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Outreach
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Hemlock Woolly Adelgid Management and Quarantine Regulations Impacting Nursery Production

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Introduction. Hemlock woolly adelgid (HWA), *Adelges tsugae* (Annand), is an insect native to Japan, China, and the Pacific Northwest. The first population detected in the eastern United States was documented in Richmond, Virginia in 1951. Asian hemlock species are resistant to feeding damage by HWA, but on eastern [*Tsuga canadensis* (L.) Carrière] and Carolina hemlock (*Tsuga caroliniana* Englem) HWA can cause death of even large and healthy trees. Worldwide, there are nine *Tsuga* species, however, HWA has only been problematic with eastern hemlock and Carolina hemlock.

In the decade following its discovery in the eastern US, HWA was recognized only as an ornamental and landscape pest of minimal importance. In the 1960s, HWA infestations were observed in forest

ecosystems in the Blue Ridge Mountains, VA, and the severity of HWA's outbreak intensified. Once HWA was introduced into native stands of hemlocks, it was able to spread more quickly. Native hemlock species exhibited severe stress and mortality in forest ecosystems as the insect spread. Spread of HWA is aided by wind, including extreme weather events, such as hurricanes, birds, deer, logging activities and movement of other hemlock wood products.

HWA Distribution. Hemlock woolly adelgid has expanded its range in the eastern US from Virginia to other states, including Connecticut, Delaware, District of Columbia, Georgia, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, and West Virginia (Fig. 1).

HWA Lifecycle. Hemlock woolly adelgids produce two generations per year: a short-lived progrediens generation and a longer-lived sistens

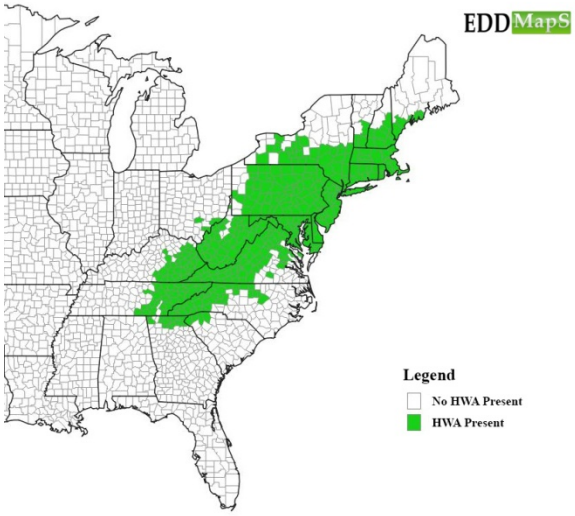

Figure 1. Map of HWA range in the eastern United States (©EDDMapS).

generation. In early spring, the progrediens generation hatches and lives approximately 3 months with each nymph producing 25 - 125 eggs. The sistens generation hatches in late spring, remains dormant until late fall, lives approximately nine months, and each nymph produce 50-175 eggs. The first-instar HWA nymphs, also called crawlers, are the only mobile phase (Fig. 2a). While crawlers do not move far on their own, they can be passively dispersed by wind, wildlife, and movement of infested nursery plants. Crawlers seek feeding sites at the base of hemlock needles (Fig. 2b). HWA inserts

their straw-like mouthparts into the hemlock and begin feeding on carbohydrate-rich fluids near the xylem. As HWA grow they progress through four larval instars, and produce "wool," which is a wax-like protective material. Hemlocks begin to decline once HWA nymphs deplete carbohydrate reserves. HWA feeding causes decreased growth, reduced ability to move water, bud death, less twig flexibility, and reduced mechanical strength of needles. Visible symptoms of an infestation are graying needles, dead branches, and canopy thinning. Hemlocks may die in as little as 2-4 years after initial infestation. Hemlocks in the southern US die more rapidly because winter temperatures are not cold enough to reduce HWA populations.

