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July 21, 2016

MEMORANDUM TO THE NATIONAL ORGANIC STANDARDS BOARD

FROM: Miles V. McEvoy
Deputy Administrator
National Organic Program (NOP)

SUBJECT: Hydroponic and Aquaponic Task Force Report

The Hydroponic and Aquaponic Task Force Report is available for your review.

In September 2015, AMS convened the Hydroponic and Aquaponic Task Force to further explore the issue. The task force was comprised of sixteen (16) diversely qualified individuals that represent both the soil-based organic and hydroponic communities. The objective of the task force was to develop a report for the NOSB that: 1) describes the current state of technologies and practices used in hydroponics and aquaponics; and 2) to examines how those practices align or do not align with the Organic Foods Production Act (OFPA) and the USDA organic regulations.

Please use this report to make a recommendation to AMS. Based on your recommendation, AMS will take the necessary steps to establish clear standards for these production systems. The public will be invited to provide comments during your deliberations, as well as when AMS develops guidance or initiates rulemaking on this issue.

AMS greatly appreciates the time and effort that the Hydroponic and Aquaponic Task Force members volunteered in writing this report. Members of the task force include:

- Will Allen, Milwaukee, Wisconsin
- Colin Archipley, Esondido, California
- John Biernbaum, Ph.D., East Lansing, Michigan
- Angela Caporelli, Frankfort, Kentucky
- Dave Chapman, East Thetford, Vermont
- Marianne Cufone J.D., New Orleans, Louisiana
- Amy Lamendella, Santa Cruz, California
- Charlie Shultz, San Marcos, Texas
- Eric Sideman, Ph D., Strafford, New Hampshire
- Pierre Sleiman, Encinitas, California
- Stacy Tollefson, Ph.D., Tucson, Arizona
- Jose Edgardo Torres, Sahuarita, Arizona
- Jessica Vaughan, Freedom, California
- Jeffry Evard, Plainfield, Indiana
- Sam Welsch, Lincoln, Nebraska
- Theresa Lam, East Brunswick, New Jersey

National Organic Standards Board (NOSB) Hydroponic and Aquaponic Task Force Report

July 21, 2016

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1. 2010 Recommendation Subcommittee Report

Subcommittee Members

John Biernbaum, MSU and MOFFA
Dave Chapman, Greenhouse Organic Farmer
Theresa Lam, NOFA-NJ
Amy Lamendella, CCOF
Eric Sideman, MOFGA
Sam Welsch, OneCert

Summary of 2010 Subcommittee Report

In 2010 the National Organic Standards Board passed a recommendation onto the National Organic Program called **Production Standards for Terrestrial Plants in Containers and Enclosures.** This recommendation was the culmination of more than a decade of work by the NOSB, and was the final recommendation of the Board on this topic. Six years later, the NOP felt that there were a few points relating to hydroponic production that were left ambiguous, and so created the Hydroponic and Aquaponic Task Force. The Task force formed three Subcommittees: one was to describe "organic hydroponic" production and discuss the ways in which it aligns with OFPA and the USDA organic regulations, one was to discuss alternative labeling, and we ("the 2010 Recommendation Subcommittee") accepted the task of providing clarification and further support for the position taken in the 2010 NOSB recommendation and consider the alignment of soilless production systems with organic law and regulation.

The Federal Register Notice announcing the formation of this task force had simple objectives: "There are two main objectives of the task force: (i) To describe current hydroponic and aquaponic production methods used in organic production, and (ii) to assess whether these practices align with OFPA and the USDA organic regulations. The task force will prepare a report advising the NOSB on proposed standards or guidelines for hydroponic and aquaponic methods in organic agriculture. The report may be used to inform the NOSB on recommendations concerning hydroponic and aquaponic systems and for possible guidance or rulemaking by the NOP."

Observing that the framework of organic farming is based on its foundation of sound management of soil biology and ecology, it became clear to the NOSB that systems of crop production that eliminate soil from the system, such as hydroponics, cannot be considered as acceptable organic farming practices. The 2010 Subcommittee of the Task force came to the same conclusion. Similar to the NOSB in 2010, we based our conclusion on historical founding principles of the organic farming movement, regulatory text in the Organic Foods Production act, Regulatory Text of the USDA National Organic Program, good soil management practices, and international organic standards.

The organic farming movement began in the early part of the twentieth century, pioneered by farmers and academics who were responding to obvious problems with "modern" agriculture (where little organic matter is added to the soil) such as depletion of soil fertility and structure, decline of livestock health caused by low feed quality, soil erosion, etc. The basic premise of organic farming was that agricultural soil needs continuous restoration by means of adding manure and/or compost, managing cover crops and crop residue, and adding natural rock powders. The earliest organic certification programs based their standards on this premise. OFPA and the NOP regulatory text did an excellent job of representing this heart of the early certification programs by using the word "must" or "shall" (rather than "may") in the sections regulating soil management.

Organic farming practices are centered on the basic principle of feeding the soil rather than the crop. This simple slogan rests on the idea that the successful management of soil is all about taking care of the organic fractions; the living organisms, the recently dead and decomposing organisms, the slow to decay organic matter, and the very stable organic matter often referred to as humus. The key to an organic farming system is to build and maintain these interactions. It is through the interaction of the organic matter fractions with the mineral fractions that a productive and sustainable soil system is developed and maintained. In an organic farming system the bulk of the crop's nutrients comes from complex organic molecules being fed into these organic fractions, and some portion of the material and mineral fraction being converted to nutrient forms available for plant uptake. Some of the organic material becomes part of the organic fraction of the soil, building the soil. Section 6513 (b)(1) of OFPA states, "...foster soil fertility, primarily through the management of the organic content of the soil...". Our interpretation of this OFPA section is that direct crop feeding with available fertilizers is to be used only as a supplement when necessary.

The 2010 Task Force Subcommittee recognize that there are some parts of an organic system that do not directly link to the soil, for example production of transplants. Furthermore, there are some commodities produced that include a less than obvious link to soil, such as sprouts, crops grown in containers, etc. In this report, we discuss these and explain the link to the soil, and explain why some of these may not be applicable to the premise that organic production takes place in the soil. We discuss the continuum between “grown in the ground” and “grown in a nutrient solution” and how to draw the line between a system that feeds the soil, and a system that does not meet organic principles because it is based on simply feeding the crop.

The basic standard of all of the countries in Europe is that hydroponic production is prohibited. We believe, that although some international standards allow crops to be grown in containers of biologically active media mimicking a soil system, and also restrict the amount of crop nutrients coming from direct feeding, there is no international organic standard that allows the bulk of the crop nutrients to come from direct crop feeding.

Conclusions

The NOSB in their 2010 recommendation made it clear that they support the historical premise that organic production should take place in soil. Our subcommittee of the Hydroponic/Aquaponic Task Force agrees, and has worked to clarify any ambiguities that we and/or the NOP recognized.

The crux of our conclusion is to clarify the distinction between organic fertility management and conventional fertility management. In organic management, the source of the bulk of the crop nutrients are from the biological activity decomposing complex organic molecules (compost, manures, seed meals, etc.) and the mineral fractions in the soil. In contrast, in non organic production the bulk of the plant nutrients are supplied in available forms. It is the management of the soil that is at the heart of organic production. In contrast, in a non organic system it is the management of the fertilizers.

The NOSB will ultimately have to recommend its clear intention for the role of soil. This will be a very important recommendation for the future of organic certification. No matter what one thinks about which path is best, we can all accept that many in the organic community are opposed to the inclusion of hydroponic as organic[1]. Failure to address that concern will inevitably undermine public and farmer support for the USDA Organic label.

Container Growing, (including hydroponic production)

Based on the work of this subcommittee, there appear to be the following choices to satisfy both the language of OFPA and the intent of the 2010 recommendation:

- Limit organic certification to what is grown in the ground, with the exceptions of transplants, ornamental, and herbs (The common standard used in most European organic certification). This would be the single path that is in clear alignment with the language of OFPA. The majority of the subcommittee supports this option.

