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Current Management Recommendations for Laurel Wilt of Avocados

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The laurel wilt pathogen [(*Raffaelea lauricola* (*Raf*)] causes a lethal disease affecting at least nine woody Lauraceae species in Florida, including avocado (*Persea americana*). The initial vector for this pathogen, the redbay ambrosia beetle (*Xyleborus glabratus*), was detected in Miami-Dade County in 2010. In 2011 dying native swampbay trees (*Persea palustris*) were found positive for *Raf* in Miami-Dade County, then in early 2012 the first avocado tree succumbed to *Raf* in a commercial grove. At least two other ambrosia beetle (AB) species have now been implicated as the main *Raf* vectors in commercial avocado groves. Recommendations for controlling the spread of laurel wilt (LW) have four components: early detection through scouting, sanitation of affected trees, prophylactic systemic fungicide treatments and ambrosia beetle control. Currently early LW detection consists of an industry-wide helicopter survey every 6 to 8 weeks to identify groves with suspect trees. This information is provided to grove owners and managers. Frequent ground-based scouting is also employed. In groves where LW has not previously been detected, sampling is recommended for verification; in groves previously positive for LW no sampling is warranted. Sanitation procedures include immediate removal and destruction of LW affected trees by uprooting or grinding, chipping, and/or burning. Prophylactic fungicide treatments consist of infusions of propiconazole to entire groves or trees adjacent to LW affected trees (called hot-spot treatment). Ambrosia beetle (AB) control consists of bark directed applications of chemical and/or biological insecticides within one acre of LW affected trees.

In 2002, the redbay ambrosia beetle (*Xyleborus glabratus*) was first detected in Port Wentworth, GA (Fraedrich et al., 2006). Over the next several years extensive redbay (*Persea borbonia*) tree mortality was noted in Georgia and South Carolina; by 2004 the association between a previously undescribed vascular fungus *Raffaelea* sp. and dying redbay trees was made (Fraedrich et al., 2008; Mayfield, 2007). Subsequently, laurel wilt (LW) was detected in Duval County, FL (2005) then Indian River County (2006). In early 2010 the first redbay ambrosia beetle was identified in Miami-Dade County (FDACS-DPI, 2010); by 2011, LW was detected in native swamp bay (*P. palustris*) trees (Ploetz et al., 2011), and by Spring 2012, the first report of a commercial avocado tree (*P. americana*) succumbing to LW was confirmed (Green, 2012).

Since early 2006, research on the management of the laurel wilt pathogen and its ambrosia beetle vectors (*X. glabratus*, *X. bispinatus*, and *X. volvulus*) has been on-going (Atkinson et al., 2013; Carrillo et al., 2013; Evans et al., 2015; Inch and Ploetz, 2012; Ploetz et al., 2011). As a consequence, recommendations for mitigation and control may periodically change. Currently, the industry has implemented a detection and suppression program with the goal of limiting the incidence of LW in commercial groves.

In order to manage LW, suppression of the LW fungal pathogen (*Raffaelea lauricola*) and the ambrosia beetle vectors is necessary. This document describes the current recommendations and options to control ambrosia beetles and prevent of the spread of the LW pathogen among avocado trees in commercial groves.

Early Detection

A key component to controlling laurel wilt is detecting symptomatic trees as soon as possible followed by immediate implementation of control tactics. The Avocado Administrative Committee has funded a helicopter survey of the ~150 sq. mile avocado production area of Miami-Dade County since Fall 2011. The survey team flies at an altitude of about 200 ft to identify LW symptomatic trees, marking their location on a GPS device. The sightings data are compiled, the street locations are determined with Google Earth, and the information then provided to avocado grove owners and managers to ground-truth. In groves in which LW has not been previously diagnosed (or where a new LW suspect tree are many rows from a previously affected tree or area), a sample of the sapwood may be taken for laboratory analysis and disease confirmation. In groves where LW has been verified in one or more avocado trees, further sampling of LW

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symptomatic trees may be unnecessary (i.e., it may be assumed they have LW). In addition, grove owners and management companies are urged to frequently scout their groves for LW symptomatic trees.

