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FINAL REPORT

SRC PROJECT SIRC-3 (UQ 3S)

EPIDEMIOLOGY AND CONTROL OF SUGARCANE MOSAIC VIRUS IN THE ISIS DISTRICT

by

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OBJECTIVES

1. To determine if sugarcane mosaic virus (SCMV) presently spreading in the Isis district is the same as or different from SCMV in other districts with respect to virulence in sugarcane and other crop and weed plants.

2. To compare SCMV from Isis with SCMV from other districts with respect to ability to be aphid transmitted.

3. To monitor the seasonal abundance of aphid vectors in the Isis district and to correlate aphid numbers with prevalence of weed hosts, seasonal conditions, etc.

4. To consider strategies for the control of SCMV in the Isis district in the light of research results.

ACHIEVEMENT OF OBJECTIVES

The following comments summarize our assessment in this regard:

1. To determine if sugarcane mosaic virus (SCMV) presently spreading in the Isis district is the same as or different from SCMV in other districts with respect to virulence in sugarcane and other crop and weed plants.

There was no consistent difference in virulence between isolates of SCMV from Isis and Brisbane. Attempts to obtain isolates of SCMV from other districts, eg. Moreton Mill district and Northern New South Wales, were made on several occasions, but without success.

SCMV was shown to have low virulence to *Sorghum verticilliflorum*, wild sorghum, a common weed in the Bundaberg and Isis districts. This species is unlikely to be a major factor in the epidemiology of SCMV.

2. To compare SCMV from Isis with SCMV from other districts with respect to ability to be aphid transmitted.

Evidence from aphid-transmission experiments indicated that an Isis isolate of SCMV was transmitted by *Aphis gossypii*, *Myzus persicae* and *Rhopalosiphon maidis*, but not by *Hyperomyzus lactucae*, *Aphis nerii* and *Hysteroneura setariae*. The positive transmissions by *A. gossypii* and *R. maidis* are consistent with previous results with a Brisbane isolate (Teakle & Grylls 1973), whereas that with *M. persicae* is new. Since isolates of SCMV from other districts were unavailable (See Objective 1), no further comparison of vector ability was possible. The three other aphid species have not previously been tested as SCMV vectors in Australia.

3. To monitor the seasonal abundance of aphid vectors in the Isis district and to correlate aphid numbers with prevalence of weed hosts, seasonal conditions, etc.

The seasonal phenology of most of the aphids (*A.craccivora, A. gossypii, B. helichrysi, M. sacchari, M. persicae, R. maidis* and *T. citricidus*) that were trapped at Bundaberg in 1989-91 generally was similar to that obtained at Bundaberg in 1961-62 by Hughes *et al.* (1964, 1965). The same species were also trapped, except for *L. erysimi* and a few other species trapped by Hughes *et al.* infrequently and in low numbers. These differences may reflect different trapping efficiencies of the pan traps used by Hughes *et al.* and the cylinder traps used in this study. The relative numbers of the major aphid species trapped at Bundaberg were also consistent between the two studies. *M. sacchari* (a non-vector of SCMV1-SC) and *A. gossypii* (a variable vector) were the most prevalent, and there were few of the other known vector species.

No differences were found in seasonal phenology of aphids between Bundaberg and North Isis. The exception was *T. nigriabdominalis* which was trapped more often at Bundaberg than at North Isis.

The spread of SCMV-SC in the Isis district in 1985-87 was rapid and extensive (Jones 1987), but since has been restricted. This may reflect, in part, differences in environmental conditions in these two periods. In the years 1984-1987 the Isis district had above-average spring (September-November) rainfalls with reasonable summer (December-February) rainfalls. These were followed by 5 years of below-average spring rainfalls, generally coupled with below-average summer rainfalls. In years with at least normal rainfall, the growth of crops and weeds would be encouraged and large aphid populations would develop on the more abundant food plants. More alates are formed when aphids are crowded, have lower food quality, have relatively short days, and have neither high nor low temperatures (Hughes *et al.* 1964). This will result in aphid flights which will promote the transmission of SCMV-SC. Similar weather-related scenarios occur in other aphid-virus systems (Plumb 1977, Dixon 1987).

In this study SCMV-SC was transmitted in a nonpersistent manner during probing for less than 1 min. Hence, even aphids which do not normally colonise sugarcane will transmit the virus to sugarcane. Five known vectors of SCMV-SC,*A. craccivora, A. gossypii, M. persicae, R. maidis* and *R. padi*, were trapped in North Isis in 1989-91. These species varied in their seasonal incidence. *R. padi* was present only in winter, *M. persicae* occurred only in spring, and *A. craccivora, A. gossypii* and *R. maidis* were trapped mainly in spring, summer and autumn. Thus, vectors of SCMV-SC are actively moving in all seasons, and could transmit the virus to susceptible, young sugarcane. As all vectors were also trapped at Bundaberg, they would act to spread SCMV-SC if it were introduced to that area.

4. To consider strategies for the control of SCMV in the Isis district in the light of research results.

(a) Since SCMV in the Isis is shown to be similar in virulence to SCMV in Brisbane, no especially severe quarantine or eradication procedures are warranted. Normal quarantine and eradication procedures to reduce spread within the Isis district should be applied, and unnecessary movement of cane between the Isis and other districts prohibited.

(b) Control of weeds in and around SCMV-infected fields could reduce the populations of aphid vectors and the transmission of SCMV-SC marginally. For instance, wild sorghum, *Sorghum verticilliflorum*, is a good host of *R. maidis*, a relatively efficient vector of SCMV-SC. However, many of the vectors of SCMV-SC have a wide host range amongst either monocotyledonous or dicotyledonous hosts and can migrate considerable distances. Therefore, control of SCMV is unlikely to be achieved by weed control during seasons of high rainfall, abundant weed growth, high aphid vector populations and abundant aphid flights.

(c) Maintaining an absence of cereal and fodder crops around infected cane crops is important, since maize and sorghum crops are good hosts of *R. maidis*, a relatively efficient vector of SCMV-SC.

(d) Avoidance of planting cane in infected farms during periods when aphid vector flights occur most commonly is theoretically a control possibility, since young cane is highly susceptible. However, because of erratic annual rainfall distribution patterns and almost year-round flights of potential vectors, this strategy would be difficult to apply. The relatively dry springs of 1989 and 1990, during the project, may have allowed much young cane to pass through the susceptible period of growth with little infection pressure. It is conceivable that the increased availability of irrigation in the Isis district will increase the flexibility in planting times and allow young cane to pass through the most susceptible stage with minimal risk.

RESEARCH RESULTS

Epidemiology and Control of Sugarcane Mosaic Virus in the Isis District

INTRODUCTION

After being of minor importance in Australia for many years, sugarcane mosaic virus (SCMV) became active in the Isis district, causing losses of 20-50% in susceptible canes such as Q95, Q103 and Q137 (Jones, 1987). A comparison of an isolate of SCMV from Isis with one from the BSES Pathology Farm, Brisbane, showed that the Isis isolate was more virulent in sugarcane differential clones CP31-294 and CP31-588 and in sorghum differential inbred lines Atlas, NM31 and SA 8735 (Srisink, 1989). This raised the possibility that a more

virulent form of the Australian sugarcane strain was spreading in the Isis, and that it would be wise to prevent it from reaching other districts.

