THE CONTROL OF SUGARCANE DISEASES IN FIJI

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ABSTRACT

The diseases downy mildew and Fiji are the only ones which have caused major losses in Fiji cane areas. In recent years they have been reduced to a very low level by the release of resistant varieties coupled with an intensive system of disease control. The intensive disease control system involves establishment of a detailed checking system to locate infected fields, roguing of diseased plants, and the use of disease-free seed. The intensive control system combined with resistant varieties has reduced the incidence of both diseases to such low levels that a less rigid system of disease control has been in use since 1967.

INTRODUCTION

Downy mildew and Fiji diseases are the only ones which have caused appreciable economic losses in Fiji. Fiji disease is endemic in the natural flora and cannot be eradicated. Downy mildew, on the other hand, has only 1 alternate host—corn. These facts have resulted in a basic philosophy for sugarcane disease control in Fiji: downy mildew should be eradicated and Fiji disease should be reduced to safe levels in the commercial crop.

HISTORY OF FIJI DISEASE IN FIJI

It is not known whether Fiji disease was introduced with sugarcane in the original Melanesian migrations or was a more recent introduction by 19th century European planters. However the disease has long been widespread both in the wild grass Erianthus maximus and in Saccharum edule in village gardens. Robinson and Martin (8) have given a brief history of Fiji disease until 1950. They recorded that by 1886 it was widespread in commercial crops on the Rewa River. By 1906, North (7) was able to say of its incidence, "It practically destroyed some thousands of acres of cane and grave fears were entertained for a time that it might threaten the very existence of the industry." This devastation was recorded photographically by Muir (5) of the Hawaiian Sugar Planters' Association.

This outbreak was brought under control by a clean seed programme
and the release of the Badila and Pompey varieties, which were more resistant to the disease. For many years the level of infection remained low. Occasional outbreaks were brought under control with clean seed and intensive roguing. This situation was disturbed by the release of a higher yielding but susceptible variety, Ajax, during the 1940's. Ajax often became badly infected. The position was aggravated further by the release of Pindar in the early 1950's. By 1960 it was common to find Pindar fields with many hundreds of diseased stools per acre. Since then the situation has been brought under control with the release of resistant varieties coupled with the intensive system of disease control described in this paper.

**HISTORY OF DOWNY MILDEW DISEASE IN FIJI**

Daniels et al. (1) have reviewed the history of downy mildew disease in Fiji up until 1967. It was first detected at Rarawai in 1910 by North (6), who considered the disease a recent introduction from New Guinea by way of Australia. Within 2 years of its original entry, the disease was found in all mill areas except Nausori, and serious losses were evident. North estimated losses as high as 73% in individual fields. The situation would have been disastrous if the varieties Badila and Pompey had not been available. These varieties are resistant to both downy mildew and Fiji disease.

POJ 2878 and Marcus were released in the early 1930's but had to be rapidly withdrawn because of susceptibility to downy mildew disease. Most hybrid varieties available until the 1950's were susceptible. The variety Eros was released at Labasa but had to be withdrawn for the same reason. The presence of the disease, thus, delayed the cultivation of the higher yielding hybrid varieties until the 1950's and caused very large losses to the Fiji industry.

However, by 1955 the 2 resistant hybrid varieties Pindar and Ragnar had been extended and were grown on a considerable portion of the area. This enabled the disease to be brought to very low levels, and by 1965 it had been eradicated in some isolated areas, such as Penang. In these areas, the eradication of the disease has allowed growing of the higher yielding but susceptible variety Waya. In the remainder of the cane area the disease has been reduced to a negligible incidence, but it has not been eradicated because the varieties that replaced Pindar (withdrawn because of Fiji disease susceptibility) were less resistant to downy mildew disease.