- If certification includes crops grown in containers, it will require additional standards to cover the practices that are not covered by existing regulations. The critical question is how to ensure that container grown plants get most of their fertility from the natural processes of the soil or compost based media in the containers. This could require a limitation on the percentage of nutrition that could be gained from additional fertilizers after planting, and the amount of fertility obtained from liquid feeding. We suggest a limitation of no more than 50% of the required fertility being added after planting, and no more than 20% to be added as a liquid fertilizer after planting. For perennials these limitations should be on an annual basis. A similar limitation suggested by IFOAM EU is intended for field crops as well as greenhouse crops. Another suggestion is to follow the recommendation of Dr. Martine Dorais of Laval University and the Agassiz Research and Development Centre to grow in 100 to 180 liters of soil per m^2. At this volume she has demonstrated that no liquid fertilizing is necessary, and fertility can be provided by the biological activity of the growing medium in the beds. We recommend defining the growing area to include the paths between rows. This choice deviates from a strict interpretation of the language of OFPA, but is closer to the intention.

Enclosures

[1] A clear demonstration of the depth of this opposition was the Moratorium letter presented to Secretary Vilsack in April of 2016. This letter called for an immediate moratorium on all new hydroponic certification until final standards in accord with the 2010 recommendation could be completed. It was signed by 65 organic leaders, 15 former NOSB members, and 40 organizations whose total membership exceeds 2.2 million people. (Appendix H)

- Greenhouses need to be more specifically defined as having transparent roofs and walls to permit the passage of sunlight. Controlled indoor environments without transparent roofs and walls can be used for transplant production but not for organic crops.
- Electric lighting may be used as a supplement to the sun, but not as a replacement for the sun when producing organic crops. Transplants can be produced with only electric lighting.

Growing Media

- Regulations relative to container growing media for transplants and organic crops need to be refined and evolved to require compost based media. This will require expanded definitions and guidelines relative to the production and acceptable characteristics of compost. The primary goal is to align with the expectations regarding containers as outlined above. At a bare minimum, a substrate used in pots or containers should have a minimum of 20% compost.

Rotation of Crops

Regarding rotation of crops in greenhouses, there seem to be two choices:

- Require rotations for all annual crops. This may be accomplished by rotating the crops, or by rotating the soil in the beds on a schedule of once every number of years. Then the rotated soil should be removed and be renewed by cover cropping or composting before returning to the greenhouse.
- Accept that greenhouse crops are grown in a specialized environment, and may require that issues such as soil biodiversity and health can be treated in a similar way to a perennial crop, with liberal use of compost, mulch, and interplanting.

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Introduction

This report is intended to offer clarification of the 2010 NOSB recommendation on Terrestrial Plants in Containers and Enclosures Greenhouses. That recommendation took years of work, and received extensive public review. In our opinion, it was a strong statement in support of traditional organic principles continuing as the basis for standards in the NOP. However, there were a few points found by the NOP to be left ambiguous. So five years later, the task force is now reviewing the recommendation, and offering possible ways of going forward. It is the subcommittee's mission to honor the intentions and conclusions of the 2010 recommendation as much as possible.

To understand the 2010 recommendation, it is necessary to understand the history of the organic movement. Long before the USDA became involved, there was a worldwide agricultural movement based on a simple idea: Feed the soil, not the plant[2]. This slogan became the mantra for the organic community (Kuepper, 2010). The organic movement grew in response to another movement; an industrial/agricultural revolution that began in the late 1930's, and exploded in the 1940's. At that time, it was becoming popular to use fertilizers that were chemically manufactured to make the nutrients in them soluble, and thus rapidly available to plants. These synthetic fertilizers were able to circumvent the natural biological processes that has been the basis for all plant nutrition for the last 350 million years. It was, indeed, a revolution.

There were several consequences of this agricultural revolution. First, yields immediately increased. Plants grew faster and bigger. Productivity, as measured in pounds per acre, went up (Pratt, 1965). Second, insect and disease challenges increased (Yepsen, 1976). This was not a problem for this agro/ industrial revolution as they also were developing many potent pesticides and fungicides to control these problems. As time went by, the chemical agriculture industry went even further, and developed herbicides to reduce the challenges of weed control.

However, there were also unintended consequences. Concerns of many over human illness as a result of pesticide residue have consistently increased since 1940 (Carson, 1962). Concerns also grew that food from this agricultural revolution no longer supplied everything that people and livestock needed for health (Howard, 1940: Howard, 1952).

Thus in the early 1940's, a number of thinkers and farmers began the organic farming movement, based on the work of others who came before. The term "organic farming" was first coined by Lord Northbourne. It was quickly picked up by Sir Albert Howard, Lady Eve Balfour, J.I. Rodale, and others. These early organic pioneers were intently focused on the life in

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[2] This was cited as a foundational belief of organic farming in the 1980 USDA Report and Recommendations on Organic Farming. See Appendix G.

the soil. These pioneers were the first proponents of what is sometimes called "Deep Organic"[3], meaning that it is based on principles of soil systems that embrace the lessons of soil ecology which includes an understanding of soil microbiology, soil zoology, plant biology, nutrient cycling, and the system of animal, plant, and soil community. The farming techniques which they championed were intended to enhance and further develop these biological processes in the soil.

Their concerns were not about finding natural substitutes for the chemically enhanced fertilizers. This approach of substitution is sometimes called "Shallow Organic". The pioneers had a completely different approach to understanding the soil/plant system, which involved cultivating the complexity in that system in order to cultivate stability and health. It was their belief that a complex soil/animal system would produce food that had the greatest health benefits for both humans and other animals in a sustainable way.

The complexity of this soil system was based on the rich diversity of life in the soil. This varied web of organisms includes bacteria, fungi, protozoa, nematodes, springtails, mites, spiders, worms, and burrowing mammals.

This system is powered by the sun, via the plants. Plants use the energy from the sun to drive photosynthesis. They feed the soil bacteria and fungi by exuding sugars and enzymes out through their roots. Plants will give somewhere between 30% to 60% of their photosynthates to the bacteria and fungi living in the rhizosphere, the area right around their root hairs (Jackson, L. et al., 2012; Kallenbach and Grandy, 2011). These bacteria and fungi, in turn, provide the plants with minerals which they have obtained from the mineral fraction of the soil. Additionally, as decaying plant matter is deposited in the ground, either as animal manure or as decaying plant material, that organic matter is eaten and digested by the many forms of life in the soil, both microbial and animal. These life forms are busy eating each other as well, but if we take away the organic matter (which includes manures and the plant roots), we are killing the life in the soil.

This complex system is the basis of all life on the planet. It has been evolving over the last 400 million years. Organic agriculture is a movement that acknowledges this process, and that tries to participate in it by maintaining and building the soil on the farm.

In our opinion, the 2010 recommendation refers to these principles. We believe that the recommendation stresses that the regulation of organic agriculture is much more than a list of permitted and prohibited materials. In our opinion the NOSB recommendation interprets the OFPA and the NOP Regulation as a reflection of the belief that organic farming was meant to be a way of growing healthful crops as part of a system that was based on healthy soil. To quote

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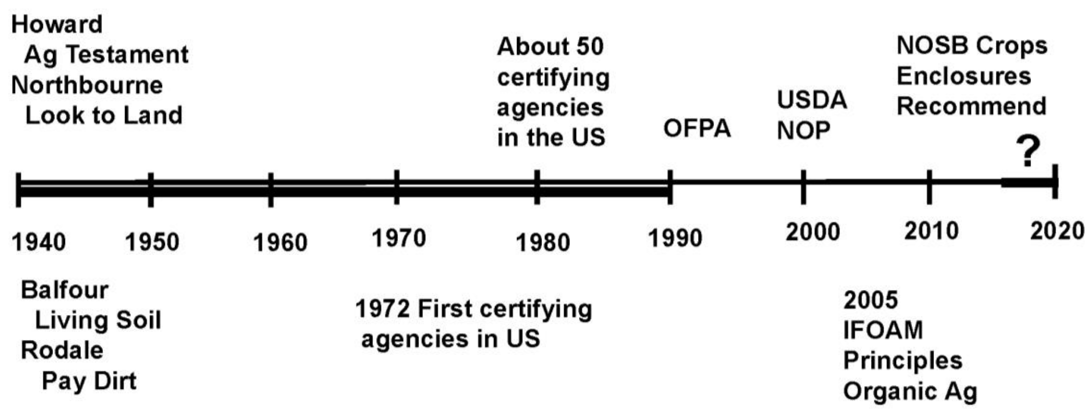
[3] The terms "Deep Organic" and "Shallow Organic" were first coined by Dr. Stewart Hill in the 1980's at a NOFA talk.

the first sentence of Sir Albert Howard's book, An Agricultural Testament: "The maintenance of the fertility of the soil is the first condition of any permanent system of agriculture."