Also, the reasons for the rapid field spread of SCMV in the Isis district were unknown.

Field spread of SCMV is the result of vector transmission, presumably by aphids. Sugarcane is a known host of 10 species of aphids (Blackman and Eastop 1984), of which *Geoica lucifuga* (Zehntner), *Hysteroneura setariae* (Thomas) (rusty plum aphid), *Melanaphis sacchari* (Zehntner) (sugarcane aphid), *Rhopalosiphum maidis* (Fitch) (corn aphid), *Sitobion miscanthi* (Takahashi) (grain aphid), and *Tetraneura nigriabdominalis* (Sasaki) (oriental grass root aphid) occur in Australia. The seasonal phenology of aphid vectors may be important in determining when SCMV is spread. Alternate and alternative hosts may also influence the incidence and timing of spread and the importance of alternative hosts as virus reservoirs.

A. Aphid transmission efficiency

1. Experimental design

Seven species of aphid (6 of which were collected in the Isis district) were tested for their ability to transmit, and their efficiency of transmission of an Isis isolate of SCMV-SC. The aphid species were colonized on suitable host plants, ie., *Rhopalosiphon maidis* Fitch on *Sorghum bicolor* cv. NK220Y, *Myzus persicae* Sulzer on White Icicle radish, *Aphis gossypii* Glover on Green Gem cucumber, *Melanaphis sacchari* Zehntner on Q95 sugarcane, *Hyperomyzus lactucae* L. on sowthistle (*Sonchus oleraceus*), *Aphis nerii* Fonsc. on wild cotton (*Asclepias sp.*), and *Hysteroneura setariae* Thomas on crow's foot grass (*Eleusine indica*). Aphid cultures were kept in growth cabinets at 20-25^{o}C, 70% R.H. and 12h light and 12h dark.

Aphids were collected and starved from 2h to overnight after which they were placed on SCMV-SC infected young leaves from either sugarcane or Iochief sweetcorn and allowed to feed. Iochief sweetcorn seedlings 40-50mm in height were used as test plants, 5 aphids being placed on each. Sugarcane variety Q95 of 2 heights a) 55-120mm or b) 1000-1500mm were also used as test plants, 10 aphids being placed on each plant. Aphids were killed after being allowed to feed on test plants overnight. Test plants were kept in the glasshouse and observed for symptoms for approximately 1 month.

2. Results

The number of plants infected by SCMV-SC and the transmission efficiencies of different aphid species is shown in Table 1. Three species, *R. maidis, A. gossypii* and *M. persicae*, were found to transmit SCMV. *M. persicae* was the least efficient vector. *R. maidis* was the most efficient vector when sweetcorn was used as the virus source and test plant, but *A. gossypii* showed slightly greater transmission efficiency when sugarcane was used as the virus source plant and sweetcorn used as the

test plant. *R. maidis* could also transmit SCMV from sugarcane to young and older sugarcane plants.

H. lactucae, A. nerii and *H. setariae* failed to transmit SCMV-SC from sugarcane to sweetcorn. Transmission also failed when *M. sacchari* was tested using sugarcane as both source and test plants, and also when using sweetcorn as both source and test plants.

3. Discussion

R. maidis has been shown to transmit SCMV on many previous occasions (Abbott, 1961; Pembroke, 1961; Teakle and Grylls, 1973; and Srisink, 1989), and is suspected to be one of the major vectors in some cane growing areas of the USA (Abbott, 1961). In the Isis district *R. maidis* commonly colonizes wild sorghum (*Sorghum verticilliflorum*), which is present all year, growing around cane fields and along roadsides. Considering this aphid species ability to transmit, and its close year-round proximity to cane, it might be the major vector of SCMV in the Isis district.

Aphis gossypii is also a known vector, with Steindl (1971) showing transmission of SCMV, from sugarcane to sugarcane. *Myzus persicae* was shown to transmit SCMV by Shaunak and Pitre (1970) and Srisink (1989).

Hyperomyzus lactucae and *Melanaphis sacchari* failed to transmit SCMV-SC and have never been reported as vectors. However, only limited testing was conducted with *M.sacchari* and tests using more aphids might have resulted in transmission. *Aphis nerii* indicated as a non-vector in this work, has been reported to transmit SCMV from sugarcane to sugarcane (Tate and Vandenberg, 1939). Similarly, *Hysteroneura setariae* failed to transmit, however Ingram and Summers (1936) reported *H. setariae* as a vector of SCMV.

Table 1. Sugarcane mosaic virus transmission efficiencies of seven aphid species.

Aphid	Virus acquisition host	Test plant	No.infected/ no.inoculated	Transmission efficiency per aphid
R. maidis	sc[1]	sw.c[2]	14/66	4.7
R. maidis	sw.c	sw.c	11/19	15.9
R. maidis	sc	young[3] sc	13/28	6.1
R. maidis	sc	older[4] sc (smallest shoot)[5]	2/ 7	3.3
R. maidis	sc	older sc (tallest shoot)[6]	3/ 6	6.7
A. gossypii	sc	sw.c	11/50	4.8
A. gossypii	sw.c	sw.c	16/34	11.9
M. persicae	sc	sw.c	13/81	3.4
M. persicae	sw.c	sw.c	17/33	13.5
M. sacchari	sw.c	sw.c	0/12	0
M. sacchari	sc	young sc	0/12	0
H. lactucae	sc	sw.c	0/39	0
A. nerii	sc	sw.c	0/36	0
H. setariae	sc	sw.c	0/40	0

[1] sugarcane

[2] sweetcorn

[3] sugarcane 55-120mm in height

[4] sugarcane 1000-1500mm in height

[5] aphids were placed on the smallest shoot of a cane plant which previously had the tallest shoot removed

[6] aphids were placed on the tallest shoot of a cane plant

B. Virulence testing of SCMV-SC isolates from Brisbane and the Isis district

1. Experimental design

In 3 previous tests using single isolates of SCMV-SC Srisink (1989) consistently demonstrated that an Isis isolate was more virulent than a Brisbane isolate. The following experiments were designed to further test this finding by using more isolates from each district.

In test 1, 3 Brisbane isolates and 7 Isis isolates were used. Each isolate was serially inoculated into 6 day old Iochief sweetcorn seedlings twice before being inoculated into 4 sorghum inbred lines. Sorghum inbred lines Atlas, NM31, BTx3197 and SA8735 sown 15-18 seeds per 125mm pot were mechanically inoculated at 10 days old with infected leaf material from Iochief sweetcorn. After 5 days necrotic local lesion counts per plant were recorded. The numbers of plants showing systemic chlorosis and necrosis were recorded each day until all plants were showing systemic necrosis.

In test 2, 11 Isis isolates were used, 6 of which comprised 3 samples from the same field, and 5 from glasshouse grown infected setts from the Isis district. As before, 3 Brisbane isolates were also used. Each isolate was transferred through sweetcorn seedlings twice before being inoculated into *S. bicolor* cv. NM31 only.