In 1970, one of the areas which was declared disease-free in 1968 became reinfected. The amount of infection (10 stools in 5 fields) is so low that it only became apparent because of heavy infection in adjacent corn areas. The cause of this outbreak is not known but could be due to 1) latent infection in cane masked by recent severe droughts, 2) the importation of infected seed from a diseased area, or 3) undetected infection in a village garden. If we had not had prior experience of successful eradication in other areas, this recent outbreak could throw doubt on the concept that the disease can be eradicated. However, the Penang mill area was declared free of downy mildew in 1962 and has remained disease-free since then despite the growing of the susceptible variety Waya and extensive areas of corn. We continue to believe that complete eradication of the disease is possible.
Early Methods

The basic methods of controlling Fiji and downy mildew diseases were formulated in 1913 by North (6). They include:

a) The use of resistant varieties.

b) The destruction of diseased stools prior to and during the wet season: January to April. Downy mildew spreads rapidly during wet weather, and this season is also favourable for the increase in populations of Perkinsiella vitiensis, the leafhopper vector of Fiji disease. Both diseases spread rapidly during the wet season.

c) Badly infected fields are harvested early, the trash burnt and the fields ploughed out.

d) Planting material is selected carefully from fields remote from infected plants.

e) The growing of corn is discouraged in the cane area.

f) The movement of seed cane from infected to healthy areas is prohibited.

While these methods could be implemented in toto in the estate-managed industry which North catered for, the methods were not entirely practicable when the large estates were broken up and smaller farms were turned over to independent farmers in the 1920's. For example, it was no longer possible to insist that all fields be planted from isolated seed beds. Farmers were often most unwilling to buy seed from outside sources. Under the small farming system, the movement of seed cane was no longer under control, and as late as 1967 we have had cases of diseased cane being transferred by farmers to healthy areas. Farmers also began growing corn for food and, thus, encouraged the rapid multiplication of the downy mildew fungus. Under present conditions the growing of corn can only be controlled by persuasion.

However, the main principles set down by North were applicable to the altered conditions. Under the small farm system the cane areas were broken up into sectors each of approximately 200 growers. Each sector was administered by a field officer, and one of his duties was to organise disease control. This involved the employment of regional roguing gangs which examined fields, row-by-row, to remove diseased stools. Farmers with badly infected fields were urged to buy seed from clean sources, and transport facilities were provided. The overall disease control operation was co-ordinated by technical field officers located at mill centres. These measures continued to be effective while resistant varieties were being grown. However, they could not cope successfully with either downy mildew in the susceptible varieties POJ 2878, Marcus and Eros or Fiji disease in Ajax and Pindar. This eventually led to all these varieties being withdrawn from cultivation.

With the heavy Fiji disease infections in Pindar in the late 1950's, it was felt that more precise methods of disease control should be introduced, and several new methods were tried on a limited scale. However, the more general implementation of a revised system was delayed by industrial troubles in the period 1960-61. By 1962, fields with up to 500 Fiji diseased stools per acre were not uncommon and the situation demanded urgent action.
The Intensive Disease-Control Scheme

The campaign had two lines of attack. On the one hand, the resistant varieties Homer and Spartan had become available, and these were extended rapidly; on the other, a new, more rigid disease control system was introduced. The re-organization involved:

Establishing a checking system. The normal regional roguing gangs were retained, but they were called disease “inspection teams” to indicate their changed status. In addition, “check teams” were appointed at mill and district centres at the rate of approximately 1 check team for every 10 inspection teams. The check teams were under the control of technical field officers, who directed operations from disease control centres. The inspection teams continued to rogue the crop row-by-row but were given increased responsibilities in the recognition and reporting of minor diseases. The basic job of the check teams was to check a random 10% of all fields, allocated by the technical field officer. The inspection teams, being regionally placed, did not require motor transport; the check teams had motor transport. The two types of teams worked quite independently of each other.

Roguing at optimum time. A system was established where fields were rogued on a systematic basis within 2 months of planting or ratooning. Field officers notified the disease control centres when each farmer planted or ratooned individual fields. At the control centre, these data were entered as symbols on small disposable field maps. Sufficient work for 2 weeks was entered on each map. At 6-8 weeks after planting or ratooning, depending on weather conditions, an inspection team was handed its 2-week work plan. The progress of each team was then assessed at 2-week intervals. This change in procedure enabled the fields of small cane to be inspected quickly, and diseased stools were removed before much secondary spread could occur.

