Greenhouse and Nursery Water Treatment Information System

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Stabilized Hydrogen Peroxide

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Background

Hydrogen peroxide (H_2O_2) is a strong oxidizer that forms when water combines with ozone in the atmosphere. The bonds that hold the hydrogen and oxygen atoms together (Fig.1) in H_2O_2 are unstable, which causes the molecule to break along the oxygen-oxygen bond, releasing free hydroxyl radicals (OH) that serve to oxidize organic matter.

Fig 1. Hydrogen peroxide molecule (Wikimedia commons)

As with most other chemical water treatment methods, hydrogen peroxide disinfects by oxidizing the cell membranes and inner cell structures of pathogens, destroying them.

Due to efficacy issues with pure hydrogen peroxide solutions, many hydrogen-peroxide based disinfection products also incorporate stabilizers such as silver ions, to produce a more stable and powerful disinfectant (Toté et al., 2009). This form of hydrogen peroxide degrades slower, allowing it to have a residual effect. This means it remains in the water in low concentrations all the way down the irrigation line for a certain period of time, allowing for extended disinfection throughout the system.

Another variety of hydrogen-peroxide based disinfectants involve activation using acid addition, to form a compound called peroxyacetic acid. The information below deals primarily with other stabilized hydrogen peroxide disinfectants. Hydrogen peroxide-based disinfectants can vary widely in composition, which may affect phytotoxicity potential and effectiveness. It is important to examine technical information provided by the producer to determine if a product is right for your intended application.

Application method

Hydrogen peroxide compounds are sold in liquid or granular form. They can be applied to irrigation water via an injector system. This system must incorporate a special injector that is resistant to corrosive chemicals and has a high injection ratio (Fisher, 2011). Dosing of high concentrations (shock treatment) can be used to clean the irrigation system. Alternatively, for control of pathogens, low concentrations can be applied in a continuous treatment (Nederhoff, 2000).

Safety concerns and handling information

Concentrated hydrogen peroxide should not be mixed with any pesticides or fertilizers, due to its nature as a strong oxidizer (Fisher, 2011). It may also eventually cause breakdown of plastic greenhouse structures via oxidation (Stewart-Wade, 2011). Proper safety measures must be taken when handling.

Hydrogen peroxide tends to break down fairly quickly to water and oxygen, and as such poses no danger to the environment (EPA, 2002).

Critical Levels for Pathogens

To our knowledge, no official studies on the effectiveness of non-peracid hydrogen peroxide based disinfectants (ex. silver stabilized hydrogen peroxide) for treating greenhouse pathogens have been performed, as the majority of hydrogen peroxide disinfectants are peracid-based. For more information on critical levels for peracid/peroxyacetic acid go here. However, it is likely that critical levels for various pathogens will differ between peroxyacetic acid products and stabilized hydrogen peroxide products.

The product Huwa-san (a silver stabilized hydrogen peroxide) has been shown to be effective for disinfection in other systems (Toté et al., 2009), and has reportedly been used in greenhouse systems. Further studies are needed to determine critical levels required for control of certain pathogens.

Critical Levels for Plants

As with other chemical oxidizers, hydrogen peroxide degrades all organic material, including that of living plant tissue. As such, an excessively high concentration will be harmful to plants. There is very little information available on the phytotoxicity of hydrogen peroxide. The table below summarizes the findings of the studies that have been performed.

Plants	Critical Level (ppm)
Lettuce Seedlings (Nederhoff, 2000)	HP: 85
Hydroponic Lettuce (Nederhoff, 2000)	HP: 8
Cucumber in rockwool (Vanninen and Koskula, 1998)	125

It should be noted that these phytotoxicity levels are for peracid disinfectants, as opposed to other forms of stabilized hydrogen peroxide. As stabilized hydrogen peroxide often incorporates potentially toxic ions, it is likely to have some phytotoxic effect, although how critical levels would compare to peracids is currently unknown. It is recommended, as with any water treatment method, that the producer perform a phytotoxicity test on a small group of plants under simulated production conditions prior to widespread application (Fisher, 2011). This is particularly important for hydrogen peroxide due to the lack of information on phytotoxicity.

Monitoring

Test strips are currently the most convenient means of measuring hydrogen peroxide concentration in the irrigation solution (Nederhoff, 2000). Test strips typically cost approximately $1 per strip and can be purchased from producers such as Merck or Quantofix (Nederhoff, 2000).

In combination with other technology

Like other pathogen control methods that work through oxidation, presence of organic particles in irrigation water decreases the effectiveness of hydrogen peroxide-based disinfection. As such, this method should be combined with a filtration system for any water source that may contain particulate organic matter (Newman, 2004). The number and fineness of filters needed will depend on how "dirty" the water source being used is (see filtration).

Hydrogen peroxide technology (like ozone) can be combined with UV disinfection to increase its effectiveness. If hydrogen peroxide is injected before water is subjected to UV light, the UV light will break the bond between the oxygen molecules (decompose hydrogen peroxide), quickly producing hydroxyl radicals which are stronger oxidizing agents that the hydrogen peroxide itself (Runia and Boonstra, 2004). However, determining the appropriate initial hydrogen peroxide concentration is crucial as excess hydrogen peroxide will react with applied UV light, reducing the radiation available for pathogen destruction (Runia and Boonstra, 2004). Excess hydrogen peroxide that does not react with UV light may also produce phytotoxic effects when it reaches plants (Runia and Boonstra, 2004).