Test 3 utilized Isis isolates only. Nine of the Isis isolates each comprised 5 leaf samples from the same field. Five glasshouse grown Isis isolates previously used in tests 1 and 2 were also included. Isolates were transferred into sweetcorn seedlings before being inoculated onto sorghum inbred line NM31.

From the results of test 3, 10 samples were chosen to be repeated. Five samples showing less than 40% systemic necrosis and 5 samples showing 100% systemic necrosis were taken from sweetcorn virus source plants originally used in test 3, and inoculated into Sorghum inbred line NM31.

Test 3B was identical to test 3A except that the 10 isolates were transferred through sweetcorn seedlings twice before being inoculated onto sorghum inbred line NM31.

2. Results

The results of the necrotic local lesion count in test 1 are shown in table 2. Sorghum inbred line NM31 showed more local lesions than the other sorghum lines. The Isis samples Dilger, Coco and Vella exhibited the highest numbers of local lesions across all 4 sorghum inbred lines used. Systemic necrosis development in NM31 sorghum for test 1 appears in graph 1. NM31 sorghum was used in subsequent tests, it having shown the broadest range in time taken for symptom development. A selection of data from these tests is illustrated in graphs 1-5.

Results from test 1 indicate that there is no clear division of virulence between the Brisbane and Isis isolates when sorghum inbred lines are used as test plants.

In test 2 (graph 2), systemic symptoms developed slower due to greater inoculation damage, and some pots did not develop 100% systemic necrosis.

In tests 3, 3A and 3B the main aim was to determine if virulence levels in Isis isolates were consistent from one test to the next. Graph 3 shows 5 isolates which caused 100% systemic necrosis and 5 which caused less than 40% systemic necrosis. When these isolates were retested for test 3A (graph 4), the results did not correlate with test 3. Virulence was generally lower, but some isolates, for example the isolate labelled M_1, showed an increase in virulence. Test 3B (graph 5), showed a continuing decline in virulence of the previously high virulence isolates, and an increase in virulence of some of the previously low virulence isolates, such as those labelled M_1 and M_2 in graph 5.

3. Discussion

Results from the tests indicate that there is no consistent difference in virulence of the Brisbane and Isis isolates when infecting sorghum inbred line NM31. It was noted that the 5 Isis isolates labelled A to E, which were used in all three tests, 1, 2 and 3, all showed consistently high to moderate virulence. However high and low virulence isolates were found in both districts.

In experiments conducted by Srisink (1989), results indicated that the Isis isolate was more virulent than the Brisbane isolate when sorghums were used as test plants. This conclusion could have been drawn, due to a coincidental use of a high virulence sample from the Isis district (similar to sample D), and a low virulence sample from the Brisbane area (similar to sample R).

Test 3A and 3B did not yield expected results. In test 3A virulence might have declined due to the use of infected sweetcorn plants from the previous test as the inoculum source. The overall virus activity might have dropped in the 6 weeks after their inoculation, compared with use after the usual 2 weeks. Serial inoculation of sweetcorn seedlings in preparation for test 3B with isolates used in test 3 was used to boost virus activity. However results from test 3B were still not comparable to test 3. Perhaps under the prevailing conditions 2 weeks was not enough time for isolates of low activity to replicate sufficiently before being transferred into the second sweetcorn host, and some isolates had low concentrations of virus particles.

Table 2. Average number of necrotic local lesions per plant.

Sample source	Cane var.	Average no. NLL[1] per plant & sorghum lines			
		Atlas	NM31	BTx3197	SA8735
B[2]-Glasshouse	CP31-294	7	24	7	0
B-PPF[3] inoculation	CP29-116	4	7	4	2
B-PPF natural infection	61S145	7	26	3	8
I[4]-Coco	CP51-21	31	52	17	17
I-Dilger	Q137	37	64	39	32
I-Glasshouse	Q95	3	19	9	1
I-Kingston	Q95	10	25	14	6
I-Mungomery	Q137	5	14	6	3
I-Upham	Q95	13	16	11	2
I-Vella	Q95	23	52	12	10

[1] Necrotic local lesions

[2] Brisbane

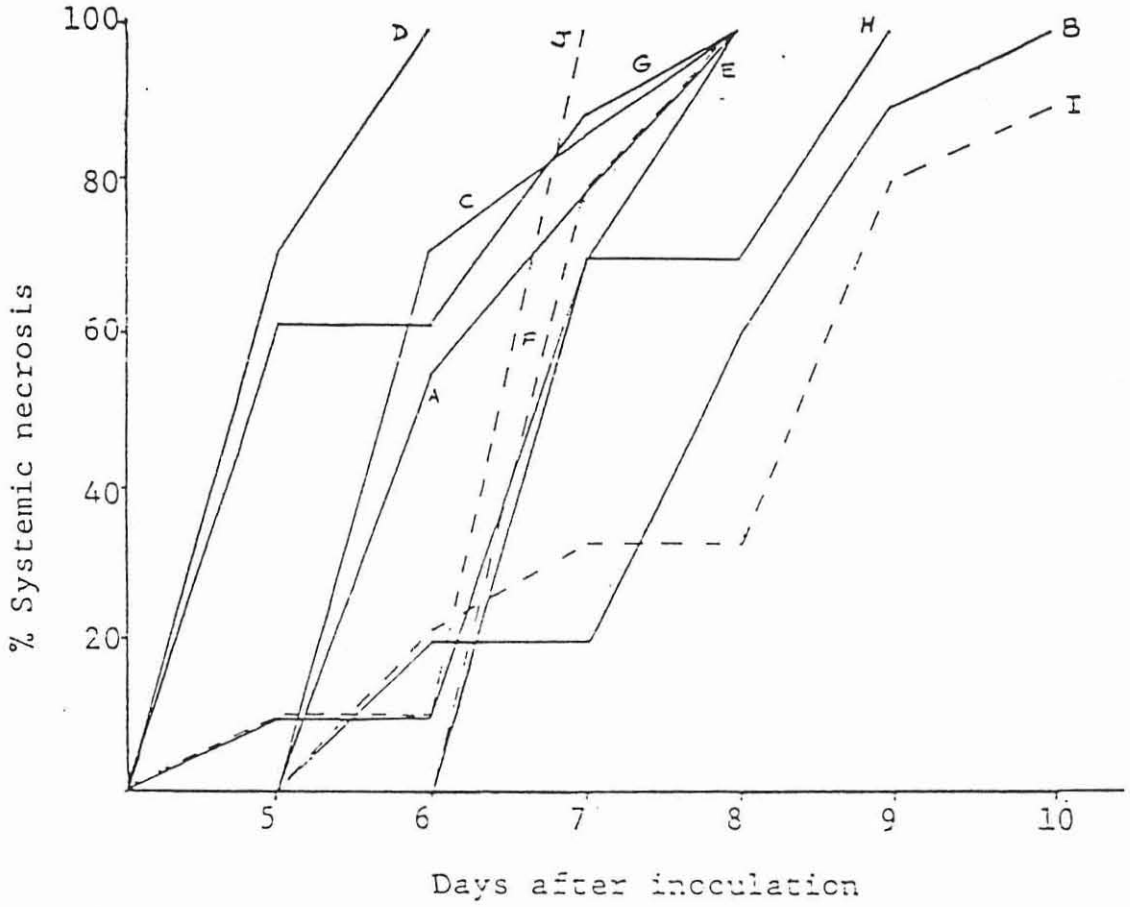
[3] Plant Pathology Farm (BSES)

[4] Isis

Table 3 Spring (September-November) and summer (December-February) rainfall (mm) at Childers Post Office

Year	Spring	Summer
1984-85	224.2	326.9
1985-86	218.4	361.9
1986-87	217.4	393.6
1987-88	175.9	128.2
1988-89	86.4	537.2
1989-90	148.2	107.2
1990-91	89.8	269.2
1991-92	158.4	804.8
96-year mean	191.8	482.0

Graph 1. Test 1. Systemic necrosis reaction in NM31 sorghum of Brisbane (B) and Isis (I) SCMV samples.



