Practical Armored Scale Management

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Armored scales are small insects that feed by inserting their sucking mouthparts into the needles of trees and withdrawing the contents of plant cells. They are named for the waxy "test" or armored cover that protects the soft-bodied insect. Armored scales are distinguished from soft scales by the characteristic that the test is not attached to the scale body. Therefore, we can evaluate whether armored scales are alive or dead by flipping the scale cover over and observing the condition of the scale insect underneath.

Armored scales typically have two generations per year, with a life cycle consisting of eggs, immature nymphs (two stages for females, up to four for males) and adult males and females. Adult males have two wings and only function to fly to and mate with the sessile females that remain under the test. Mature scales or scales with their eggs pass through the winter. Eggs are protected under the mother scale's cover. Hatchlings are oval, yellowish-white and mobile. Called crawlers, they are tiny enough that they can become airborne; these are the only dispersive stage.

Unlike other sucking insects like aphids and adelgids, which excrete honeydew as a waste product, armored scales inject their waste and toxic saliva back into the plant, which causes injury to the surrounding tissue. Often, armored scale damage is characterized by splotchy yellow, white or brown spots on foliage, poor growth and, sometimes, needle loss. Most species of Christmas Trees are susceptible to economically significant injury from some species of armored scales. True firs and Douglas-fir are attacked by two species – elongate hemlock scale and cryptomeria scale – both of which are native to Asia. Spruces are damaged by hemlock scale, and certain species of pines are damaged by pine needle scales (two species), which are native to North America.

Fig. 1. Male and female elongate hemlock scales have distinctively different appearances; this image shows the more numerous female scales. Males produce white wax "wool" that some may confuse with adelgids. This wool rubs off on neighboring foliage to leave a grayish film. This species is principally a pest on true firs and Douglas-fir.

Shortcomings of Conventional Management Methods

For many years, there have been two basic approaches for managing armored scales in Christmas Trees: full foliar sprays of insecticides to intercept and kill crawlers as they move on the surface of the plant; or use of systemic insecticides (products that are transported in the sap of the tree) to kill the scales as they feed upon the plant. Systemic products with which growers may be familiar are disulfoton (Di-

Syston® granules), which were applied to the soil and then picked up by the tree's root system, and dimethoate (Cygon® and other trade names), which was applied through multiple foliar sprays.[1] Older materials that are used to target the crawlers included chlorpyrifos (Lorsban® and other names). All of these materials are organophosphate insecticides, which have been greatly restricted for use in Christmas Tree plantations because the U.S. EPA considers them to pose a significant risk to applicators and wildlife. (They tend to be toxic to birds and fish).

For several years I have been investigating alternatives to these insecticides with the following objectives for finding superior products:

- lower toxicity to applicators
- selectively kill scales rather than their predators and parasites
- acceptable cost
- low toxicity to birds, fish and pollinators that may be found in the row middles
- good efficacy with as few applications as possible
- low potential to cause phytotoxicity.

As a result of these tests, I have systematically eliminated many potential options from serious consideration for managing armored scales. For example, horticultural oil, which is a standard treatment for managing armored scales on many ornamental landscape plants, is impractical in Christmas Tree plantations because:

1. The mode of action, suffocation, requires nearly perfect spray coverage. Because scales develop on the undersides on needles, and often older needles on the lowest whorls of the trees, obtaining perfect spray coverage is practically impossible and so the effectiveness of these sprays suffers.

2. Many species of Christmas Trees are injured by horticultural oil. For example, Douglas-fir becomes chlorotic, and true firs have to be sprayed during dormancy to prevent yellowing of the current season's growth.[2]

Based on their use in IPM programs in other crops, some insecticides would appear to have good prospects in Christmas Tree scale management. Two examples are the insect growth regulators buprofezin (Talus®) and pyriproxifen (Esteem®).[3] In my trials, however, Talus was ineffective. Esteem required two applications to provide significant benefit and was harsh on an important parasitic wasp. A new systemic insecticide, spirotetramat (Movento®) was also ineffective.

Successful New Options

Two approaches that I have worked on appear to be practical for managing armored scales:

1. A basal bark spray with dinotefuran (Safari®) and
2. A full foliar spray with bifenthrin (OnyxPro®, Talstar® or a generic equivalent).

These methods each have their own strengths and weaknesses so it is important that growers recognize these limitations and use the most appropriate strategy.

