

Greenhouse Pest Message, April 1, 2025
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Controlling pathogens is a constant challenge in greenhouse production. Fogging has become a popular method of applying fungicides, and has received widespread attention in the greenhouse industry. Fogging applications have been used in agriculture and pest control for over a century. There are a few historical examples that show how fogging has been used in the past. Carbolic acid was misted in the operation room during surgeries to minimize bacteria; formaldehyde was used to fog mushroom production houses, poultry farms, and citrus packing sheds to control pathogens; schools are fogged with hydrogen peroxide to minimize viruses; greenhouses were fogged with nicotine (now banned by EPA) and sulfur to reduce insect pressure; potato and onion storage sheds are thermal fogged with Sprout Nip to prevent early sprouting. The effectiveness of a fine mist application to control pathogens is evident in all these contexts. These treatments have primarily been for insects and improving plant physiology. Early research showed distinctively that fogging of nicotine was effective to control insects in the greenhouse, however, comparisons with conventional sprays were not made. Despite the importance of this application method, limited academic research has been conducted to verify the current control levels being observed in practice with fogging of fungicides.



Photo: Examples of different models of thermal and cold fogging machines used in greenhouses.

Currently, greenhouses and high tunnels in Connecticut use fogging as a pest management tool. The fungicides are mixed and loaded in a DRAMM autofogger or other model that uses pressurized air, and applied to the entire greenhouse. Droplet size from these machines ranges from 1-50 μl , with mean droplet size $\sim 20 \mu\text{l}$. The fine mist of fungicides spreads to all corners of the greenhouse. The fungicides are mixed either by volume or area, in very low amounts of water (Ultra Low Volume). Growers consider the greenhouse size, the volume of water/acre (usually below 15 gal), and volume output. Fogging is a great tool because products can be applied at night (improving timing for REIs), additional applicators are not necessary, and less total product is needed.

There are some challenges specific to fogging. Fungicides that have clay in the formulation may be difficult to apply with the fogger. There are Do Not Fog lists that are

available that are usually based on the product consistency. Fungicide formulations are made for 1) convenience, 2) stability, 3) compatibility, and 4) biology. Fogging as a method of application has not received as much attention by chemical companies; most fungicides are designed for conventional sprayers. For example, China clay is added to formulations to improve suspension in dilute sprays, and active ingredients that are more soluble in oil are formulated as ECs. Since ULV sprays are highly concentrated, it is important they do not sediment out of suspension. Agitation improves the suspension and fog, and fogging machines often come with an agitator. Sometimes oils can be added to ULV applications to improve visibility. The crop being treated can also influence the application success. A waxy leaf will retain fine droplets, however, leaves with micro-hairs may reflect the droplets. If the leaf or greenhouse surfaces have water droplets and condensation, these can absorb fungicides, limiting distribution. Additionally, fogging raises the humidity of the growing area, causing the plant stomata to open, increasing transpiration.



Photo: Seedlings under fog; properly spaced fans that can help to improve airflow and fog movement in the greenhouse.

A major challenge for greenhouses that use fogging is that the labels are often vague for this treatment method. Even in Europe, where fogging is widely used, the labels often contain limited information on this topic. One of the reasons is the large expense and area needed to run a “fog trial” successfully. If you see fogging listed on a label, it is unlikely that the product was tested in a university study *for efficacy*. Providing full coverage does not mean that there is disease control. An interesting study from California looked at fogging disinfectants in packing houses. The authors found that the toxicity of the disinfectant did not relate to its effectiveness, likely because of other properties (such as distribution, persistence, droplet size, or vapor pressure). This is likely true in the greenhouse as well.

A common concern with fogging is worker safety. Prior research showed that nicotine air concentrations remained below risk level 1 hour after the application, however, wipe samples indicated significant exposure risk remained (broom handle, hose, window crank, manager desk, vinca plant, top of fridge). Fogging is not a targeted spray, and residues will appear everywhere in the enclosed structure. Studies with fluorescent dye found all surfaces coated in the

greenhouse, however, with stationary foggers the heaviest deposition was still ~5 meters in front of the fogger.

Mixing and loading for fogging will take trial and error and on-farm testing. Current recommendations from pulsFog suggest applying products to area or volume, with recommendations for g/mL product per 1000m² or 3000m³. According to Royal Brinkman from the Netherlands, the fog treatment is by volume, while Dramm recommends applying by area, and provides detailed instructions (link below). Companies providing foggers always recommend testing the product before widespread use, to limit potential phytotoxicity, which has been observed on some petals and flowers.

Fogging best practices:

- Install fans to improve coverage and airflow.
- Higher humidity levels in the greenhouse will reduce rapid evaporation of the fungicide.
- Fogging cuts the fungicide rate, but some pathogens require a higher ai rate for effective control than they would receive with a conventional spray.
- WPs and clay formulations may clog the fogger orifice.
- Plants closest to the apparatus will have more coverage, use fans as needed to improve coverage.
- The undersides of leaves usually are not covered.
- Carrier solutions are available for certain formulations to improve coverage.
- Fogging is a great way to apply sanitizers and disinfect the greenhouse.
- Follow PPE recommendations for WPS. For ex. T-methyl concentration decreased 99% in air samples by 3h after application.

Some additional links on fogging below:

<https://gpnmag.com/wp-content/uploads/ColdFogging.pdf>

<https://www.bfgsupply.com/media/3259/fogging-fact-sheet.pdf>

<https://www.dramm.com/media/MLVH-MAN1.pdf>