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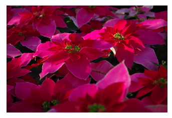

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Mealybugs and Systemic Insecticides

By Amy L. Willmott and Raymond A. Cloyd

Mealybugs, one of the most damaging insect pests, can be difficult to mitigate. This study will help determine factors that will improve the efficacy of systemic insecticides.

Mealybugs are one of the most destructive insect pests of greenhouse and interior plantscape environments. One of the commonly encountered mealybug species of greenhouses is the citrus mealybug, Planococcus citri (Figure 1). Citrus mealybugs are considered phloem-feeders like aphids, whiteflies, leafhoppers and soft scales. The phloem is the food-conducting tissue of plants. Citrus mealybugs withdraw plant fluids directly from the phloem sieve tubes using their stylet-like mouthparts.

Mealybugs can cause both direct and indirect damage to plants. Direct damage occurs during feeding on plant vascular tissues, which results in plant stunting, wilting, yellowing of leaves, leaf drop and possibly plant death. Indirect damage is associated with the excretion of honeydew, a clear sticky liquid that is an ideal growing medium for black sooty mold fungi, which can reduce the ability of plants to photosynthesize. Mealybug populations are difficult to mitigate with insecticides because they spend some or all of their life cycle in inaccessible areas on plants such as leaf junctures and on the underside of leaves, which may be extremely difficult to reach with sprays of contact insecticides especially when plants have complex plant architectures (many branches and leaves) (Figure 2).

Despite this, insecticides, including those with contact and also systemic activity, are still primarily used to control or regulate citrus mealybug populations. Systemic insecticides are applied preventatively to the growing medium as a drench or granule for uptake or absorption via the roots, and then translocated throughout the plant through the vascular system. Most systemic insecticides are translocated through the plant via the transpiration stream, which is the movement of water through the plant by means of the xylem or water-conducting tissues. They are primarily active on xylem and phloem-feeding insect pests with piercing-sucking mouthparts such as aphids, whiteflies, mealybugs, leafhoppers, planthoppers and soft scales, as these insect pests feed exclusively within the xylem vessel elements or phloem sieve tubes. During the feeding process, these insects withdraw and ingest lethal concentrations of the systemic insecticide's active ingredient and are subsequently killed.

There are a number of advantages associated with using drench or granular applications of systemic insecticides compared to foliar sprays. For instance, drench applications reduce exposure to workers and natural enemies such as parasitoids and predators. In addition, systemic insecticides are translocated through the plant vascular system including the xylem and phloem, protecting growth that would have been missed when applying a contact insecticide, as well as any new growth following an application. This may provide protection for extended periods of time. Furthermore, applying systemic insecticides, as drenches or granules, reduces the amount of material lost due to evaporation, light degradation and irrigation (wash-off).

Factors that may impact the effectiveness of systemic insecticides in regulating insect pest populations include plant species, plant age, water solubility, growing medium type, transpiration rate (movement of water through the xylem) and insect pest feeding behavior. It is the last factor, insect pest feeding behavior, that we wanted to investigate and determine if this actually influences the efficacy of systemic insecticides. In greenhouse production systems, systemic insecticides are commonly used to control or regulate populations of phloem-feeding insects such as the citrus mealybug. However, minimal information is available on the actual efficacy of systemic insecticides against citrus mealybugs. Therefore, we conducted a number of experiments to assess the effectiveness of systemic insecticides against the citrus mealybug and to also quantify the feeding location (plant stem, leaf top and leaf bottom) on coleus (Solenstemon scutellarioides) plants.

For the sake of brevity, all four experiments were conducted in a greenhouse at Kansas State University (Manhattan, Kan.). We evaluated the following systemic insecticides: azadirachtin (Azatrol), spirotetramat (Kontos), imidacloprid (Marathon II), dinotefuran (Safari) and thiamethoxam (Flagship). Both azadirachtin and spirotetramat were applied before (preventatively) and after (curatively) coleus plants were infested with citrus mealybugs whereas the neonicotinoids (imidacloprid, dinotefuran and thiamethoxam) were applied preventatively and then the residual activity was recorded for seven weeks. In all the experiments, labeled rates were used and citrus mealybug feeding location (plant stem, leaf top and leaf bottom) was recorded.

Results and Discussion

In both experiments associated with azadirachtin and spirotetramat, the level of citrus mealybug mortality for both green and red coleus was less than 30 percent across all three weeks as either preventative or curative treatments. Both active ingredients have very low water solubilities (azadirachtin=0.50 ppm and spirotetramat=29 ppm), which likely influenced their movement throughout the plant and thus ability to control or regulate citrus mealybug populations during the three-week period. Most mealybugs were located on the plant stem for the green coleus, and both the plant stem and leaf bottom for the red coleus (Figures 3 and 4). For the experiments with neonicotinoid insecticides imidacloprid, dinotefuran and thiamethoxam, citrus mealybug mortality was highest 21 and 28 days after treatment for all three systemic insecticides with thiamethoxam and dinotefuran providing the highest mortality (more than 60 percent); however, mortality declined substantially 35, 42 and 49 days after treatment (Figure 5). Both thiamethoxam and dinotefuran were numerically higher in regards to citrus mealybug mortality than imidacloprid 21 days after treatment, which is likely related to the differences in water solubility among the three systemic insecticides: thiamethoxam (4,100 ppm), dinotefuran (39,000 ppm) and imidacloprid (510 ppm). Most of the citrus mealybugs were located on the plant stem for all the treatments (Figure 6).

