Greenhouse Vegetable Production

Moderator: Chris DiCicco

2:00 pm	ASD: Anaerobic Soil Disinfestation • Sally Miller, Ohio State University
2:30 pm	Producing High Quality Vegetable Transplants • Dr. Timothy Coolong, University of Georgia
3:00 pm	Worker Protection Standards for Greenhouse Workers (OH CORE, 0.5 hrs) • Ben Phillips, Michigan State University Extension
3:00 pm	Maximizing Greenhouse Production Efficiency • Ben Hartman, Clay Bottom Farms

ASD: Anaerobic Soil Disinfestation

Great Lakes Expo 2019
Sally A. Miller and Anna Testen*
Department of Plant Pathology
The Ohio State University, Wooster, OH 44691
miller.769@osu.edu; @OhioVeggieDoc; Ohio Veggie Disease News u.osu.edu/miller.769/
*Current address: USDA ARS, Plant Introduction Research Unit, Ames, IA 50011

Vegetable production in protected culture has increased in order to meet higher demand for local produce, capture lucrative early and late season markets, and reduce the impacts of climatic variability. Farmers often grow high value crops with few rotation options in greenhouses or high tunnels/hoophouses. The lack of rotation favors the buildup of soil pathogens, and soilborne disease complexes are an emerging problem. Key soilborne disease complex members in tomatoes in the Great Lakes Region include Verticillium wilt (*Verticillium dahliae*), corky root rot (*Pyrenochaeta lycopersici*), black dot root rot *(Colletotrichum coccodes)*, white mold (*Sclerotinia sclerotiorum*) and root knot nematodes (*Meloidogyne* spp.). Pythium (*Pythium* spp.) and Rhizoctonia (*Rhizoctonia solani*) root rots can also damage tomatoes and other crops grown in protected culture systems. Lettuce drop, caused by *S. sclerotiorum* and/or *S. minor*, is also an aggressive disease that can negatively impact lettuce production. *Sclerotinia sclerotiorum* has a broad host range and can damage any dicot vegetable crop under cool, moist conditions.

Managing soilborne diseases requires an active form of soil disinfestation to support sustained vegetable production. The utility of existing soilborne disease management options including fumigation, steam sterilization, and solarization is limited in protected culture production systems in temperate regions. Unlike these methods, anaerobic soil disinfestation (ASD) does not require chemical pesticide inputs, active use of fuel, or high soil temperatures to reduce soil pathogen populations. ASD is also effective in suppressing weeds common to vegetable production.

Anaerobic soil disinfestation requires amending soil with a carbon source, irrigating soil to saturation and tarping the amended area for several weeks with a plastic mulch. Carbon sources are usually agricultural byproducts such as wheat bran or middlings (midds), rice bran, molasses, or residues from cover crops. Soil microbes break down these carbon sources, depleting oxygen and producing toxic byproducts in the process. Unlike soil solarization, ASD does not require extremely high temperatures to kill soilborne pathogens, but higher temperatures are associated with higher levels of pathogen die-off. Higher soil temperatures are easier to achieve in protected culture systems than open field systems, even at early and late periods in the planting season.

Our research has shown that ASD significantly reduces the incidence and severity of tomato diseases including corky root rot, black dot root rot, and root-knot. The process also killed sclerotia of the white mold/lettuce drop pathogens and significantly reduced Rhizoctonia root rot. ASD also suppressed the germination of seed/tubers of common lamb's quarters, black nightshade, yellow nutsedge, American pokeweed and redroot pigweed. While numerous

amendments have positive effects as carbon sources in ASD, wheat bran and molasses have been the most effective in disease and weed suppression. Wheat midds are a less expensive alternative to wheat bran and provide similar results.

ASD is a relatively new tool and research is still underway to fully understand its benefits and limitations. We do know that ASD at least temporarily changes the composition of microbial communities in soil. The communities favored by anaerobic conditions suppress pathogens and weeds by production of toxic compounds such as volatile organic acids and may also compete for nutrients. Addition of amendments with a high C:N ratio may result in complexing of soil nitrogen through microbial activity, limiting nitrogen availability for the crop. Therefore, soil tests should be done after ASD and a source of nitrogen added if necessary to insure sufficient nutrient availability for the following crop.

For more information on soilborne diseases and ASD, see the following fact sheets:
https://ohioline.osu.edu/factsheet/hyg-3315 (ASD)
https://ohioline.osu.edu/factsheet/hyg-3314 (Tomato soilborne diseases)

Does it require a respirator?

