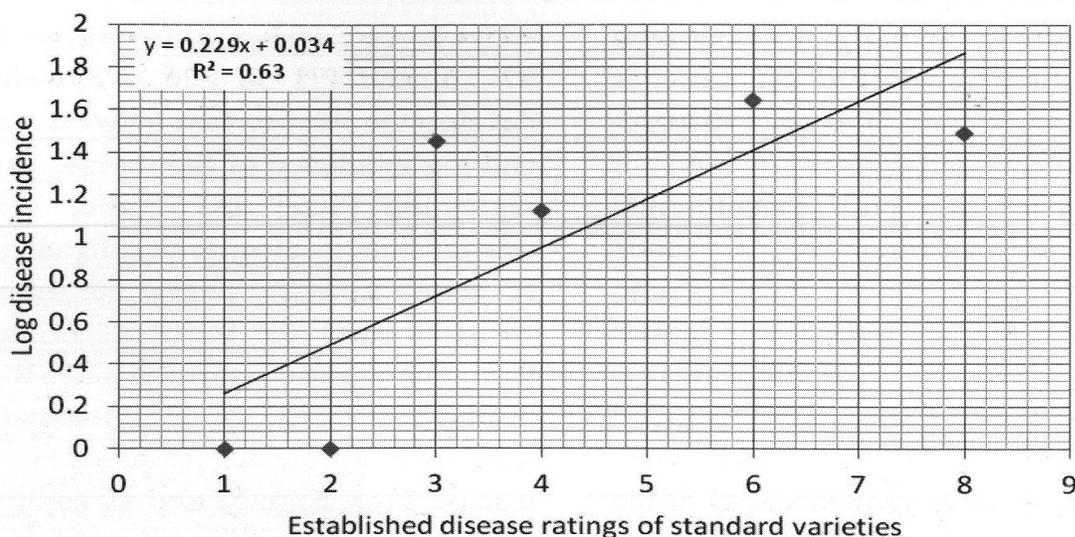
775 = 2, Co 1001 = 3, Co 997 = 4, M 351 57 = 6, and PH 56 226 = 8 were used to develop the relationship between smut rating and log incidence of the disease using linear regression (Steel and Torrie, 1980). This relationship is always developed in variety screening trials to assign smut ratings to test varieties since the incidence of the disease varies upon environmental factors prevailed during the period of experimentation. This technique eliminates seasonal variation in disease expression caused by additive effects of the environment in assigning smut ratings to test varieties. In this experiment, log incidence of smut in the test varieties was used to assign smut ratings based on the scale of 1 to 9 where; 1 = highly-resistant and 9 = highly-susceptible (Hutchinson, 1970) using the regression equation developed (Fig. 2).

### Effect of smut incidence on yield components

The relationship between disease incidence and yield components (hand refractor meter brix, stalk diameter, stalk length, plot cane yield and number of stalks/plot) were appraised by Spearman's Rank Correlation coefficients.

## RESULTS AND DISCUSSION

The linear regression equation derived for the trend line was  $Y=0.229X + 0.034$ ;  $R^2=0.63$ ; where; Y is log disease incidence calculated using observed percentage disease incidence and X is the established smut disease ratings of the standard varieties (Fig. 2)



**Fig. 2.** The regression line developed for assigning smut ratings to test varieties using standard varieties with established ratings to smut disease

Smut ratings assigned to standard varieties and test varieties based on their log-transformed values of observed disease percentages are presented in Table 1 with their sugar- and cane- yield components. Among the 29 tested varieties (except 6 standard varieties) eighteen varieties were categorized as resistant (highly-resistant and resistant) and four varieties were classified as moderately-resistant to smut disease by this method. Therefore, these varieties can be advanced into preliminary yield evaluation prior to the final yield assessments in identifying high-yielding candidate varieties with smut-resistance for commercial cultivation. The variety, SL 02 1104 was identified as susceptible to smut while five varieties were identified as moderately-susceptible to the disease. The highly-resistant variety SL 02 94 and resistant variety SL 02 235 were identified as top ranking varieties for cane yield and hand refractometer brix that approximates sugar content (TSS) in juice. The highly-resistant SL 02 315 has shown high sugar content in juice but with comparatively-low cane yield. No significant mean differences were observed between tested varieties and the

commercial standard Co 775 for all cane- and sugar- yield components evaluated in this study.

Significant negative correlations exist between disease incidence and plot weight (-0.23, n=102, p <0.01), number of stalks (-0.20, n=102, p <0.03) and hand refractometer brix (-0.22, n=102, p <.02), revealed that smut infection significantly reduces cane yield and sugar content in juice (Table 2). Kumar *et al.* (2003) reported significant negative correlation with almost similar magnitude for cane yield and disease incidences. The significant correlation coefficients estimated in this study are comparatively low in magnitude (around 0.2). This is due to large number of observations collected from a mixture of varieties established in small plots.

Significant correlation coefficients with higher magnitudes could be expected in the absence of confounding effects of the varieties. Hence, a detailed study to assess the effect of *Sporosorium scitamineum* on sugarcane yield components is proposed to estimate possible cane- and sugar- yield losses due to sugarcane smut under different

infection levels in Sri Lanka. This suggested study should be planned to quantify cane- and sugar- yield losses due to smut in

commercial plantations using large sample sizes and infected and healthy plots.