So, why were the systemic insecticides not effective against the citrus mealybugs? First, the lack of effective control may be associated with the feeding behavior of the insect as citrus mealybugs tend to congregate on plant stems, which may allow them to avoid ingesting lethal concentrations of the active ingredient. Furthermore, it is possible that systemic insecticides are primarily located within the xylem of stems where the main transport within the plant occurs. In addition, it may be that the leaves act as a sink for the insecticide, and once the insecticide reaches the sink, then there is movement from the xylem to the phloem, thereby affecting phloem-feeders more effectively. In fact, the phloem-feeders may avoid higher doses because the movement of the insecticide between the xylem and phloem is not as pronounced compared to the insecticide residues at the sink area.

Second, citrus mealybugs may be less susceptible to systemic insecticides than aphids and whiteflies, which could be affiliated with their feeding behavior that is different in the number and length of time of intracellular punctures and stylet mobility during the phloem-searching process. This may impact the ability of systemic insecticides to provide sufficient control or regulation of citrus mealybug populations. Also, females that are producing eggs or offspring (young) do not feed, and with an extended egg-laying period of at least four weeks, the female may survive and continue to lay eggs beyond the residual activity of the systemic insecticide. Another important factor to consider that may impact the effectiveness of systemic insecticides, although not related to feeding behavior, is the plant growth stage. For example, if plants are in the reproductive phase or flowering then this may influence the rate of transpiration. Plants typically transpire less during flowering, which would negatively affect the movement or translocation of the systemic insecticides within the plant tissues. Therefore, reduced transpiration would lead to less absorption of the active ingredient by the roots, thus less active ingredient would be translocated throughout the plant, resulting in less control or regulation of citrus mealybug populations.

It has been suggested that timing of application may influence the efficacy of systemic insecticides, as applications conducted during late fall through winter may be less effective than applications made in spring through summer. This is due to the higher amount of sunlight and thus light intensity, and longer days, which could affect the transpiration rate. For instance, systemic insecticides have been demonstrated to be less effective when applied in January or February compared to applications made March through August. In our study, preventative treatments of azadirachtin and spirotetramat were applied in March whereas curative treatments were applied in May. The preventative treatments (March-April) resulted in less than 20 percent mortality, and the curative treatments (May-June) resulted in less than 30 percent mortality. As such, there were no differences in citrus mealybug mortality between azadirachtin and spirotetramat. The experiment with the neonicotinoid insecticides was conducted from July through September, with the highest citrus mealybug mortality (77 percent) provided by thiamethoxam. In previous research, we have shown that light intensity may influence the uptake of systemic insecticides thus affecting their ability to control or regulate populations of phloem-feeding insect pests including whiteflies and mealybugs.

In conclusion, feeding behavior may impact the effectiveness of systemic insecticides in regulating populations of the citrus mealybug. In our study, most citrus mealybugs were located on the plant stem and were alive with females laying eggs, which indicates that citrus mealybug may not be ingesting lethal concentrations at this location or an insufficient concentration of active ingredient is being translocated through the stem. Further research is being conducted to evaluate the effect of systemic insecticides on the citrus mealybug and quantify the concentration of active ingredient in plant tissues where citrus mealybugs tend to feed.

PDF: Mealybugs and Systemic Insecticides

Amy L. Willmott and Raymond A. Cloyd
Amy L. Willmott is research associate and Raymond A. Cloyd is professor and extension specialist in the department of entomology at Kansas State University. Cloyd can be reached at rcloyd@ksu.edu.

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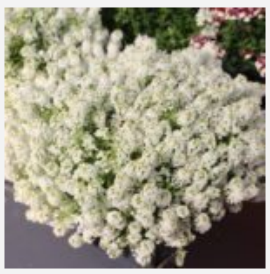