A: I-Glasshouse

B: I-Kingston

C: I-Vella

D: I-Coco

E: I-Upham

F: B-Glasshouse

G: I-Dilger

H: I-Mungomery

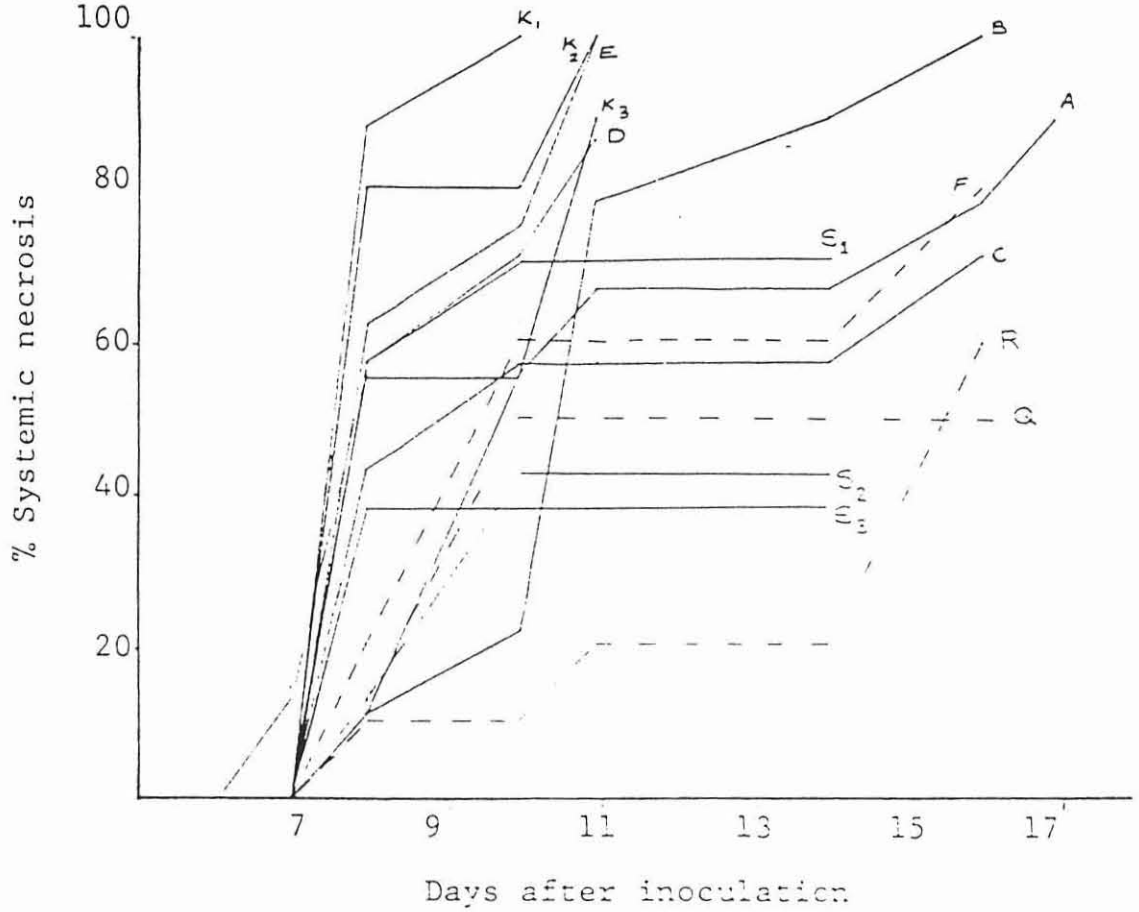
I: B-PPF[1] inoculation

J: B-PPF natural infection

[1] BSES Plant Pathology Farm

- - - Brisbane samples

Graph 2. Test 2. Examples of the systemic necrosis reaction in NM31 sorghum of Brisbane (B) and Isis (I) SCMV samples.



A: I-Glasshouse

B: I-Kingston (gl)[1]

C: I-Vella (gl)

D: I-Coco (gl)

E: I-Upham (gl)

F: B-Glasshouse

K: I-Dilger Q78 1[2]

K: I-Dilger Q78 2

K: I-Dilger Q78 3

Q: B-PPF Q78

R: B-PPF unknown

S: I-Dilger Q137 1

S: I-Dilger Q137 2

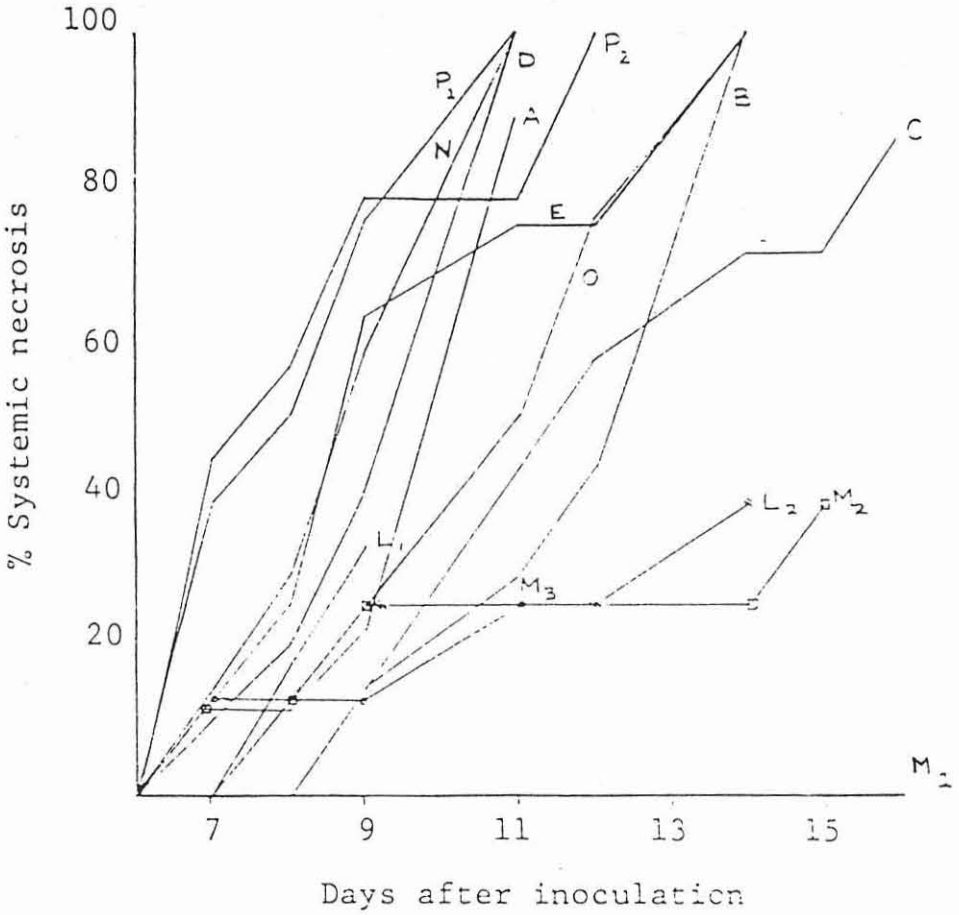
S: I-Dilger Q137 3

- - - Brisbane samples ____ Isis district samples

[1] samples taken from plants grown in the glasshouse but were originally from the Isis district

[2] three samples were tested from each cane field

Graph 3. Test 3. Examples of the systemic necrosis reaction in NM31 sorghum of Isis SCMV samples.



