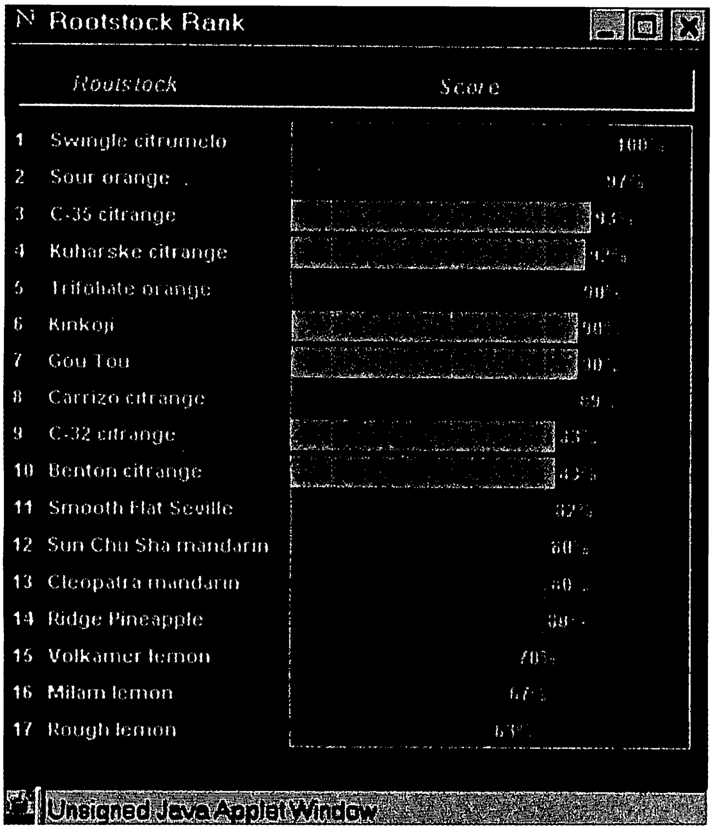
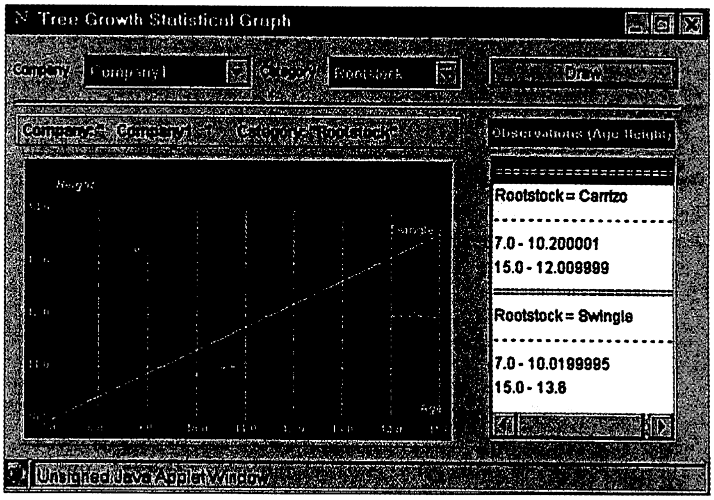


Rootstock		Score
1	Swingle citrumelo	100%
2	Sour orange	97%
3	C-35 citrange	93%
4	Kuharske citrange	92%
5	Trifoliate orange	90%
6	Kinkoji	90%
7	Gou Tou	90%
8	Carrizo citrange	89
9	C-32 citrange	83%
10	Benton citrange	83%
11	Smooth Flat Seville	82%
12	Sun Chu Sha mandarin	80%
13	Cleopatra mandarin	80
14	Ridge Pineapple	80
15	Volkamer lemon	70%
16	Milam lemon	67%
17	Rough lemon	63%

Figure 7. Rootstock selection output.

ODBMS Architecture (Beck, 1999), use of multi-threads and more advanced components. All the DISC modules have been distributed to Florida users for testing. The improvement on DISC is currently being made based on their feedback.



Rootstock= Carrizo

7.0 - 10.200001
15.0 - 12.008999

Rootstock= Swingle

7.0 - 10.0199995
15.0 - 13.8

Figure 8. Tree size analysis.

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RESET VS. REPLANT: THE CASE OF HIGH ANNUAL TREE LOSS

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Abstract. **Reset options for replacing trees lost in a citrus grove were discussed in a previous FSHS paper (Muraro and Castle, 1996). Using a discounted cash budget model, several scenarios were analyzed which included no tree loss and tree loss with and without tree replacement. The hypothetical grove used in the analysis was planted at 116 trees per acre (25' × 15'). The reset scenarios showed a positive result over no reset scenarios. However, the 1996 FSHS paper did not address grower questions with regards to resetting in more densely planted hedge row groves, or under high tree loss rates due to disease problems such as citrus tristeza virus (CTV) or replanting low productive groves where incompatible rootstock, sci-**

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on and soil conditions exist. This paper extends the previous paper by analyzing grove situations for annual tree losses that occur at greater than 10% and resetting options are considered for more densely planted groves. Case studies are used to compare actual grower experiences with predicted results.

