

## Spread of Greening by *Trioza erytreae* (Del Guercio) in Swaziland

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Although greening disease has affected about 20 per cent of the citrus in Swaziland, little has been recorded on its distribution and history. There is also little published data from southern Africa on the infectivity of the vector

of greening. Results reported in this paper outline the incidence of greening disease in Swaziland, and describe studies on vector infectivity and on the rate of spread of greening into a new planting.

### INCIDENCE OF GREENING

Citrus production is a young industry in Swaziland. The first commercial groves, mainly sweet orange, were planted in the Malkerns district in 1952, as were larger plantings of grapefruit and sweet orange in the hot Lowveld region. Citrus distribution is shown in figure 1. The Malkerns district is in the Middleveld region, with an average altitude of 660 m while the Lowveld region is at an average altitude of 220 m. Ngonini, at 500 m, is climatically intermediate between the two.

**Middleveld.** Early in the 1960s, citrus in the Malkerns district declined, and developed severe foliar deficiency symptoms. In 1965, McClean and Oberholzer implicated greening disease as the major cause of that decline. Both authorities contended that greening had been epiphytotic in the 1958–1960 period, and found that the disease was severe in trees planted then or shortly afterwards. Populations of citrus psylla, *Trioza erytreae* (Del Guercio), had been particularly high in the Middleveld region during the late 1950s and early 1960s. Outbreaks of *T. erytreae* were accompanied by a spread of greening in several citrus regions in the Transvaal during those years (6). Legislation was introduced in 1967 prohibiting movement of citrus propagation material from the Middleveld region. During the last five years, much citrus has been either removed or abandoned. Remain-

ing trees have improved, due probably to a trend to higher summer temperatures, which inhibit both the causal organism and the vector (10).

The full syndrome occurs in all groves in this district (8). Zinc-deficiency symptoms are particularly common at all times of the year. Catling (1, 4) found that greening may reduce tree canopy area by at least 30 per cent and that clusters of leaves showing foliar symptoms occur on the tree canopy at densities of 1.2 to 6.2/m<sup>2</sup>.

Incidence of greened fruit was studied in blocks of 50 trees in four groves, over two seasons. Fallen fruit collected at weekly intervals, and a large sample of ripe fruit at picking, were examined for visual symptoms of greening. Doubtful fruit were screened by the albedo-fluorescence method (9). A large proportion of the fruit (diameter 2 to 3 cm) that dropped after January was affected (35.2 to 81.9 per cent per tree). At picking, the proportion of affected fruit per tree varied from 1.8 to 33 per cent. More diseased fruit was found in Valencia than in the navel cultivar.

**Lowveld.** Greening is present in a small batch of trees on the Swaziland Irrigation Scheme, with no apparent spread from that locus. Although the disease is unknown in the rest of the Lowveld region, the possible existence of a strain of the organism causing latent infection cannot be overlooked.