2018 Worker Protection Standard respirator requirement guide for vegetable growers

Ben Phillips, MSU Extension; Deb Chester, MSU; Craig Anderson, Farm Bureau

The Worker Protection Standard and respirators

The Worker Protection Standard (WPS) is a regulation designed to protect farm workers from dangerous exposure to pesticides. A recent update in 2015 has aligned the WPS with most of the Occupational Safety and Health Administration (OSHA) provisions for using respirators. The revised WPS includes specific requirements for the use of respirators when using pesticide products under the Agricultural Use Requirements *that requires the use of a respirator*. This revision requires all those who mix, load and apply pesticides (including self-employed handlers) to have a medical evaluation, and annual fit-tests for each type of respirator required by the pesticide product label and annual training regarding the proper use of each respirator to be used by the handler.

Remember, the WPS does not apply when the pesticide is used in a manner not directly related to the *production* of agricultural plants and *post harvest treatments* of the harvested portions of an agricultural plant under the Agricultural Use Requirements on the pesticide label. When using a pesticide for uses other than those covered in the Agricultural Use Requirements section of the label, the worker exposure is subject to the requirements of the OSHA Hazard Communication Standard, and either MIOSHA Part 700 or Part 451, including the need for respiratory protection. The Safety Data Sheet for a pesticide would indicate if you need a respirator for non-agricultural uses.

Where can I find more Worker Protection Standards (WPS) resources?

Up-to-date pesticide resources can be found on the National Pesticide Safety Education Center website (https://npsecstore.com/) and the Pesticide Educational Resources Collaborative website (http://pesticideresources.org/).

Respirator label language

To find whether your pesticide requires a respirator to mix, load, or apply, see the Personal Protective Equipment (PPE) requirements listed in the Precautionary Statements section of the label in the ”Hazards to Humans (and Domestic Animals)” subsection.

The product formulation, toxicity, and type of application influence the type of respirator needed. Manufacturers use criteria approved by the EPA to assign PPE respirator requirements on labels. The respirator precaution statement can be very general, but some product statements can also be quite specific, with different instructions for mixers, loaders, applicators, and application type. Some may include details on half-mask or full-mask, and some may feature exemptions when using

engineered controls, such as closed or mechanical transfer mixing/loading systems, water-soluble packaging, or enclosed sprayer cabs.

Others may list multiple respirator options with National Institute of Occupational Safety and Health (NIOSH) respirator classes and filter series. Labels can be confusing because respirator terminology was changed by NIOSH. In 1995, NIOSH took over full responsibility for respirator certifications from the Mine Safety and Health Administration (MSHA). Some pesticide labels continue to use the old MSHA terms.

What is a respirator?

A respirator is a personal protective device that is worn on the face, covers at least the nose and mouth, and is used to reduce the wearer's risk of inhaling hazardous airborne particles (including dust particles and infectious agents), gases, or vapors. The many types of respirators available include (1) particulate respirators, which filter out airborne particles; (2) "gas masks," which filter out chemicals and gases; (3) airline respirators, which use compressed air from a remote source; and (4) self-contained breathing apparatus, which include their own air supply. Often, a Grade D air cylinder or an air compressor supplies the breathable air. The category of particulate respirator can be further divided into (1) disposable or filtering facepiece respirators, where the entire respirator is discarded when it becomes unsuitable for further use due to excessive resistance, sorbent exhaustion, or physical damage; (2) reusable or elastomeric respirators, where the facepiece is cleaned and reused but the filter cartridges are discarded and replaced when they become unsuitable for further use; and (3) powered air purifying respirators (PAPRs), where a battery-powered blower moves the air flow through the filters.

Filter Series

When the ambient air contains particulates (e.g. dusts, mists), air-purifying respirators use filters that are classified on the basis of oil degradation resistance and filter efficiency. To describe oil degradation resistance, NIOSH classifies a filter as N (not oil resistant), R (oil resistant), or P (oil proof). Among the N, R, and P series classes, there are also three filter trapping efficiency levels: 95, 99, and 100. A filter classified as High Efficiency (HE) can only be used on powered air-purifying respirators. Respirators that have particulate filters will not protect you against gases, vapors and the non-particulate components of fumes, mists, fogs, smoke and sprays.