Simplified Organic Farming Certification Time Line



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Section 1. Regulatory Issues: How OFPA and NOP Regulatory Text Address Soil

Background

Before OFPA:

The organic farming movement began in the early part of the twentieth century, pioneered by farmers and academics who were responding to obvious problems with "modern" agriculture such as depletion of soil fertility and structure, decline of livestock health caused by low feed quality, soil erosion, etc. The Pioneers (Sir Albert Howard, Lady Eve Balfour, Rudolf Steiner, Jerome Irving Rodale, Aldo Leopold, William Albrecht, and others) fostered the notion that the success and sustainability of farming relies on management of the soil's health (Kuepper, 2010; Lockeretz, 2007). Most at that time referred to this as humus farming. They recognized that the soil is a complex system composed of countless biological interactions, and that ordinary practices of crop production leads to weakening of these interactions and subsequent loss of fertility and health. The kingpin of what they termed "humus farming" - named after the very stable organic matter at the heart of healthy soil, later to be called "organic farming" (Paull, 2014) - is that in order to maintain and increase productivity, continuous restoration of the soil is needed by means of "manuring", managing crop residue, composting, cover cropping, and adding natural rock powders (Howard, 1940).

During the 1960s the counterculture began to link the organic agriculture movement with the wider environmental movement, and it gained more and more recognition in the general public. A role in this growing recognition was played by the new generation of farmers that arose from what is now termed the "back-to-the-land" movement. These farmers marketed their products in farmers markets, from their own farm stands and to the growing number of "health food stores". As the demand grew for organic food and farmers began bringing the food from their communities to the cities, the distance between the producer and the customer grew. Third party certification emerged as a means of assuring customers, who were now far removed from their farmer, that the products they purchased were truly organic.

In 1971 Rodale Press's Organic Farming and Gardening Magazine initiated an organic certification program based upon standards developing at that time in Europe. In 1972 the Maine Organic Farmers and Gardeners Association ran their first organic certification program based on the Rodale Organic Certification Program. California Certified Organic Farmers was soon to follow in 1973. Many more certifiers organized during the next decade, and by the 1980s farmers across the country could find an organic certifier close to home. Although there were minor variations in what practices and materials were allowed, the standards used by each certifier were remarkably similar. Farmers had to submit a plan to the certifier that gave detailed explanation of what practices and materials were used on the farm in production of the crops to be called organic. Of course most synthetic pesticides and fertilizers were not allowed by organic standards, but the real crux of the standards was not what was prohibited, but rather what was required. Organic certification standards required on-farm practices and use of materials that fostered soil health by means of managing crop residue, using livestock manures, composting, cover cropping and adding natural rock powders. In other words, these early organic certification programs reflected the farming practices suggested by the pioneers of organic farming.

OFPA, the USDA organic regulations, and the NOSB:

Later, these same farming practices were reflected in the federal regulations that arose. The writing of the Organic Foods Production Act (OFPA) was a grassroots effort. Although not everyone involved with the organic movement in the 1980s supported the idea of a federal regulation, those writing the regulation made a tremendous effort to include representatives from organic certifiers from coast to coast. As a result, OFPA represents the standards that guided organic production prior to its passage. And, the National Organic Program (NOP) attempted to carry this over when they wrote the regulatory text that implements the law, especially the sections on managing the soil (Section 205.203). Both OFPA and the USDA organic regulations were written with the understanding that the foundation of organic farming is soil management. The Preamble to the USDA organic regulations contains statements confirming the fundamental essentiality of soil in certified organic production, including, but not limited to:

- "The soil fertility and crop nutrient management practice standard in section 205.203 establishes the universe of allowed materials and practices."
- "A producer of an organic crop must manage soil fertility, including tillage and cultivation practices, in a manner that maintains or improves the physical, chemical, and biological condition of the soil and minimizes soil erosion."
- "The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials."
- "The fundamental requirement of the soil fertility and crop nutrient management practice standard, that tillage, cultivation, and nutrient management practices maintain or improve the physical, chemical, and biological condition of the soil and minimize erosion, remains unaltered."

Soil is fundamental to organic agriculture. By using the word "must" or "shall" rather than "may" in the sections regulating soil management, both OFPA and the USDA organic regulations require those producing organic crops to do so in soil.

The National Organic Standards Board (NOSB) came to this same conclusion after decades of working on standards for container and greenhouse growing. The NOSB worked on container growing standards because OFPA and the USDA organic regulations did not specifically address this aspect of farming and the NOP intended for such standards to be included. The Preamble to the USDA organic regulations published on Dec. 21, 2000 recognized the importance of greenhouse regulations: "The NOP intends to provide standards for categories where the Act provides the authority to promulgate standards. During the 18-month implementation period, the NOP intends to publish for comment certification standards for apiculture, mushrooms, greenhouses and aquatic animals. These standards will build upon the existing final rule and will address only the unique requirements necessary to certify these specialized operations." The NOSB proposed regulations for greenhouse standards in 2001 (NOSB 2001). Hydroponic production was not mentioned in these, but that was not an oversight. Eric Sideman was on the NOSB at the time of this discussion. He writes, "Hydroponic production standards were presented for discussion, but we rejected them because such production was thought at that time (as it was again in the 2010 NOSB Recommendation) to not meet basic organic production principles. Jim Riddle was a fellow NOSB member at that time and he concurs with my memory. Although we on the NOSB at that time expected the NOP to reject hydroponic production as an organic method, they did not, and furthermore the NOP did not publish certification standards for greenhouse standard as intended by the end of the implementation period in October 2002."

In 2003, the NOSB published a discussion document that questioned whether or not hydroponics and other soil-less systems could be certified (NOSB 2003). The NOSB also made the statement, "The NOSB agrees with the NOP position that mushroom, apiculture, and greenhouse operations can be certified as organic, and that the products of such operations can be labeled "organic" and carry the USDA organic seal. Further, the NOP should proceed with regulatory amendments, using recommendations submitted by the NOSB. … Though the issue has been discussed, the NOSB has not submitted a recommendation on hydroponic production standards since adoption of the final rule. NOSB recommends that the Crops Committee place the item on its work plan. Rulemaking for hydroponic standards should not proceed until the NOSB has submitted a final recommendation." In response, the NOP wrote, "NOP concurs with the NOSB and agrees … not to propose hydroponic standards until the NOSB has submitted a final recommendation (NOP 2005).

The NOP maintained that hydroponic production is allowed if done in full compliance with the USDA Organic Regulations. The NOP did not provide any further guidance to certifiers how the provisions of OFPA could be met. Many certifiers do not certify hydroponics operations because they believe such operations do not fully comply with OFPA and USDA organic regulations.

The 1995 recommendation states: "Hydroponic production in soilless media to be labeled organically produced shall be allowed if all provisions of the OFPA have been met." Hydroponics were not mentioned in the final rule. According to Michael Sligh, founding member of the NOSB from 1992-1997 who also served as the founding chair, the NOSB discussion was very brief and represented a placeholder for future discussion. He writes, "my understanding of that statement, that 'all provisions of OFPA have been met', was the key to my voting for that very brief recommendation…. I understood OFPA to be about organic farming, which meant that the goal ... is to optimize the health and productivity of interdependent communities of soil life, plants, animals and people.” (See Appendix J for complete letter.)