Basal Bark Spray with Safari

Dinotefuran (Safari) is a neonicotinoid insecticide. Registration specifically for its use on Christmas Trees is pending with the EPA; until then certain states may allow its use based on nursery or ornamen-

Fig. 2. Cryptomeria scale are extremely damaging because they build up to such high populations on foliage, their feeding quickly causes spotting on foliage, and high populations will cause needle loss. These are especially damaging on true firs. The translucent scale cover allows you to look through to see the yellow scale body underneath, giving it a "fried egg" appearance. The yellow dot in the center of the scale is also a good identifying characteristic.

Fig. 3. The hemlock scale is injurious to all spruces. These scales are easily recognized by the dark brown (almost black) scale cover with a white dot in the center. The bit of white projecting from the side of the scale is an insect pathogenic fungus that can also kill elongate hemlock and cryptomeria scales.

tals registrations. This class of systemic products only moves upward in plants. It is highly water soluble, which both presents some risk of potential leaching in soil and also gives it rapid mobility within Christmas Trees. In trials I conducted in 2008 and 2009, I found that this insecticide was efficiently absorbed through bark and transported in sap to the foliage where it then killed armored scales.

When targeting cryptomeria and elongate hemlock scales in Fraser firs, this product was most effective when applied as a basal bark spray during a window of opportunity in Connecticut that lasted from before bud break (late April) to mid-June. Between mid-June and mid-July, the effectiveness rapidly diminished.[4] Experiments in eastern hemlock trees have shown it to be highly effective against armored scales when applied in basal bark sprays in September so autumn applications should be investigated for Christmas Trees, too.

There are several advantages to applying this product as a basal bark spray, rather than as a full foliar spray (which can also be effective if there is thorough spray coverage).

- The risk of leaching is mitigated due to minimal soil contact.
- Because it only moves upwards and outwards in the trees, a basal spray can reach all the foliage.
- There is no exposure of pollinators.
- There is minimal exposure of the worker to the residues while spraying.
- Because residues on the plant surface are so limited, a basal trunk spray is compatible with beneficial predators and parasites.

Safari is a relatively expensive insecticide and, therefore, it was important to determine the minimum dosage resulting in acceptable scale control. My dose-response experiments were conducted in a Choose & Cut field where the trees varied from 3 to 8 feet tall. When I collected data, I kept the samples from 4-, 5-, 6- and 7-foot-tall trees separate and I was able to analyze the influence of tree height on insecticide effectiveness.

One equation described most of the variation in the experiment, and we now have a model that can be used to predict the amount of insecticide required to treat trees of various sizes. Essentially, systemic insecticides are diluted within the living tissues of the tree. The amount of living tissue (and, therefore, an effective dose) is approximately proportional to the cube of the tree height. The consequence of this functional relationship is that small trees (4 or 5 feet tall) should effectively be treated with about 0.5 lb. of Safari 20SG per acre, 6-foot trees with about 0.75 lb., and trees taller than 7 feet will require 1 lb. or more per acre. Because this constitutes a steep increase in expense as trees increase in size, the Safari basal trunk spray is probably best used in trees 6 feet or shorter. However, dinotefuran can effectively control scales on even the largest trees, if adequate product is used.

Most fields have varied sizes of Christmas Trees. The basal trunk spray is readily adjusted to have the dose match the size of each tree. Many growers are using a 3-gallon backpack sprayer and a wand fitted with a pressure-regulating controlled flow valve (14 or 21 psi). An appropriate mixture to use is 3.5 oz. of Safari 20 SG in 3 gallons of water. When fitted with a vertically-oriented flat fan nozzle (Spraying Systems 6503E or 6504E), the sprayer can be precisely calibrated so that 0.5 fl. oz. are delivered to the base of the trunk of the tree from one side (this is calibrated for 6-foot-tall trees). Addition of surfactants to this spray mixture does not enhance absorption into the trees. The operator then walks slowly down one side of a row of trees, spraying only the base of the trunks, and then walks up the other side of the same row to complete the spray so that the entire circumference of the tree trunks is treated.

The objective is to simply wet the base of the tree trunk from the ground level to about 10 inches in height. Less time is required to spray smaller trees, so the dosage will automatically be adjusted for trees 6 feet in height or shorter. For trees taller than 6 feet, the operator needs to slow down and spray a wider band – perhaps a 15-inch band on 7-foot-tall trees and a 20-inch band on 8-foot trees.