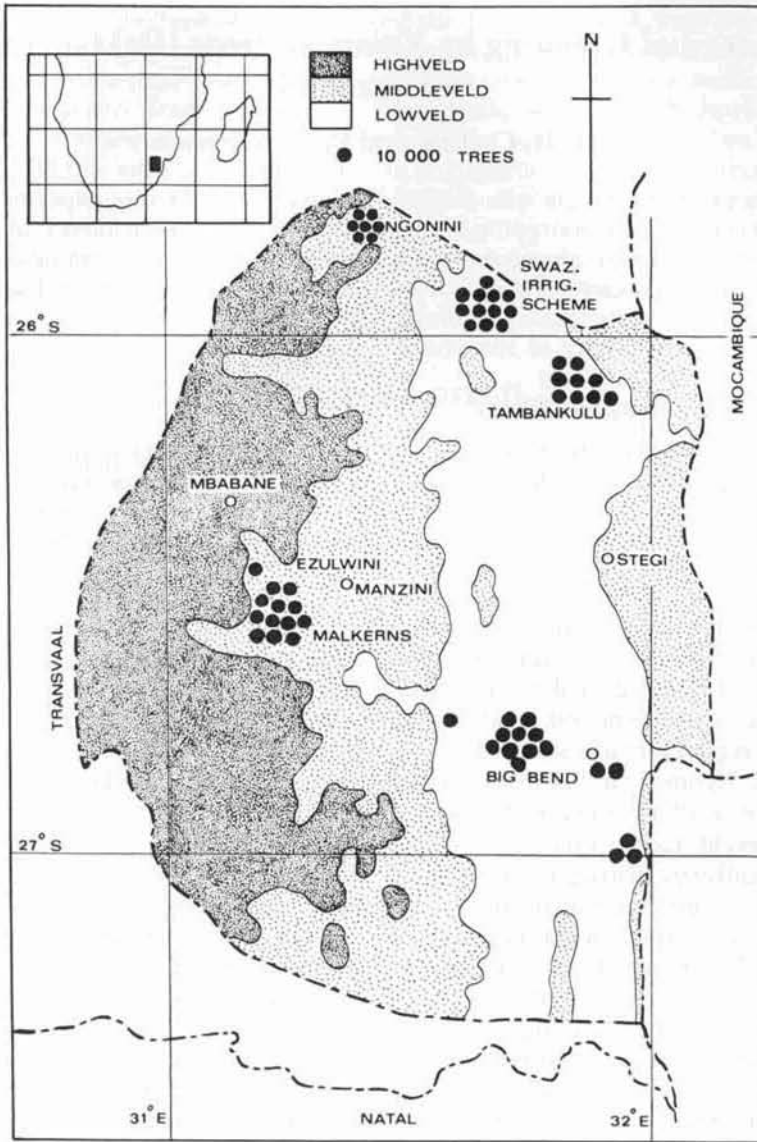


Fig. 1. Citrus plantings in Swaziland. (Insert shows location of Swaziland.)

*Trioza erytreae* is probably not infective in the Lowveld region.

**Ngonini.** Greening is present in this intermediate region, but at lower den-

sities than in the Middleveld. McClean (unpublished) observed a gradual spread of the disease in this intermediate region.

#### IDENTITY AND INCIDENCE OF THE VECTOR

Following evidence presented by McClean and Oberholzer (?), many trans-

mission experiments have shown that *Trioza erytreae* is the principal, if not

the only vector of greening in southern Africa. Schwarz *et al.* (11) mention successful transmissions by this insect in Swaziland. Catling (4) found that two other psyllids, *Diaphorina punctulata* Pettey and *D. zebdana* Capener, and the aphid *Toxoptera citricidus* (Kirk.) feed on citrus in Swaziland, but are nonvectors.

In a preliminary transmission test at Malkerns, five out of eight potted Valencia seedlings exposed to *Trioza erytreae* developed greening symptoms. In a second experiment, with both adults and nymphs, involving 50 Valencia seedlings with 10 controls, no visual symptoms of the disease developed. Application of the albedo-fluorescence test to bark shavings 18 months after the exposure period showed that plants exposed to adults were positive for greening, while nymph-fed plants and controls were negative.

At Tambankulu in the Lowveld, 32 Orlando tangelo seedlings were exposed in the field. Twelve became infested with *Trioza erytreae*. No symptoms developed in the seedlings, but bark tests showed three to be positive. In a second experiment, 25 seedlings (type unre-

corded) were exposed to large populations of citrus psylla originating from Tambankulu. No symptoms developed subsequently, and bark tests failed to reveal the marker substance. It is probable that the bark-fluorescence method is unreliable when applied to one- to two-year-old plants. McClean (1971, personal communication) is of this opinion. Schwarz (9) did not find fluorescent-marker substance in the bark of one-year-old twigs, but did find it in two- to three-year-old twigs. Many of the seedlings used in the studies described above were barely two years old when tested, and probably unsuitable.

Correlation between altitude and the incidence of greening and vector activity has been described in detail (2, 6, 10). Citrus psylla is more abundant in the higher, cooler citrus areas of Swaziland. Field observations indicate that it does not possess strong dispersal powers (5). Wind direction during spring and summer in Swaziland is mainly from the east, toward the Middleveld, so that in seasons when vector populations are at their highest, it is unlikely that many infective adults will reach Lowveld citrus.

## INFECTIVITY OF VECTOR POPULATIONS IN THE FIELD

**Possible seasonal fluctuation.** A preliminary field experiment indicated possible seasonal fluctuation in vector transmission efficiency (3). Because only one of the exposed plants developed definitive visual greening symptoms, and results were therefore based on the unreliable bark-fluorescence test, this experiment was repeated in detail during the 1969-1970 season.