All of the NOSB’s discussion documents in 2008 and 2009 continued to examine “The over-riding question of whether soil-less systems are compatible with organic production.” (NOSB 2008, NOSB 2009a, NOSB 2009b) In 2010, the NOSB recommended greenhouse standards for the USDA organic regulations and concluded that “hydroponic and aeroponic systems are prohibited.” (NOSB 2010)

In response to the 2010 NOSB recommendation, the NOP wrote on September 30, 2010, “The NOP thanks the NOSB for their completion of work on greenhouse standards through their April 2010 recommendation. The NOP will develop a proposed rule based on the NOSB final recommendations.” The NOP has not yet developed a proposed rule on this topic.

The 2010 NOSB recognized a few exceptions to the principle of growing only in soil, for example producing transplants, crops that do not naturally grow in soil, etc. We will discuss those later in our report, but first here is a summary of sections in OFPA and the USDA organic regulations that require that organic production takes place in soil.

Organic Foods Production Act and National Organic Program Regulatory Text

OFPA Section §6513(b)(1)

§6513. Organic plan
(b) Crop production farm plan
(1) Soil fertility
Soil Fertility: “An organic plan **shall** contain provisions designed to foster soil fertility, **primarily** through the management of the organic content of the soil through proper tillage, crop rotation, and manuring.” [emphasis added]

This section of OFPA does not list any exceptions and is applicable to all organic crop production. By using the word "shall" rather than "may", it is requiring that the organic plan describe farming practices designed to foster soil fertility, thus implicitly requiring that production takes place in the soil. The simple dictionary definition of soil is, “the upper layer of earth that may be dug or plowed and in which plants grow.”

By using the word “primarily” when it states that soil fertility must come “primarily through management of the organic content of soil...”, OFPA established the foundation of fertility in organic farming as coming from “management of the organic content of the soil through proper tillage, crop rotation, and manuring”. When those practices are implemented, other sources of fertility are only minor sources.

This subcommittee sees only one conclusion: when other sources become the primary source of fertility, then that operation is violating this mandatory part of OFPA. This conclusion is supported by statements in the Preamble to the USDA organic regulations that emphasize that soil is the primary source of fertility: "A producer of an organic crop must manage soil fertility, including tillage and cultivation practices, in a manner that maintains or improves the physical, chemical, and biological condition of the soil and minimizes soil erosion. The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials…. Crop nutrient management. The fundamental requirement of the soil fertility and crop nutrient management practice standard, that tillage, cultivation, and nutrient management practices maintain or improve the physical, chemical, and biological condition of the soil and minimize erosion, remains unaltered…. Additionally, we clarified that producers may manage crop nutrients and soil fertility by applying mined substances if they are used in compliance with the conditions established in the National List."

National Organic Program Regulatory Text Sections 205.202, 203, and 205

The following sections of the USDA organic regulations reflect the mandatory soil fertility requirements in OFPA.

§205.202 Land requirements.

Any field or farm parcel from which harvested crops are intended to be sold, labeled, or represented as "organic," must:
(a) Have been managed in accordance with the provisions of §§205.203 through 205.206;

§ 205.203 Soil fertility and crop nutrient management practice standard.

(a) The producer **must** select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.
(b) The producer **must** manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials.
(c) The producer **must** manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances….

§205.205 Crop rotation practice standard.

The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation:
(a) Maintain or improve soil organic matter content;
(b) Provide for pest management in annual and perennial crops;
(c) Manage deficient or excess plant nutrients; and

(d) Provide erosion control.

Similar to OFPA, by using the word "must" rather than "may" in these sections, the USDA organic regulations require these farming practices, thus implicitly requiring that production takes place in the soil.

In its 2010 recommendation, the NOSB identified the same sections listed above as the relevant areas of OFPA and USDA organic regulations that exclude hydroponic and other soil-less growing systems from certification. The NOSB recommendations of both 2010 (NOSB 2010) and 2001 (NOSB 2001) indicated that a producer operating a greenhouse with crops grown in containers may need to be exempt from requirements of 205.202, 205.203(a) and 205.205 along with the crop rotation and cover cropping requirements in section 205.203(b). By recommending these exceptions, the NOSB was proposing amendments to the USDA organic regulations that would "build upon the existing final rule and will address only the unique requirements necessary to certify these specialized operations." (NOP Preamble 2000).

Hydroponics Task Force Regulatory Considerations

In a presentation to the Hydroponics Task Force in 2016, the NOP stated that it was "Unable to accept exemption from 3 year requirement" and that it would require "Justification for exempting operations from – Crop rotation – Cover cropping" requirements. (NOP 2016) The reasons for these exceptions seem obvious to this subcommittee. It appears that the NOSB thought the 3 year requirement would not be applicable to a greenhouse using containers that would be filled with soil that meets the 3 year requirement. Crop rotation and cover crops may also not be necessary for container growing in a greenhouse if the operator is able to meeting the functions of a crop rotation through other practices. The text of the NOSB's proposed standards describes alternative practices that would be acceptable.

According to the NOP, (NOP 2016) other challenges to drafting regulations based on the NOSB 2010 recommendation include:

- Insufficient information to draw a line between hydroponics and other types of production in containers/enclosures.
- Clarification of requirement for growing media that supports diverse soil ecology.
- No mention of aquaponics

The NOP also said it needs answer to these questions:

- If hydroponic systems are not allowed to be considered organic:
  - Clarify and justify how to determine the line between hydroponic production and container grown crops

  - If soil ecology is the basis for not allowing hydroponics, how is soil ecology defined?
- If hydroponic systems are allowed to be considered organic, specify:
  - How these systems can integrate cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve bio-diversity.
  - What would be required of organic hydroponic systems – key components of measurable and enforceable standards.
  - How these products would be labeled.

These questions point out the difficulty of trying to alter the definition of soil to justify container growing. Although the characteristics of soil vary considerably from place to place, it is always clear what the soil of any given place is. If the NOP found these challenges too great to promulgate regulations from the NOSB recommendation because of the inability to draw a line between difference types of container growing, it would appear that the requirements for soil in the OFPA and USDA organic regulations would prevent the certification of any container grown crop. It is the lack of greenhouse standards that created the confusion and inconsistency about certification of greenhouse operations that grow crops in containers.

The NOSB proposed that it may be possible to certify container growing with a compost based growing media if it provides the beneficial symbiotic ecological relationships found in soil. However, this subcommittee recognizes that it may be difficult to develop standards that would enable the implementation of this recommendation. There are aspects of soil ecology that may not be able to be reproduced in containers. We discuss this in later sections of this report.

Exceptions That Need to be Addressed in Future Regulation (Applicability of OFPA and USDA organic regulations to various types of soil-less production systems)

Some agricultural products that may be deemed organic are not directly from soil production. We believe that the NOSB, in their 2010 recommendation, recognized that as OFPA and the USDA organic regulations are written now, there should be a link to soil in order that organic certification of such products be a sound and reasonable interpretation of the intent, or the product should be of a type that does not naturally need soil to live and grow. Furthermore, production practices of all agricultural products deemed organic should meet the Principles of Organic Production and Handling as described by the NOSB in their adopted guideline of 2001.

The 2010 NOSB recommendation (Production Standards for Terrestrial Plants in Containers and Enclosures) addressed exceptions to the premise that plants be grown in soil. Some exceptions, e.g., sprouts, mushrooms, etc., they said were outside the scope of the recommendation. From this subcommittee's perspective, the recommendation could be bettered, and more easily accepted by the NOP, if it explained how each of these exceptions to the premise that crops be grown in soil; 1) are linked to soil, or 2) are not naturally living or growing in soil so there is no reason for farming them in soil. Furthermore, how each meets the Principles of Organic Production and Handling (NOSB, 2001) should be made clear.

The following crops may or may not be considered exceptions to the premise that crops be grown in soil. We present an explanation as to why, if we think they should be exceptions, or we raise issues where we believe there is reasonable debate as to whether or not they should be exceptions.

Soil requirements are not applicable to four types of soil-less production: sprouts, mushrooms, wild aquatic plants, and annual seedlings.

These four types of production are in alignment with USDA organic regulations.

Sprouts and wild harvest of aquatic plants are addressed by the USDA organic regulations. The Preamble to the final rule indicated that additional standards would be needed for production of mushrooms and greenhouse production.