Establishing individual responsibility. The inspection teams marked out a card as each field was inspected. On the card it was possible to locate each row in the field and, thus, the rows inspected by individual operators. The number of stools (if any) removed from each row was recorded. A similar card was submitted by the check team. If the 2 cards did not agree within close limits, the technical field officer investigated the situation. The technical field officer also conducted off-programme inspections to check the progress of each team.

The use of clean seed. There was greater emphasis on clean seed. Each farmer had a seed bed marked out on his farm. This seed bed was inspected several times during its growth and, if it remained disease free, was used by the farmer for his own plantings. If the seed bed became infected, the farmer was informed of a nearby source of clean seed or was supplied with clean seed from a remote disease-free source.

Ensuring the use of clean seed of new varieties. Pindar was removed from the approved planting list and replaced by the Fiji-disease-resistant varieties Homer and Spartan. The seed beds of these varieties were inspected monthly. Thus the extension of Homer and Spartan, in addition to being part of the resistant variety programme, also formed a part of the clean seed programme.

Identification of infected areas. Maps showing disease incidence were constantly up-dated. Special attention was given to the most heavily infected
areas. Currently, in the final stages of the programme, farms within a 1 mile radius of any infected farm are being checked at frequent intervals.

These measures have had a very dramatic effect on the incidence of both diseases (See Table 1).

Table 1. The number of stools infected with downy mildew and Fiji disease, 1962-1970

<table>
<thead>
<tr>
<th>Crop year</th>
<th>Downy mildew</th>
<th>Fiji disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>5000*</td>
<td>280,000*</td>
</tr>
<tr>
<td>1963</td>
<td>3686</td>
<td>190,459</td>
</tr>
<tr>
<td>1964</td>
<td>5741</td>
<td>128,788</td>
</tr>
<tr>
<td>1965</td>
<td>8414</td>
<td>42,767</td>
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<tr>
<td>1966</td>
<td>2954</td>
<td>14,539</td>
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<tr>
<td>1967</td>
<td>2928</td>
<td>8,066</td>
</tr>
<tr>
<td>1968</td>
<td>8832</td>
<td>5,610</td>
</tr>
<tr>
<td>1969</td>
<td>1947*</td>
<td>2,025</td>
</tr>
<tr>
<td>1970</td>
<td>579</td>
<td>690</td>
</tr>
</tbody>
</table>

* Estimates based on incomplete records

The Modified Disease-Control Scheme

By 1967, the 2 diseases had been reduced to low levels, and in order to save costs consideration was given to modifying the system towards one involving reduced inspection. Experience gained during the 1962-1967 campaign had uncovered 3 facts which enabled a reduced inspection system to be adopted with some degree of confidence:

a) Secondary spread of Fiji disease was negligible in the resistant varieties Ragnar, Homer and Spartan, even when they were introduced into badly infected areas.

b) The few odd stools showing secondary infection of Fiji disease in Ragnar, Homer and Spartan caused no economic loss. However, if used as planting material, these infected stools could lead to rapid multiplication of disease.

One stool of these varieties produces sufficient seed cane for 30-50 plants.

c) Downy mildew disease can be detected adequately by walking down every 10th row and looking for infected cane within and across rows.

These facts indicated that Fiji disease could be controlled in Ragnar, Homer and Spartan by attention to clean seed and that downy mildew disease could be detected by a less intensive inspection. With these facts established it was possible to modify the intensive system. The modified scheme became known as the "Seed bed inspection scheme," thus emphasizing the importance of the use of clean seed.

The modified programme differed from its predecessor in the following respects:

Personnel reduced. The number of men in the inspection teams was reduced by about 70%. The check teams were increased to double their previous strength. Both were provided with motor transport. The inspection teams examined all fields but inspected only 1 row in 10. A card-record scheme was again employed. As soon as any disease was found, the inspection team did not
proceed any further. The card was simply marked to record the field as infected. They did not dig out any diseased stools.

