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Substrates and fertilizers for organic container production of herbs, vegetables, and herbaceous ornamental plants grown in greenhouses in the United States

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ABSTRACT

The value of organic greenhouse production in the United States is $112 million, and organic floriculture production has increased 40% in greenhouses since 2008. The U.S. National Organic Program (NOP) guidelines allow organic production in containers. One of the primary concerns for current and potential organic container growers is managing container substrate and plant fertility. This manuscript provides a review of current literature on organic substrates and fertilizers for container grown herbs, vegetables and herbaceous ornamentals according to NOP guidelines. Organic-approved substrates can be purchased from commercial suppliers or produced in house. Many organic substrate components are similar to those used in conventional production (peat moss, pine bark, perlite, vermiculite, rice hulls, and whole pine tree) but lack a synthetic wetting agent. Growers who mix their own substrates often add compost at percentages ranging from 20 to 50%. Compost has high water holding and cation exchange capacity. It is often locally or regionally produced and purchased, which impacts variability and quality. For this reason, growers often need to manage substrates with compost more carefully. Single source or blended organic fertilizers may be incorporated in substrates prior to planting. These are derived from a variety of plant and animal based sources. A small number of mined components may be added to substrate-incorporated fertilizers (i.e. limestone). These fertilizers will typically last for four to five weeks, and are often supplemented with liquid fertilizers for longer-term crops or species with high nitrogen requirements. Liquid fertilizers also tend to be more quickly plant available compared to substrate-incorporated fertilizers. With careful management, it is possible to grow container plants in organic production systems that are comparable to those produced in conventional production systems.

1. Introduction

The increase in consumer demand for organically-grown crops has been recognized by many greenhouse producers in the United States (e.g. Treadwell et al., 2007). As interest in organic greenhouse production increases in the U.S., nutrient management is often cited as a key challenge to the adoption of organic production practices (Burnett and Stack, 2009). Organic substrates typically use a blend of various allowed bulk materials to achieve appropriate physical properties (water and air holding capacity). Organic nutrient management for container production often includes the use of a combination of fertilizers, such as pre-plant amendments with compost or other organic-certified materials to provide an initial nutrient charge that is supplemented with liquid organic fertilizers as the production cycle progresses. Length of the production cycle often dictates the best strategy for using organic nutrient sources: shorter production cycles, such as for vegetable transplants, can often be accomplished solely with nutrients amended to the substrate pre-plant, but longer-term greenhouse crops, such as tomatoes, typically require that liquid organic nutrients be used to supplement pre-plant incorporated nutrients. Ornamental crops are also produced using organic-based nutrient sources, but they are frequently produced solely with liquid organic fertilizers regardless of length of the production cycle.

The objective of this article is to highlight organic greenhouse production methods of containerized plants with a focus on allowable production practices, the size of the industry, and a

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review of organic substrate and fertilizer practices used in the United States.

1.1. Guidelines for organic greenhouse production in the United States

According to the United States Department of Agriculture (USDA), organic greenhouses and other farms in the United States, 'Preserve natural resources and biodiversity. . ., only use approved materials, and receive annual onsite inspections' (USDA, 2015). The USDA NOP guides the development of standards for organic greenhouse production (USDA—Agriculture Marketing Service, 2015a). These guidelines were developed in 2000 (Greer and Diver, 2000). While the USDA provides the legal guidelines and definition of organic, accredited certifying agents certify greenhouses and their products. All greenhouse growers who sell more than $5,000 of product each year are required to go through the certification process (Baier, 2012). There are approximately eighty agents who have the ability to certify greenhouses; they are national and international organizations. Typically, when a grower is becoming certified, they go through a transition process, and an accredited certifying agent assists them as they work through this process. After this initial process, they need to renew their certification each year.

Throughout the United States, there may be minor regional or state differences in the interpretation of the guidelines for the NOP. Growers may choose which accredited certifying agent they work with. However, not all eighty agents work in every state. Some groups, such as Oregon Tilth Certified Organic, are qualified to certify growers in every state, Puerto Rico, and the Virgin Islands. By comparison, some growers work with a regional accredited certifying agent, such as the Maine Organic Farmers and Gardeners Association or the Northeast Organic Farmers Association which certify growers in a limited number of states. The full list of accredited certifying agents is available through the USDA-Agricultural Marketing Service (2015b).