**Table 1.** Smut disease reaction and Mean  $\pm$  Std. error of the yield components

Variety	Disease reaction	Brix (%)	Rank Brix	Diameter (mm)	Length (cm)	Weight (kg/plot)	Rank weight	Stalks/plot
<i>Co 740</i>	HR	15.62 $\pm$ 0.58	30	20 $\pm$ 0.9	189.2 $\pm$ 8.5	26.7 $\pm$ 3.5	33	33 $\pm$ 4
SL 02 1155	HR	16.09 $\pm$ 0.06	27	24 $\pm$ 1	232.8 $\pm$ 8.5	52.7 $\pm$ 1.5	7	63 $\pm$ 8
SL 02 1259	HR	20.83 $\pm$ 0.41	1	26 $\pm$ 2.2	227.3 $\pm$ 5.7	38.0 $\pm$ 4.0	25	33 $\pm$ 3
SL 02 1371	HR	17.64 $\pm$ 0.79	20	28 $\pm$ 3	222.7 $\pm$ 12.3	39.2 $\pm$ 11	23	41 $\pm$ 7
SL 02 201	HR	18.25 $\pm$ 1.23	14	23 $\pm$ 0.6	228.3 $\pm$ 10.9	48.3 $\pm$ 5.5	14	47 $\pm$ 7
<b>SL 02 315</b>	<b>HR</b>	<b>19.25<math>\pm</math>0.83</b>	4	<b>27<math>\pm</math>1.4</b>	<b>229.7<math>\pm</math>7.9</b>	<b>50.3<math>\pm</math>5.4</b>	11	<b>45<math>\pm</math>2</b>
SL 02 665	HR	17.24 $\pm$ 0.78	24	22 $\pm$ 0.7	188.0 $\pm$ 18.5	35.0 $\pm$ 4.0	28	49 $\pm$ 8
SL 02 706	HR	18.34 $\pm$ 0.79	13	26 $\pm$ 0.4	225.7 $\pm$ 8.9	44.8 $\pm$ 4.6	17	44 $\pm$ 2
<b>SL 02 94</b>	<b>HR</b>	<b>19.16<math>\pm</math>0.67</b>	5	<b>25<math>\pm</math>0.7</b>	<b>266.3<math>\pm</math>21.3</b>	<b>58.7<math>\pm</math>4.5</b>	3	<b>60<math>\pm</math>10</b>
<i>Co 775</i>	<b>R</b>	<b>18.49<math>\pm</math>0.99</b>	11	<b>25<math>\pm</math>1.7</b>	<b>224.7<math>\pm</math>23.9</b>	<b>40.0<math>\pm</math>6.1</b>	21	<b>40<math>\pm</math>6</b>
SL 02 1168	R	17.81 $\pm$ 1.08	16	22 $\pm$ 2.1	230.3 $\pm$ 14.1	45.7 $\pm$ 6.2	16	60 $\pm$ 5
SL 02 1299	R	20.49 $\pm$ 1.20	3	23 $\pm$ 0.8	204.0 $\pm$ 9.6	18.5 $\pm$ 1.8	34	18 $\pm$ 2
SL 02 130	R	16.72 $\pm$ 0.83	26	28 $\pm$ 0.7	248.0 $\pm$ 8.6	50.7 $\pm$ 6.2	9	45 $\pm$ 2
SL 02 1386	R	17.83 $\pm$ 0.71	15	25 $\pm$ 0.9	271.0 $\pm$ 14.4	55.7 $\pm$ 12	5	41 $\pm$ 7
SL 02 204	R	17.62 $\pm$ 0.9	21	25 $\pm$ 1.4	237.7 $\pm$ 13.0	48.7 $\pm$ 9.5	13	51 $\pm$ 0
SL 02 228	R	17.09 $\pm$ 1.36	25	24 $\pm$ 1	246.0 $\pm$ 19.6	39.0 $\pm$ 2.9	24	38 $\pm$ 2
<b>SL 02 235</b>	<b>R</b>	<b>20.70<math>\pm</math>1.38</b>	2	<b>26<math>\pm</math>0.4</b>	<b>228.2<math>\pm</math>19.5</b>	<b>50.7<math>\pm</math>3.5</b>	10	<b>53<math>\pm</math>11</b>
SL 02 302	R	18.96 $\pm$ 0.26	7	25 $\pm$ 0.7	216.3 $\pm$ 15.5	33.3 $\pm$ 2.9	30	41 $\pm$ 1
SL 02 658	R	17.72 $\pm$ 1.56	18	24 $\pm$ 1.6	217.7 $\pm$ 9.3	47.3 $\pm$ 5.2	15	54 $\pm$ 7
SL 02 895	R	19.08 $\pm$ 0.95	6	24 $\pm$ 0.6	248.3 $\pm$ 22.0	33.7 $\pm$ 4.9	29	37 $\pm$ 3
SL 02 1033	MR	15.68 $\pm$ 1.20	29	27 $\pm$ 0.5	210.7 $\pm$ 15.2	53.0 $\pm$ 12	6	49 $\pm$ 6
SL 02 1426	MR	14.69 $\pm$ 0.64	33	27 $\pm$ 0.5	262.4 $\pm$ 28.5	52.0 $\pm$ 5.5	8	49 $\pm$ 0
SL 02 932	MR	18.45 $\pm$ 1.26	12	24 $\pm$ 1	241.3 $\pm$ 13.1	59.0 $\pm$ 11	2	53 $\pm$ 7
SL 02 945	MR	14.65 $\pm$ 1.02	34	26 $\pm$ 1.5	224.7 $\pm$ 2.3	44.3 $\pm$ 2.9	20	37 $\pm$ 5
<i>Co 997</i>	MS	15.33 $\pm$ 1.35	31	22 $\pm$ 0.2	238.3 $\pm$ 18.9	37.0 $\pm$ 1.5	26	37 $\pm$ 1
SL 02 1204	MS	17.48 $\pm$ 1.48	23	23 $\pm$ 0.5	203.0 $\pm$ 16.7	33.3 $\pm$ 0.9	30	34 $\pm$ 1
SL 02 1273	MS	18.68 $\pm$ 0.52	10	25 $\pm$ 0.8	257.3 $\pm$ 12.0	44.7 $\pm$ 5.5	18	33 $\pm$ 1
SL 02 1277	MS	18.73 $\pm$ 0.46	8	24 $\pm$ 1.1	208.0 $\pm$ 25.2	18.3 $\pm$ 4.7	35	29 $\pm$ 6
SL 02 219	MS	17.68 $\pm$ 0.25	19	23 $\pm$ 0.6	231.7 $\pm$ 14.8	30.0 $\pm$ 5.5	32	26 $\pm$ 3
SL 02 357	MS	17.80 $\pm$ 0.91	17	26 $\pm$ 1.2	215.7 $\pm$ 21.5	36.7 $\pm$ 8.8	27	38 $\pm$ 7
SL 02 652	MS	15.09 $\pm$ 1.17	32	27 $\pm$ 0.3	213.3 $\pm$ 18.0	39.7 $\pm$ 6.9	22	41 $\pm$ 8
<i>Co 1001</i>	S	17.57 $\pm$ 0.30	22	23 $\pm$ 0.8	233.3 $\pm$ 13.8	49.3 $\pm$ 2.9	12	57 $\pm$ 4
<i>M351 57</i>	S	14.64 $\pm$ 0.95	35	24 $\pm$ 0.8	243.0 $\pm$ 18.9	44.7 $\pm$ 4.8	18	42 $\pm$ 8
<i>PH 56 226</i>	S	15.83 $\pm$ 1.45	28	26 $\pm$ 0.9	212.3 $\pm$ 19.1	59.3 $\pm$ 9.5	1	58 $\pm$ 6
SL 02 1104	S	18.66 $\pm$ 1.46	9	27 $\pm$ 1.1	199.7 $\pm$ 22.0	56.2 $\pm$ 15	4	56 $\pm$ 7

