THE STERILE-MALE TECHNIQUE AS A POSSIBLE METHOD FOR CONTROLLING THE LEAFHOPPER VECTOR OF FIJI DISEASE OF SUGARCANE

A. Ayub Husain  
*South Pacific Sugar Mills Ltd., Lautoka, Fiji*

P. B. Hutchinson  
*Colonial Sugar Refining Co. Ltd., Sydney, Australia*

A. W. Osborn and E. Shipp  
*School of Biological Sciences, University of N.S.W., Kensington, N.S.W., Australia*

**SUMMARY**

It is possible to expose sugarcane leafhoppers to a level of gamma radiation which effectively sterilizes them without appearing to affect their mating ability. The sterile male release procedure could be used to eradicate the insect and thus stop the transmission of Fiji disease of sugarcane. Although at present the procedure is too expensive for commercial use, current work could reduce the costs to an acceptable level.

**INTRODUCTION**

Fiji disease of sugarcane has been important in Fiji since the beginning of the century. Recently, due to the use of resistant varieties and to an intensive system of inspection, roguing and seed selection, the disease has been controlled in the commercial crop. However, areas of infected wild canes act as a reservoir from which the disease may reinfect the commercial crop. To eradicate the wild cane would be too expensive and therefore a programme of inspection of crops and seedbeds is necessary. More serious still are the limitations imposed on the breeding and selection of new varieties.

It is reasonably certain that Fiji disease is caused by a virus. The disease is not transmitted mechanically but, in Fiji, is spread by the Fijian sugarcane leafhopper *Perkinsiella vitiensis* (Kirk). No other insects tested were able to transmit the disease in Fiji, so that the eradication of the insect would thus be an effective alternative to the eradication of the infected wild cane in preventing the re-introduction of the disease to the commercial crop.

Fiji disease is also a problem in the cane-growing areas of northern N.S.W., Australia, and we have considered the possibility of eradicating the sugarcane leafhopper from these areas. The work to be described has thus been divided between Fiji with *P. vitiensis* and N.S.W., where the vector is *P. saccharicida*.

Control of insects can be achieved by use of insecticides, by biological control...
with introduced insects, by trapping or by use of chemical lures. These methods suffer from the disadvantage that they become increasingly inefficient as the population decreases; the inevitable residue initiates new generations immediately the programmes are relaxed.

In Fiji and in other countries where species of *Perkinsiella* occur, some control has been achieved with predators and parasites (e.g. the egg-predator *Cyrtorhinus mundulus* (Bred.)) but the population of these drops to a low level during periods of low leafhopper populations and the predator cannot cope with the increased population of leafhoppers in late summer. The routine use of insecticides would upset the biological control which already exists. Also, since the wild cane areas as well as the commercial cane would have to be treated continuously, the recurring costs would almost certainly be prohibitive.

A method of control which becomes more effective as the natural population declines is the “sterile-male” technique. The method consists of flooding the natural population with males in which the sperm has been rendered sterile. Thus no embryos develop following mating of these males with the natural population of females. The method has been successfully applied in the eradication of the screw-worm fly from Florida and in the eradication of a fruit fly from Guam. We have investigated its application to the sugarcane leafhopper

**The scope of our investigations**

We have investigated (i) a suitable method for producing sterility, particularly in males, without affecting mating competitiveness or longevity, (ii) a technique for distributing the sterile insects among the normal population, (iii) seasonal variations in the normal field population of the insect in order to determine the optimal time for release of sterile insects, (iv) the mass-rearing of insects for sterilization and release. In addition we studied the geographical distribution of the insect and possible hosts other than sugarcane.

**Reproductive sterilization**

Sterility could be induced in the 5th (final) instar nymphs with gamma rays from a cobalt 60 source. While a dose of 10000 rads produced sterility in males of *P. saccharicida*, a considerably higher dose (i.e. 20000 rads) was required to reduce survival. Fertility of females was eliminated by relatively low doses (3500 rads) without affecting fecundity. When sterile leafhoppers were cross-mated with normal insects in cage experiments, the numbers of progeny depended on the sterile to fertile ratio. A ratio of 1:7 reduced viable progeny to 25% of that in control cages. Thus *P. saccharicida* can be sterilized by radiation and the radiation-induced sterility does not interfere unduly with mating competitiveness. The latter aspect still has to be confirmed under field conditions.

**Distribution techniques**

The nymphs are wingless and rarely move far from the plant on which they hatched.
Young adults can fly but do so only occasionally after sexual maturity is reached one to two weeks after the final moult. Thus, unlike the screw-worm fly which aids its artificial distribution by flying considerable distances, the sugarcane leafhopper would have to be closely distributed over the treated area. We believe that the insects would best be released from helicopters.

A trial release was made from a Bell 47/D1 helicopter at Castle Hill (near Sydney), N.S.W., over a half-acre plantation of sugarcane free from leafhoppers. A number of unirradiated 5th instar nymphs were released through the open doorway while the helicopter was travelling 60 ft. above ground level at about 30 knots. The nymphs survived the descent and were successful in establishing a breeding population on the cane.

**Leafhopper populations in the field**

Fluctuations in the natural population of *P. vitiensis* in Sigatoka, Fiji, were related to the rainfall. There was a delay of approximately a month between increased rainfall and increased populations. Further work confirmed these results and also showed that leafhopper populations are low during several months each year. Leafhopper populations are also influenced by the egg-predator *Cyrtothrips mundulus* and this mirid would certainly augment the effects of a sterile-insect release programme.

**Alternate hosts of *P. vitiensis***

When the 14 species of plants listed in Table 1 were inspected at several locations at monthly intervals for a period of a year, no *P. vitiensis* could be found. Plants of these species were also grown in an insectary alongside stools of the wild cane, *Erianthus maximus* (variety Fiji 10), known to be a favoured host variety. Ten male and ten female leafhoppers were caged on each plant and daily records of their survival were kept (see Table 1).