Scouting for HWA. Scouting for egg sacs and crawlers to treat early in an infestation can improve management success. In Tennessee, scouting should begin in winter and continue through early spring. HWA infestations are easily recognizable by their white, woolly egg sacs and crawlers on branch tips (Fig. 3). Branches with graying foliage may indicate an infestation and if present, HWA crawlers will be feeding at needle cushions at the base of needles in early spring. **Management of HWA in Nurseries.** In nursery production, treatment

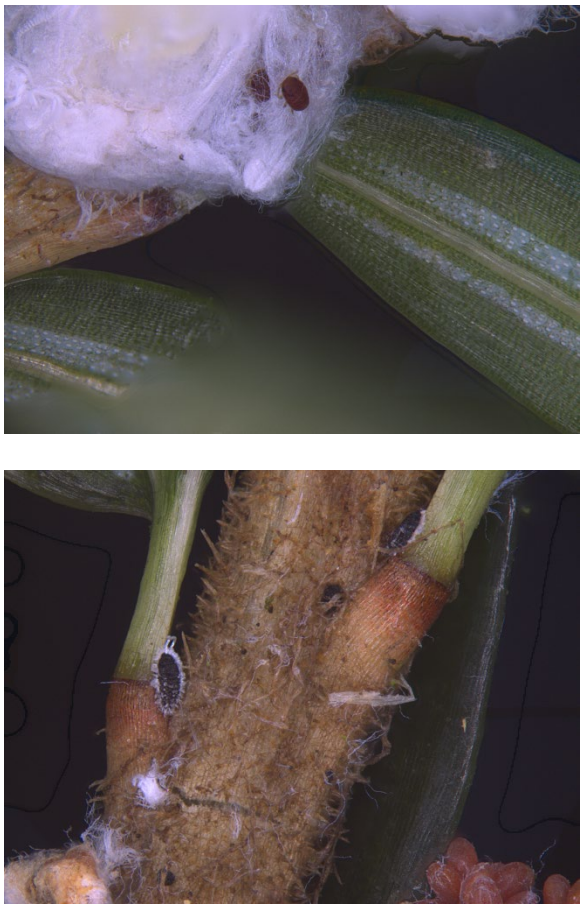

Figure 2. HWA crawlers emerging from wool (top). Second instar HWA nymph feeding at base of needle (bottom).

Figure 3. Adult HWA with woolly egg sacs.

options include either foliar sprays or systemic drenches of insecticides. The best time for foliar treatments is early spring when first generation crawlers are most vulnerable. Systemic insecticide drench applications are another option for season-long control.

Localized infestations may be removed with pruning before treating the entire plant.

Insecticides suitable for treatment of hemlock under nursery conditions include the active ingredients acetamiprid, imidacloprid, dinotefuran, bifenthrin, spirotetramat and horticultural oil (Table 1). All of these products provide over 95% control for up to 46 days post application. Additionally, all of these products and application methods prevent second generation HWA establishment, with the exception of bifenthrin and horticultural oil. The longevity of many of these season long products permits growers to manage HWA with a single application in the spring when first generation HWA are most vulnerable. Dormant applications of horticultural oil are an inexpensive and effective way to prevent HWA establishment in production and should be considered as an annual prevention treatment for both HWA and mites.

If a fast acting treatment is required, foliar applications of spirotetramat or dinotefuran are options for growers wanting to treat and ship plants quickly.

Several other products are labeled for adelgid control in nursery crops but have not been tested on HWA (Table 2). These products include additional neonicotinoids (thiamethoxam), pyrethroids (*tau*-fluvalinate), neonicotinoid-pyrethroid combination products, the anthranilic

diamide chlorantraniliprole, abamectin, azadirachtin, various carbamates, organophosphates and insecticidal soaps. More research is necessary to evaluate the effectiveness of these other products on HWA.

The most effective management programs will include the use of a systemic product for long residual control and a foliar application of a contact product prior to shipment. Rotation of products with different modes of action (different IRAC code numbers) and the use of horticultural oil are recommended to slow pesticide resistance development in HWA. Proper irrigation of hemlock trees will aid in uptake of systemic treatments and mitigate water stress caused by HWA infestations allowing for faster tree recovery.