Disease Symptoms of Laurel Wilt

Early symptoms of LW are green to dark bluish-green wilted leaves in sections of the canopy (Fig. 1). These symptoms are particularly suspect if the symptomatic tree is located next to or near a completely desiccated, declining or dead tree. Disease symptoms also include brown, desiccated (dead) leaves that remain on the tree and may not drop for up to 12 months (Fig. 1). Subsequent symptoms include stem and limb dieback, plus the sapwood (underneath the bark) may have dark blueish-black streaks. Trunks and/or limbs can exhibit numerous small diameter holes with sawdust tubes (toothpick-like protrusions from the bark), and/or sawdust clinging to the bark, which is evidence of ambrosia beetle activity (i.e., boring into the tree) (Fig. 1).

Some visual symptoms of laurel wilt are similar to trees affected by phytophthora root rot, flooding, lightning strike, and freeze damage (Table 1). However, some pre-existing or existing environmental factors (e.g., flooding and freezing) may help separate the weather related tree decline from LW tree decline. If in doubt, a sample should be taken from a LW suspect tree.

Fig. 1. Avocado tree affected by laurel wilt showing leaf desiccation and drop, leaf wilting and browining, ambrosia beetle boring and fras tubes along tree trunk, and sapwood discoloration in reaction to the presense of the LW pathogen (*Raffaelea lauricola*).

Specific Recommendations for Groves with Laurel Wilt Affected Trees

Sanitation: rapid tree removal and its importance. A major component of LW control is to remove and completely destroy diseased and ambrosia beetle infested trees as soon as it is apparent that they have LW. Grove managers should not hesitate to remove and destroy a wilted tree—waiting to see if more of the tree canopy develops symptoms or turns brown allows time for the pathogen to spread to adjacent trees through their connected root systems. This in turn reduces the chances that infusion of adjacent healthy trees with fungicide and/or trenching to sever

Table 1. Potential causes of avocado tree decline

Potential cause of tree decline	Environmental conditions[z]	Symptoms	Comments
Phytophthora root rot (*Phytophthora cinamomi*)	Flooding or frequent (persistent) soil saturation. Poor soil drainage. Low-lying area prone to wet/ saturated soil conditions.	Leaf wilting (may or may not be sudden Leaves may remain on the shoots although in some cases there is rapid leaf drop Leaf desiccation/browning Progressive tree dieback Necrotic fibrous root system Tree decline and death	Some groves have areas within the grove with a known history of Phytophthora root rot problems. May spread to adjacent trees with similar soil conditions. Trees attacked by wood boring beetles.
Lightning	Most common during spring/ summer and early fall (i.e., the rainy season)	Leaf wilting Leaf desiccation/browning Leaves may remain on the shoots although in some cases there is a sudden pronounced leaf drop Sudden stem, limb and/or trunk dieback Scorching of limbs and/or trunk Tree decline and death	Typically trees adjacent to the affected tree have terminal shoots in the tops of the trees that are dead (with desiccated brown leaves). Trees attacked by wood boring beetles.
Freezing	Historically, may occur from mid-Nov. through first week of March	Water soaking of leaves (mottled, dark green color) Leaf desiccation/ browning Leaves may remain on the stems but eventually fall off Sudden stem, limb and/or trunk dieback Tree decline and death	Typically, entire areas within the agricultural area are affected similarly although there are micro-climates (e.g., low lying areas, “cold spots”) that may experience more frequent or severe cold temperatures than others. Trees may be attacked by wood boring beetles

[z]Environmental conditions with respect to south Miami-Dade County.

roots among trees will be successful in stopping the spread of the disease.

Rapid and complete tree removal and destruction is recommended because the LW pathogen is not only capable of surviving in declining trees, but can move quickly from an infected avocado tree to adjacent healthy trees through root-grafts. The LW pathogen is also capable of surviving in declining trees (Spence et al., 2013). In addition, ambrosia beetles are attracted to declining avocado trees and could in turn become contaminated with, and subsequently further spread, the pathogen. Cutting trees to stumps only, will not control the pathogen or ambrosia beetles.