A: Glasshouse

B: Kingston (gl)[1]

C: Vella (gl)

D: Coco (gl)

E: Upham (gl)

L: Upham Q95 1[2]

L: Upham Q95 4

M: Upham Q147 1

M: Upham Q147 3

M: Upham Q147 4

N: Dilger Q95 2

O: Mungomery 2

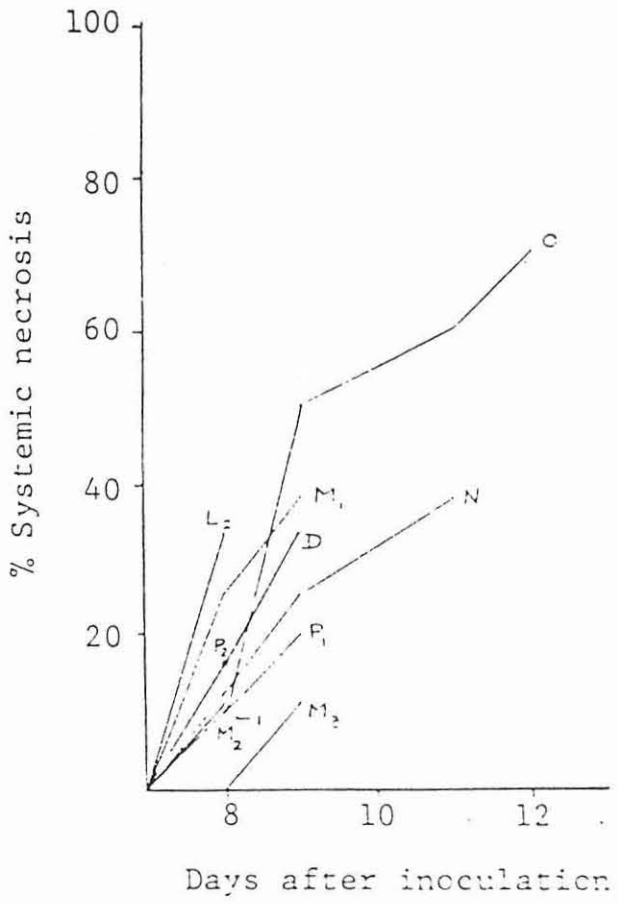
P: Upham Q137 1

P: Upham Q137 4

[1] samples taken from plants grown in the glasshouse but were originally from the Isis district

[2] five samples were tested from each cane field

Graph 4. Test 3A. Repeat test of 10 Isis samples from test 3.



*D: Coco (g1)[1]

L: Upham Q95 1[2]

L: Upham Q95 4

M: Upham Q147 1

M: Upham Q147 3

M: Upham Q147 4

*N: Dilger Q95 2

*O: Mungomery 2

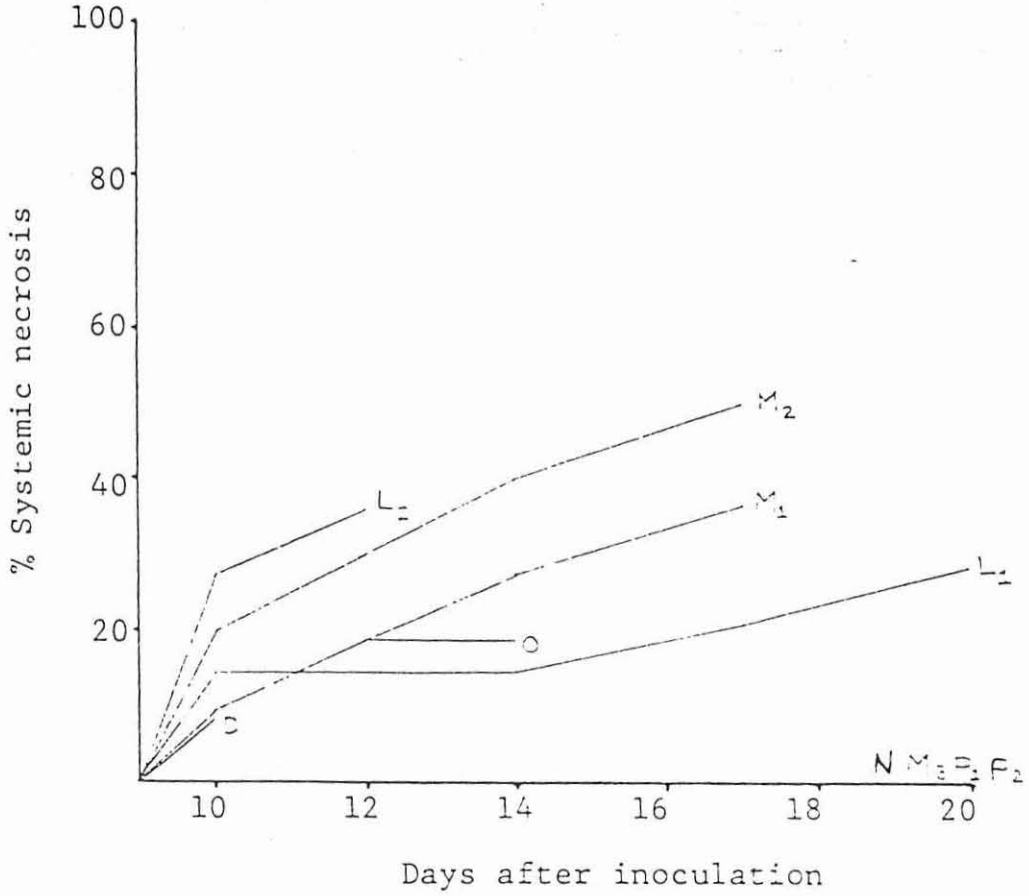
*P: Upham Q137 1

*P: Upham Q137 4

* Samples marked with a star caused 100% systemic necrosis of NM31 sorghum in test 3. Remaining samples caused less than 40% systemic necrosis.

[1] samples taken from plants grown in the glasshouse but were originally from the Isis district

Graph 5. Test 3B. Repeat test of 10 samples from test 3.



