



Greenhouse Cleaning and Sanitation: What's Out There for Green Growers?

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Growing conditions are critical for growing healthy greenhouse plants but, unfortunately, most other life forms, including pathogens, insects, algae and weed growth also favor these conditions. This means, growers have to clean and sanitize to keep pests in check. Spending a little extra time cleaning the greenhouse can save a significant amount of time and money on pest management and produce healthy plants for market.

Visible algae, weeds, soil and plant debris in greenhouses are not only unsightly, but can act as an alternate host environment for pests and pathogens. Algae are a diverse group of organisms that can thrive in various environments such as water, hard surfaces, soil, etc. In greenhouse production, algae are typically seen growing on benches, floors, walls, irrigation lines and on growing media. Water and light, coupled with an ample nutrient source, creates good conditions for algae growth. Algae mats on surfaces of growing media can impede water and nutrient transfer. It also acts as a breeding ground for nuisance pests in greenhouses, such as fungus gnats and shore flies. In irrigation lines, algae growth can cause issues such as clogged filters and reduced water flow. In addition, extreme growth on walkways can be a safety hazard for workers.

Weeds in crop containers or on benches, work tables and floors can be unsightly and compete with water and nutrients applied to growing plants. In addition, weeds can harbor and serve as alternate hosts for some of the major greenhouse pests such as thrips, whiteflies, mites and viral pathogens such as Impatiens Necrotic Spot Virus (INSV) and Tomato Spotted Wilt Virus (TSWV).

Disinfection is critical to prevent plant pathogens, especially plant viruses that can easily spread from plant to plant through contaminated tools. Unlike plants infected with bacterial and fungal pathogens, once plants are infected with a viral disease, they cannot be saved and must be destroyed. Therefore, it's very important to follow preventative sanitation measures to avoid introduction of the virus particles into the greenhouse in the first place. Also, fungal pathogens such as *Rhizoctonia* and *Thielaviopsis* can spread through the soil and plant debris attached to pots and flats and cause plant root infections.

Growers also have to adopt chemical control measures for effective cleaning and sanitation/disinfection. Even though a wide variety of sanitizers/disinfectants are available in the market, the potential toxicity for some of these chemistries and their long residual nature in the environments has made the greenhouse community look for effective yet safer chemistries that are easy on plants, humans and the environment. Some of the available green chemistries and their functions are listed in Table 1.

Any successful chemical sanitation/disinfection program usually involves a thorough pre-cleaning step. This step helps in improving the efficiency of the applied sanitizer by reducing the sanitizer demand created from gross contamination. Pre-cleaning involves sweeping up any loose soil and plant debris on the floors, work benches, tables and using chemical cleaners (alkaline/acid based detergents) to remove any hard organic or inorganic deposits.

Peracetic Acid (PAA) based sanitizers/disinfectants like BioSafe Systems SaniDate 12.0, are excellent alternatives to traditional chemistries (Table 1). They are organic approved, non toxic and have a very short half life in the environment. PAA is very effective on a broad range of microorganisms (vegetative bacterial cells, endospores, yeasts, mold spores and viruses) and algae (Figs. 1 and 2). They work through the oxidation of the outer cell membranes of microorganisms (with the exception of viruses in which the mode of action is not yet clear) and algae resulting in immediate inactivation or death of target cells/particles. PAA based products have shown to be effective disinfectants on plant pathogens like *Botrytis cinerea* (Copes, 2004), *Thielaviopsis basicola* (NCSU, 2003), and Tobacco Mosaic Virus (Lewandowski and Adkins, 2009).

PAA can be applied as a sanitizer/disinfectant using a 200-400 PPM concentration immediately after the pre-cleaning step. Apply as a spray or dip on to surfaces to be treated ((benches, work tables, floors, walls, growing media in pots/containers (do not use > 60 PPM PAA when applying to growing media surface)) with a minimum of 10 minutes of contact time. Allow surfaces to air dry without any water rinse. On floors, walkways and walls follow with a power spray wash as required. Alternatively, PAA can be injected into the power spray wash at 200-400 PPM. For treating non-porous surfaces, such as wooden benches, the addition of a compatible non-ionic surfactant is recommended to reduce the surface of the applied spray and better penetration into the pores. As a tool or implement disinfectant, PAA can be applied as a dip using 200-400 PPM PAA with a 30 second to one minute contact time.