Steps for properly destroying LW affected trees. Remove the entire tree by pulling or pushing it over. Pushing trees over before cutting is easier than trying to dig or uproot stumps from the ground. Once the tree has been removed, it should be chipped or burned. Trunks of large trees may be ground to sawdust-chips with equipment designed for this (i.e., stump grinders) or burned. Call FDACS-Div. of Forestry at 305–257–0875 (Miami-Dade County) or 954–475–4120 (Broward County) for permission to burn (obtain a burn permit). Wood cut into smaller pieces will burn faster and more completely. Large pieces of wood may need to be burned more than once (restack to expose non-burned wood) in order to be destroyed. Wood chips should be spread out, not mounded, and thoroughly sprayed twice, seven-days apart, with an approved insecticide (e.g., Malathion, Danitol®, Talstar-S or Hero®), plus an adjuvant (i.e., NuFilm®, Vapor Gard® or Pentrabark®). Some biopesticides (e.g., BotaniGard®) have also been shown to kill ambrosia beetles. Avocado groves under organic production should chip where possible and spray twice using an organically certified biopesticide (i.e., Mycotrol®), burning all wood that cannot be chipped.

Systemic Fungicide and/or Trenching Options to Prevent The Spread of The LW Pathogen by Root Grafts Among Adjacent Trees

The LW pathogen is capable of moving from LW affected to healthy avocado trees via root grafts. The spread to adjacent trees may be reduced by immediate tree removal and destruction (described above), prophylactic fungicide treatment of avocado trees, and trenching to sever tree roots among adjacent avocado trees (Fig. 2, A and B). Prophylactic treatment of all the trees in a grove is an option but may be cost prohibitive and therefore treatment of a limited number of trees adjacent to LW affected trees (called spot treatment) may be more economic (Table 3).

Whole grove systemic fungicide treatments. Treating an entire grove with systemic fungicide is an option to prevent the onset of an LW infestation that may be difficult to control once started. The benefits of treating all the trees is that they are all potentially protected, even in the event of a *Raf* contaminated ambrosia beetle infestation occurring, and may reduce the need for ambrosia beetle control. However, the upfront costs may make this too costly for some producers, and there is no 100% guarantee that an LW infestation would not occur. Some producers have been successful employing this strategy.

Spot treat with systemic fungicide. Spot treatment for LW consists of prophylactically treating a limited number of healthy avocado trees adjacent to LW affected trees with propiconazole (Tilt® fungicide) (Fig. 2A). Research has shown that spot treatment of two or more healthy avocado tree adjacent to LW affected trees is more effective than treating just one adjacent tree (RC Ploetz, personal communication).

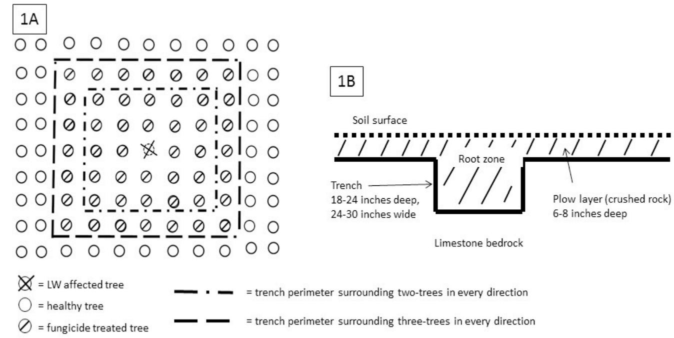

Fig. 2A. Depiction of the layout for a spot treatment: healthy avocado trees (○), trees spot treated with fungicide (∅), and LW affected avocado tree (⊠) and the layout for the soil trench perimeter surround two (— • —) to three (— — —) trees in all directions: 2B. Depiction of the soil profile and root zone where roots must be severed by trenching among healthy trees and a LW affected avocado tree.

However, the key to the spot fungicide treatment is early detection and destruction of LW affected trees and the immediate treatment of the adjacent healthy trees with Tilt® fungicide. Currently there is an emergency exemption (Section 18) for the use of Tilt® in commercial avocado groves. A more permanent registration of Tilt® is underway through the IR-4 Program.