*D: Coco (gl)[1]

L: Upham Q95 1[2]

L: Upham Q95 4

M: Upham Q147 1

M: Upham Q147 3

M: Upham Q147 4

*N: Dilger Q95 2

*O: Mungomery 2

*P: Upham Q137 1

*P: Upham Q137 4

* Samples marked with a star caused 100% systemic necrosis of NM31 sorghum in test 3. Remaining samples caused less than 40% systemic necrosis.

[1] samples taken fron plants grown in the glasshouse but were originally from the Isis district

[2] samples were tested from each cane field

Greater virulence of field isolates than isolates preserved for varietal testing has been reported previously (Teakle & Grylls 1973, Ghen *et al.* 1990). It is likely that during active field spread selection favours rapidly replicating forms of SCMV, whereas slower replicating forms are favoured when spread ceases.

C. Wild sorghum: Importance to the process of transmission of SCMV-SC in the field

It has been reported that wild sorghum (*S. verticilliflorum*) is susceptible via mechanical inoculation to JGMV and the 3 Australian strains of SCMV (Teakle and Grylls, 1973), but natural infection is so far restricted to JGMV and SCMV-Sabi (Srisink, 1989). Experiments were designed to investigate further whether wild sorghum is found infected with SCMV-SC in the field and if not, possible reasons why.

1. Experimental design

1.1 Field survey for wild sorghum infected with SCMV

In March 1991 a field survey for SCMV in wild sorghum was performed. Samples were collected from 4 locations in the Isis area and 5 locations in the Bundaberg area. The samples were tested by ELISA using antibodies produced against the Isis isolate of SCMV-SC.

1.2 Mechanical inoculation of wild sorghum

Four pots of wild sorghum each containing 7-10 seedlings, 100-120mm in height, were infected via mechanical inoculation with JGMV, SCMV-Sabi, the Isis isolate of SCMV-SC and SCMV-BC.

Two virus recovery tests were conducted one month apart, starting 6 weeks after the wild sorghum was inoculated. Iochief sweetcorn and *S. bicolor* cv. NK220Y seedlings were used as index plants in sap transmission tests.

Recovery of SCMV-SC was also attempted via an aphid transmission test, approximately 1 month after inoculation. *R. maidis* was starved for 1h and placed on a wild sorghum leaf showing mosaic symptoms. The aphids were then observed feeding before being placed (10 aphids/test plant) onto young sugarcane 60-100mm in height.

1.3 Aphid transmission tests

a) Transmission of SCMV-SC from sweetcorn to wild sorghum

Aphid transmission tests were conducted using SCMV-SC infected Iochief sweetcorn as the virus source, wild sorghum seedlings at the 2 leaf stage as test plants and *R. maidis* as a possible vector. Five aphids were used per test plant. After 4.5 months a sap extract of the wild sorghum plants was inoculated onto Iochief sweeetcorn test seedlings.

b) Transmission of SCMV-SC from sugarcane to wild sorghum

Aphid transmission tests were conducted using infected Q95 sugarcane as the virus source, 2 age groups of wild sorghum as test plants and *R. maidis* as a possible vector. The first group of wild sorghum test plants were 80-100mm in height. Aphids were placed 5 per test plant.

The second group of wild sorghum test plants were 250-350mm in height and divided into 2 groups, where upon 10 plants were inoculated with 5 aphids per test plant and 9 plants were inoculated with 10 aphids per plant.

A virus recovery test was conducted approximately 1 month after the transmission tests. Aphid inoculated wild sorghum was indexed via mechanical inoculations onto Iochief sweetcorn seedlings.

2. Results

2.1 Field survey for wild sorghum infected with SCMV

None of the wild sorghum samples from the Bundaberg and Isis areas contained SCMV when tested by ELISA.

2.2 Mechanical inoculation of wild sorghum

Three weeks after having been inoculated, the 4 pots of wild sorghum plants showed symptoms indicating virus infection. Both recovery tests resulted in the viruses being mechanically transmitted into sweetcorn and sorghum. JGMV showed necrotic symptoms in sorghum and mosaic symptoms in sweetcorn and the three SCMV strains showed mosaic symptoms in sweetcorn.

Recovery of SCMV-SC from wild sorghum, using *R. maidis* and 5 young sugarcane test plants failed.

2.3 Aphid transmission tests

a) Transmission of SCMV-SC from sweetcorn to wild sorghum

Four out of 7 wild sorghum seedlings showed mosaic symptoms indicating infection with SCMV-SC. The efficiency of transmission of SCMV-SC per *R. maidis* aphid was 15.6%. In a mechanical recovery test more than 4 months after inoculation, no transmission of virus from wild sorghum to the sweetcorn occurred.

b) Transmission of SCMV-SC from sugarcane to wild sorghum

Symptoms did not develop on any of the aphid inoculated wild sorghum plants. Sweetcorn used as test plants for the virus recovery test also remained healthy.

3. Discussion

Results from the field survey were comparable with results from Srisink (1989), in that wild sorghum was not found

naturally infected with SCMV-SC. Wild sorghum has been found naturally infected with SCMV-Sabi (Srisink, 1989), and can be infected via mechanical inoculations with all 3 strains of SCMV and JGMV (Srisink, 1989; Teakle and Grylls, 1973). When a mechanical inoculation test was conducted, plants remained infected for 3.5 months, recovery of the virus indicating no recovery of the wild sorghum. However, the failure to recover virus using an aphid transmission test might indicate low virus concentration. In this test, only 5 test plants with 10 aphids/plant were used. More extensive testing might have led to some virus transmission.

Aphid transmission tests with wild sorghum as test plants and sweetcorn as virus source plants were successful, with a relatively high transmission efficiency resulting. However, the plants had recovered after 4.5 months, possibly indicating that wild sorghum is not a good host for prolonged multiplication of SCMV-SC.

D. Seasonal abundance of aphid vectors in Isis and Bundaberg districts

This section of the study sought to determine the seasonal prevalence of alate aphids in sugarcane crops in the Isis area, and to make comparisons with the aphids in the non-SCMV-infected Bundaberg areas. Aphids commonly trapped were compared for their efficiency of SCMV transmission in laboratory tests. Together with information on the field spread of SCMV, this would allow the relative importance of different aphids in SCMV etiology to be determined. Possible disease control strategies can then be considered.

1. Experimental Design

Alate aphids were trapped at two sites, G. Upham's farm at North Isis (a known focus SCMV infection), and the BSES Research Station, Bundaberg (free of SCMV). Four traps were placed on the edges of sugarcane fields at each site from July 1989 to June 1991. Traps were monitored every two weeks and trapped alate aphids identified using the keys of Eastop (1966) and Blackman and Eastop (1984) and counted.

Traps were based on the design of Larsson (1986). Each trap was 35 cm long, painted bright yellow and mounted 1.5 m above ground level. The transparent PVC wrap was coated with Tanglefoot adhesive.

2. Results and Discussion

Monthly aphid counts for *M. sacchari, R. maidis* and *T. nigroabdominalis*, the three species trapped and known to feed on sugarcane, are given in Figure 1 (North Isis) and Figure 2 (Bundaberg).