1) Sprouts (soil not applicable, in alignment with USDA organic regulations) Sprouting seeds does not need to take place in soil because sprouting should be considered a processing of an organic product. The seed is the certified organic product, and sprouting the organic seeds is simply processing. It is not analogous to growing a crop since no new crop production is occurring. The seed is the organic product; it is simply germinating. For the sprout to be considered organic the seed must have been produced on a farm according to the organic standards.

Sprout production requires only organic seed and water. Soil is not used, so the requirements for soil are not applicable. Sprout production can be certified as a handling operation, not as a farm because it does not require soil.

2) Mushrooms (soil not applicable, in alignment with USDA organic regulations) Mushrooms are not plants and so, similar to other non-plant agricultural products, should be exempt from a required direct link to soil. Mushrooms are in the kingdom Fungi. Unlike plants, mushrooms do not depend on minerals from soil. Rather, mushrooms are nourished by food fed to them by the producer. The key to the organic status of mushrooms should be that the food must be produced according to organic production standards.

3) Wild Aquatic plants (soil not applicable, in alignment with USDA organic regulations) These species naturally occur in aquatic (soil-less) systems and so it is not unreasonable for NOP to

accept an organic status without a soil link in their production, if all other criteria of OFPA and the USDA organic regulations are met.

The preamble to the USDA organic regulations in 2000, described changes that were included to specifically allow for the certification of wild aquatic plants: “Finally, we changed the definition of "wild crop" to specify that harvest takes place from a "site" instead of "from land," thereby allowing for aquatic plant certification.” However, this allowance was specifically for wild aquatic plant certification. The USDA organic regulations do not have any specific standards for non-wild aquatic plant certification.

4) Seedlings and planting stock raised in soil-less media (soil not applicable, in alignment with USDA organic regulations) The raising of these in a soil-less media is a short period of the whole production time. These crops will spend most of their time growing in the soil, and the short period of time in preparation for their field production should be an exception.

Seedlings are specifically mentioned in OFPA and USDA organic regulations. § 205.204(a) requires annual seedlings to be certified organic. Nonorganic annual seedlings may only be used if a temporary variance is granted in accordance with § 205.290(a)(2). The requirements for soil would apply to crops grown from seedlings, but may not be applicable to the seedling itself.

Some soil-less growing systems are not in alignment with USDA organic regulations because their fertility does not come from soil.

5) Fertigation as primary fertility source (Not aligned with OFPA and USDA organic regulations) Fertigation is the injection of fertilizers, soil amendments, and other water-soluble products into an irrigation system. Fertigation is not limited to greenhouse production or container growing. When fertigation becomes the primary source of fertility, it does not comply with the OFPA requirement that fertility come “primarily through the management of the organic content of the soil.” It would take a change in OFPA to allow systems that depend primarily on fertigation to be certified organic.

6) Hydroponic production of terrestrial plants (Not aligned with OFPA and USDA organic regulations) Hydroponics violates OFPA and USDA organic regulations because practices do not meet the requirements of the Sections noted above. Because fertility comes from water delivery of nutrients rather than soil, it appears that it would take a change in OFPA to certify hydroponic and aquaponics systems as organic.

The 2010 recommendation from the NOSB considered that such production does not meet the principles of organic production. They concluded that such production does not include the very basis of organic production, i.e., providing nourishment to the living fraction of the soil and this in turn providing available minerals to crops.

Some operators of hydroponic systems claim to employ biological activity to reduce complex molecules to simple mineral components that plants can use. However, this subcommittee was not provided with sufficiently detailed information to determine whether or not this is the primary source of crop nutrition. Furthermore, even if it is, we question whether removing soil from the system meets the intent of the OFPA. The so called “bioponic” systems are so new that there is no published research data on how they actually function. Is such hydroponic production actually based on a system that bypasses the soil food web and fertilizes the plants directly using immediately available nutrients?

Some container grown systems that use a combination of soil/compost as the source of fertility may be close enough to soil-grown that they could be certified with some amendments to USDA organic regulations.

7) Container production of crops to maturity (Debatable, not in full alignment with USDA organic regulations, but may be in alignment with 2010 NOSB recommendation) The media in containers may or may not contain soil and the corresponding biological activity creating available nutrients for plants. Furthermore, the amount of the media may or may not be large enough to supply the bulk of crop nutrients. This is fodder for debate in the NOSB and NOP.

Options include:

a) simply prohibiting the production of crops to maturity in containers,
b) or requiring containers of such size that the bulk of the crop nutrients comes from the soil in a container. In other words, limiting the amount of crop nutrients coming from soluble, plant available fertilizers.

The NOP has previously addressed the issue of crop nutrients being from available form rather than resulting from the soil. For example, the amount of nitrogen for a crop from sodium nitrate is limited to 20% of the total nitrogen needs. Hence, a possible guideline that assures container production meets the intent of OFPA and the USDA organic regulations is to require a minimum amount of biologically active soil/compost capable of supplying the bulk of crop nutrients, and limiting the portion of nutrients coming from immediately available form, as was done for sodium nitrate.

8) Microgreens (debatable, not in full alignment with USDA organic regulations, but are in alignment with the 2010 NOSB recommendation). Microgreens are raised past the stage where the product would be considered processing an organic seed (sprouts). They grow a short period of time past germination, and can be grown in a compost based medium. Such production may, or may not be considered an exception. Hydroponic production of microgreens would be considered under the hydroponic production system discussed above (item 36). Similar to growing crops in containers (addressed above) microgreen production is

trying to provide compost-based production by having ALL of the nutrients come from the seed and/or media. Because microgreens are raised for such a short period, this is truly possible.

Either type of container grown crops (microgreens or full maturity crops) may require changes to USDA organic regulations to be certified organic. On the other hand, perhaps the Rule as written would support a container system that mimics a soil system, i.e., one that contains appropriate media (compost) that decomposes and releases plant nutrients, and one that is large enough and contains enough media that the crop is primarily getting its minerals from the media.

Consistent with OFPA and USDA organic regulations

One of the key purposes of OFPA is "to assure consumers that organically produced products meet a consistent standard" (OFPA §6501). It is clear from the inconsistent way that hydroponic, aquaponics, and container systems are currently being certified that purpose is not being met. In its 2010 recommendation, the NOSB questioned the appropriateness of certifying soil-less systems and pointed out the need for exceptions from mandatory sections of OFPA and current regulations in order to certify container grown crops. "Although the regulations do not specifically state 'soil only production', the exclusion of soil from organic production of normally terrestrial, vascular plants violates the intent of the regulations. This intent can be seen in these sections of the rule that require proper stewardship toward improving and maintaining the soil ecology within an organic farming system." (NOSB 2010). Although the NOSB did not explain the need for exceptions from mandatory sections of OFPA and current regulations in order to certify container grown crops, it seems obvious to this subcommittee that additional standards are necessary. It appears that the NOP is now requesting justification for those exceptions or alternate methods for meeting the requirements.

The statements from the NOP that hydroponics are covered by existing regulations (NOSB 2003) was confusing to accredited certifiers. Such a statement by itself does not make hydroponic systems certifiable. Certifiers who have certified hydroponic operations can only do so by ignoring mandatory sections of OFPA and USDA organic regulations or designating such sections as "not applicable". This has led to inconsistent application of the regulations. Most certifiers do not certify hydroponics and many refuse to certify hydroponics because they have determined that these systems cannot comply.

Some people point to §6512 of OFPA as justification for certification of hydroponics, but other sections of OFPA preclude such certification because it is not consistent with the fundamental requirement for fertility to come primarily from management of organic content of the soil.

§6501. Purposes

It is the purpose of this chapter—

(1) to establish national standards governing the marketing of certain agricultural products as organically produced products;
(2) to assure consumers that organically produced products meet a consistent standard; and
(3) to facilitate interstate commerce in fresh and processed food that is organically produced.

§6506. General requirements

(a) In general
A program established under this chapter shall—
… (7) provide for appropriate and adequate enforcement procedures, as determined by the Secretary to be necessary and ***consistent**** with this chapter;

§6512. Other production and handling practices

If a production or handling practice is not prohibited or otherwise restricted under this chapter, such practice shall be permitted unless it is determined that such practice would be ***inconsistent**** with the applicable organic certification program.