Sodium Percarbonate (SP) such as GreenCleanPRO from BioSafe Systems is another green option for algae control on hard surfaces (Table 1). SP is a white granular form of hydrogen peroxide designed for use as an algaecide on hard surfaces and water treatment applications. The alkaline nature of the product coupled with the presence of hydrogen peroxide as an oxidizer, makes it a powerful algaecide. GreenCleanPRO can be applied anytime during growing season and in between crops as a broad cast on wet surfaces (floors, walkways, benches, etc). Upon contact with water, SP granules release hydrogen peroxide and start oxidizing the algae that is visible through the release of bubbles. Dead algae needs to be removed with high pressure spray.

Cultural methods of weed control, such as manual removal can be labor intensive and time consuming. There are a limited number of herbicides that are approved for use inside greenhouses. Ammonium Nonanoate, the active ingredient in AXXE from BioSafe Systems is one such organic approved herbicide available for greenhouse growers to control both broadleaf and grass weeds (Table 1). It's a C-9 saturate-chain fatty acid soap salt and classified as a post emergent contact burn down herbicide. Results are normally seen within 24-48 hours after a single application (Fig. 3). Ammonium Nonanoate is non-volatile and biodegrades quickly in the environment with a very short half life.

Adopting greener practices for all aspects of plant production is the new mantra, and fortunately the industry has some options for the growers to head in this direction.

Table 1. Available Green Products from BioSafe Systems for Cleaning and Sanitation of Greenhouses*

Active Ingredient (s)	Product	Product Application	Use Rate(s)	Application Method
Hydrogen Peroxide (18.5%) + Peracetic Acid (12.0%)	SaniDate 12.0	Hard Surface Sanitizer/Disinfectant + Algaecide	1:600 (0.21 fl. oz. per gallon of water)	Spray or Dip with a minimum contact time of 10 minutes
Sodium Percarbonate	GreenCleanPRO	Algaecide	1.0-2.0 lbs. per 1,000 sq. ft. of treated surface	Apply as dry granules on wet surfaces with a contact time of up to 1 hr followed by power wash
Ammonium Nonanoate	AXXE	Broad spectrum Herbicide	6.0%-15.0% v/v	Apply as targeted spray directly on to weed

*For more specific information about each of the listed products in the table, please refer to the product specimen label

Figure 1. Peracetic Acid on Algae on Growing Media
 Untreated (Left) Treated (Right)



Figure 2. Peracetic Acid on Algae on Hard Surface
 Untreated (Left) 48 hrs after Treatment (Right)

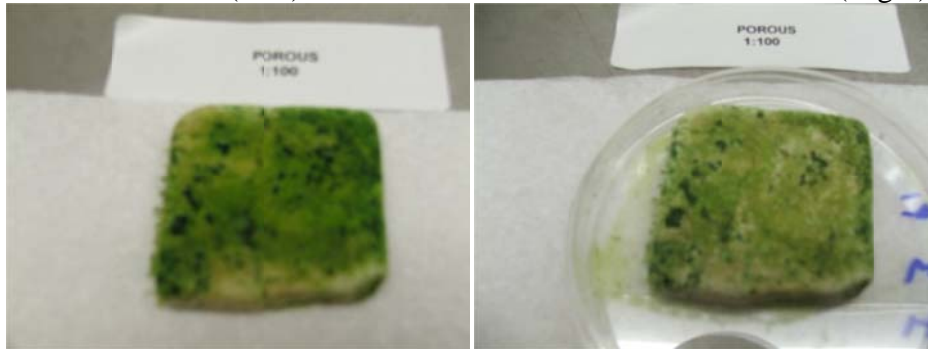


Figure 3. Ammonium Nonanoate Herbicide (AXXE) on Broad Leaf Weeds
 Before Treatment (Left) Immediately after Treatment (Middle) 48 hrs after Treatment (Right)



Product	Size	Item No.	Price
SaniDate 12.0	30 gal	71-35351	\$1,028.31
GreenCleanPRO	50 lb	74-20521	\$109.83
AXXE	2.5 gal	72-1050	\$197.85



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