The Effect of the Rootstock and *Citrus tristeza virus* Isolates on the Percentage of Huanglongbing-affected Fruits from Palmer Navel and Delta Valencia Trees

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ABSTRACT. Current Huanglongbing (HLB) control measures in South Africa have enabled the planting of citrus in previously abandoned areas such as Alkmaar, Schoemanskloof and White River in the Nelspruit district. Additional measures might contribute to stabilizing citrus production in these areas. The objective of this study was to assess the effect of different *Citrus tristeza virus* (CTV) isolates and rootstocks on HLB incidence in Palmer navel and Delta Valencia. Symptomless and HLB-affected fruit of the two scions on five different rootstocks (rough lemon, Volkamer lemon, Gou Tou, Troyer citrange, Yuma citrange) were counted before harvest (fallen fruits) and at harvest. The percentage of HLB-affected fruits from Valencia trees was slightly higher than in the navel trees (19.4% and 16.4%, respectively). Of the navel trees, those on Volkamer lemon rootstock had the highest percentage of HLB affected fruits (24.0%), followed by trees on Troyer citrange (20.2%). The lowest incidence occurred on trees with Rough lemon rootstock. Valencia trees on the two trifoliate rootstocks (23.2% for Yuma and 28.7% for Troyer) had more affected fruits than those on the other rootstocks. The lowest infection occurred on trees on Gou Tou rootstock. Overall it appears that the CTV isolates did not affect the HLB incidence. However, there were instances where the percentage infection differed by 10% or more between trees on the same rootstock but with different CTV isolates, as with Valencia on Yuma with ST or T55 isolates (21.6% and 30.4%, respectively), or Valencia on Troyer with GFMS 10, T55 or Micveh T isolates (22.7%, 33.0% and 35.3%, respectively).

Citrus Huanglongbing (HLB) remains a limiting factor for citrus production in the cooler areas of southern Africa despite present control measures. These include the establishment of new orchards with certified plant material, chemical control of the insect vector and removal of infected plant material (1). The effect of the rootstock on the occurrence of HLB has previously been shown (6), however, the C*itrus tristeza virus* (CTV) status of those trees was unknown. A CTV isolate reducing the incidence of HLB on fruit from Valencia trees has been found (7). It was also reported that the HLB bacterium and CTV were rarely found in the same cell of the plant (2). The reasons for these phenomena are unknown but may be the result of chemical changes in the plant cell or the production of protective substances in the plant tissue that prohibit entrance or multiplication of the pathogen (3). Whatever the reason, it reveals a way to exploit additional measures to restrict HLB disease.

Current control measures enabled the replanting of previously abandoned areas such as Alkmaar, Schoemanskloof and White River. Additional measures that can be incorporated in the current measures will contribute to stabilizing citrus production in these areas.

The objective of this study was to assess the effect of different CTV isolates and rootstocks on the percentage of HLB-affected fruit from Palmer navel and Delta Valencia trees.

MATERIALS AND METHODS

Experimental design. An 8-yr-old orchard from a previous CTV trial was used for the investigation.

Palmer navel and Delta Valencia trees on rough lemon, Volkamer lemon, Gou Tou, Yuma citrange and Troyer citrange rootstocks were separately pre-immunized with two mild (GFMS 12, T55), two moderate (GFMS 10, Micveh T) and two severe (GFSS 1, ST) CTV isolates. Control trees were planted virus-free but with the abundance of the aphid vector *Toxoptera citricida* (Kirkaldy), these would become infected with various CTV strains. The trees were planted during 1992 according to a split-plot design with six replications (5). The effect of HLB was evaluated in each treatment from the eighth year after planting for 3 yr.

Data collection. Many HLB-affected fruits fall before harvest (4). To include those fruit in the study, fallen fruit was collected on a weekly basis, starting at approximately 3 mo before harvest, and the numbers of affected fruit were recorded. At harvest all fruits were inspected and HLB symptoms were recorded. Affected fruit are usually smaller, have an olive-green color that can occur on only part of or on the whole fruit, exhibit a white deposit when pressure is applied on the green part, have high shoulders and exhibit lopsidedness. The data of the fallen and harvested fruits was combined and the percentage of HLB-affected fruits was calculated.

RESULTS AND DISCUSSION

The percentages of HLB-affected fruits from the navel and Valencia trees on the different rootstocks infected with various CTV isolates are presented in Tables 1 (navel trees) and 2 (Valencia trees).

Navel. Of the navel trees, those on Volkamer lemon rootstock had the highest percentage of HLB-affected fruits (24.0%) followed by trees on Troyer citrange (20.2%). The smallest HLB incidence occurred on trees with rough lemon rootstock (10.7%). The CTV isolates had no differential effect on the percentage of HLB-affected fruits from trees on rough lemon, Volkamer lemon and Gou Tou rootstocks. However, trees on Yuma citrange and Troyer citrange rootstocks with the ST isolate, had significantly more HLB-affected fruits (20.2% and 27.6% respectively) than trees with the Micveh T isolate (7.5% and 16.9% respectively), but the number of affected fruit of trees with both CTV isolates did not differ from the controls trees on Yuma and Troyer citranges (10.9% and 23.9% respectively). Trees on Troyer citrange that were pre-immunized with isolates

TABLE 1
THE EFFECT OF *CITRUS TRISTEZA VIRUS* (CTV) ISOLATES ON THE AVERAGE PERCENTAGE OF HUANGLONGBING INFECTED FRUIT OVER 3 YR IN PALMER NAVEL ON DIFFERENT ROOTSTOCKS*