HWA Quarantine Regulations. All hemlock producers are required to follow state-level quarantine restrictions in order to limit movement of HWA into non-infested areas. Currently, six states in the United States and Canada have quarantines that restrict the movement of hemlock plants from infested areas. States with quarantines include Maine, Michigan, New Hampshire, Ohio, Vermont, Wisconsin and all of Canada (Table 3). Areas of the country that these states will reject shipments of hemlock from include all or parts of Alaska, California, Connecticut, Delaware, Georgia, Idaho, Kentucky, Massachusetts, Maryland, Maine, Montana, North Carolina, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, Vermont, Washington, West Virginia, and British Columbia in Canada. Regulated items may include live HWA insects, propagated materials of *Tsuga* spp. (hemlock), *Picea jezoensis* (Yeddo spruce), and *Picea polita* (Tiger-tail spruce); Christmas trees; fresh wreaths, foliage and branches; forest products with bark attached (logs and lumber); bark chips; wood mulch with bark; firewood; and dried branches. Non-regulated items may include seeds, cones, debarked

wood or lumber, processed wood material (banisters, flooring, furniture, etc.), railway ties, wood mulch without bark, composted wood mulch with bark, wood shingles and shakes, wood shavings or wood chips without bark and wood packaging material.

Specific guidelines for each state must be followed if hemlock materials are shipped to those locations (Table 4). Restrictions may differ whether shipping from infested to infested areas, infested to non-infested areas, and non-infested to non- or infested areas. Some states prohibit all hemlock material or restrict only materials from infested counties or some infested and adjacent counties. Some states require phytosanitary certificates whether or not the products were produced in an infested county. Rules for using insecticides on live hemlock material may be included in the quarantine guidelines. Additional restrictions may apply to how hemlock is shipped through infested areas. For example, states may require the trees to be shipped in a closed box trailer. Additionally, shipments of hemlock may require a second inspection upon arrival to ensure no HWA arrived on the shipment. If HWA is observed on received materials, single plants or entire shipments may be destroyed. Additional regulations may be placed on the sale of hemlocks by nurseries and landscapers, including Record of Sale requirements. Nursery growers who wish to ship hemlock are obliged to follow the most up-to-date treatment and certification guidelines for each quarantine location.

Rules for treating hemlock shipments and quarantine areas are updated regularly. The quarantine summary provided here is only a guide, because the actual quarantine regulations are the law and supersede any information provided in this publication. For the most up-to-date information on quarantines and shipment certification, contact your state department of agriculture inspection service.

Table 1. Product information and efficacy data following a single treatment application to nursery grown 7-gallon hemlock [1]

Product	IRAC	Active Ingredient	Application Method[1]	Application Rate	Percent Control	
					1st Generation (42 DAT)	2nd Generation (154 DAT)
TriStar® 30SG	4A	acetamiprid	Foliar	8 oz/100 gal	100%[3]	100%
Talstar® F	3A	bifenthrin	foliar	0.22 oz/gal	97%[3]	50%
Safari® 2G	4A	dinotefuran.	granular	2.6 g/gal	100%	100%
Safari® 20 SG	4A	dinotefuran	foliar	8 oz/100 gal	100%[3]	100%
Marathon® 1% G	4A	imidacloprid	Granular	5 g/gal pot	100%	100%
CoreTect™	4A	imidacloprid	tablet	5 tablets/pot	98%	100%
Marathon® II	4A	imidacloprid	foliar	1.7 oz/100 gal	96%[3]	100%
Horticultural Oil	NA	paraffinic oil	Foliar	1.5 oz/gal	100%	0%
Kontos™ (Low Rate)	23	spirotetramat	foliar	1.7 oz/100 gal	99%[3]	100%
Kontos™ (High Rate)	23	spirotetramat	foliar	3.4 oz/100 gal	100%[3]	100%
Kontos™ (Low Rate)	23	spirotetramat	drench	0.006 oz/gal of pot	98%[3]	100%
Kontos™ (High Rate)	23	spirotetramat	drench	0.01 oz/gal of pot	100%[3]	100%

[1]Data summarized from Frank and LeBude. 2011

[2]drench and granular are soil media applications; foliar is a foliar spray

[3]Significant reduction in live insects within 24 hours post treatment

Table 2. Products available for management of adelgid species[1] in nursery, landscape, greenhouse, interiorscapes forests, and Christmas trees[2]