§6513. Organic plan

… (b) Crop production farm plan
(1) Soil fertility
An organic plan ***shall**** contain provisions designed to foster soil fertility, ***primarily**** through the management of the organic content of the soil through proper tillage, crop rotation, and manuring.
…(g) Limitation on content of plan
An organic plan shall not include any production or handling practices that are ***inconsistent**** with this chapter.
[*emphasis added]

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Section 2. Soil as the Foundation

The Science of Growing in the Ground

There is an ongoing discussion about whether it is possible to replicate the complexity of a healthy soil system in a hydroponic system. The organic movement was built on maintaining and improving the soil in an effort to realize many benefits. The organic movement began as a belief system. In free ranging discussions with a number of soil scientists who have been longtime advocates of organic farming, we have come up with the following thoughts about the ways in which science has come to support that belief system. [4]

Reliance on a complex soil system is the foundation of organic farming. This soil system is based on biological complexity. A biologically complex system is a stable system. A biologically simple system is an unstable system. Modern "conventional" farming has worked on a strategy of making simpler systems that are nonetheless more easily controlled by human intervention. The soil on a "conventional" farm is biologically simpler than the soil on a well-managed organic farm (Birkhofer et al 2008; van Geel et al 2015; Tuck et al 2015; Bedini et al 2013). Nonetheless, most "conventional" farms have soil that has significant biological diversity. A hydroponic system, even with "added biology" is much simpler biologically than almost any soil system, including those of "conventional" farms. It is important to understand that there is an active biology even in "conventional" hydroponics. It is just less complex, and thus more vulnerable to disease, than a complex soil biology.

As Dr. Larry Phelan has written, "It is a fundamental principle of ecology that ecosystems with greater biological diversity are more stable and less susceptible to invasion". As an example, fungal, bacterial and total phospholipid fatty acid microbial biomass increased by over 40% on both conifer and aspen litter types in mixture, and microbial community composition changed significantly when plant litter types were mixed. Microbial diversity also increased with increasing plant litter diversity (Chapman and Newman, 2009). As the complexity of the environment increases, more niches are created and variation in resources provides opportunities for partitioning, allowing more species to coexist by reducing competition. The relationship between complexity/diversity and stability and invasibility is discussed in any Introductory Ecology textbook. Hydroponics are by design more simple than a soil environment. It is absurd to suggest that a hydroponic system, irrespective of the matrix used, can match the complexity of soil in terms of the physical environment, the resource base, or the biological community. [5]

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[4] Scientists included Dr John Spargo- Penn State University, Dr. Larry Phelan- Ohio State University, Dr. Will Brinton- Woods End Laboratories, Dr. Bill Liebhardt- UC Davis, Dr. Fred Magdoff -University of Vermont, Dr. John Reganold- Washington State university, Dr. Walter Jehne CSIRO, Healthy Soils Australia, Dr. Stuart Hill- University of Western Sydney.

[5] Personal communication from Dr. Phelan with the task force subcommittee.

The complexity of the soil system is best understood as a soil food web, as it is not a simple causal chain, but rather is a series of many interconnected relationships. It is a food web because everything in it is eating and being eaten by something else. There is constant cycling and recycling of nutrients.

It is our opinion that this web cannot be replicated by simply "adding biology", because we are not smart enough to know which biology to add, nor how much. The microbes that are cultured in a compost tea might not be the microbes that are needed by the plant. The mycorrhizal fungi that are added might not be the mycorrhizal fungi that are needed for the immediate challenges facing the plant. One strain of mycorrhizal fungi will help with disease suppression but hinder insect resistance. Another might do the opposite. We are not knowledgeable enough to get it right. The key to organic farming is to create the conditions in which the diverse biology will flourish.

The plant is a key part of the soil system. It actually is selective in cultivating the optimal bacteria and fungi in the soil to serve its own constantly changing needs. (Kallenbach and Grandy, 2011) It does this by feeding the appropriate microbes with root exudates that are up to 1/3 of the photosynthates it produces. It selectively feeds the microbes it needs. This process of the plant's supplying necessary energy to the life of the soil has been a basic part of the coevolution of the plant/soil community. [6]

Those microbes are intelligent in responding to the needs of the plants. There are many mycorrhizal fungi that are present in a healthy soil system. They are the living interface between the plants and the soil. They will selectively regulate which substances in the soil liquid stream will be permitted to be taken up by the plant. They allow beneficial substances in appropriate amounts and reject damaging substances.

The animals in the soil are also very critical in managing the microbiology. By animals, we mean the beetles, mites, protozoans, spiders, springtails, nematodes, worms, termites, slugs, and small mammals that live in a healthy soil system. These animals are critical in selectively influencing the makeup of the soil bacteria and fungi.

The basis for organic farming is to positively influence the conditions on the land and in the soil to optimize the growth of a very diverse and vibrant soil community. The amount of life below the surface of the soil is greater in biomass than the amount of life above the surface.
The soil is critical in managing the resource of water as well. See Role of Soil in Organic Agriculture that follows. The soil's ability to successfully manage the water is based on the activities of the entire soil food web, not just on the addition of organic matter.

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[6] Personal communication with Dr. Walter Jehne.

The complex soil system is not just important for providing proper nutrients. It is also critical for supplying chemicals that protect the plant from both insects and diseases.

A healthy soil system is based on recycling. There are critical cycles that the soil is a key participant in. These cycles include the mechanisms whereby carbon is sequestered in the soil. A healthy soil is our greatest defense against climate change.

The soil system is the basis for our survival on the planet. Plants, humans, other animals (both above and below the surface of the soil), and microbes have coevolved over the last 350 million years. In that time very sophisticated, interrelated mechanisms have evolved whereby healthy plants thrive and supply the needed nutrition for healthy mammals.

It is the opinion of this subcommittee that we do not fully understand most of these processes. What we know is much smaller than what we don't know. We can participate in and influence this system, but we cannot control it.

As Dr. Stuart Hill has said, quoting an old phrase, "If the animal is sick, look to the plant. If the plant is sick, look to the soil. If the soil is sick, look to the farmer."

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Role of Soil in Organic Agriculture

The authors of the OFPA and NOP Regulatory Text, and the members of the 2010 NOSB recognized the importance of soil, organic matter, soil organic matter, and soil biology. A discussion of more details can help better understand how organic matter in the soil system not only feeds the microorganisms but also plays the key role in building better soil physical and chemical properties. Moreover, a better understanding of the role of organic matter and soil organic matter will lead to a better understanding of why OFPA, the NOP Regulatory Text, and the 2010 NOSB Recommendation are written to include soil management as a mandatory part of the Organic System Plan.

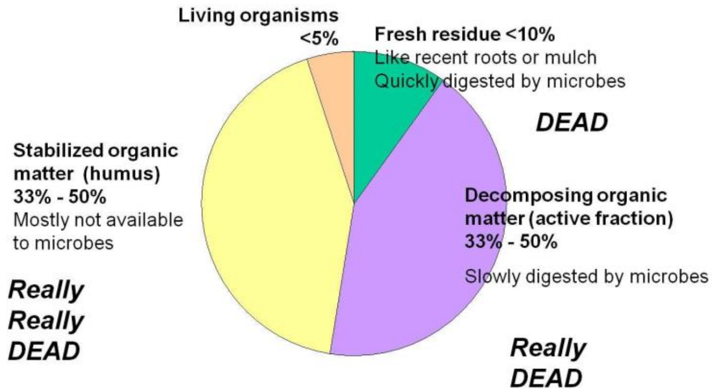
The USDA Organic Regulation definition of organic matter is incomplete in that it appears to refer only to recently decaying or fresh organic matter, for example, the organic matter added to the soil through the use of cover crops, animal manure and mulches. The term organic matter has also been used to describe the stable, long term humus in the soil, more accurately referred to as “soil organic matter” (SOM). Compost is an example of organic matter that can contain both recently decaying as well as long term stable humus forms (SOM). Fine dark lines or particles in soil aggregates are visible examples of SOM. (Madgoff and van Es, 2009)

Our current understanding of successful organically managed soil systems allows and requires more detailed and differentiated definitions of “organic matter”. The approach used in the 2010 recommendation separates the living organisms and dead plant material as two separate and distinct things. However, in modern perspectives the living organisms are or can be characterized as one of the organic matter fractions.