Disease and/or pest pressures can cause significant annual tree losses. For example, some citrus growers are losing trees on sour orange rootstock to citrus tristeza virus (CTV) at rates that exceed 25% per year. If nothing were done, an entire block of trees on sour orange rootstock would become unprofitable within five years. The Florida Department of Citrus' economic research (Brown, 1999) has estimated that over 14% of the orange trees and over 26% of the seedless grapefruit trees are planted on sour orange rootstock. Thus, if tree loss due to CTV were to exceed 25% per year, total annual production could be severely impacted.

Questions being asked are should a grower maintain a continuous and immediate reset strategy or should a grower consider replanting the entire block as a solid set planting? If a grower considers the latter option, when should the block be replanted; immediately or delayed to some specified future time? There are horticultural and economic factors, such as tree density, rootstock selection, poor soil drainage and low market prices which may cause unsatisfactory production and economic returns. Thus, at what point should a grower consider renovating the grove, changing the rootstock-scion combination, tree density or bed structure?

A generic answer to these questions is not possible because the tree replacement decision depends on a number of factors whose combination would be unique to each grove situation. This paper will evaluate five tree replacement scenarios with respect to CTV tree losses being experienced by growers with orange groves on sour orange rootstock.

Materials and Methods

Data from a south Florida orange yield study (Roka et al., 1997) and from interviews with south Florida citrus growers experiencing rapid CTV decline in sour orange rootstock blocks were used to estimate the expected yields and returns of a hypothetical orange grove planted at 145 trees per acre. This is the average tree density of orange groves in south Florida that are 10 years and older. All previous and new reset/replacement trees were assumed to be planted on CTV tolerant rootstocks. Average yield for an orange grove in south Florida was used to calculate the annual production (Table 1).

Annual tree-loss-rate without rapid CTV was assumed to be 3% per year. When the tree-loss-rate from CTV reached the 5% level, the analysis assumed a rapid annual tree-loss-rate over 5 years ranging from 10% to 25% per year (Table 2). Financial outcomes were calculated by a cash budget analysis with comparisons among reset/replacement scenarios based on a discounted net present value cash flow. A discount rate of 10% was used in the analysis. Annual cultural costs for a mature processed orange grove were based on 1998-99 summary data (Muraro et al., 1999). On-tree price was assumed to be $4.50/box. Tree removal and reset costs varied depending upon the total number of trees being replaced each year (Table 3).

Table 1. Average yield per tree for oranges grown in southwest Florida.

Age of trees	Box yield per tree[z]
3	0.33
4	0.67
5	1.33
6	2.33
7	3.00
8	3.30
9	3.30
10+	3.30

[z]Based on the southwest Florida yield study (Roka et al., 1997); average for all varieties.

All previous resets at the 3% annual tree-loss-rate were assumed to have been planted on CTV tolerant rootstocks. The costs and yields for each cash budget analysis scenarios were adjusted to reflect the specific reset situation. For example, the scenarios with CTV losses where no resetting occurred, annual grove care costs were adjusted to reflect the reduced number of trees remaining in the block. Also, the production for each scenario incorporates yields, by age of tree, of the remaining original trees planted, the previous reset trees planted along with the reset trees due to CTV decline. The cash budget analysis does not incorporate an annual inflation factor.

For comparative purposes, the five scenarios were divided into the following two groups:

Group A—Without CTV decline

#1—zero annual tree loss with no previous resets and without CTV decline

#2—previous resets at 3% loss per year and without CTV decline

Group B—With CTV decline

#3—previous resets at 3% loss per year; reset as CTV trees are removed

#4—previous resets at 3% loss per year; no resetting when CTV trees removed then replanting after 6 years

#5—previous resets at 3% loss per year; push and replant entire sour orange rootstock block in Year 2

Results and Discussion

A 15-year cash budget analysis was used to compare the five scenarios. Two values were calculated to summarize the economic returns from each scenario. The first value, cumulative annual cash flow, is the 15-year sum of annual net cash returns. The second value is the net present value (NPV) of the 15-year income stream. NPV discounts annual returns to

Table 2. Descriptive and cost values used in CTV[z] reset strategy analysis.