Cartridges/Canisters

The terms 'cartridges' and 'canisters' are used interchangeably in air purifying respirators. They are both containers with a filter, sorbent or catalyst, or a combination of these items designed to remove specific contaminants from the air passed through the container. Often, a 'cartridge' is the term for a half or full-face respirator and a 'canister' is the term used for a gas mask. Essentially the terms are interchangeable. It is important to remember to *select the appropriate*

cartridge/canister for the contaminant in question. For example, a cartridge/canister specifically designed to remove organic vapors will not remove an acid gas or a particulate, a particulate cartridge will not remove organic vapors, and a cartridge/canister designed specifically for ammonia will not remove an organic vapor. You may require more than one cartridge to protect against multiple hazards; for example, you may need a chemical cartridge and a particulate filter in combination. Cartridges/canisters are color coded to help you select the appropriate one. You can find the color-coding requirements of labels for canisters and cartridges online from the OSHA Respiratory Protection Bulletin (https://www.osha.gov/dts/shib/respiratory_protection_bulletin_2011.html).

NIOSH TC Codes

What do NIOSH codes mean? A NIOSH TC-number is assigned to respirator masks and cartridges after they are reviewed and approved by NIOSH. There may be a filter series identifier (eg N95) as well. NIOSH approval numbers are for the entire respirator unit – you will void the approval if you use one manufacturer's mask and another manufacturer's cartridge/canister. You should use only NIOSH-approved respirators. The categories are as follows:

Air Purifying Respirators:

TC-84A: Non-powered dust/mist respirators with particulate filter or combination chemical cartridge with particulate filter are one the two most common styles of respirator required on pesticide labels. They are often a disposable facemask with or without a N, R or P designation, but may be a full or half-face mask with a N, R or P designated particulate-removing filter, **AND/OR** combination chemical cartridge or canister with an N filter.

TC-23C: Non-powered respirators with chemical cartridge or powered air-purifying respirators with chemical cartridge **OR** a particulate filter were one of the two most common styles of respirator required on pesticide labels. Older pesticide labels sometimes require an MSHA TC-23C respirator with both a chemical cartridge **AND** a particulate prefilter. *However, currently only TC-84A respirators are tested with combinations of filters and cartridges.* So, in these special cases where labels have not yet gone through the re-registration process, growers will actually be expected to use a TC-84A combo respirator, and not the TC-23C listed.

TC-21C: powered dust/mist particulate respirators (no chemical cartridge combination). These are half-face or full-face masks, hoods or helmets with a battery-powered fan that moves air through the filters and circulates it through the mask. High Efficiency filters selected for the contaminant(s) must be used with these types of respirators. These feature interchangeable cartridges for different particulate filter series and a pre-filter.

TC-14G: gas masks with canisters are sometimes listed as an option for certain soil fumigants. They are similar to full-face TC-23C respirators, but are designed

specifically for chemical gas or biological exposure. These feature interchangeable cartridges for different particulate filter series.

Atmosphere-Supplying Respirators:
TC-13F: self-contained breathing apparatus (SCBA) is an atmosphere-supplying respirator; the respirator face piece is connected to portable breathable air in cylinders carried on the back of the wearer.

TC-19C: supplied-air respirators (SAR) are an atmosphere-supplying respirator; the respirator face piece is connected to a "fixed" air source (not designed to be carried by the wearer).

EPA-approved medical evaluation forms

The Environmental Protection Agency (EPA)-approved medical evaluation forms are questionnaires that employees must fill out for a physician or other licensed health care professional (PLHCP) to review. The forms are available in English (http://pesticideresources.org/wps/hosted/medical-eval-english.docx) and Spanish (http://pesticideresources.org/wps/hosted/medical-eval-spanish.docx).

How employers must handle the forms. What do they need from you?

Sections 1 and 2 of Part A of the form are required by the law and must be completed in private by the employee during normal working hours or at a time and place that is convenient for them. While the regulation does not require all of the following information, the employer must complete the following information for the health care provider:

- The type and weight of respirator that the employee will use.
- How long and how frequently the employee will use the respirator.*
- How much physical work the employee will do while using the respirator.*
- Other PPE the employee will use.*
- The temperature and humidity extremes of the working environment.*

*Not required, but the questions can be found in Part B, Section 2 of the medical form.

The health care provider may determine that additional questions about the respirator activities are necessary and/or a physical examination. These could include the questions in Part B, Section 1, a pulmonary function test (PFT) or electrocardiogram (ECG). If an employee answers yes to questions 1-8 in Part A, Section 2, it is the employer's decision to allow any use of a respirator—i.e., transfer to other jobs that don't require one—before arranging for a follow-up medical exam.

How health care providers must handle the forms. What do you need from them?

The health care provider will give the employer and employee a written medical determination (medical release) of the medical evaluation results. An

employee cannot use a respirator until this written medical determination is received allowing such use. The determination will include the following information:

- Whether the employee is medically able to use a respirator.
- Any restrictions on the employee's use of the respirator.
- The need for follow-up medical evaluations.
- Verification that the health care provider has given the employee a copy of the written medical determination.