The success of a biologically active, productive soil under Organic management has been characterized as a balance of four organic matter fractions. (Snapp and Grandy, 2011)

1. Living Organisms
2. Recently dead micro and microorganisms and plant material up to several years old.
3. Slow decaying organic matter in the range of decades old (5 to 50 years)
4. Stable and humus organic matter that exists for decades to centuries (50 to 500 years) and has been identified as “soil organic matter” or “SOM”.

The proportions or percentages of these four fractions have been characterized as:



The key to an organic farming system is to build and maintain the interactions of the organic matter fractions with the mineral fractions. It is through these interactions that a productive and sustainable soil system is developed and maintained (Magdoff and Van Es, 2009). These interactions build soil structure that provides and retains a balance of water and air holding capacity, as well as good water drainage, that is needed for healthy/diverse microbial populations, which in turn, retain and cycle nutrients, and for crop growth (Moebius-Clune et.al, 2016).

Although the 2010 recommendation emphasizes the importance of soil biology, it did not address the essential water and air balance nor the nutrient cycling and retention that are dependent on organic matter and SOM. A biologically active soil comes from cultivating soil structure that provides adequate air and water holding capacity. Furthermore, the organic matter or carbon content of soils are now understood as short and long term carbon "pools" or reserves that are used by and composed of microorganisms; abiotic and biotic pools. In other words, the soil system is an interwoven balance of living organisms that not only build the soil structure, but depend on it for their own survival.

Soil Physical Properties

In an agricultural context, mineral soils are often defined as a mixture of soil particles of varying textures/sizes (sand, silt, clay) in combination with organic matter (range of 1 to 5% by volume), with a desired composition of 50% solid and 50% pore space. The dry bulk density or weight of "typical" or "ideal" mineral soils is generally reported as 1.3 gram per cubic centimeter (~83 pounds per cubic foot). When present in deep undisturbed/structured continuous columns of two feet or more and after an application of an excess of water and drainage of water by gravity, there is a desired mixture of approximately 50% air/large pore space and 50% water/small pore space. The biological and chemical activity in the organic matter fraction is the key to the development of the pore spaces by forming secondary aggregation of soil particles. This aggregation creates a crumb-like structure that creates large pores which allow water movement and available oxygen, and small pores for water and nutrient holding capacity. It is the decomposition of organic matter by microorganisms in soil that creates the glues and cements that build soil structure (Magdoff and Van Es, 2009).

Living, decaying and long term SOM are necessary for continued maintenance of water absorption into and retention by mineral soils. Water absorption is influenced by soil texture, structure, crusting and macropore channels from decaying roots or earthworms (living organic matter). Soil aggregate formation and stability are two measures of soil health (Moebius-Clune et.al, 2016).

Soil Chemical Properties

The longer term organic matter or "humus" fraction also provides electrical or "magnetic" negative charges important for retaining a reserve of essential cations for plant growth (Ca^{++}, Mg^{++}, K^{+}, $NH4^{+}$, Fe^{++}, Mn^{++}, Zn^{++}, Cu^{++}). A key to the regulation of the rate of plant growth (not too fast and not too slow) is the balance between readily available / soluble nutrients and a long term supply of nutrients either associated with charged soil particles or in the pools of living and decaying organic matter. Just as it is possible to over fertilize plants in non-organic systems with the over application of soluble nutrients, it is also possible to over fertilize plants in organic systems by over application of soluble nutrients from organic fertilizers, or building too large pools of organic matter from manure or compost. It is the size of both the biotic and abiotic nutrient retention potentials that impacts the success of an organic soil management system.

Soil Biological Properties

The nutrient retention potential of soil is in part characterized as cation exchange capacity of the non-living soil, as well as the living organic matter fraction that rapidly responds to short term nutrient fluxes by increasing or decreasing populations. Soluble nutrients can result in increased biological activity/populations that can sequester the available pool of nutrients. In a healthy soil system, knowledge of how these cycles work allows farmers to match nutrient availability with peak crop growth rates.

"Organic" Soil

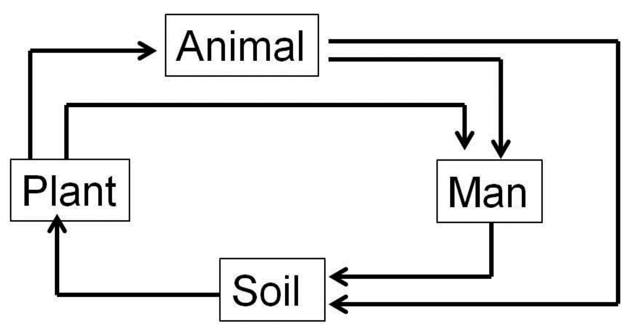
The key distinction between organic fertility management and conventional fertility management is that in organic the source of the bulk of the crop nutrients are from the biological activity decomposing complex organic molecules (compost, manures, seed meals, etc.) and the mineral fractions. In contrast, in non organic production the bulk of the plant nutrients are supplied in available forms. It is the management of the soil that facilitates this complex system in an organic system. In contrast, in a non organic system it is the management of the fertilizers.

When does a "soil" become "certified organic"? The short answer is never. Soil is not certified as organic. The organic systems plan (OSP) that characterizes all the management practices that allow a soil to be productive is what is certified as organic. These practices can include crop rotation, tillage, use of cover crops to prevent erosion, catch crops to prevent leaching of nutrients, application of manure, mulch or compost to provide living, decaying and stable forms of organic matter. These practices are also identified to prevent erosion / soil loss and to build soil through the formation of stable soil aggregates. Our knowledge and management of soil physical properties (water/air), chemical properties (CEC, pH) and biological properties (diversity, biomass) together define an organic agriculture management system. Without the multiple, integrated roles that soil provides, it is not possible to have organic agriculture.

The lack of a definition of soil from an organic farming perspective and the language used in the 2009/2010 recommendation allowed certain certification agencies and hydroponic growers to conclude that it was microorganisms or biology alone that made a system organic. Organic Agriculture is rooted in the management of soils, not the presence or absence of soil biology.

Regarding Organic Hydroponics

Lord Northbourne in the book *Look to the Land (*1940), often referenced as one of the first uses of the term "organic agriculture", spoke of concerns about the then recently developed commercial hydroponic systems in the opening pages of the book (pg 4). He spoke of how hydroponics can be misleading if applied to field soil systems and of the need to see the soil as a living whole and not a dead medium. Northbourne also spoke of the essential interdependent cycle that connected plants, animals and humans to the soil (pg 34) and the importance of the cycle to human health.



A question to ask in regards to hydroponic systems of any type is whether multiple generations of plants can be grown from seed to seed under continuous hydroponic production. Decades ago Sir Albert Howard (2007) questioned the reliability of the long term soil and nutrient management trials at Rothamsted Experiment Station (UK) in part because each year fresh seed was introduced. The trial did not include continuous seed to seed production over many generations that would provide a better test of the system viability. Northbourne (1940) also pointed out the same need for a "considerable number" of generations to be grown with hydroponics to produce multiple generations of plants to be tested by exclusively feeding to multiple generations of animals (pg 5).

Hydroponics is presented as a sustainable alternative to soil, in part due to the potential for nutrient recycling and the conservation of limited water resources. Comparing water use efficiency of hydroponics in greenhouses or controlled environments to field soils seems less appropriate than comparing it to other containerized systems in greenhouses or controlled environments. Regarding water use and nutrient efficiency, well managed non-leaching containerized systems using compost based growing media suitable for use in an organic systems plan can be as good as hydroponic systems.

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Section 3. Containers and Growing Media

The Challenge of the 2010 Recommendation

The key question that the 2010 NOSB recommendation did not clearly address was exactly how to draw the line between "grown in the soil" and "hydroponic". There are a few other questions that require clarification, such as the use of 100% artificial lighting and the requirement for crop rotation, but this section of the report will focus on the big question of how to define what is acceptable as "grown in the soil".