IRAC #	Active Ingredients	Activity	Selected Trade Names[3]	Use Sites[4]	R.E.I. (hours)
1A	carbaryl	contact	Sevin SL Sevin T&O	LFC N	12
1B	chlorpyrifos	contact	Dursban 50W	N	24
	oxydemeton methyl	systemic	Harpoon	LFC	0
			MSR Spray Concentrate	NC	10-18 days
3A	bifenthrin	contact	OnyxPro	LNI	12
	tau-fluvalinate	contact	Mavrik Aquaflow	LGNI	12
3A+4A	bifenthrin + clothianidin	contact/systemic	Aloft LC, G, LC, SC	L	N/A
	bifenthrin + imidacloprid	contact/systemic	Allectus SC	LI	N/A
	cyfluthrin + imidacloprid	contact/systemic	Discus N/G	NGI	12
	lambda-cyhalothrin + thiamethoxin	contact/systemic	Tandem	L	N/A
	zeta-cypermethrin + bifenthrin + imidacloprid	contact/systemic	Triple Crown T&O	LI	N/A
4A	acetamiprid	contact	TriStar 8.5 SL	LNG	12
	dinotefuran	contact/systemic	Safari 2G; 20 SG	LNGI	12
			Zylam Liquid	L	12
			Transtect 70	LF	N/A

	imidacloprid	contact/systemic	Xytect 75 WSP; 2F	LNGI	12
			Marathon II; 60 WP	NGI	12
			Merit	LIF	N/A
			CoreTect	LNGIF	N/A
			Discus Tablets	NG	12
	thiamethoxam	contact/systemic	Flagship 25 WG	NGC	12
			Meridian 0.33G; 25 WG	LI	N/A
6	abamectin	systemic	Aracinate TM	LNGIF	N/A
23	spirotetramat	contact/systemic	Kontos	NGI	24
28	chlorantraniliprole	contact/systemic	Acelepryn	LI	N/A
Unknown	azadirachtin	contact	Azatin O	LNGI	4
			Tree-Azin	LF	Until dry
Unclassified	horticultural oil	contact	Ultra-Pure Oil	LNGIC	4
	insecticidal soap	contact	M-Pede	LNGI	12

[1]Products listed are labeled broadly for adelgids, but not necessarily tested on HWA.
[2]Always check product labels for up-to-date product use restrictions.
[3] Trade names are provided as examples only.
[4]Use site codes: L = landscape, N = nursery, G = greenhouse, I = interiorscape, F = Forest, C = Christmas trees

Table 3. Regulated areas in the United States and Canada under various quarantine programs[1,2]

Country	State	Counties
United States	AK	All Counties
	CA	All Counties
	CT	All Counties
	DE	All Counties
	GA	Dade, Dawson, Fannin, Gilmer, Habersham, Lumpkin, Murray, Pickens, Rabun, Stephens, Towns, Union, Walker, White
	ID	All Counties
	KY	Bell, Breathitt, Carter, Clay, Elliott, Fayette, Floyd, Harlan, Jackson, Johnson, Knott, Knox, Laurel, Lawrence, Lee, Leslie, Letcher, Madison, Martin, McCreary, Menifee, Morgan, Owsley, Perry, Pike, Powell, Pulaski, Rockcastle, Rowan, Whitley, Wolfe
	MA	All Counties
	MD	All Counties
	ME	Androscoggin, Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, York
	MT*	All Counties
	NC	Alamance, Alexander, Alleghany, Ashe, Avery, Buncombe, Burke, Caldwell, Caswell, Catawba, Cherokee, Clay, Durham, Forsyth, Graham, Haywood, Henderson, Iredell, Jackson, Macon, Madison, McDowell, Mitchell, Orange, Polk, Rockingham, Rutherford, Stokes Surry, Swain, Transylvania, Wake, Watauga, Wilkes, Yancey
	NH	Belknap, Carroll, Cheshire, Hillsborough, Merrimack, Rockingham, Strafford, Sullivan
	NJ	All Counties
	NY	Albany, Bronx, Broome, Cayuga, Chemung, Columbia, Delaware, Dutchess, Erie, Greene, Kings, Livingston, Monroe, Nassau, New York, Orange, Otsego, Putnam, Queens, Rensselaer, Richmond Rockland, Schenectady, Schoharie, Schuyler, Seneca, Steuben, Suffolk, Sullivan, Tioga, Tompkins, Ulster, Westchester, Wyoming, Yates
	OH	Hocking, Lawrence, Meigs, Monroe, Vinton, Washington
	OR	All Counties
	PA	Adams, Allegheny, Beaver, Bedford, Berks, Blair, Bradford, Bucks, Cambria, Cameron, Carbon, Centre, Chester, Clarion, Clearfield, Clinton, Columbia, Cumberland, Dauphin, Delaware, Elk, Fayette, Forest, Franklin, Fulton, Huntingdon, Indiana, Jefferson, Juniata, Lackawanna, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Warren, Wayne, Westmoreland, Wyoming, York