M. sacchari was the most common of these three species, with peaks of activity in spring and mid-late summer. *M. sacchari* was also the most common species in trapping by Hughes *et al.* (1964) at Bundaberg in 1960-1961. However, they recorded main

activity in March-May 1961. Winter and spring 1960 was very dry at Bundaberg and the summer wet season below average; heaviest rains were delayed until February 1961. Bundaberg also had sharp frosts in July-August 1960 (BSES Annual Report). Winter 1989 and 1990 were reasonably wet and warm, which may have allowed the early build-up of *M. sacchari* in the following springs. However, both springs were relatively dry, possibly reducing numbers until after the summer rains. Numbers may also have been reduced in spring by harvesting.

R. maidis was less common than *M. sacchari* but had a similar phenology. Hughes *et al.* (1964) recorded *R. maidis* at Bundaberg only in April 1961.

T. nigroabdominalis occurred at North Isis only in October 1989, but at Bundaberg it occurred in both Septembers and Januarys and in March 1990. Few alates were caught in any one trapping period. Hughes *et al.* (1964) recorded *T. nigroabdominalis* as a minor species at Bundaberg during December 1960, and February-April, September and October 1961.

M. sacchari is known especially from *Saccharum* spp. and *Sorghum* spp., but is sometimes found on other grasses such as *Echinochloa, Panicum* and *Pennisetum* (Blackman and Eastop 1984), but the species is composed of a complex of races or subspecies which may differ in their ability to transmit SCMV.

R. maidis has a wide host range in the Poaceae, Cyperaceae and Typhaceae (Blackman and Eastop 1984). Maize and sorghum are the most important hosts in the Bundaberg area, with sugarcane a relatively minor host. It is able to transmit SCMV (Blackman and Eastop 1984).

T. nigroabdominalis has numerous species of Poaceae as secondary hosts (Blackman and Eastop 1984); primary hosts (*Ulmus* spp.) are probably not used in northern Australia. It feeds on the roots of grasses and its capacity to transmit SCMV is unknown.

Other species trapped were:

1. *Aphis gossypii* Glover (cotton aphid, melon aphid) - caught mainly during summer and autumn at both sites. A common pest of cucurbits, solonaceous plants and Malvaceae including *Hibiscus*. It is unlikely to feed on grasses.

2. *Brachycaudus* sp. probably *helichrysi* (Kaltenback) (leafcurl plum aphid) - a few individuals were caught during early spring. Secondary hosts are mainly Compositae. It is unlikely to feed on grasses.

3. *Myzus persicae* (green peach aphid) - few individuals were caught in spring 1990. It is an important virus vector with a very wide secondary host range, but none are grasses.

Hughes *et al.* (1964) recorded another 19 species of aphids in their trap at Bundaberg. Of those, *Rhopalosiphum padi* (L.) (oat aphid, wheat aphid), *Schizaphis graminum* (Rondani) (greenbug) and *Sitobion avenae* (F.) (grain aphid) are the only ones likely to feed on grasses.

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Fig. 1. Results of aphid trapping of *Melanaphis sacchari*, *Rhopalosiphum maidis* and *Tetraneura nigriabdominalis* at North Isis.

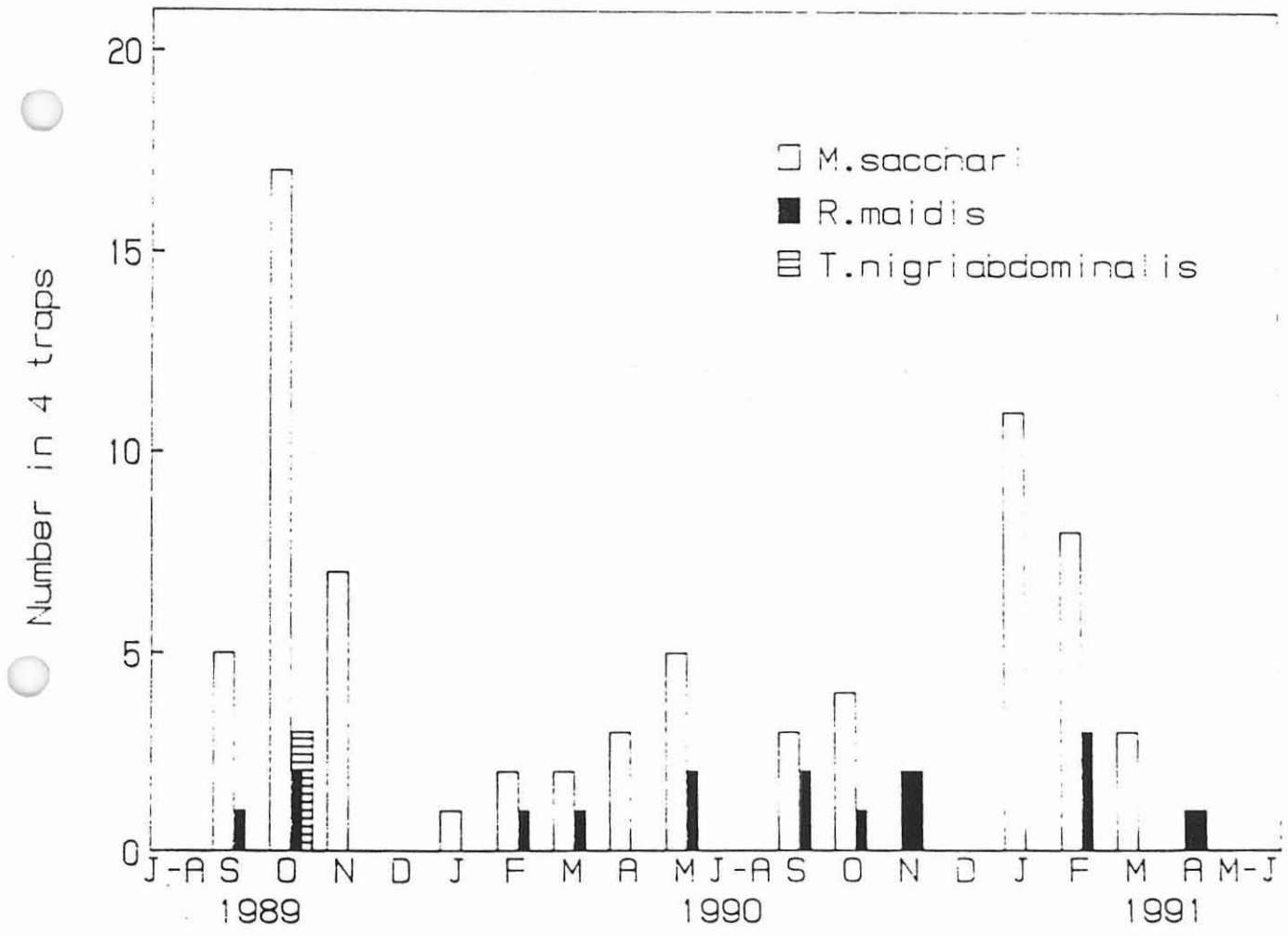
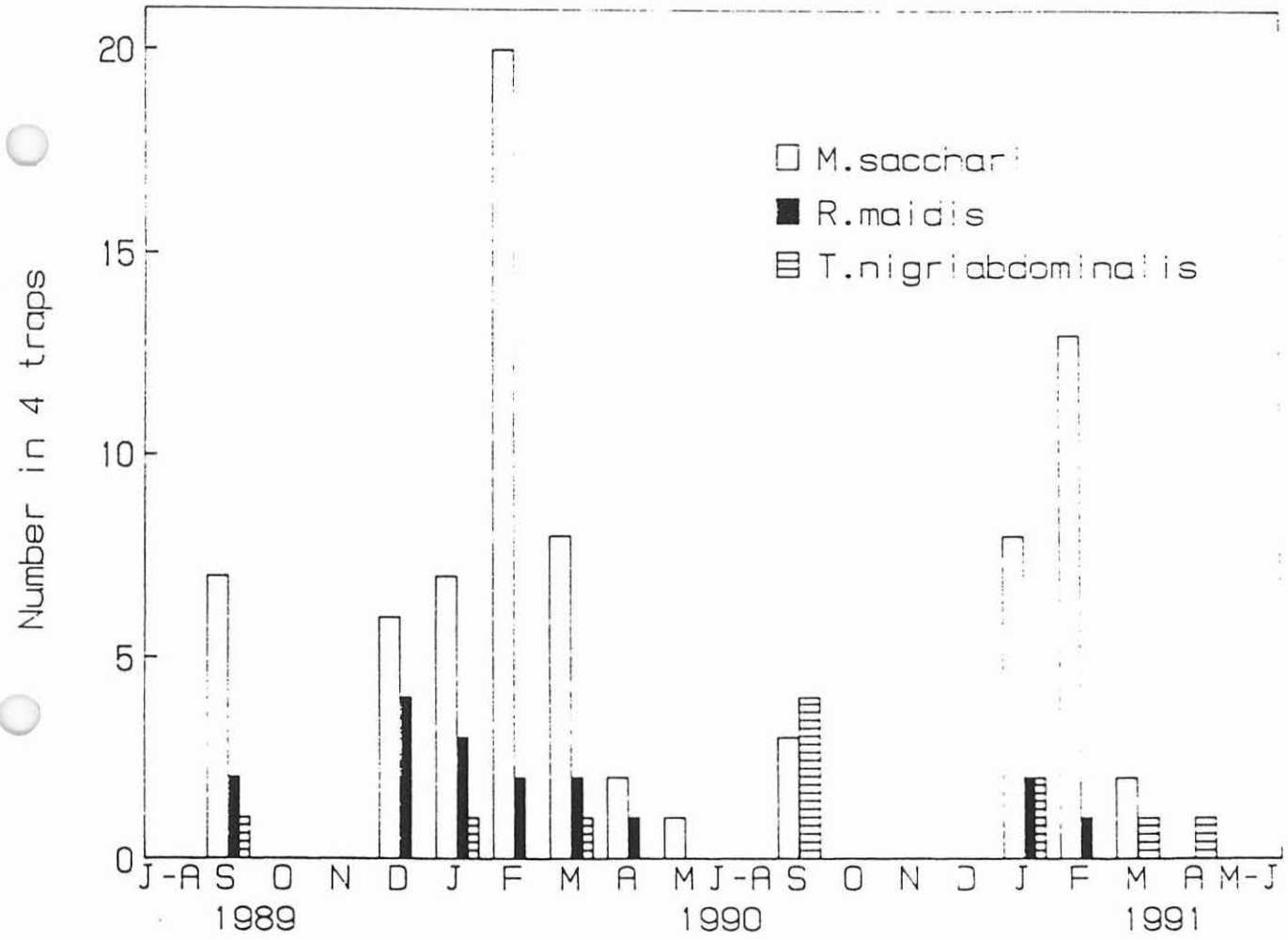