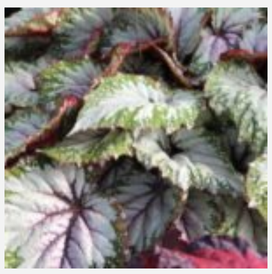

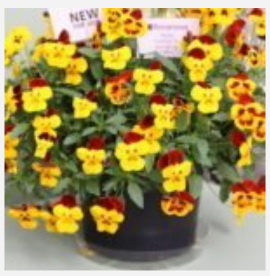

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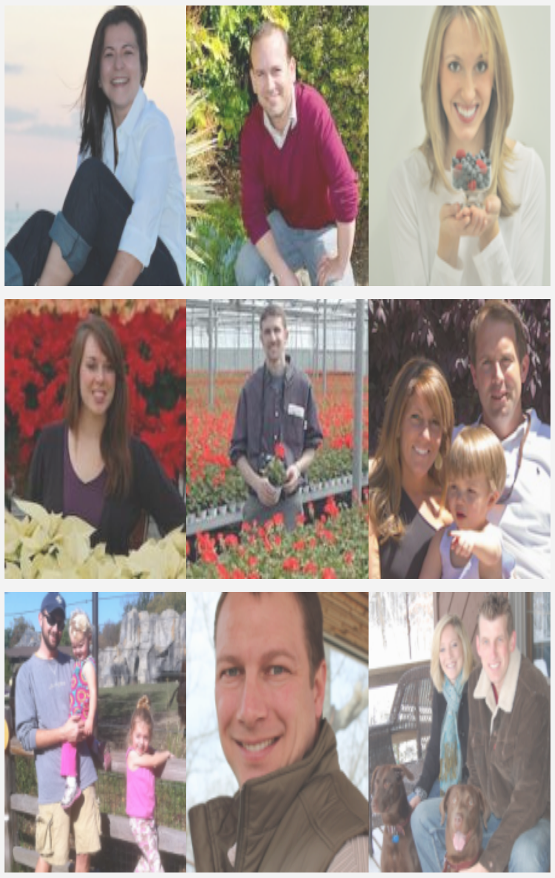

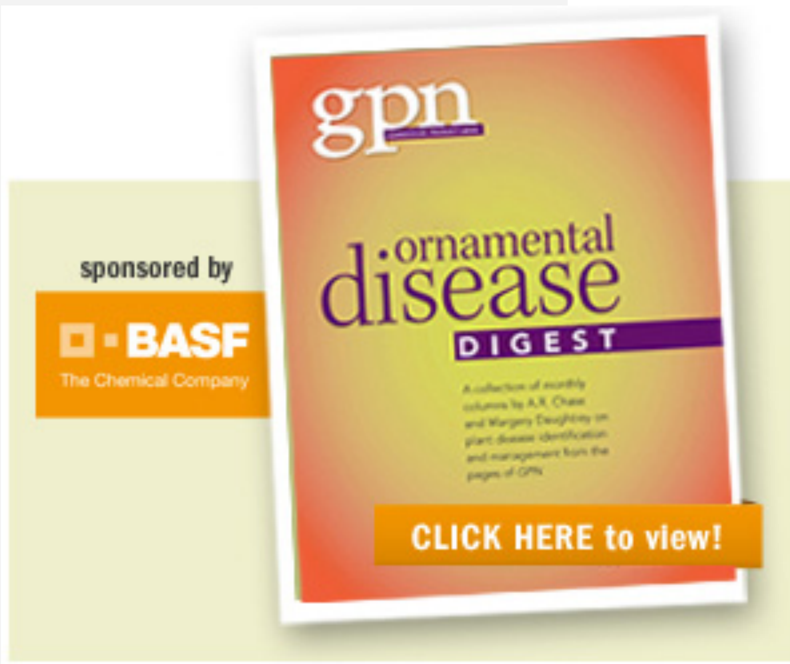

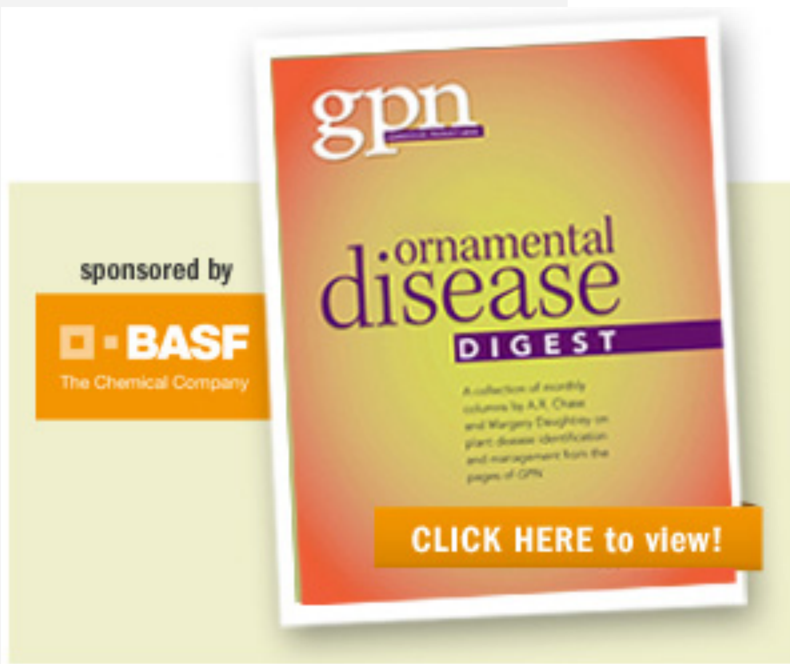

75 Applewood Drive, Suite A
P.O. Box 128
Sparta, MI 49345

frontdesk@greatamericanpublish.com

616.887.9008