FEASIBILITY OF FUNGICIDAL CONTROL OF YELLOW SPOT

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ABSTRACT

The effectiveness of Benomyl sprays (270 g a.i./ha) for controlling yellow spot disease in the profusely flowering susceptible variety S 17 was evaluated under severe epiphytotic conditions. Sprays applied with mist blowers at intervals of 1, 3 and 4 weeks were compared. There were no differences between treatments at 3- and 4-week intervals. Although they did not control infection as well as weekly sprays, they were nearly as effective in giving a substantial increase in sucrose content. Spraying also improved juice purity but had no effect on cane yield at harvest early in the season.

There was a greater response to fungicide control in flowered than in vegetative canes at harvest time. In an industrial trial, four fungicide sprays with mist blowers at intervals of 5 weeks gave 57% control of infection and an increase in sugar yield of 1 to 2 tons/ha. Disease control was also effective when Benomyl was applied above the leaf canopy with ULV sprayers. Therefore, fungicidal control of yellow spot in sugarcane could be feasible and economic and can be a useful temporary measure to reduce losses in case of change of resistance in varieties, pending their replacement.

INTRODUCTION

Yellow spot disease caused by Cercospora koepkei Kruger of sugarcane occurs in several tropical countries. It can be severe in high rainfall areas, causing losses in both cane and sugar yields (Egan6, Hughes and Ocfernia7, Ricaud1,12).

So far, its control relies solely on the use of resistant varieties. This is, however, not entirely satisfactory; the recurrence of severe epiphytotics associated with changes in varietal resistance has been reported (Egan6, Ricaud et al.13,14).

Attempts to control the disease by fungicide spraying have been reported (Egan4, Prakasam and Satyanarayana9, Ricaud12). Fungicide Benomyl was found to give good control but unfortunately several sprays are required.
The heavy losses assessed in variety S 17 in the recent epiphytotics in Mauritius have prompted further investigations on fungicidal control.

MATERIALS AND METHODS

Four field trials of each of the following were conducted:

(i) Two small-plot trials to determine the optimum interval for fungicide spraying.
(ii) A strip-type trial to assess the feasibility of control on an industrial scale.
(iii) A small-plot trial in which an ultra low volume sprayer was used for spraying over the top of the cane canopy to simulate aerial spraying.

The first three trials were conducted in 1978 and the fourth in 1979.

Plant material

The trials were carried out in 2nd or 3rd ratoon fields of the susceptible variety S 17, a high sucrose, profusely flowering variety adapted for early harvest in the super-humid zone of Mauritius (average annual rainfall is greater than 2500 mm), in which severe epiphytotics of the disease occur yearly since 1976.

Fungicide spraying

Benomyl (50% wp methyl 1-(butylcarbamyl) - 2-benzimidazole carbamate) was used for spraying at the rate of 270 g a.i./ha. For the first spraying in each trial, Dithane M-45 (a co-ordination product of zinc ion and manganese ethylene-bisdithiocarbamate, 80% WP) was added to the spray suspension at the rate of 860 g a.i./ha. In the first 3 trials, mist blowers were used for spraying and the spray jet was directed towards the undersurface of cane leaves. One thousand liters of fungicide suspension in water, to which were added 80 ml of spreader sticker Triton B 1956 were applied per hectare.

In the fourth trial, Micron ULVA 8 ultra low volume sprayers (Micron sprayers Ltd. U.K.) were used and the sprays were drifted on the cane leaves from slightly above (0.2 m) the canopy. The fungicide was suspended in a 5% oil in water emulsion, applied at the rate of 25 l/ha. Sunspray 7E (Sun Oil Co., Belgium) was used.

Spraying was started early February and continued in most treatments until the end of May or early June when infection started to subside. Weekly sprays were performed until the end of June.

Treatments and layout

In the 3 small-plot trials, the effectiveness of spraying at intervals of 1, 3 and
4 weeks was compared. Unsprayed plots served as control. A 4 x 4 latin square design was adopted, plot size being 6 rows x 10 m, two of which were non-experimental guard rows.

In the industrial trial, plots receiving 4 fungicide sprays at intervals of 5 weeks from mid-February to end of May were compared to unsprayed plots. A randomized block design with 4 replicates was used, each plot consisting of 16 rows x 96 m (i.e. 0.25 ha).

Data and statistical analysis

The effectiveness of treatment was assessed by determining disease build-up, cane yield and sugar content. The results on disease infection for the 1979 trial only are presented in this paper.

The incidence of flowering was less than 75% in the first 2 trials and data for infection and sugar content were collected separately for flowered and vegetative stalks. In the industrial trial where the incidence was greater than 85%, vegetative stalks were juvenile and stunted, therefore only flowered stalks were considered.