Infusion with propiconazole (Tilt®) has been shown to protect avocado trees from laurel wilt from 8–18 months (Crane et al., 2015). Infusion and injection are techniques used to place Tilt® inside trees. However, recent research clearly indicates infusion to be more effective than injection, permitting faster and more complete distribution of fungicide. Anecdotal evidences suggest injection of high concentrations of the currently available formulation of propiconazole (Tilt®) takes six to eight months to disseminate within the tree, compared to rapid dissemination if it is infused into the flare roots. Infusion of fungicide may be accomplished with passive and pressurized infusion equipment. Many infusion systems are available commercially and plans for simple, inexpensive systems have been published (Crane et al., 2014).

Trenching to isolate LW affected trees. In some groves where spot treatment with fungicides has not been entirely successful, trenching a perimeter between healthy and potentially LW affected trees has been tried (Fig. 2, A and B). However, like spot treatments with infusion, early detection of LW and implementation of sanitation procedures along with the trenching reduce the likelihood of root-graft spread of LW among adjacent trees.

To isolate the LW affected tree, dig a perimeter trench that surrounds 2–3 healthy trees in all directions from the LW affected tree or area (Fig. 2A). In order to sever the roots among avocado trees, the trench must reach the limestone bedrock layer. Generally, a trench 6–8 inches deep will sever tree roots between trees in-row and between-row areas of the plow layer but the trench needs to be 18–24 inches deep where cross trenches correspond to the row and tree spacing (Fig. 2B). Rooting among trees in irrigation trenches also need to be severed; however, this results in the need for costly irrigation repair.

Ambrosia Beetle Control With Insecticide Applications

Ambrosia beetles are most likely to be found in three locations in a grove: (a) inside infested trees, (b) on tree surfaces, or (c) in the air. The largest portion of the ambrosia beetle population is found inside infested trees. Contact insecticides have not been shown to prevent ambrosia beetle emergence from already infested trees or wood and only a few contact insecticides have been found to provide good control of ambrosia beetles on wood surfaces (Table 2).

Chipping and burning wood eliminates ambrosia beetles inside tree stumps and wood and stops their reproduction. However, to kill ambrosia beetles on tree surfaces, applications of contact insecticides and/or biopesticides to about one acre of trees surrounding the affected tree is recommended to help control or prevent further beetle movement in the grove. After removing LW affected trees, two applications of insecticide directed to the trunk and medium to large wood (not the foliage) should be made at a 10- to 15-day interval. Malathion, Danitol® and Epi-mek® are registered for bearing avocado trees. In order to reduce the chances of beetle resistance these products should be rotated (Table 2). Use an adjuvant such as NuFilm® to prolong the efficacy of the insecticide. Using Vapor Gard® and Pentrabark® adjuvants may cause phytotoxicity on leaves. For non-bearing avocado trees, Talstar-S® and Hero® may be applied (Table 2); use an adjuvant to prolong the efficacy. The biopesticides BotaniGard® and Mycotrol® are also registered for avocado and have been shown to control some ambrosia beetle species.

Economics of Managing Laurel Wilt Disease

Although several factors determine whether a new management practice/technology will be adopted by a grower, two major ones are the economics and adoptability of the practice. The former has to do with cost of implementation and the expected benefits to be derived from doing so. This includes not only the cost of administering the treatment and material involved but also the possibility of any potential negative consequences. The benefits, on the other hand, include not only the revenue from the damage prevented (e.g., sale of fruits that otherwise would have been lost), but also takes into consideration the likelihood of the treatment being successful. Adoptability deals with the ease with which the system can be incorporated into the grower's current routine including the amount of time and energy that must be expended in order to become comfortable with the proposed system. Thus for some growers, based on current varieties grown, yield and prices, the existing control of laurel wilt will prove to be uneconomical, especially when viewed from a narrow short term perspective (Table 3). In addition, since the success of the proposed vector/pathogen control options require adherence to a number of time sensitive (i.e., frequent scouting and immediate implementation of sanitation recommendations and fungicide application) and uncommon production practices (i.e., sanitation and periodic infusion or injection of fungicides), full adoption of the system may be somewhat stymied. Notwithstanding the above, the analysis which follows considers aspects of the economics of the proposed management options to control laurel with particular focus on the cost implications.