Six series of Orlando tangelo seedlings were exposed between July, 1969, and February, 1970, in an affected citrus grove at Malkerns Research Station (table 1). Each series consisted of 40 plants exposed for 40 days. Ten unex-

posed plants were kept in a screenhouse as controls for each series. Plants had been kept in a screenhouse prior to use, and most of them were actively growing during the exposure period. During exposure, plants were inspected daily, and numbers of adult *Trioza erytreae* on each plant were recorded. At the end of the exposure period, insects were killed and plants were held at 19° to 24° C to induce greening symptoms. In February, 1970, the plants were taken to Pretoria for virus-indexing tests. They were kept under insect-free conditions, and were regularly inspected for greening symptoms until planted out in January, 1971.

TABLE 1  
ACTIVITY OF TRIOZA ERYTREAЕ ON TEST PLANTS EXPOSED TO GREENING  
IN A CITRUS GROVE AT MALKERNS RESEARCH STATION, SWAZILAND,  
DURING 1969-1970

Plant series	Plants with immatures or adults	Plants with eggs and nymphs	Total vector days*
	per cent	per cent	
1. July 1-Aug. 9 .....	5.0	0.0	2
2. Aug. 10-Sept. 18 .....	35.0	12.5	38
3. Sept. 19-Oct. 28 .....	37.5	25.0	48
4. Oct. 29-Dec. 7 .....	67.5	50.0	186
5. Dec. 8-Jan. 16 .....	47.5	...	44
6. Jan. 2-Feb. 10 .....	72.5	12.5	185
Total .....	...	...	503

\* Vector day = one adult/plant/day.

Results of the experiment are given in table 1. Of 240 exposed plants, 106 were observed with either adults or immatures, and 40 with eggs and nymphs. Although there were 503 "vector days" during exposure, greening, as confirmed by indexing, was transmitted to only one plant, exposed between December 8 and January 16 (series 5). Several other plants were suspects. The low rate of transmission in this second, more carefully controlled experiment, failed to reveal any seasonal fluctuation in vector transmission.

**Rates in spring and summer populations.** Between October 8 and December 9, 1968, 127 Orlando tangelo seedlings were exposed to single *Trioza erytreae* adults in the insectary at Malkerns. The test insects were collected from diseased trees in the Malkerns dis-

trict, and allowed no additional acquisition feeding. Test seedlings were held under insect-free conditions in a screenhouse before and after exposure. Twenty unexposed plants served as controls. One half of the plants were exposed to adult feeding for a maximum of 7 days (mean, 4.7 days), the remainder were exposed for a maximum of 14 days (mean, 11.9 days).

None of the control plants developed greening symptoms. Subinoculations to indicator plants confirmed greening in two exposed plants, one from a male feeding for six days in October and another from a female feeding for thirteen days in November-December. These data indicate that single males and females can transmit the greening pathogen, and that 1.6 per cent of the population tested were carriers.

#### SPREAD OF VECTOR AND GREENING INTO NEW PLANTINGS

Fifty Valencia trees on Rough lemon rootstocks originating from a nursery in the Swaziland Lowveld, where greening symptoms are unknown, were planted at Malkerns Research Station in December, 1967, and given standard

fertilization and irrigation. Vector counts were carried out either weekly or bimonthly to 1970, and insecticide was applied whenever the vector density approached 0.5 colony per tree during the first year after planting. Higher

