The Economics of Living With Citrus Viroids in Belize

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ABSTRACT. It is not uncommon for citrus growers to accept and accommodate to the presence of citrus diseases, thereby, sustaining huge financial losses year after year. Economic losses may be extreme despite the fact that methods are available for their successful control. This paper discusses the financial losses and economic impact of viroid diseases in Belize due to the planting of uncertified and viroid-infected budlines on sensitive rootstocks under the warm conditions favorable for viroid replication. Similar problems are currently occurring in other countries of Central America, Mexico and the islands of the Caribbean where the threat of spread of tristeza is forcing growers to change from the sour orange rootstock to tristeza-tolerant, but viroid-sensitive rootstocks.

In a consultancy visit to Belize in Central America, Roistacher (7) observed the severe losses caused by exocortis in plantings on citrus tristeza virus (CTV)-tolerant but exocortis-sensitive rootstocks of citrange and Rangpur lime. The citrus industry in this country was facing the possible invasion of the brown citrus aphid, *Toxoptera citricida* (Kirkaldy),[1] and, since the predominant rootstock was sour orange, they were facing the subsequent destruction of much of their country's citrus plantings by CTV-decline. This situation had induced many growers to plant new citrus on tristeza-tolerant rootstocks giving little or no regard to certification. The method used for budwood selection in Belize was to cut budwood from a prolific bearing tree bearing good sized fruit. This practice had been ongoing for many years and was successful for their citrus industry on the sour orange rootstock. However, most of these prime budwood source trees carry graft-transmissible pathogens (3, 4), particularly viroids which were not expressed in the Valencia or grapefruit trees growing on the sour orange rootstock. These pathogens can be detected only when using sensitive scion/rootstock combinations or by indexing.

The use of exocortis-infected budlines grafted on sensitive rootstocks resulted in production of slow-developing trees with significantly lower yields, severe bark cracking of the rootstock and the eventual debilitation and even tree death (3, 4, 7, 8). It has been shown that viroid symptoms are more intense under warm temperatures (5). Fig. 1 shows the comparative temperatures in Belize and Riverside, California. On average, maximum day and minimum night temperatures in Belize are 5.4°C and 9.6°C warmer, respectively than at Riverside. Probably, for this reason, trees of navel or Valencia orange on citrange rootstocks infected with exocortis in California do not show the debilitation or bark cracking to the extent observed under the warmer conditions in Belize.

Financial losses to citrus growers are considerable and the decision as to what budwood to select for propagation is of major concern for all citrus nurserymen and growers in Belize. This paper reports on the financial impact to farmers and to their country by graft-transmissible pathogens, mainly the viroids, and suggests ways in which these losses can be minimized through programs of certification and education.

[1]*Toxoptera citricida* was detected in Belize on October 25, 1996 and has since been widely distributed throughout the country.

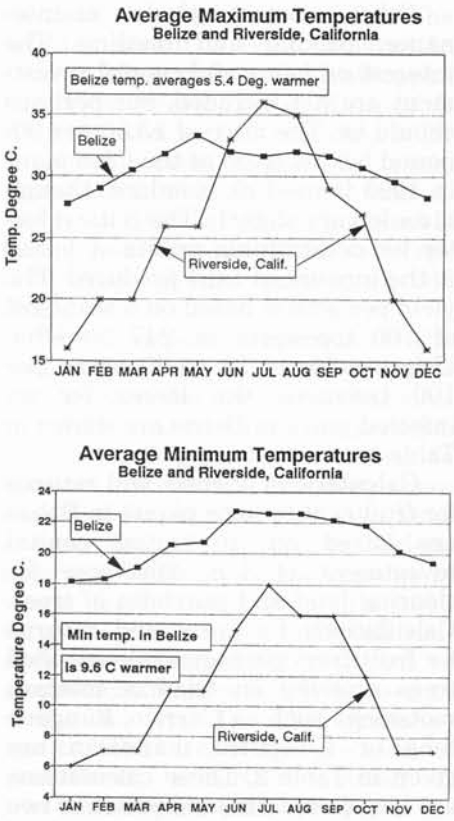

Fig. 1. The comparative temperatures in Belize and Riverside, California. On average, maximum day and minimum night temperatures in Belize are 5.4°C warmer during the day and 9.6°C warmer during the night than at Riverside.

THE ECONOMICS OF CITRUS CERTIFICATION FOR BELIZE

A number of citrus groves on citrange or Rangpur lime rootstocks throughout Belize were observed in severe decline and the rootstocks showed severe bark cracking symptomatic of exocortis infection. Budwood from many of these groves, when indexed to citron, showed severe epinasty, typical for the citrus exocortis viroid (3, 4).