The information in Table 3 estimates of the costs which may be incurred when carrying out various aspects of the recommendations to control the disease complex, while Table 4 presents cost information in the form of various combinations (options). Based on the information presented in Tables 3 and 4, several insights can be gleaned. For one, the information suggests that, given the assumptions of a grove with 100 trees and assuming a fungicide treatment longevity of 12 months, treating the entire grove could cost between $1,046 and $1,190 depending on the application device chosen (e.g., Table 4 options 1 and 2). This would imply a 40% to 50% increase in current management costs. While well managed groves with high yielding varieties would be in a position to absorb this annual cost, many groves would be hard pressed to show profitability and remain viable in the long run. For example, considering that an average net return from an acre of avocados is about $1,200, and although the benefit of the treatment would outweigh the cost, it might not be sufficient to entice some growers to adopt this practice. Were the price received for the fruit and/or yield per acre to increase somewhat, such options would definitely become far more attractive.

Option 3 focuses on the situation where the infected tree is detected early and properly disposed of. The estimated average cost for this option is $100 plus the cost of the revenue forgone from the destruction of the tree. Compared to options 1 and 2, this option appears to be a much more cost effective treatment. However, it should be noted that the level of protection afforded by this option is far less than is the case with either options 1 or

Table 2. Contact insecticides for ambrosia beetle control. Applications should be directed to the trunk and medium to large wood to about one acre of trees surrounding the infected tree.

Product	Rate per acre	Spray interval	Potential no. of applications allowed per year per acre	Comments—estimated days of efficacy[z]
Danitol 2.4 EC (fenpropathrin)	21.3 oz	14	1	14–21
Malathion 5EC (malathion)	24 oz/100 gal	7–10	Open	10–14
Hero (liquid)[xy] (zeta-cypermethrin+ bifenthrin)	10.3	14	6	14-21 (non-bearing trees only)
Epi-mek 0.15EC (abamectin)	20 oz	30	2	Not known
Talstar S[xy] (bifenthrin)	40 oz	NA	1	Not known; non-bearing trees only; may not need adjuvant
BotaniGard ES[w] (*Beauvaria bassiana*)	32 oz	7–14	Open	Not known
Mycotrol-O[w] (*Beauvaria bassiana*)	32 oz	7–14	Open	Not known; organic production

[z]The estimated days of efficacy is influenced by numerous factors including weather conditions (e.g., rainfall, temperature, and UV light intensity).
[y]Only for non-bearing trees; do not apply within 1 year of harvest.
[x]Special Local Need (SLN Section 24C).
[w]The biological control insecticides BotaniGard ES and Mycotrol do not need an adjuvant and should be stored in a cool (< 85 °F), dry place.

Table 3. Estimated costs associated with various laurel wilt pathogen and ambrosia beetle recommended control treatments.