Fig. 2. Results of aphid trapping of *Melanaphis sacchari*, *Rhopalosiphum maidis* and *Tetraneura nigriabdominalis* at Bundaberg.



CONCLUSIONS

1. Sugarcane mosaic virus (SCMV) at Isis and Brisbane appears to occur as a single strain comprised of isolates with varying virulence to sugarcane and sorghum. Virulence to sugarcane and sorghum is correlated.

2. Isolates from Isis were not uniformly more virulent to sorghum than isolates from Brisbane, no special quarantine measures to restrict spread of SCMV from Isis are indicated.

3. Virulence of SCMV isolates to sorghum varies from test to test, probably because of technical problems in experiments and because isolates can alter in virulence.

4. *Rhopalosiphum maidis, Aphis gossypii* and *Myzus persicae* were found to be vectors of SCMV, whereas *Melanaphis sacchari, Hyperomyzus lactucae, Aphis nerii* and *Hysteroneura setariae* failed to transmit.

5. *R. maidis* is reported to multiply on sugarcane so could be an important vector of SCMV. *R. maidis, A. gossypii* and *M. persicae* can aquire and transmit during probes, so could transmit SCMV while migrating through infected cane fields.

6. Although *Sorghum verticilliflorum* is an important alternative host of *R. maidis,* it is a poor host of SCMV and is unlikely to be a source of SCMV infection.

7. Although in Natal *R. maidis* is active in summer, especially January (Harborne 1988), in the Isis district this species showed some activity throughout the year (Fig. 1). Therefore, changing the cane planting time in the Isis will not prevent SCMV spread by *R. maidis*.

DIFFICULTIES ENCOUNTERED

1. Drought conditions in the Isis district seem to have restricted spread of SCMV during this study. The reasons for this are unknown but could include fewer aphids, fewer alternative hosts of aphids and more resistant sugarcane.

2. The ability to compare the virulence of SCMV isolates from the Isis district with isolates from other areas was reduced because the virus was found to be active only in the Brisbane district. Efforts to obtain the virus from northern NSW, Bundaberg and the Moreton district were unsuccessful.

RECOMMENDATIONS FOR FURTHER RESEARCH

The present relative inactivity of SCMV-SC means that further research on aphid transmission and aphid phenology is not warranted.

APPLICATION OF RESULTS TO INDUSTRY

1. Since the virulence of SCMV-SC isolates from the Isis district resembles that of isolates from the Brisbane

district, severe quarantine and eradication procedures to prevent spread of the virus from the Isis district to other districts are not warranted. Normal procedures to minimize spread should be maintained.

2. The eradication of *Sorghum verticilliflorum* (wild sorghum) from in and around sugarcane fields is not warranted from the standpoint of carryover of SCMV-SC. However, *S. verticilliflorum* is an important alternative host of *Rhopalosiphum maidis*, known to be a vector of SCMV-SC, so its control should reduce spread of SCMV-SC.

3. Sweet corn and other crops susceptible to SCMV-SC and hosts of *R. maidis* should not be grown near infected sugarcane. Sweet corn is 2-3 times better as a source of SCMV-SC than sugarcane.

4. Control of SCMV-SC in sugarcane by aphicide spraying is unlikely to be successful. Vector aphids show some activity during each season of the year. Since vector aphids can acquire and transmit SCMV during short probes, they can spread the virus while migrating from other hosts through cane fields.

PAPERS ARISING FROM PROJECT

Accepted:

Noone, D. 1991. Epidemiology and control of sugarcane mosaic virus in the Isis district. Master of Science Qualifying Report, Dept. of Microbiology, University of Queensland, 106 pp.

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