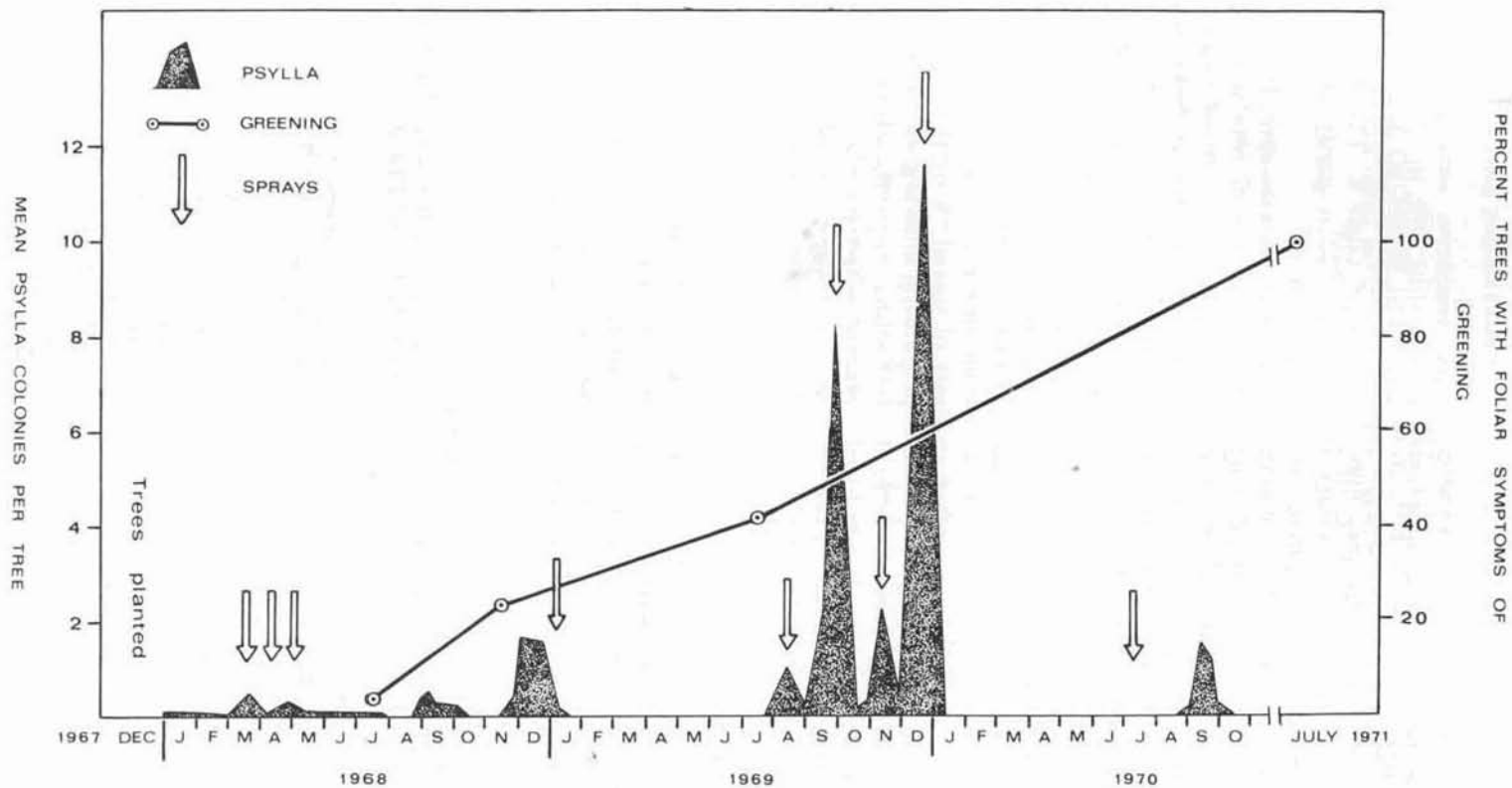


Fig. 2. Populations of *Trioza erytreae*, applications of insecticides, and incidence of foliar symptoms of greening in 50 test citrus trees at Malkerns, Swaziland

populations were allowed thereafter. The incidence of greening symptoms was recorded.

The vector colonized the trees immediately (fig. 2), requiring four sprays in the first year. Foliar symptoms first showed at seven months. At 11 months, 24 per cent of the trees showed symptoms, and at 20 months, 42 per cent. By 20 months, five trees were severely stunted by the disease, but the remaining ones were growing satisfactorily. In the 1969-70 season, vector populations were higher, and four sprays were applied. At harvest in July, 1970, 13.7 per cent of the fruit showed greening symptoms. Degree of greening, effect on canopy area, and fruit yield are shown in table 2 for the 1971 and 1972 harvests. Rating of foliar symptoms on a scale of 1 to 4 in increasing severity was based on examination of each tree by two observers. In 1971, out of the total of 50

trees, symptoms were present in 41 trees, and in 1972, in 49 trees. In 1971, most of the trees were rated 2; in 1972, most were rated 4. The higher fruit yield in 1972 is partly attributed to higher rainfall.