Activity	Unit	Cost per unit ($/unit)	Frequency/ number	Total Cost ($)	Assumptions/Comments
Collecting and testing samples from LW suspicious tree	Tree	80	1	80	Assumed $40 for collecting sample and $40 for lab test
Destruction and removal/ disposal of LW affected tree	Tree	100	1	100	Include the costs to cut, chip and spray chips and burn stump
Systemic fungicide treatment with Tilt®					Unit costs were calculated on the assumption that the treatment lasts for 12 months. Total cost is based on the recommendation of removing the infected tree and treating the adjacent 16 trees.
Macroinfusion					Macroinfusion uses a dilute solution of fungicide plus water.
• Infuse entire grove	Tree	10.46	100	1046	Assume passive IV bag system used and 100 trees per acre.
• Low pressure application[z]	Tree	14.94	16	239	
• Passive IV Bags[y]	Tree	10.46	16	167	
Injection					Injection of non-diluted (or very slightly diluted) fungicide.
• Inject entire grove	Tree	11.90	100	1,190	Assume Wedgle direct-inject system used and 100 trees per acre.
• Injection-Quik-jet	Tree	11.93	16	191	ArborJet, Inc., Wodburn, MA
• Injection – Wedgle Direct-Inject	Tree	11.90	16	190	ArborJet, Inc., Wodburn, MA
Trenching (2-tree treatment)					
20 x 20	ft	0.5	400	200	
20 x 25	ft	0.5	450	225	The unit cost of $0.50 per ft is based on custom rate. Some growers might find it to be more cost effective to rent the machinery especially if a large area needs to be trenched. We computed a cost of $0.14 per ft for this option based on the following assumptions: The cost for renting the equipment for a day $250, labor $120, fuel $50, area trenched in one day 3,000 ft = $420 or $0.14/ft.
24 x 24	ft	0.5	480	240	
25 x 25	ft	0.5	500	250	
Trenching (3-tree treatment)					
20 x 20	ft	0.5	560	280	
20 x 25	ft	0.5	630	315	
24 x 24	ft	0.5	672	336	
25 x 25	ft	0.5	700	350	
Disinfest area (ambrosia beetle control)					Spray directed to bark of trunk and major limbs only for trees within 1 acre of laurel wilt affected tree. Total cost is based on two applications and includes the application cost.
Danitol®	Acre	35.63	2	71	
Malathion	Acre	30.03	2	60	
Hero®	Acre	23.38	2	47	For application to non-bearing trees only.
BotaniGard®	Acre	59.5	2	119	
Nu-Film 17® adjuvant	Tank	4.5	2	9	

Table 4. Cost implications for various LW and AB control options.

Laurel wilt control options	Total cost ($)	Assume 1 LW affected tree.
Option 1: Infuse all trees in the grove	1046	All trees treated (1 acre).
Option 2: Inject all trees in the grove	1190	All trees treated (1 acre).
Option 3: Sanitation only	100	Complete destruction.
Option 4: Sanitation plus spot treatment (infusion)	267	Assume Passive IV bag system, 16 trees.
Option 5: Sanitation plus spot treatment (injection)	290	Assume Wedgle direct-inject system, 16 trees.
Option 6: Sanitation plus trenching (3-tree)	436	Assume plant spacing of 24 ft x 24 ft.
Option 7: Sanitation plus trenching (3-tree) plus AB control (1 acre)	505	Assume malathion insecticide plus adjuvant.
Option 8: Sanitation plus AB control (1 acre)	169	Assume malathion insecticide plus adjuvant.
Option 9: Sanitation plus spot treatment (infusion) plus AB control (1 acre)	336	Assume malathion insecticide plus adjuvant.
Option 10: Sanitation plus spot treatment (injection) plus AB control (1 acre)	359	Assume malathion insecticide plus adjuvant.

2 and is heavily dependent on strict monitoring of the grove in question. Moreover, one can easily see how this cost could rise considerably were the number of trees that had to be removed in a given year increased noticeably. Options 4 and 5 add an additional level of protection to the sanitation option by treating the adjacent trees after properly disposing of the affected one. The estimated costs for these options ranges between $267 and $290. As with the previous option, although being more cost effective compared to options 1 and 2, cost could escalate quite rapidly were the number of affected trees to increase. For instance, were five trees to become affected by LW it would require, in addition to the removal of all five trees, the treatment of an additional 32 trees for a total cost of about $850. This of course underscores the need to be vigilant and take action immediately to remove the LW infected tree once detected rather than waiting. As pointed out elsewhere, research and anecdotal evidence has shown that not controlling LW results in approximately four to six new LW affected trees per month (RC Ploetz, personal communication).

The estimates further suggest that if a grower is reluctant to monitor and unable to remove LW affected trees in a timely manner, then infusion of the entire grove may be the best option since only six separate LW infestations would result in over 100 trees requiring some type of treatment. Option 6 combines sanitation and trenching and, like infusion/injection (options 4 and 5), is aimed more at preventing root transmission of the pathogen. The cost estimate for this option is $436; however, it should be pointed out that this option could incur additional cost in cases where the irrigation system is damaged or has to be relocated. Option 7 is similar to option 6 but adds an additional level of protection by taking steps to suppress the ambrosia beetle population. The cost therefore increases from $436 to $505, with similar concerns regarding possible accrual of additional costs. Option 8 considers the situation in which the tree is properly disposed of and steps taken to suppress the ambrosia beetle population but no specific action is taken to limit possible root transmission. The estimated cost of this option is $169. Options 9 and 10 are similar in that they both encompass the full range of recommendations aimed at early detection and removal of infected trees and steps taken to suppress the ambrosia beetle population and prevent root transmission of LW. The costs for these options vary between $336 and $359. Save options 1 and 2, these options afford the highest level of protection and are cost effective as long as the number of infected trees remain fewer than 5. It bears repeating that consistent scouting and immediate implementation of tree destruction procedures is necessary for success.