Once complete, employers must keep records of **the medical determination** listed above. It **should *not* include any** completed medical questionnaires or detailed notes from any additional medical examinations. That information is confidential and should not be in the possession of the employer.

Vegetable pesticides that require respirators

So, what commonly used pesticides labeled for vegetable use have respirator label language? You can view a list of 500 products, in order by trade name here: http://bit.ly/doineedarespirator. The chemicals on this list that do not require a respirator for agricultural production under WPS may still require a respirator for non-agricultural uses under OSHA's Hazard Communication Standard, MIOSHA Part 700 or Part 451. To find out if a non-agricultural use requires a respirator, look at the Safety Data Sheet. If the label did not require a respirator for agricultural use we indicated "no". If the label required any type of respirator for any or all processes we indicated "yes, see label". Always double-check the label and Safety Data Sheet that comes with your specific product and formulation.

Can I use it in the greenhouse?

A greenhouse chemical usage guide for vegetable growers

Author: Ben Phillips, MSU Extension; Craig Anderson, Farm Bureau

Pesticide use in the greenhouse

Vegetable growers often use greenhouses or hoophouses to start transplants for field production, or for full-season protected culture. Certain types of pests and diseases can be reduced in these controlled settings, but the occasional outbreak may require treatment from a pesticide. Vegetable transplants can sometimes benefit from preventative applications of a fungicide before they reach the field.

Many foliar-applied pesticides have longer residuals in certain greenhouse settings. Usually, pesticides degrade with exposure to sunlight. Greenhouses that use UV-blocking materials remove a large spectrum of light between 10 and 400 nm that we cannot see with our own eyes, but contributes to pesticide degradation. Therefore, sidewalls and coverings that block UV-light increase residual activity of pesticides. Glass and acrylic sheeting, and untreated polyethylene films allow the most amount of light across the entire spectrum to penetrate to the crop canopy. Fiberglass, polycarbonate and rigid PVC sheeting, as well as PVC and treated polyethylene films can either partially-block or fully-block UV light.

Greenhouse label language

The label is law. Label language will indicate whether a certain pesticide application is allowed in a greenhouse, and a restriction statement is usually found in the "Directions for Use" section. Very often, greenhouse applications are only allowed on certain crops or crop stages. Some labels contain different rates and recommendations for the same crop inside and outside of a greenhouse. For example, streptomycin is an antibiotic that is only allowed on tomato transplants in the greenhouse as an effective control for bacterial diseases, and is not allowed for use on outdoor tomatoes at all.

Occasionally, a label will not indicate greenhouse restrictions, but also will not provide special instructions for greenhouse use. When the label is silent on greenhouse use, it is classified as an implied use, and can be used as long as the target crop is on the label.

How does Michigan define a greenhouse?

The Michigan Department of Agriculture and Rural Development (MDARD) defers to the Worker Protection Standard (WPS) for its definition of a greenhouse. The most recent update to the WPS has termed it "enclosed space production", and defines it as "production of an agricultural plant indoors or in a structure or space that is covered in whole or in part by any nonporous covering and that is large enough to permit a person to enter". So, if a pesticide label does not allow its use in an "enclosed space production" area, then you cannot use it in a poly film hoophouse

even when the sidewalls rolled up and end walls are open. EPA anticipates that most greenhouses, hoop houses, high tunnels and similar structures will fall within the definition of enclosed space production, but a final determination will be made on a case-by-case basis applying the parameters of the definition to each situation.

Some operations will use "shade cloth" during certain production/market phases. Shade cloth used within a greenhouse would be subject to the "enclosed space production" procedures. Where "shade cloth" is the sole "covering" the employer will need to determine if the particular material is porous or nonporous.

In addition, there are "porous" versions of Polyethylene (PE), Polypropylene (PP), Polyvinylidene fluoride (PVDF), Polytetrafluoroethylene (PTFE), and Ethyl Vinyl Acetate (EVA). As there has not been guidance issued on these materials consider the traditional greenhouse structures to be "enclosed space production" areas.

Worker pesticide safety and greenhouse applications

Greenhouse pesticide applications require compliance with re-entry and spray notification regulations under the WPS. The following table is modified from the "How to Comply with the 2015 Revised Worker Protection Standard" manual, and identifies the entry restrictions when applying pesticides for enclosed space production to ensure workers and other persons are not exposed to the pesticide(s) being applied. The restrictions depend on the types of pesticide(s) or application method used. Read the table by starting in Column A and following the scenario to Column D.