At the Duquesney's farm in southern Belize, the major portion of 5-yr-old trees of Valencia on Rangpur lime rootstock were in severe decline and the rootstock showed

Fig. 2. Severe bark cracking on Rangpur lime rootstock on a 5-yr-old tree in Belize. The entire grove was stunted and unproductive with yields averaging less than one fourth box (10.2 kg) per tree.

typical severe exocortis bark cracking as shown in Fig. 2. The contrast between trees showing bark scaling and a few escape trees was dramatic (7, 8). The yield from the trees on this farm averaged less than one fourth box (10.2 kg) per tree (the standard box in Belize is 90 pounds or 40.823 kg). On another farm in the south of Belize, all trees of 4-yr-old Valencia on Carrizo citrange rootstock showed severe bark cracking on the rootstock typical of exocortis infection. In an 8.1-ha block, no fruit was harvested in the third year and only 20 boxes of fruit (817 kg) were harvested from 2,000 trees in the fourth year, averaging 0.41 kg per tree. On a third farm in western Belize, 3-yr-old Valencia orange trees on Carrizo citrange rootstock were observed in severe decline and the trunks showed severe bark cracking. Although this farm was well-managed, the yields were estimated at

one fourth box per tree (10.2 kg); whereas non-infected trees of the same age averaged three boxes per tree (122.5 kg) in their third year.

Under the best growing conditions, infected trees on exocortis-sensitive rootstocks in Belize may produce a maximum of one half box (20.4 kg) fruit per tree. However, this is rare for infected trees showing decline and severe bark cracking, and generally yields were found to be one fourth box (10.2 kg) or less per tree. In addition, rootstock trunks of citrange and Rangpur lime showing severe bark cracking are predisposed to Phytophthora infection, as the fungus can readily enter through the lesions, and many trees usually die before their eighth year. Other pathogens may also contribute to tree debilitation and low yield. Based on these observations, estimated yields of 0.1 to 0.3 boxes (4 to 12 kg) of fruit per tree are used to calculate the costs and returns of a grove planted with viroid-infected budwood in Belize from the third to eighth year (10 to 30 boxes of fruit per 100 tree-acre).

Other costs include maintenance, picking and hauling. The interest on loans and capital investment are not included, but perhaps should be. The price of $3.50 per 90-pound box received at the juice plant in 1995 is used as standard, though it could vary slightly. The critical factor for determining profits or losses is the amount of fruit produced. The yield per acre is based on a standard of 100 trees/acre or 247 trees/ha. Using yields of 10 to 30 boxes per 100 tree/acre, the losses for an infected grove in Belize are shown in Table 1.

Calculations of costs and returns for fruit sent to juice plants in Belize are based on an initial capital investment of U.S. $600/acre for clearing land and purchase of trees. Calculations for costs and returns for fruit from pathogen-free certified trees growing on tristeza tolerant rootstocks such as Carrizo, Rangpur lime or Cleopatra mandarin are given in Table 2. These calculations are based on estimated yields of two boxes (82 kg) per tree in the third year and six boxes (245 kg) per tree

TABLE 1
CALCULATION OF COSTS AND LOSSES IN U.S. $ FOR A 100 TREE/ACRE EXOCORTIS-INFECTED SWEET ORANGE TREES ON EXOCORTIS-SUSCEPTIBLE ROOTSTOCK IN BELIZE

Description	Year[z,y,x]							
	1	2	3	4	5	6	7	8
Initial capital ($)	600							
Maintenance ($)	75	125	175	250	300	350	400	400
Pick and haul ($)	0	0	6	9	12	15	18	18
Working costs ($)	75	125	181	259	312	365	418	418
Cumulative costs ($)	675	800	981	1,240	1,552	1,917	2,335	2,750
Yield-boxes/acre	0	0	10	15	20	25	30	30
Income/box ($)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total income/acre ($)	0	0	35	53	70	88	105	105
Yearly loss ($)	-675	-125	-146	-207	-242	-278	-313	-313
Cumulative loss ($)	-675	-800	-946	-1,153	-1,395	-1,672	-1,985	-2,298

[z]Estimated yields are from 10 boxes/acre in the 3rd year to 30 boxes/acre in the 7th and 8th year.
[y]Figures courtesy Citrus Research and Education Institute, Dangriga Town, Belize.
[x]Picking and hauling costs calculated at $0.60 per 90 pound box (41 kg) of fruit delivered to the juice plant. Figures do not include interest costs. The total costs include the initial costs plus maintenance.