Frequently Asked Questions

1. *How long does it take to infuse a tree with Tilt®?* Approximately 20 minutes is required to infuse one tree. However, experience has shown tree uptake of the fungicide may take between 20 minutes and over 24 hours per tree; infusion rates depend primarily upon the transpiration rate of the avocado trees, as well as, current weather conditions and tree water status.

   In general, trees that have recently received substantial water from rainfall and/or irrigation are in a physiological state capable of rapid transpiration on bright sunny days, and can absorb the fungicide relatively quickly. However, trees that have recently experienced drought or are under drought stress may have a low transpiration rate and take much longer to absorb the fungicide. The potential rate of transpiration generally increases with increasing temperature and decreasing relative humidity and generally decreases during cool weather and/or high relative humidity. Rootstock can also affect the rate of transpiration and avocado trees in Florida are commonly grafted onto seedling rootstocks, consequently there is a potential for trees to transpire at variable rates due to differences in genetics and the water conducting ability of the seedling rootstocks.

2. *Does injecting, rather than infusing, trees with Tilt® protect avocado trees?* There is clear evidence that infusion is superior to injecting trees with Tilt®, though a number of groves injected with Tilt® prior to and after LW infestation have remained LW free and controlled LW, respectively. It also appears diffusion of Tilt® fungicide throughout the tree is slow and the re-treatment interval shortened using injection.

3. *When is a tree considered positive for LW?* A tree is positive for LW when a proper xylem wood sample has been taken and submitted to either UF/IFAS TREC Diagnostic Lab (Homestead or Gainesville) or FDACS-Division of Plant Industry Lab (Gainesville) and determined through laboratory testing to be positive for the pathogen (*Raffealea lauricola*) that causes LW. Note that false negatives may occur because: (a) the amount of LW pathogen in a tree may be very small and unevenly distributed within the tree, (b) the wood sample may have been taken improperly, and/or (c) the wood sample may miss the location where the pathogen is present.

4. *When is an avocado grove positive for LW?* A grove is considered positive for LW when one or more avocado trees have tested positive for the pathogen causing LW.

5. *Does every tree in a grove that shows symptoms of LW have to be laboratory-tested to be assumed positive for LW?* No, not every symptomatic tree needs be laboratory tested for it to be assumed infected with the LW pathogen. The LW pathogen is capable of moving from a LW infected avocado tree to adjacent avocado trees via root grafts among trees. If one tree in the grove is confirmed as having LW, adjacent or nearby trees showing wilt, leaf desiccation, and tree die-back probably have LW. This is especially true if the grove has little to no history of Phytophthora root rot or other pathogen-induced decline and has not been recently flooded. We suggest that a newly LW symptomatic tree five or more rows away from a documented LW positive tree may warrant LW testing and documentation.

Conclusion

To control the spread of laurel wilt, implementation of early detection of the disease (frequent scouting), tree sanitation, prophylactic systemic fungicide treatment and ambrosia beetle control are recommended. Early detection of LW and destruction of affected trees is critical if disease spread is to be limited. The cost of controlling LW is relatively high and may be unsustainable for those groves where (a) fruit production is historically low; (b) multiple LW affected trees (hot spots) make implementing the sanitation plus fungicide and insecticide treatment uneconomic and; (c) prices for avocados are too low to make LW control economically sustainable. Several factors influence whether the grower will adopt a recommended practice/technology including economics and adoptability. Ultimately the decision as to whether or not to adopt a technology is a subjective decision made entirely by the grower and should be respected.

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