Disease build-up was monitored at intervals of 4 to 5 weeks from the beginning of February until August. Percent leaf area covered by yellow spot was assessed visually on leaves 1 to 10 on 10 stalks (or 2 x 10, if both flowered and vegetative assessed) taken at random from each replicate plot, as previously described (Ricaud 1980).

Cane yield was determined at harvest at 12 months. In the first 2 trials, the 2 middle rows were weighed for each plot. In the industrial trial 2 plots of 6 rows x 70 m, diagonally opposite each other in each strip, were cut and loaded separately in 2 crates which were weighed at the factory.

Stalk samples were analyzed at harvest for Brix, pol % cane, fiber % cane and reducing sugar content. These data were used to calculate IRSC (industrial recoverable sucrose % cane), purity, reducing sugar/sucrose ratio, tons sugar per hectare and tons profitable sugar per hectare. The latter is an index that takes into consideration harvest, transport and processing costs and penalizes cane with low sucrose when comparing yields from experimental plots.

In the first 2 trials, 10 stalks were sampled from each plot for analysis, for both flowered and vegetative stalks separately. Vegetative stalks were cut at their apex and flowering stalks at the base of the inflorescence. In the industrial trial, there were 3 sub-samples of 10 stalks per strip. The strips were subdivided approximately into 3 sub-plots from which the stalks were taken in random rows along a diagonal. In addition, for the industrial trial, analyses at harvest were also made on samples from the crates, using a core sampler. Each crate was analyzed separately and an aliquot from two cores was taken from each.
Pol % cane was also determined 1 and 2 months before harvest for the 3 trials, and 1 month after harvest on rows left standing, in the industrial trial.

For statistical analysis of infection build-up, the arcsine transformation was applied to the percentage values. In the Latin square trials, data for flowered and vegetative canes were analyzed separately. For comparison of flowered vs vegetative, a pooled variance was calculated.

RESULTS

Optimum spraying interval

Climatic conditions in 1978 were very favorable for yellow spot infection. Similar results were obtained in both trials to determine the optimum interval for fungicide spraying, results for only one of them are presented.

There was no significant difference in the degree of control between spraying at 3- and 4-week intervals (Fig. 1). Both gave highly significant disease control compared to unsprayed plots but were less effective than weekly sprays which kept down infection to a very low level. Considering the cumulative infection over the period of observations (area under infection curves), spraying at 3- and 4-week intervals reduced disease build-up in flowered stalks by about 58% compared to 90% for weekly sprays. Differences among spray intervals in the flowered and vegetative stalks were highly significant in July. However, harvest data showed no significant differences in cane yield among the different treatments.

![Figure 1](https://example.com/fig1.png)

**FIGURE 1.** Progress of yellow spot infection in flowered and vegetative canes of variety S 17 in plots sprayed with Benomyl at intervals of 1, 3 and 4 weeks and in unsprayed plots.
Fungicide spraying resulted in a substantial and significant increase in sucrose content in both flowered and vegetative stalks in June and at harvest in July (Fig. 2). There were no significant differences among the 3 spraying intervals, except for flowered stalks at harvest which showed significant (P 0.05) response to weekly sprays than to the other 2 spraying intervals.

Results in July showed that vegetative stalks responded less to spraying than flowered stalks, the minimum sucrose gain from any of the 3 treatments being 11.3% in vegetative compared to 23.0% in flowered stalks. This is due to the fact that the sucrose content of diseases canes in unsprayed plots in July is significantly higher in vegetative than in flowered stalks. In June, flowered and vegetative stalks were equally affected by the disease and the minimum gain from spraying was 28.2% and 23.4%, respectively.

**Figure 2.** Increase in sucrose content in flowered and vegetative canes of variety S 17 resulting from the control of yellow spot by Benomyl sprays at intervals of 1, 3 and 4 weeks. (LSD — * P 0.05, ** P 0.01, *** P P 0.001)

**Figure 3.** Control of yellow spot infection in variety S 17 on an industrial scale by four sprays of fungicide Benomyl. (Arrows indicate dates of spray).
Spraying also improved juice purity at harvest in flowered stalks although there were no significant differences among the 3 spray intervals. A mean of 92.8% was recorded for sprayed plots and 86.2% for unsprayed plots. In vegetative canes there were no significant differences among the three sprayed and unsprayed plots.