TABLE 2
CALCULATION OF COSTS, LOSSES OR GAINS IN U.S. $ FOR A 100 TREE/ACRE GROVE OF A VIRUS-FREE CERTIFIED SWEET ORANGE TREES ON EXOCORTIS-SUSCEPTIBLE ROOTSTOCK IN BELIZE

Description	Year							
	1	2	3	4	5	6	7	8
Initial capital ($)	600							
Maintenance ($)	75	125	175	250	300	350	400	400
Pick and haul ($)	0	0	120	180	240	300	360	360
Working costs ($)	75	125	295	430	540	650	760	760
Cumulative costs ($)	675	800	1,095	1,525	2,065	2,715	3,475	4,235
Yield-Boxes/acre	0	0	200	300	400	500	600	600
Income/box ($)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Total income/acre ($)	0	0	700	1,050	1,400	1,750	2,100	2,100
Annual profit or loss ($)	-675	-125	405	620	860	1,100	1,340	1,340
Cumulative Profit or loss ($)	-675	-800	-395	225	1,085	2,185	3,525	4,865

[z]Estimated yields are from 200 boxes per acre in the 3rd year to 600 boxes per acre in the 7th and 8th years.
[y]Figures courtesy Citrus Research and Education Institute, Dangriga Town, Belize.
[x]Picking and hauling costs calculated at $0.60 per 90 pound box (41 kg) of fruit delivered to the juice plant. Figures do not include interest costs. The total costs include the initial costs plus maintenance.

in the seventh and eighth year or 20 to 60 boxes per 100 tree/acre. From the data in Tables 1 and 2, we can see the important losses incurring to citrus growers in Belize due to graft-transmissible pathogens, particularly viroids, and the profits that could be realized if certified pathogen-free budwood is used. If trees are kept for eight years, a citrus grower using infected budwood on a tristeza-tolerant, but exocortis susceptible rootstock could suffer a loss of U.S. $2,298/acre or $5,678/ha. If the interest on all capital investments were included, these losses would be higher. From the data in Table 1, it is evident that a grove of infected trees should be pulled as quickly as possible to prevent compounding the loss. Primarily because of the high costs of the initial capital investment, it is not unusual for a citrus grower to hold on to sick trees, even if they are non-productive, in the hope that they may recover. However, under the warm tropical conditions in Belize, we have observed that these infected trees do not recover, but steadily decline and many die. Even if the infected tress were pulled, there remains the question of what budwood to use for re-propagation and replanting, when no certified budwood is available.

From the data shown it is evident that a certification program is urgently needed to prevent major losses caused by graft-transmissible pathogens carried by the budwood sources presently used. This is true, not only for Belize, but for other countries in Central America, Mexico and the islands of the Caribbean. Most citrus in this region are on sour orange rootstock and the continuous northward movement of *T. citricida* threatens them with a subsequent spread of tristeza. A mandatory certification program (6) should be developed as has been done in Spain and South Africa and recently in Florida which prohibit the propagation of any budline that is not certified. The potential for profit by the planting of certified budlines is shown in Table 2. The projected cumulative profits by using pathogen-free budwood after 8 yr is U.S. $4,865/acre or $12,021/ha. These fig-

ures may seem somewhat high since they are based on projected yields of six boxes (245 kg) of oranges per tree after 7 and 8 yr in the field, and assumes no other tree losses due to blight, phytophthora and other pests and problems. However, it is known that these yields are achieved in well-managed groves in Belize and even higher yields could be attained with certified trees under good management, considering the excellent growing conditions for citrus in the country.

CONCLUSION

In the near future, the northward movement of *T. citricida* through several countries in Central America and the Caribbean islands will cause the rapid spread of tristeza (1, 2). It is most probable that citrus plantings on sour orange will eventually be destroyed as has occurred in all countries where *T. citricida* and tristeza are endemic. It will, therefore, be necessary to replant on CTV-tolerant rootstocks, some of which are sensitive to exocortis and other viroids. In Belize, there are many new plantings on citrange and Rangpur lime rootstocks using budwood of unknown sanitary status carrying various graft-transmissible pathogens, particularly viroids. Severe decline, bark cracking and low yield are currently observed in these plantings and the growers are sustaining severe economic losses, as shown by the financial data presented here. An additional problem is the lack of certified, indexed and pathogen-free budwood sources that could provide buds with a guaranteed sanitary condition for new plantings and replantings. Based on these findings (7, 8), the citrus industry of Belize has established a strong certification and indexing program for production of virus and viroid-free budwood. The information and data presented here are strong argument to launch a mandatory certification program for citrus (6) in countries facing the threat of invasion of *T. citricida*. The costs needed for training personnel, developing a small laboratory, building a screenhouse with a temperature controlled room for indexing, and obtaining the equipment and supplies required to support the program are relatively quite small when compared with the current (and future) losses suffered by the citrus industry if pathogen-free budwood is not made available to the growers through a certification scheme.

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