	RI	All Counties
	SC	Greenville, Oconee, Pickens, Spartanburg
	TN	Anderson, Bledsoe, Blount, Campbell, Carter, Claiborne, Cocke, Cumberland, Fentress, Franklin, Grainger, Greene, Grundy, Hamblen, Hamilton Hancock, Hawkins, Jefferson, Johnson, Knox, Loudon, Marion, McMinn, Monroe, Morgan, Pickett, Polk, Putnam, Rhea, Roane, Scott, Sequatchie, Sevier, Sullivan, Unicoi, Union, Washington
	VA	Albemarle, Alleghany, Amherst, Appomattox, Arlington, Augusta, Bath, Bedford, Bland, Botetourt, Buchanan, Buckingham, Campbell, Caroline, Carroll, Chesterfield, Clarke, Craig, Culpeper, Dickenson, Essex, Fairfax, Fauquier, Floyd, Fluvanna, Franklin, Frederick, Giles, Grayson, Greene, Hanover, Henrico, Henry, Highland, King William, Lee, Loudoun, Lunenburg, Madison, Montgomery, Nelson, Northumberland, Orange, Page, Patrick, Pittsylvania, Prince William, Pulaski, Rappahannock, Roanoke, Rockbridge, Rockingham, Russell, Scott, Shenandoah, Smyth, Spotsylvania, Tazewell, Warren, Washington, Wise, Wythe
	VT	Bennington, Windham, Windsor
	WA	All Counties
	WV	Barbour, Berkeley, Boone, Braxton, Cabell, Clay, Fayette, Grant, Greenbrier, Hampshire, Hardy, Harrison, Jackson, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marion, Marshall, Mason, McDowell, Mercer, Mineral, Mingo, Monongalia, Monroe, Morgan, Nicholas, Pendleton, Pleasants, Pocahontas, Preston, Putnam, Raleigh, Randolph, Ritchie, Roane, Summers, Taylor, Tucker, Tyler, Upshur, Wayne, Webster, Wirt, Wood, Wyoming
Canada	BC	All Counties

[1]Canada lists Montana as subject to its import quarantine.

[2]Quarantined regions as of 13 Oct. 2018. Check with your state plant inspectors for updates on quarantined areas.

Table 4. Hemlock Quarantines and Regulations

Location	Regulated Items	Rules Summary[1]	Regulatory Documents
Maine	*Tsuga* spp. (hemlock); seedlings, nursery stock, and any hemlock wood products with bark such as, but not limited to logs, lumber, chips, and uncomposted shipments of bark	No hemlock imports from infested counties to uninfested counties; shipments from non-infested counties require phytosanitary certificate	01-001 Department Of Agriculture, Conservation & Forestry Division of Animal & Plant Health. Chapter 266: Hemlock Woolly Adelgid Quarantine. http://www.maine.gov/dacf/php/horticulture/importinghemlocks.shtml accessed 16 Nov 2018
Michigan	HWA in any living form; *Tsuga* spp. (hemlock) and *Picea polita* (Tiger-tail spruce); nursery stock, uncomposted chipped/shredded/ ground or otherwise mechanically processed products bearing twigs or needles, including branches, boughs, logs, lumber and firewood	No hemlock imports from infested or adjacent counties; hemlocks moved from infested counties within the state require compliance agreement; hemlocks from non-infested areas into state are exempt	Michigan Department of Agriculture and Rural Development, Pesticide and Plant Pest Management Division. Hemlock Woolly Adelgid Interior State Quarantine. 5 June 2017. Michigan Department of Agriculture and Rural Development, Pesticide and Plant Pest Management Division. Hemlock Woolly Adelgid Exterior State Quarantine. 24 June 2014 http://www.michigan.gov/mdard/0,4610,7-125-2390_46323---,00.html
New Hampshire	*Tsuga* spp. (hemlock); seedlings, nursery stock, and any hemlock wood products with bark such as, but not limited to logs lumber,	No hemlock imports from infested counties; shipments from non-infested areas require phytosanitary certificate	State of New Hampshire, Department of Agriculture, Markets and Food, Department of Resources and Economic Development, Hemlock Woolly Adelgid Quarantine, Joint