Growers wishing to determine which fertilizers, substrates, or pest management products would be appropriate to use during organic production could check in a few places. One would be the list of allowed products through the USDA NOP Guidelines. Since the interpretation of these guidelines varies slightly according to certifying agent, many growers work closely with their accredited certifying agent to ensure that they are following appropriate organic greenhouse production procedures. There is also an independent group called the Organic Materials Review Institute (Organic Materials Review Board, 2014) that reviews products for compliance with NOP guidelines and provides a fairly comprehensive list of certified organic products.

The NOP standards in the United States differ from some international organic standards. One difference for greenhouse production is that growers may produce crops either in containers or directly in the soil (Schmutz et al., 2014). Since container production is not prohibited, growers often purchase or produce certified organic container substrates. While these substrates may contain soil or compost, they also usually contain other naturally derived components, such as peat moss. Another difference for organic production in the United States compared to most other countries is that organic production in hydroponic systems is not prohibited.

1.2. Status of organic greenhouse production in the United States

The most recent survey of organic greenhouse production indicated that it is valued at $112 million (USDA-NASS, 2014). Greenhouse crops are diverse and include food ($76 million), floriculture crops ($27.3 million), and propagative material ($8.8 million). The value of greenhouse crops has increased over time. For example, the economic value of organic floriculture (greenhouse and open field) alone has increased 43% since 2008 (USDA-NASS, 2014). There are 2.1 million m^2 of organic production under protection in approximately 1785 greenhouses. This has more than doubled compared with 2008 numbers when there were 744 greenhouses covering 0.7 million m^2 (United States Department of Agriculture—NASS, 2008, 2014).

Our focus in this review will be on the unique industry of organic greenhouse production in containers in the United States. Many growers in cold climates produce vegetable or herb transplants in containers in greenhouses for on-farm use and/or to extend the season. Container-grown plants are also grown for sale through retail markets to home gardeners. There has been market research to determine consumer interest in organic container-grown plants, however, that information has provided conflicting results. Yue et al. (2011) reported that there was less consumer interest in organically grown container plants, compared to conventional or locally grown plants. By comparison, Hawkins et al. (2012) reported that consumers were highly interested in organically grown vegetable/herb and ornamental container grown plants. Both surveys of interest in container-grown plants were regional, rather than national. Yue et al. (2011) surveyed consumers in four states (Indiana, Michigan, Minnesota, and Texas), and Hawkins et al. (2012) surveyed consumers in Maine. Given consumers' diverse interests in organic products throughout various regions in the United States, it would be interesting to provide more national economic and marketing data for growers in the future.

Hawkins et al. (2012) also indicated that consumers would be willing to pay 10–15% more for organically grown container plants than conventional plants. Although consumers will pay more for container grown plants, they will pay a greater premium (up to 25% more) for organically grown vegetables (Rippy et al., 2004). The greater price premium that growers receive for food compared to ornamental plants could partly explain why there is more greenhouse production of food compared to container-grown plants. If a 10–15% increase in premium does not cover higher production costs for container grown plants, it would be difficult to justify the adoption of organic production techniques.

There are challenges for organic growers and conventional growers who wish to transition to organic production. Research could remove barriers for these growers. One of the primary challenges for organic growers and those interested in transitioning is managing substrate and fertility issues (Burnett and Stack, 2009). The remainder of our review will focus on those production areas.

1.3. Organic substrates

Organic substrates (also referred to by the NOP as growing media, potting media, and soilless media) must use only allowed materials and may not contain prohibited substances such as synthetic wetting agents and fertilizers (Treadwell et al., 2007). Alternatives to synthetically-derived starter fertilizers or wetting agents are available in approved organic forms (Treadwell et al., 2007). If restricted substances are used they must be used in manner that meets the ingredient restrictions. As in conventional substrates, bulk materials and amendments used for approved organic substrates must be formulated so as to supply proper physical, chemical, and biological properties to support plant growth and be free of diseases and weed seeds. Several commercially available organic substrates formulated for professional growers by potting mix manufacturers are available on the market. These manufacturers' distribution may be regional [including but not limited to: McEnroe (Millerton, NY, U.S.), Vermont Compost Company (Montpelier, VT, U.S.)] or national [including but not limited to: Berger (Saint-Modeste, Quebec, Canada), Lambert Peat Moss (Rivière-Ouelle, Québec, Canada), Premier Tech Horticulture (Quakertown,

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