Average trees per acre	145
Average annual tree loss rate	3.0%
Expected annual CTV tree loss rates after year 1:	
Year 2	5.0%
Year 3	10.0%
Year 4	20.0%
Year 5	20.0%
Year 6	20.0%
Year 7	25.0%
On-tree price/box	$ 4.50
Maintenance/grove care cost/acre	$745.18[y]
Present value discount rate	10.0%

[z]Citrus tristeza virus (CTV).
[y]Budgeting costs and returns for southwest Florida (Muraro et al., 1999).

Table 3. Reset costs used in CTV[z] reset strategy analysis.

	Number of reset/replacement trees per acre				
	1-2	3-5	6-10	11-25	26+
	$/tree[y]				
Tree removal	5.21	4.53	3.62	2.93	2.34
Planting cost (site preparation, tree cost, wrap, stake, etc.)	6.28	5.96	5.62	5.91	5.40
Annual supplemental grove care costs for reset trees:					
Year 1	3.72	3.44	3.25	3.10	2.92
Year 2	3.24	2.93	2.55	2.24	2.03
Year 3	2.61	2.32	2.00	1.71	1.44

[z] Citrus tristeza virus (CTV).

[y] Costs of planting and maintaining reset trees (Muraro, 1996).

reflect the "time value of money," which states that a dollar today is worth more than a dollar to be received sometime in the future. Therefore, positive or negative annual returns will have a greater effect on the NPV depending when they occurred during the 15-year analysis period. Cumulative and NPV are summarized by scenario in Table 4.

Group A—Without CTV decline. Scenarios 1 and 2 were included in the analysis as comparative examples of an orange grove with no tree losses and one with a typical tree loss and an annual reset program. Scenario 1 with zero tree loss had the highest cumulative 15-year cash flow ($21,121/acre) and NPV ($10,710/acre). Scenario 1 shows the economic returns of a citrus block with no annual tree loss. Scenario 2 with an annual 3% tree loss rate and without CTV decline represents a more realistic/typical economic comparison of a Florida orange grove. With a cumulative cash flow of $14,367/acre and an NPV of $7,285/acre, Scenario 2 demonstrates the positive benefits of a well-managed reset/replacement program in a citrus grove.

Group B—With CTV decline. Scenarios 3, 4 and 5 demonstrate the economic impact that CTV decline has on a sour orange citrus grove. Whether the CTV decline trees are replaced as they are removed (scenario 3) or if the entire sour orange rootstock block is pushed and replanted (scenario 5), the cumulative net cash flows are comparable; $5,777/acre for a reset program (scenario 3) and $6,283/acre for an immediate replant strategy (scenario 5). Both of these values are about 60% less than the more typical tree loss/reset situation (scenario 2). For scenario 4, where CTV trees are removed but are not replanted until the block becomes non-profitable (after year 6), the cumulative net cash flow was only $3,611/acre.

When comparing the 15-year discounted net present value (NPV) for Scenarios 3, 4 and 5, the time value of money is demonstrated. Although the cumulative net returns were similar for Scenarios 3 and 5, the NPV ($2,469/acre) for the "remove and reset" Scenario 3 was 70% greater than the NPV ($1,437/acre) for the "push and replant" Scenario 5. Even the "annual tree removal and replant after 5 years" Scenario 4 had an NPV ($2,176/acre) 50% greater than the NPV for Scenario 5. The lower NPV for Scenario 5 was a result of lost production and high negative cash flow during the first six years of the analysis.

Cumulative yields over the 15-year analysis for Scenarios 3, 4 and 5 were 4,251 boxes/acre, 3,252 boxes/acre and 4,014 boxes/acre, respectively. However, the yield distribution during the 15-year period reflected the reason for the lower NPV returns for the three scenarios. The annual resetting program of Scenario 3 resulted in some production in each year of the analysis. Scenario 4 had continuous, but declining yields, through year 6 when the entire block would have been replanted. Thus, negative returns occurred during the middle of the analysis period for Scenario 4. However, in Scenario 5 where all trees were removed and replanted, no yields, or low yields, would have occurred during the first six years resulting in a high negative cash flow.

Summary

Whether to reset trees when lost due to disease or wait to replant an entire block is dependent upon both horticultural and economic factors. A grove owner could be motivated to replant an entire block if there is a need to change existing infrastructure. For instance, should beds be reshaped for better drainage and/or irrigation? Is the tree density adequate? Is the rootstock/scion combination meeting expected production goals? In addition, changes to marketing programs

Table 4. Summary of 15-year cumulative cash flow for CTV[z] reset analysis of a southwest Florida orange grove planted on sour orange rootstock.