![Graph showing sucrose content in variety S17 following control of yellow spot using Benomyl sprays in an industrial scale trial.](image)

**FIGURE 4**: Increase in sucrose content in variety S17 following control of yellow spot using Benomyl sprays in an industrial scale trial. (LSD - \*P0.05, **P0.01, ***P0.001)

**Industrial trial**

Spraying significantly reduced disease build-up in the industrial trial (Fig. 3). The cumulative infection level was reduced by 57%. Spraying, even at intervals of 5 weeks, resulted in a substantial and significant increase in sucrose especially at harvest in August and September (Fig. 4).

Harvest data are presented in Table 1. As in the previous trials, disease control did not give any increase in cane yield. However, the increase in sugar yield was at least 1 ton/ha. The higher response to spraying shown by the results with the field sampling technique was consistent with data from the analyses obtained one month earlier. In addition to the gain in sucrose, a marked and significant increase in juice purity was recorded, which was also reflected by the reducing sugar/sucrose ratio values.

**Overhead spraying**

Full results of the trial for investigating spray application from above
the cane canopy are not yet available. Preliminary data are shown here to indicate the feasibility of aerial spraying. Climatic conditions in 1979 were such that after an early start of infection, disease progress slowed down. Surveys in May revealed that fungicide application by the Micron ULVA sprayers gave significant disease control. Infection levels were 0.7%, 2.4% and 2.0% in plots sprayed at 1-, 3- and 4-week intervals respectively, as compared to 15.2% in the unsprayed control.

**TABLE 1. Increase in sugar yield in variety S 17 as a result of yellow spot control using Benomyl sprays**

<table>
<thead>
<tr>
<th>Sprayed</th>
<th>Unsprayed</th>
<th>LSD</th>
<th>Gain %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons cane/ha</td>
<td>76.1</td>
<td>76.4</td>
<td>NS</td>
</tr>
<tr>
<td>IRSC ++</td>
<td>11.8 †</td>
<td>9.0</td>
<td>2.4 ***</td>
</tr>
<tr>
<td></td>
<td>11.0</td>
<td>9.7</td>
<td>1.0 *</td>
</tr>
<tr>
<td>Tons sugar/ha</td>
<td>8.98</td>
<td>6.88</td>
<td>1.60 *</td>
</tr>
<tr>
<td></td>
<td>8.37</td>
<td>7.38</td>
<td>0.93 *</td>
</tr>
<tr>
<td>Tons profitable sugar/ha † †</td>
<td>5.93</td>
<td>3.83</td>
<td>1.70 **</td>
</tr>
<tr>
<td></td>
<td>5.33</td>
<td>4.33</td>
<td>0.82 **</td>
</tr>
<tr>
<td>Purity</td>
<td>91.5</td>
<td>85.0</td>
<td>2.5 *</td>
</tr>
<tr>
<td></td>
<td>89.5</td>
<td>86.7</td>
<td>4.5 **</td>
</tr>
<tr>
<td>Reducing sugar/sucrose ratio (x 100)</td>
<td>2.1</td>
<td>7.3</td>
<td>4.8 **</td>
</tr>
</tbody>
</table>

+ LSD = *P 0.05, **P 0.01, ***P 0.001
++ IRSC = (Pol % cane x 0.9) – 1.8
† Data in bold characters are for field sampling technique. Data in light characters are for core sampler.
† † Tons profitable sugar/ha = TC/ha x \( \frac{(IRSC - 4)}{100} \)

**DISCUSSION**

The estimation of losses due to yellow spot disease by the use of regular sprays of Benomyl has previously been reported (Egan, Ricaud). These have shown that the gains obtained from spraying by these workers and confirmed by the present writers clearly indicated that these are the result of disease control and not a ripening effect of Benomyl. It has been found also that the severe effects of the disease in S 17 are due to its profuse flowering. The lesser response to spraying in vegetative stalks at the "time of harvest may be attributed to the recuperation of such stalks as the disease subsides and new green leaves develop.

Previous attempts to control yellow spot by Benomyl sprays had shown
that their effect did not last long and that 2 sprays applied early, although
giving a slight beneficial response, were not efficient (Ricaud12). It was observed
that 4 to 5 sprays at intervals of 4 to 5 weeks, although not as good as weekly
sprays in controlling infection, were nearly as effective in reducing the effects
of the disease on sugar content. For many diseases the correlation between loss
and amount of infection is not linear (Chiarappa); infection levels must be
above a certain threshold for losses to be apparent or important. Present results
indicate that this applies for yellow spot. A slight reduction in the infection
rate may be sufficient to get returns. It should be pointed out that with the
system of disease assessment used, for an infection level of 15%, any of the
4 topmost and efficient leaves has a maximum of 5% spotting.