Checking system modified. The check team inspected fields, row-by-row, working to a programme supplied by the technical field officer. This programme of farms to be inspected included farms on which disease had already been found by the inspection teams and a statistically random selection of fields which had been found to be disease-free by the inspection teams. The check teams have no means of knowing whether they are inspecting known diseased or known disease-free fields. The system thus provides a check on both types of teams. The random data also provide an estimate of all disease in the crop.

Seed bed inspection. The system relies heavily on seed bed inspection. Two additional procedures help assure the success of this operation. First, the young ratoons of seed beds are inspected; if disease is detected, the fields already planted from the seed bed are immediately rogued. Second, if the farmer for some reason did not use his seed bed, the newly planted field is completely inspected.

Ploughing out infected fields and replanting with resistant varieties. Since disease incidence has been reduced to a low level, it is justifiable to recommend the ploughing out of infected fields and replanting with resistant varieties. A plough-out campaign for the few remaining downy mildew infected fields is being vigorously pursued.

Roguing of known sources of infection and potential danger spots. While farmers can be urged to plough out diseased cane, many will not do so because of the cost involved. The most that can be done in such cases is to pursue a policy of intensive roguing. All fields within a 1 mile radius of a downy mildew infected field and fields of susceptible varieties are completely inspected at frequent intervals.

Extension of new varieties. All fields planted with new varieties are checked completely. At present the new varieties are Vomo, Mali and Yasawa. In spite of the high degree of resistance of these varieties, great emphasis is placed on keeping them completely disease-free during their extension period. Discarded areas are being saturated with these resistant varieties.

ANCILLARY PROJECTS AIDING DISEASE CONTROL IN FIJI

All systems of disease control are intimately interconnected with other phases of agricultural research. The following projects are mentioned because of their importance to the current disease control scheme:

Testing New Varieties for Resistance to Disease

Methods of testing have been continually improved and the testing period has been shortened appreciably (4).

Acceleration of the Breeding Cycles

A project aimed at decreasing the intergeneration period in cane breeding programmes (2), will undoubtedly result in the more rapid incorporation of genes for downy mildew resistance into new varieties.
Utilisation of New Basic Germplasm in Breeding for Disease Resistance

Commercial varieties in Fiji are largely derived from 2 clones, POJ 2878 from Java and Co 270 from India. Though interspecific hybrids with S. spontaneum these clones transmit a high degree of susceptibility to downy mildew disease. Recent work (3) has shown that the S. spontaneum clones Mandalay, 51NG 2 and Tabongo contribute resistance, and we are endeavouring to incorporate this germplasm into commercial varieties.

Downy Mildew-Resistant Corn

It is inevitable that some farmers will continue to grow corn despite proven experience that this is a dangerous practice. We are endeavouring to produce a high-yielding, downy mildew-resistant synthetic corn variety. The basic breeding stock consists of downy mildew-resistant inbred lines developed in Taiwan. A downy mildew-resistant variety of corn would be a very worthwhile safeguard against the spread of this disease.

DISCUSSION

The results of the programme from 1962-1967 indicate that the intensive system was highly effective in reducing disease incidence to acceptable levels. The results in Table 1 indicate continued progress under the modified inspection system introduced in 1967-1968. Random checks show that the modified scheme will detect all downy mildew infections. However, light infections of Fiji disease (1-3 stools/acre) are not regularly detected. Provided these stools are not used for planting (and the use of inspected seed beds ensures that they are not), no economic losses will ensue. These results indicate that the basic aim of Fiji disease control and downy mildew eradication can be met by a conscientious application of the modified system.

One problem has become evident, however. Now that the disease has been reduced to a very low level, it is very difficult to maintain enthusiasm in the disease control teams. It becomes very difficult to check the work of both types of teams when low disease incidence results regularly in no gain from the work. A current possibility for solving this problem is the replacement of the check teams by a smaller number of personnel at a higher supervisory level.

We have not considered reducing the programme below 10% inspection because we still aim for complete eradication of downy mildew disease. It is also considered prudent to monitor fields in case of possible changes in virulence of the Fiji disease virus or the downy mildew fungus. There must also be provision for detecting outbreaks of minor diseases and the possible accidental introduction of new diseases from overseas.

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REFERENCES