	15-year cash flow nominal/actual	15 year cash flow NPV @ 10.0%
	$/acre	
Scenarios:		
#1—zero annual tree loss without CTV decline	21,121	10,710
#2—previous resets at 3% annual loss rate/year without CTV decline	14,367	7,285
#3—previous resets at 3% annual loss rate/year; reset as CTV trees are removed	5,777	2,469
#4—previous resets at 3% annual loss rate/year; no resetting when CTV trees removed and replant block after 6 years	3,611	2,176
#5—previous resets at 3% annual loss rate/year; push/replant entire sour orange rootstock block in Year 2	6,276	1,437

[z] Citrus tristeza virus (CTV).

may dictate a block to be replanted rather than continuing with a reset program. Providing that the grove infrastructure and varietal selections are to be continued, resetting has been shown to be economically beneficial by maintaining a given level of production in a citrus grove. However, for replacement trees in a citrus grove to be productive and profitable, a well managed reset program must be maintained. The analysis discussed in this paper can serve as a guideline to evaluate losses from CTV decline in sour orange rootstock groves. With further refinement, the cash budget model used for the analysis will provide citrus growers with a "decision-aid" tool to evaluate the economic benefits of resetting or replanting a specific citrus grove.

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YIELD AND RELATIVE COST OF CONTROLLED-RELEASE FERTILIZER ON YOUNG BEARING CITRUS TREES

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Additional index words. Citrus sinensis, nutrition, fruit quality, juice quality.

Abstract. **Six types of commercially available controlled-release fertilizers (CRFs) (Escote, Meister 9-month, Meister 12-month, Nutricote 360, Prokote Plus, and Sierra) and conventional, water-soluble fertilizer were applied to 'Valencia' orange trees on Swingle rootstock from planting through 6-yr of age. Annual application rates were at full, one-half, and one-fourth recommended N rates by UF/IFAS. CRFs were applied once/yr and conventional fertilizer was applied 6, 5, 4 and 3 times in years 1, 2, 3 and 4-6, respectively. Fruit was harvested the 3rd through the 6th yr. Averaged across N rates, Prokote Plus, Nutricote, and Sierra produced 4-yr cumulative fruit yields of 4.9 to 4.8 boxes/tree compared with 4.3 boxes/tree for conventional fertilizer. Prokote Plus and Sierra also produced higher lbs-solids yield (27.4 lbs/tree in 4 yr) and gross dollar return ($28.58/tree in 4 yr) than the conventional fertilizer. Prokote Plus out-produced Escote in fruit and lbs-solids yield, and out-produced Escote and Meister in dollar return. The response of lbs-solids yield to N rate was described by a quadratic plateau model where the critical N rate varied from 76% of the full N rate for conventional fertilizer (at 26.9 lbs-solids/tree) to 100% of the full N rate for Prokote Plus (34.0 lbs-solids/tree), Nutricote, and Meister. The cost of fertilizing citrus with CRFs at the full N rate was four times the conventional fertilizer cost, whereas the return was 15% greater. Thus, the current cost of CRF products makes them uneconomical as the primary nutrient source in citrus production.**

Controlled-release fertilizers (CRF) supply plant nutrients in a form that delays or extends nutrient availability longer than that available from water-soluble fertilizer (Mortvedt and Sine, 1995). The mechanisms that impart controlled-release properties to fertilizers include reduced water-solubility of the material (by semi-permeable coatings, occlusion, or inherent water insolubility of polymers, natural nitrogenous organics, or protein materials) or slow hydrolysis of water-soluble low-molecular-weight compounds (Mortvedt and Sine, 1995) Coatings are either water-impermeable, with tiny holes through which dissolved fertilizers diffuse, or semipermeable, through which water diffuses until the internal osmotic pressure ruptures the coating or distends it to increase permeability (Hauck, 1985).

Nitrate-N concentrations in ground water above 10 ppm (10 mg/L, the maximum contamination limit set by EPA), have been found in central Florida groundwater beneath citrus orchards (Graham and Alva, 1997). A nitrogen best management practice (BMP) law which was passed in 1994, authorized the state to develop fertilizer BMPs designed to meet groundwater standards. One potential BMP is using controlled-release N in place of water-soluble N fertilizer, but by definition, a BMP must also be economically feasible.

Tree growth and fruit yield of Florida citrus where part or all of the fertilization program included CRF, were similar or greater than growth and yield resulting from an all water-soluble N fertilization program (Jackson and Davies, 1984; Koo, 1986; Marler et al., 1987; Ferguson et al., 1988; Obreza and Rouse, 1992; Zekri and Koo, 1991a; Zekri and Koo, 1991b; Obreza, 1993). Controlled-release technology was developed primarily to improve N fertilization efficiency and reduce costs of multiple applications. CRFs have been shown to decrease N leaching potential. Often 40% or more of the N fertilizer added to soil is not taken up by the target crop during the application season (Hauck, 1985). Management practices that increase N fertilization efficiency can decrease produc-

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