A. When a pesticide is applied:	**B. Workers and other persons, other than appropriately trained and equipped handlers, are prohibited in the:**	**C. Until:**	**D. After the ventilation time has expired, the restricted-entry interval:**
(1) As a fumigant	Entire enclosed space plus any adjacent structure or area that cannot be sealed off from the treated area.	*The ventilation criteria are met.	Continues from the time of application.
(2) As a smoke, mist, or fog, or as a spray using extra fine (XF), very fine (VF), or fine (F) nozzles	Entire enclosed space.	*The ventilation criteria are met.	Begins for the entire enclosed space.
(3) Not as in (1) or (2), and for which a respirator is required for	Entire enclosed space.	*The ventilation criteria are met.	Begins, for the treated area.

application by the pesticide product labeling.			
(4) Not as in (1), (2), or (3), and: • From a height of greater than 12 inches from the planting medium, or • As a spray using medium (M) or larger coarse (C) nozzles.	Treated area plus 25 feet in all directions of the treated area, but not outside the enclosed space.	Application is complete.	Begins, for the treated area.
(5) Otherwise.	Treated area.	Application is complete.	Begins, for the treated area.

* When column C of the Table specifies that ventilation criteria must be met, ventilation must continue until one of the following conditions is met:

i. Ten air exchanges are completed.
ii. Two hours of ventilation using fans or other mechanical ventilating systems.
iii. Four hours of ventilation using vents, windows, or other passive ventilation.
iv. Eleven hours with no ventilation followed by one hour of mechanical ventilation.
v. Eleven hours with no ventilation followed by two hours of passive ventilation.
vi. Twenty-four hours with no ventilation.

For example: **When a pesticide is applied** as a smoke, mist, or fog, or as a spray using extra fine (XF), very fine (VF), or fine (F) nozzles, **workers and other persons, other than appropriately trained and equipped handlers, are prohibited in** the entire enclosed space **until** the ventilation criteria are met. **After the ventilation time has expired, the restricted-entry interval** begins for the entire enclosed space.

A1: Since fumigants are primarily inhalation hazards, the ventilation time counts down along with the product's REI. If a fumigant had an REI of 48 hours, and

the grower chose to ventilate for 24 hours without ventilation, they must still wait another 24 hours because the REI is 48 hours total. If the fumigant had an REI of 12 hours, and the grower chose to ventilate with eleven hours of no ventilation, followed by one hour running the fans, then they would have to wait one more hour to re-enter.

A2: The REI is delayed for non-fumigants because they are considered a residual contact hazard. For a product with an REI of 4 hours, sprayed in an enclosed space with a Fine nozzle the grower would need to ventilate the entire space by any of those methods listed above before the REI would actually start ticking. If a grower chose to wait 24-hours without ventilation, then that REI is effectively 28 hours.

A3: Products that require a respirator usually have smaller droplet sizes. This increases inhalation hazard while spraying, but once dried, and the air ventilated the product would have a lower airborne likelihood from mechanical forces. An applicator/handler uses a respirator to protect themselves for the potential of inhalation due to mixing/loading/application methods used. No one is allowed into the entire space until it is vented. Then, the REI applies to just the treated area to limit residual contact activity of products.

A4: If the grower used Medium nozzles using the same product as in the A2 example, then only the 25 feet around the treated area would need to be ventilated before the REI kicks in. For greenhouses, a "treated area" can be as small as one plant.

If the Restricted-Entry Interval (REI) of the product is greater than 4 hours (in an enclosed space) or 48 hours (in an outdoor space), a warning sign must be posted for all applications. If the REI is less than or equal to 4 hours (in an enclosed space) or 48 hours (in an outdoor space), workers can be notified with either an oral warning or a posted sign. Employers must also post application locations when a label requires "dual notification" regardless of the stated REI.

Where can I find more Worker Protection Standards (WPS) resources?

Up-to-date pesticide resources can be found on the National Pesticide Safety Education Center website (https://npsecstore.com/) and the Pesticide Educational Resources Collaborative website (http://pesticideresources.org/).

Vegetable pesticides that can be used in the greenhouse

So, what commonly used pesticides labeled for vegetable use can be used in the greenhouse? You can view a list of 500 products, in order by trade name here: http://bit.ly/caniuseitinthegreenhouse. If the label is open to all greenhouse uses we indicate "yes". If the label specifically disallows greenhouse uses we indicate "no", or cautions against its use we indicate "avoid". If the label makes specific uses allowable in certain crops or crop stages we put "certain crops only, see label". In

the cases where a label implies a use by not including any greenhouse language we indicate “silent”. Always double-check the label that comes with your specific product and formulation.