	chips, and uncomposted shipments of bark		Quarantine No.1. February 2014 Revision. https://www.agriculture.nh.gov/divisions/plant-industry/hemlock-woolly-adelgid.htm
Ohio	HWA all life stages; *Tsuga* spp. (hemlock) seedlings, nursery stock, logs, lumber or chips with bark, uncomposted bark, branches	No hemlock from infested counties; shipments from non-infested counties require a phytosanitary certificate	Hemlock Pest. Ohio Administrative Code. Chapter 901:5-48. http://codes.ohio.gov/oac/901%3A5-48
Vermont	Hemlock seedlings, nursery stock, logs, lumber with bark and chips	No hemlock from infested counties; shipments from non-infested counties require a phytosanitary certificate	State of Vermont, Agency of Agriculture and Department of Forests, Parks and Recreation. Joint Quarantine #2 - Hemlock Woolly Adelgid. http://fpr.vermont.gov/node/1114
Wisconsin	Hemlock seedlings, hemlock nursery stock, hemlock logs or lumber with bark; uncomposted hemlock chips with bark, uncomposted hemlock bark	Hemlock shipments from infested counties require a phytosanitary certificate, inspection, and if needed, require treatment; compliance agreements	Hemlock Woolly Adelgid Quarantine Requirements. https://datcp.wi.gov/Pages/Programs_Services/HWAQuarantine.aspx
Canada	*Tsuga* spp. (hemlock), *Picea jezoensis* (Yeddo spruce), and *Picea polita* (Tiger-tail spruce); seedlings, nursery stock; Christmas trees; fresh decorative wreaths, foliage and branches;	Hemlock from non-regulated areas of the U.S. to all areas of Canada require phytosanitary certificate	D-07-05: Phytosanitary requirements to prevent the introduction and spread of the Hemlock Woolly Adelgid (*Adelges tsugae* Annand) from the United States and within Canada.

	forest products with bark attached such as logs and lumber with bark; bark chips; wood mulch with bark; firewood; and dried branches	Hemlock from regulated areas of the U.S. to regulated areas of Canada requires a phytosanitary certificate with declaration of insecticide treatment Hemlock from regulated areas of Canada to non-regulated areas of Canada requires movement certificate with declaration of insecticide treatment Hemlock from non-regulated areas of Canada to all areas of Canada are exempt	Effective Date: May 15, 2015. 3rd Revision. http://www.inspection.gc.ca/plants/plant-pests-invasive-species/directives/forestry/d-07-05/eng/1323754212918/1323754664992#c2

[1]A detailed explanation of rules and restrictions can be found in the Quarantine guidelines for each location. Check documents for full details and latest updates.

For additional information, contact:

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Precautionary Statement

To protect people and the environment, pesticides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store or dispose of a pesticide. According to laws regulating pesticides, they must be used only as directed by the label.

Disclaimer

This publication contains pesticide recommendations that are subject to change at any time. The recommendations in this publication are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. The label always takes precedence over the recommendations found in this publication. Use of trade, brand, or active ingredient names in this publication is for clarity and information; it does not imply approval of the product to the exclusion of others that may be of similar and suitable composition, nor does it guarantee or warrant the standard of the product. The author(s) and Tennessee State University assume no liability resulting from the use of these recommendations.

This publication also contains a summary of quarantine regulations available for various states and Canada. These regulations could be subject to change at any time, so you should check regularly. The quarantine summary provided here only as a guide, and the actual quarantine regulations are the law and supersede any information provided in this publication.

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