Greening disease spread rapidly in the test trees despite regular vector control. Vigorous growth of young trees increased their attractiveness to the vector, and accelerated the spread of greening. Another reason for the rapid spread into this small planting may have been the presence of severely affected trees adjacent to the experimental block. Planting larger blocks some distance from infected trees might retard the rate of spread. A similar rapid spread of greening in young trees was observed by Catling (unpublished) in the Philippines and Nepal. Perhaps higher vector populations are needed for significant disease transmission to mature trees.

## CONCLUSIONS

The incidence and spread of greening and its vector in Swaziland are described. Transmission experiments confirmed that *Trioza erytreae* (Del Guercio) is the main vector, and that single

males and females can transmit the greening pathogen to seedlings. An infectivity rate of 1.6 per cent of the vector population was indicated. Seasonal fluctuation in vector infectivity could

TABLE 2  
SEVERITY OF GREENING, AND EFFECTS ON CANOPY AREA AND FRUIT YIELD  
IN 50 TEST CITRUS TREES AT MALKERNS, SWAZILAND

Year	Severity of foliar symptoms*	No. trees	Mean fruits per tree	Greened fruit at picking	Mean canopy area
1971	1	9	165	9.0	6.3
	2	27	186	14.4	6.0
	3	11	124	30.3	4.4
	4	3	46	39.0	2.5
1972	1	8	223	6.6	6.5
	2	11	229	18.5	6.0
	3	8	202	26.7	5.0
	4	23	113	37.8	3.8

\* 1 = slight; 4 = severe.

not be demonstrated. The rate of spread of greening pathogen to seedlings exposed in the field was slow, whereas the

rate of spread of the pathogen into small, vigorously growing trees in the field was rapid.

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### LITERATURE CITED

1. CATLING, H. D.  
1969. The bionomics of the South African citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae). 1. The influence of the flushing rhythm of citrus and factors which regulate flushing. Jour. Ent. Soc. S. Africa 32: 191-208.
2. CATLING, H. D.  
1969. The bionomics of the South African citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae). 3. The influence of extremes of weather on survival. Jour. Ent. Soc. S. Africa 32: 273-90.
3. CATLING, H. D.  
1969. The control of citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae). S. African Citrus Jour. 426: 9-16.
4. CATLING, H. D.  
1970. Studies on the ecology and disease transmission of psyllid vectors of citrus greening disease, with special reference to the South African vector, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae). D. Sc. Thesis, Potchefstroom University, South Africa.
5. CATLING, H. D.  
1974. Notes on the biology of the South African citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae). Jour. Ent. Soc. S. Africa (in press).
6. GREEN, G. C., AND H. D. CATLING  
1971. Weather induced mortality of the citrus psylla, *Trioza erytreae* (Del Guercio) (Homoptera: Psyllidae), a vector of greening virus, in some citrus producing areas of southern Africa. Agr. Meteorol. 8: 305-17.
7. McCLEAN, A. P. D., AND P. C. J. OBERHOLZER  
1965. Citrus psylla, a vector of the greening disease of sweet orange. S. African Jour. Agr. Sci. 8: 297-98.
8. McCLEAN, A. P. D., AND R. E. SCHWARZ  
1970. Greening or blotchy-mottle disease of citrus. Phytophylactica 2: 177-94.
9. SCHWARZ, R. E.  
1968. Indexing of greening and exocortis through fluorescent marker substances. In: Proc. 4th Conf. Intern. Organ. Citrus Virol. (J. F. L. Childs, ed.). Gainesville: Univ. Florida Press, pp. 118-24.
10. SCHWARZ, R. E., AND G. C. GREEN  
1972. Heat requirements for symptom suppression and inactivation of the greening pathogen. In: Proc. 5th Conf. Intern. Organ. Citrus Virol. (W. C. Price, ed.). Gainesville: Univ. Florida Press, pp. 44-51.
11. SCHWARZ, R. E., A. P. D. McCLEAN, AND H. D. CATLING  
1970. The spread of greening disease by citrus psylla in South Africa. Phytophylactica 2: 59-60.