Note: HR = Highly-resistant, R = Resistant, MR = Moderately-resistant, MS = Moderately-susceptible and S = Susceptible, names of the standard varieties are denoted in italic fonts

**Table 2.** Spearman's Rank correlation coefficients between yield components and smut disease incidence

Yield component	Correlation coefficient
Hand refractometer brix %	-0.22 *
Cane weight (kg/plot)	-0.23 **
Number of stalks/plot	-0.21 *
Stalk length	-0.04
Stalk diameter	-0.05

Note: \* and \*\* denote for significance at probability levels 0.05 and 0.01, respectively.

Non-significant correlations observed for stalk length and stalk diameter with smut incidence revealed that sugarcane smut has no effect on stalk length and stalk diameter measured in millable stalks at harvest. This result agrees with Msechu and Keswani (1982) in a yield study conducted in Tanzania. Antoine (1961) and de Ramallo (1980) reported that the smut-infected canes tend to produce slender stalks and shorter or longer internodes, which ultimately dependent on the variety cultivated.

## CONCLUSIONS AND SUGGESTIONS

Twenty-nine varieties of SL 2002 series had shown variable reaction to sugarcane smut disease. Out of the tested varieties; eight, ten and four varieties were grouped into highly-resistant, resistant and moderately-resistant categories, respectively. Therefore, these varieties can be advanced into next variety selection stages in the sugarcane crop improvement program and /or used as parents in breeding programs to develop smut-resistant progenies. Six tested varieties were found moderately-susceptible and the variety SL 02 1104 was categorized as

susceptible to smut and therefore, these varieties cannot be considered as promising varieties since they are unable to resist sugarcane smut disease competently in Sri Lanka regardless of their yield potential.

It is proven that sugarcane smut reduces cane yield and sugar content in juice through significant negative correlations observed between disease incidence and plot weight, number of stalks and hand refractometer brix. A detailed study is proposed to quantify cane- and sugar- yield losses due to smut in commercial sugarcane plantations in Sri Lanka.

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