	CTV isolates							
Rootstocks	GFMS 10	GFMS 12	GFSS 1	ST	T 55	Micveh T	Control	Mean
Wallace rough lemon	8.4 a	13.2 a	13.3 a	8.1 a	8.2 a	9.0 a	14.7 a	10.7 x
Volkamer lemon	21.8 c	25.3 c	28.3 c	21.8 c	24.3 c	21.7 c	24.9 c	24.0 y
Gou Tou sour orange	11.6 e	10.1 e	12.9 e	14.3 e	16.0 e	11.5 e	14.6 e	13.0 x
Yuma citrange	15.5 gh	17.3 gh	13.4 gh	20.2 h	15.4 gh	7.5 g	10.9 gh	14.3 x
Troyer citrange	15.3 j	17.6 j	21.1 jk	27.6 k	18.9 jk	16.9 j	23.9 jk	20.2 y
Mean	14.5 x	16.7 x	17.8 x	18.4 x	16.6 x	13.3 x	17.8 x	

*Numbers followed by the same letter in each row in the body of the table do not differ significantly at the 5% level (Fisher's LSD). This implies similarly to the rootstock and CTV means.

TABLE 2
THE EFFECT OF *CITRUS TRISTEZA VIRUS* (CTV) ISOLATES ON THE AVERAGE PERCENTAGE OF HUANGLONGBING INFECTED FRUIT OVER 3 YR IN DELTA VALENCIA ON DIFFERENT ROOTSTOCKS*

	CTV isolates							
Rootstocks	GFMS 10	GFMS 12	GFSS 1	ST	T 55	Micveh T	Control	Mean
Wallace rough lemon	15.6 a	15.8 a	14.6 a	18.6 a	14.2 a	15.9 a	17.4 a	16.0 x
Volkamer lemon	16.6 c	16.9 c	17.3 c	13.9 c	13.2 c	16.9 c	14.5 c	15.6 x
Gou Tou sour orange	14.4 ef	12.0 e	20.3 f	11.5 e	9.8 e	10.8 e	15.3 ef	13.4 x
Yuma citrange	23.3 hij	16.4 h	19.2 hij	21.6 hij	30.4 j	23.6 hij	27.6 ij	23.2 y
Troyer citrange	22.7 l	30.2 lm	32.4 lm	22.8 l	33.0 lm	35.3 m	24.3 lm	28.7 z
Mean	18.5 x	18.3 x	20.8 x	17.7 x	20.1 x	20.5 x	19.8 x	

*Numbers followed by the same letter in each row in the body of the table do not differ significantly at the 5% level (Fisher's LSD). This implies similarly to the rootstock and CTV means.

GFMS 10, GFMS 12 and Micveh T also had significantly less HLB-affected fruits than trees with the ST isolate but not less than the control trees (natural CTV infection).

Valencia. Valencia trees on the two trifoliate rootstocks had more HLB-affected fruits than those on the other rootstocks (23.2% for Yuma and 28.7% for Troyer). This supports previous findings (6). The lowest incidence of HLB occurred on trees with Gou Tou rootstock (13.4%). A significant effect among CTV isolates on the HLB incidence occurred in trees on Gou Tou, Yuma citrange and Troyer citrange rootstocks but this was not consistent. Trees on Gou Tou rootstock with GFSS 1 had significantly more HLB-affected fruits (20.3%) than those with isolates GFMS 12 (12.0%), ST (11.5%), T 55 (9.8%) and Micveh T (10.8%). Trees on Yuma citrange with isolate T 55 had significantly higher HLB incidence (30.4%) than those with GFMS 12 (16.4%) and GFSS 1 (19.2%), while trees on Troyer citrange rootstock with the Micveh T isolate had a higher HLB incidence (35,3%) than those with isolates GFMS 10 (22.7%) and ST (22.8%). However, except for trees with GFMS 12 on Yuma citrange rootstock, incidence of HLB in these trees did not differ from that of the control trees (natural CTV infection).

Overall, HLB infection by psyllids in the Valencia trees was higher than in the navel trees (19.4% and 16.4% respectively). Navel trees usually have less new flush during growth cycles than Valencia trees and this may have contributed to a lower incidence. The CTV isolates did not affect HLB infection, however, there were interactions between rootstocks and isolates. The effects could not be ascribed to CTV virulence since they varied from mild to severe but may be related to stress where the flush rhythms are disturbed by interactions between rootstocks, scions and pathogens. The CTV isolate that induced a reduction on the HLB incidence (7) was not used in this trial since it was unknown when these trees were planted. However, there are indications that HLB can be reduced by cross-protection with CTV. There may be a chemical interference but most likely it would be only because the trees are less affected by the CTV and are in a more healthy state. Navel and Valencia trees on Troyer citrange rootstock were the most affected by HLB followed by trees on Volkamer lemon (navel) and Yuma citrange (Valencia).

CONCLUSION

The effects of CTV isolates on HLB incidence were variable, but

the CTV isolates tested will not contribute to better control. However, the results indicated that the CTV isolate present in a tree could play a role in the HLB infection, especially in combination with specific rootstocks. Trees on trifoliate rootstocks showed more susceptibility to HLB infection. These rootstocks as well as Volkamer lemon for navels should be avoided in HLB areas.

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