Combining ozone and hydrogen peroxide application (peroxone treatment) may also result in improved disinfection (EPA, 1999). The mechanics of this treatment are similar to those of combining UV-hydrogen peroxide treatment. Mixing hydrogen peroxide and ozone together in solution accelerates the decomposition rate of both (EPA, 1999). When these compounds decompose they produce the stronger-oxidizing hydroxyl radicals. By increasing decomposition rate, more hydroxyl radicals are present in solution at a certain time, and greater oxidation/disinfection can take place. To maximize disinfection potential, ozone should be added to the irrigation solution before the addition of hydrogen peroxide. Langlais et al. (2001) combined these treatment methods and successfully controlled various greenhouse pathogens using below-phytotoxic levels of hydrogen peroxide. At the same time, the beneficial microbial population of the growth media was maintained. However, because hydroxyl radicals degrade so quickly, monitoring residual levels is currently not feasible (EPA, 1999).

Cost for Technology

The use of any water treatment technology is dependent on the size of the production facility and the amount of water used. Below are tables that summarize the average water consumption and cost of the technology of a small, medium and large facility.

Size of Production Facility	Water Usage (litres/day) Greenhouse[1]	Water Usage (litres/day) Nursery[2]
Small	29,263 – 37,857	700,993 – 2,103,001
Medium	33,560 – 134,244	1,401,997 – 3,219,732
Large	117,057 – 151,431	1,609,854 - 4,829,610

Size of Production Facility	Cost Greenhouse (per day)[3]		Cost Nursery (per day)[3,4]	
	Capital	Operation (per day)[5]	Capital	Operation (per day)[5]
Small	$1500	$17 – 22	$3000	$280 - 620
Medium	$1900	$18 – 60	$3000	$500 - 900
Large	$2500	$55 – 70	$3000	$500 - 1100

1. Flowers Canada Growers. (2011). Website: http://flowerscanadagrowers.com
2. Canadian Nursery Landscape Association. (2011). Website: www.canadanursery.com/
3. Ranges have been estimated from a survey of companies and are only intended to give a rough idea of cost. To determine exact costs for your system, please contact a supplier.
4. Nurseries usually do not need to treat all their water, so nursery costs are likely overestimates.
5. Please note that operation costs of using HP can be significantly lower under circumstances which result in residual levels of product from initial application such as recycled water etc.

While installation of a hydrogen peroxide injection system is fairly inexpensive, the cost of the required chemicals (shown by operating costs) is high compared to other water treatment methods, especially considering the volume of chemical that must be added.

Costs- Maintenance

No complex machinery is required for applying hydrogen peroxide, which relieves some maintenance costs. However, undiluted hydrogen peroxide is corrosive, and as such may degrade pipes and other greenhouse structures not made from corrosion resistant materials. In this situation, eventually replacing these structures may be very difficult and costly. Certain plumbing fixtures, such as brass fittings, are not recommended to be used at the injection site. Each situation is different and each plumbing fixture affected will depend not only on compatibility but also on water chemistry, age of plumbing, etc. It is important to consult with professionals to advise on compatibility of existing plumbing and on optimum recommendations for the specific application and environment.

Pros and cons

Pros:

- Unlike some other chemical treatments such as chlorine, hydrogen peroxide degrades quickly, leaving no residual, and as such poses fewer environmental concerns (EPA, 2002)
- Effectiveness is relatively unaffected by pH changes, compared to some other oxidizers (Fisher, 2011)
- When hydrogen peroxide products degrade, oxygen, which can be beneficial to plants when located in the root zone, is produced (Fisher, 2011)

Cons:

- Lack of phytotoxicity data, even more so than for peroxyacetic acid products
- Like other oxidizers, water should be filtered beforehand to remove organic material that would otherwise reduce treatment efficacy (Fisher, 2011)
- Like other oxidizers, effectiveness is still somewhat affected by pH (optimum pH below 7.0) (Fisher, 2011)
- Corrosive, so may damage certain plumbing fixtures (Stewart-Wade, 2011)
- Like other oxidizing disinfectants, safe handling and storage may be difficult and ultimately costly (Stewart-Wade, 2011)

Summary

While stabilized hydrogen peroxide-based disinfectants ultimately have higher operating costs than some other chemical treatments, their main advantage is that they degrade faster and as such essentially pose no environmental hazard. These disinfectants are effective for surface disinfection, but their effectiveness for pathogen control throughout the irrigation system has yet to be quantified in the literature. As well, little phytotoxicity information is currently available. Caution should be taken when introducing these disinfectants, especially into hydroponic systems using inert/inorganic growing substrate where irrigation solution stays in direct contact with the root. A phytotoxicity test (as mentioned earlier) is recommended. Ultimately, to remove phytotoxicity risk, a system may be devised where residual hydrogen peroxide is removed prior to the water reaching the plants (Nederhoff, 2000). How stabilized hydrogen peroxide disinfectants compare to peroxyacetic acid disinfectants (ie. disinfectants that combine hydrogen peroxide and acid in terms of effectiveness/phytotoxicity/safety has yet to be thoroughly researched.

Suppliers

Some examples of suppliers of stabilized hydrogen peroxide products include:

Producer	Product name	Producer website
SanEcoTech	Huwa-San	http://www.sanecotec.com/

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