Unfortunately, newly hatched scales have to feed to ingest a toxic dose of dinotefuran. Especially for cryptomeria scale, this can lead to a subtle mottled foliage discoloration. For trees that have not reached marketable size, this is acceptable, because subsequent growth of foliage can be kept free of damage.

Bifenthrin as an Effective Crawler Spray

One of the problems with earlier products used to kill crawlers (dimethoate and chlorpyrifos) is that they only provided about two to three weeks of protection to trees. For example, to effectively manage scales with dimethoate, growers sprayed three times four weeks apart or four times three weeks apart. Bifenthrin, a pyrethroid insecticide, can provide up to six months of residual insecticidal activity. When growers need extended periods of protection from insect damage, one application of bifenthrin can take the place of several sprays of other products. Examples of applications for this product include protection of roots from white grub damage by doing a root dip at the time of planting, a leader spray for white pine weevil and a stump spray to kill pales weevils, and a full foliar spray at bud break to kill Douglas-fir needle midge adults.[5, 6] Other pyrethroid products have similar characteristics (such as lambda-cyhalothrin, labeled in Canada), but OnyxPro is a bifenthrin product registered for Christmas Tree use in the United States and has been the focus of my research efforts.

Because bifenthrin has such broad spectrum activity, growers need to recognize that full foliar sprays using this insecticide will kill virtually every insect and mite – pests and beneficials alike. Furthermore, because they are such effective products, pyrethroids select very intensely for resistant populations of insects and mites. In other crop systems, when pyrethroid resistance has occurred, pests are much more difficult to manage because there is no longer an effective biological control "safety net." Therefore, whenever possible, I suggest that more selective products be used rather than pyrethroids. However, when there is a large complex of pests involved, or trees are of salable size, I believe that use of a non-selective insecticide is justified. Customers dislike when beneficial predators (spi-

ders and lacewings) exit trees indoors, and a "clean-up" spray in the year prior to harvest is useful for avoiding the resulting complaints.

Advantages of using the bifenthrin foliar spray are:

1. It is relatively inexpensive.
2. An entire complex of pests present at bud break (spruce spider mite, balsam twig aphid) and later (scale crawlers) can be managed with one spray.
3. Crawlers moving through bifenthrin residues die before feeding and causing needle discoloration.

The principal disadvantage with this approach is that very thorough spray coverage is required. Adequate spray distribution generally requires some sort of air-assisted spray technology, such as either backpack or tractor-driven mist blower sprayers. The swirl of air allows small droplets to impact on the undersides of foliage, where crawlers are active. If the spray just deposits on the upper surfaces of needles, then bifenthrin selectively kill predators and parasites rather than scales, which causes the scale outbreak to worsen.

A practical concern is optimum spray timing when using bifenthrin for a crawler spray. Generally, one spray applied at bud break will be adequate and will control the various other pests, too. However, crawlers will occasionally settle under the mother scale's cover. These are protected from contact by bifenthrin and point out the advantages of using systemic insecticides. For heavily infested plantings, growers have found that two years of effort are usually required with Safari and/or OnyxPro to clean up scale infestations; larger trees prove especially difficult in which to achieve satisfactory results.

Other considerations

Here are several other cultural practices that may help to reduce the overall impact of scale insects.

- Consider growing even-age stands of trees. This may mean clear-cut harvesting infested blocks of trees to make a clean start for the next crop cycle. This avoids planting clean nursery stock next to heavily infested larger trees, which leads to rapid infestation of the young trees.
- Eliminate scale populations on small trees. It is relatively inexpensive and easy to kill scales on small trees. If they are kept clean until they are 5 feet tall, then it is unlikely that extraordinary efforts will be necessary to clean them up for market.
- If your fields have adjacent alternate hosts for scales (such as eastern hemlocks), then treat these trees with a basal bark spray of Safari to prevent re-infestation.
- Basal prune trees when they are about 4 feet tall. Maintain an herbicide strip within the tree rows. These efforts make conducting a basal trunk spray much easier.
- Use minimal applications of nitrogen. Most Christmas Trees are native to and are adapted to growing in nitrogen-poor areas. Excess nitrogen in foliage leads to better survival and faster population growth of spider mites, adelgids, aphids, and scales.

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