Although mist blowers could be used for the investigations, their regular
use in sugarcane, after the canopy has closed, is excluded. Only some form
of aerial application would be practical. In the way the mist blowers were
used, however, the lower leaves within the canopy could be treated, and the
spray jets hit the under surface of leaves where the fungus sporulates. The top-
most leaves were treated at least at their base. The systemic action of Benomyl
is translaminar and in the direction of the transpiration stream (Marsh8). This
ensures a good redistribution of the chemical to the tip of the younger leaves.
Although aircraft spraying is used quite successfully in sugarcane for insecticides
and ripeners, these are either fully systemic or there is no need for a very good
distribution as required for maximum effectiveness with fungicides. The feasi-
bility of aerial spraying of fungicides in a dense canopy crop like sugarcane should
not be disregarded. The results of the investigations with overhead spraying,
although limited, indicate that Benomyl should be used for aerial spraying against
yellow spot. The infection process of this disease has not been studied extensively,
but it is generally accepted that infection starts on the younger leaves which are
readily infected, and that development on older leaves is due to the spreading of
established lesions rather than new infection (Hughes and Ocfemia7). Most proba-
bly, therefore, only the topmost leaves need to be properly protected against the
disease.

However, fungicidal control should not replace the use of resistant varieties.
This measure should continue to have priority in the control of yellow spot. Pro-
blems which are likely to recur, have cropped up under conditions extremely favor-
able to the disease, with changes in varietal resistance (Egan5, Ricaud et al13, 14).
These are possibly due to the selection of strains of the pathogen more virulent to
the varieties, or else to assessment of their resistance conducted during periods
of low disease intensity. Rapid varietal replacement is not always possible and can
be costly, specially with long crop cycles as practiced in Mauritius. Fungicide con-
trol can then be a useful temporary measure to reduce losses.

The use of fungicides over wide areas in a field crop is not without problems.
The development of resistance to Benomyl has been repeatedly reported in many
fungal species (Marsh8). To reduce such likelihood, spray alternately with fungi-
cides having different modes of action or apply mixtures of these fungicides.

The economics of spraying are evidently the dominant factor for its adoption. The trials reported, as well as other investigations, indicate potential gains of the order of 2-3% pol % cane, representing 1.3 to 2.0 tons sugar per hectare for cane yield of 75 tons/ha. Discrepancies in estimating gains between the two sampling methods in the industrial trial are explained by the fact that only flowered stalks were taken when sampling in the field. It has also been found in ripener trials that the core sampling technique tends to minimize differences between treatments (R, Julien, private communication). As spraying results in an increase in sugar content, the profitable sugar index should also be considered for comparisons between sprayed and unsprayed plots. Actual returns from spraying will evidently depend on the efficiency of the operation, disease intensity, and cane yield. It is reasonable to expect a potential yield of 1-2 tons sugar per hectare for the variety S17 under severe disease conditions. Four to five sprays would be required, according to climatic conditions. The prospects for economic returns in fungicidal control of yellow spot on variety S17 in Mauritius are very good and helicopter spraying trials are under way.

REFERENCES

LA FACTIBILIDAD DEL CONTROL CON FUNGICIDAS PARA LA ENFERMEDAD DE LA MANCHA AMARILLA

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RESUMEN

Se evaluó bajo condiciones epifíticas la eficacia de rociar con benomyl (270 g a.i./ha) para el control de la enfermedad de la mancha amarilla en la variedad susceptible y de florecer profuso S-17. Se compararon las aplicaciones de rociar con una sopladora de neblina a intervalos de 1, 3 y 4 semanas. No hay diferencias entre los tratamientos a intervalos de 3 y 4 semanas. Aunque no se controló la infección tanto como las rociadas semanalmente, éstas fueron casi tan efectivas para darle un aumento sustancial en el contenido de sacarosa. Rociar también mejoró la pureza del jugo, pero no hay efecto en el rendimiento de la caña en la cosecha temprano de la temporada. Hay una mejor reacción al control con fungicidas en la caña florecida que en la vegetativa al tiempo de cosecha. En una prueba industrial se obtuvo 57 porciento del control de la infección y un aumento en rendimiento de azúcar entre 1 y 2 ton/ha al hacer las aplicaciones de cuatro fungicidas con sopladoras de neblina a intervalos de 5 semanas. El control de la enfermedad fue también efectivo cuando se aplicó benomyl sobre el dosel de las hojas con una rociadora de volumen ultra bajo (VUB). Se concluye que el control con fungicidas para la mancha amarilla en la caña de azúcar debe ser factible y económico, sin embargo, no debe reemplazar el uso de las variedades resistentes, pero puede ser una medición útil y temporera para reducir las pérdidas en caso de cambiar la resistencia en las variedades hasta que los mismos se reemplacen.