**Table 1**

<table>
<thead>
<tr>
<th>Species</th>
<th>Longest individual adult survival (days)</th>
<th>Egg laid</th>
<th>Number of nymphs</th>
<th>Maximum survival period of nymphs (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Coix lacryma-jobi</em></td>
<td>1</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cymbopogon nardus</em></td>
<td>1</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pennisetum purpurem</em></td>
<td>3</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Arundo donax</em></td>
<td>3</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Vetiveria zizanoides</em></td>
<td>3</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Panicum maximum</em></td>
<td>3</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Stenotaphrum spp.</em></td>
<td>3</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Zea mays</em></td>
<td>3</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Oryza sativa</em></td>
<td>4</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Timmeria confensa</em></td>
<td>4</td>
<td>no</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sorghum spp.</em></td>
<td>5</td>
<td>yes</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td><em>Sorghum halepense</em></td>
<td>10</td>
<td>yes</td>
<td>9</td>
<td>5 all alive after 11 days</td>
</tr>
<tr>
<td><em>Miscanthus floridulus</em></td>
<td>10</td>
<td>yes</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

*Erianthus maximus* (Fiji 10)
The table shows that the insects flourished on the sugarcane plants, but were unable to survive on the alternate hosts. Further trials indicated that the leafhopper could not persist on *Miscanthus floridus* which grows abundantly in inaccessible areas.

However, there are two alternate hosts, the *duruka* (*Saccharum edule*), a plant in which the inflorescence is edible, and the *vitho* (*Erianthus maximus*), a wild cane. The *duruka* is grown in Fijian villages along with chewing canes (*Saccharum officinarum*) while *vitho* is found mostly along water-courses on the dry side of the main islands and together with *Miscanthus* on the wet sides. It is far less widespread than *Miscanthus*. These plants would also have to be treated in a sterile insect release programme.

**STUDIES OF MASS-REARING OF LEAFHOPPERS**

The most expensive item in a programme for the release of sterile leafhoppers is the production of insects. Whereas the screw-worm accepts a meat diet5 and the Queensland fruit-fly may be reared on a medium consisting principally of carrots5, the sap-sucking leafhoppers have not yet been reared without access to the host plant. We have tried to rear the maximum possible number of leafhoppers per plant on sugarcane grown in pots in an insectary16.

In order to ascertain the best variety of sugarcane, we tested twenty varieties in the laboratory. Ten immature adults of each sex of *P. saccharicida* were caged until death on each of three replicates of each variety. The production of progeny was assessed by periodical removal of late instar nymphs by aspiration. A wide difference was observed in the number of leafhoppers which can be reared on different varieties. Further experiments on this aspect of mass rearing are in progress.

**THE FUTURE OF THE PROJECTS IN FIJI AND N.S.W.**

Our work to date has shown that it is possible to sterilize *P. saccharicida* with gamma radiation. Similar methods would almost certainly be applicable to *P. vitensis*. A serious handicap to the project in N.S.W. is the possible return of the insect to the treated areas. In Fiji, however, if both cane-growing islands were treated, no similar problem would be encountered. Detailed costings of a full-scale campaign for both N.S.W. and for Fiji have shown the present estimates to be prohibitive. The major expense is the rearing of large numbers of insects. We are now working in N.S.W. (i) to find conditions under which the maximum number of insects may be reared on the minimum number of plants, (ii) to develop low-cost plastic-covered insectaries and (iii) to find the lowest ratio of sterile to wild insects and the minimum frequency of release which will eradicate the insect populations to be established on 12 isolated areas of cane. The results of this work may permit the costs of the full-scale projects to be reduced to an economic level.
ACKNOWLEDGEMENT

The authors thank the Colonial Sugar Refining Co. Ltd., Sydney, Australia for its support and for its interest in this work.

REFERENCES


Discussion

J. M. Goernell: Asked whether it would be necessary to treat all wild cane in addition to commercial crops?

P. B. Hutchinson: It would be necessary to treat all the wild canes.

J. W. Wilson: Noted that there appears to be differences in the susceptibility rating of a variety depending on the country in which it had been tested.

P. B. Hutchinson: Pindar is a good example in that it is regarded as resistant in Madagascar but is susceptible under Fiji conditions. An extensive list of Fiji disease ratings had been compiled and this shows many other examples of varieties which had different ratings in different countries.

W. Y. Chen: Commented that in the case of screw-worm fly irradiation was simple since this could be carried out during the larval stage. He thought that irradiation of active late instar leafhopper nymphs would be difficult.

P. B. Hutchinson: It is possible to immobilize the insect either with CO₂ or by lowering the temperature to 10 °C.

Y. S. Patel: Asked whether it is possible to separate male or female of the 5th instar easily before treatment?

P. B. Hutchinson: Two sexes differ in the weight and it is possible to separate them in a vertical air stream. However, due to the fact that the insect was held in substantial control by an egg predator, it was now thought desirable to sterilize and liberate males as well as females.

J. M. Goernell: Asked how the 5th instar nymphs segregated?

P. B. Hutchinson: During mass rearing the parent insects are allowed access to a particular batch of plants for a period not exceeding 3 days. Thus the various nymphal stages are more or less synchronized within a given batch of plants.

R. Matters: Commented that this leafhopper seemed to be a most suitable insect for this type of work and that the main problem seemed to lie in the very large number of insects that would be required. He asked whether sterilization had been attempted by the use of chemosterilants.

P. B. Hutchinson: Since irradiation had proved successful and safe to use, it had not been necessary to work with the more dangerous chemosterilants.