The 2010 Recommendation stated:

"Observing the framework of organic farming based on its foundation of sound management of soil biology and ecology, **it becomes clear that systems of crop production that eliminate soil from the system, such as hydroponics or aeroponics, can not be considered as examples of acceptable organic farming practices**. Hydroponics, the production of plants in nutrient rich solutions or moist inert material, or aeroponics, a variation in which plant roots are suspended in air and continually misted with nutrient solution, have their place in production agriculture, but certainly cannot be classified as certified organic growing methods due to their exclusion of the soil-plant ecology intrinsic to organic farming systems and USDA/NOP regulations governing them."

And further on:

"Although the regulations do not specifically state 'soil only production', the exclusion of soil from organic production of normally terrestrial, vascular plants violates the intent of the regulations. This intent can be seen in these sections of the rule that require proper stewardship toward improving and maintaining the soil ecology within an organic farming system. It is pointed out that naturally aquatic plant species and non-vascular plant species such as mushrooms come from different (non-soil) ecological niches and would be handled separately. Sprouts (the sprouted radicle and hypocotyl of seeds) are produced without soil by design and are not subject to this recommendation.

In previous Crops Committee discussion documents, the question has been asked: "Should container culture based growing media (typically utilized in greenhouse systems) that are predominantly compost and compostable plant materials be considered 'soil'. As highlighted in earlier portions of this document, a foundational principle of organic farming is the practice of maintaining and nurturing soil health so as to foster the proliferation of the proper soil biology with their accompanying ecologies. Since all typical soil dwelling organisms, such as earthworms, protozoa, fungi, bacteria, actinomycetes, etc. can thrive in a properly designed compost based growing media, producing the beneficial symbiotic ecological relationships found in soil, such growing media should be rightfully considered soil."

These paragraphs set a high bar for what can legitimately be considered organic. The 2010 Recommendation does not articulate which specific practices can or cannot be allowed, but it makes clear that to permit growing in containers the standards must satisfy these demands.

One question asked of the task force is how to clarify which systems should be considered hydroponic, and which systems should be considered as being based on “sound management of soil biology and ecology”. There is a confusing continuum between “grown in the ground” and “grown in a nutrient solution.” The task force has spent a lot of time trying to examine the large variety of growing systems, and to create a framework for differentiating these systems. There has been a frustrating shortage of specific information on the fertility programs being used in the currently certified hydroponic operations, but we have done our best with the information we have gotten. Below is this subcommittee’s perspective of the continuum that the NOSB should consider.

At the top of the continuum is “grown in the ground.” This is clearly not considered hydroponic production anywhere in the world. It is grown in the soil, and it is grown as an integral part of the soil system. Once we take a shovelful of that soil and put it in a container, we have entered a new and challenging arena.

Every organic standard in the world accepts grown in the ground as qualifying for certification. The controversy for organic certification comes when the plants are grown to maturity in some kind of containers, and then harvested. At this point, there is no longer world consensus. This is stepping onto a slippery slope. As we have seen above, adhering to the basic language of the NOP regulations, and OFPA is very challenging.

Assessment of Alignment with OFPA and USDA Organic Regulations

For crops that are not grown directly in the ground, there is a wide range of production systems. Each system uses different production methods which have unique implications in terms of their similarity or differences to traditional in-ground systems, and their alignment with organic regulations. All of these types of systems only use approved inputs. Our subcommittee concludes that A is certifiable, B could be certifiable, but C through E is not certifiable.

A. Indoor or outdoor production of perennial or annual plants grown **in-ground**, with nutrients **primarily** supplied by the soil.

B. Indoor or outdoor perennial or annual **container** system using growing media containing compost or soil which may be regularly amended with nutrients **primarily** supplied by the soil.

---------------------------- the systems below this line are not certifiable ---------------------------
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C. Indoor or outdoor perennial or annual **container** system using growing media containing compost or soil which may be regularly amended with plant nutrients primarily supplied by liquid fertilizers. This may or may not include the addition of microbial inoculants such as compost tea.

D. Indoor or outdoor perennial or annual **container** system growing in plugs or totally soil-less, relying exclusively on the liquid system for plant nutrition. Ammonifying and nitrifying bacteria may develop in these systems over time. Microbes are added (via sources such as compost tea) to possibly make nutrients plant available. These can also use liquid nutrients that are already plant available. This includes aquaponics with a raft or an NFT system. No or very little soil or compost.

E. Indoor or outdoor perennial or annual **container** system growing in water or in an inert growing media (such as coconut coir, peat moss, vermiculite, perlite, etc.), relying exclusively on the liquid system for plant nutrition, but without the addition of microbes via sources such as compost tea.

Photos of each type

These photos may be from conventional production, as we have been unable to find organic producers who would allow us to use photos of their production, but the systems are identical in appearance. As with all of the certified hydroponic production systems we have approached, getting clear information about current fertilization practices has been difficult, as the growers we have asked, including those on the task force, are unwilling to publicly share these details. However, this has really not affected our ability to assess alignment with OFPA because these systems derive their fertility primarily from soluble fertilizers delivered through water and not primarily from organic content of soil as required by OFPA.

Type A Production System

(Indoor or outdoor production of perennial or annual plants grown **in-ground**, with nutrients **primarily** supplied by the soil.)

In the ground using a high tunnel. This system has been in production for over 12 years, certified organic since 2003, amended semiannually with compost, gypsum, and sulfur based on soil analysis. No liquids. No leaching.


In the ground with a heated greenhouse.

Type B Production System

(Indoor or outdoor perennial or annual **container** system using growing media containing compost or soil which may be regularly amended with nutrients **primarily** supplied by the soil.)

A large bed of amended soil placed over a gravel parking lot. This is in Detroit and has been very productive for several years with minimal fertilization. No Liquid. Not certified Organic.

Beds of compost 12” deep over gravel and landscape fabric. Installed July 2012 and certified organic following inspection in September 2012. Only compost, gypsum or sulfur added annually. Produces large crops culinary herbs, salad greens, tomatoes and cucumbers.

Type C Production System

(Indoor or outdoor perennial or annual **container** system using growing media containing compost or soil which may be regularly amended with nutrients with fertility primarily supplied by liquid fertilizers. This may or may not include the addition of microbial inoculants such as compost tea.)

As an example of Type C production systems, this photo shows a container operation growing tomatoes. The growing media is made from a dairy manure compost, peat, and a small amount of perlite. After a short growing period, it requires liquid feeding with regular applications of fish hydrolyzate. This growing system could not work as a Type B due to insufficient soil volume to provide adequate nutrition primarily from the soil.

Type D Production System

(Indoor or outdoor perennial or annual container system growing in plugs or totally soil-less, relying exclusively on the liquid system for nutrition. Ammonifying and nitrifying bacteria may develop in these systems over time. Microbes are added (via sources such as compost tea) to possibly make nutrients more plant available. These can also use liquid nutrients that are already plant available. This includes aquaponics with a raft or an NFT system. No or very little soil or compost.)

This photo shows a Nutrient Film Technique (NFT) system with seeds started in “plugs” of a growing medium containing compost.   Compost may provide biological activity but the nutrients are primarily provided by allowed fertilizer sources added to the recirculating solution.

Type E Container production systems

(Indoor or outdoor perennial or annual container system growing in water or in an inert growing media (such as coconut coir, peat moss, vermiculite, perlite, etc.), relying exclusively on the liquid system for nutrition, but without the addition of microbes via sources such as compost tea.)

http://www.priva.ca/en/discover-priva/testimonials/2014/southland-sod-farms-a-trailblazer-for-the-next-generation-of-raspberry-producers/

The photo above shows a system that is now being used for perennial container blueberries and raspberries.

Nursery growing containers used for berries range in volume from 5 to 10 gallons (25-40 liter). The growing media components may consist of sphagnum peat, coconut coir and perlite and may also include some compost or composted wood chips. In the last ten years, coconut coir has become a standard substrate for “conventional” vegetable hydroponics (for crops like tomatoes, cucumbers, peppers, and berries). If compost is added to the growing media (even as little as 1%), this then becomes an example of a Type C production system. In Type E production systems, fertility is derived predominantly from liquid fertilizers provided through the irrigation lines. Examples are fish emulsion hydrolyzate and/or soy products.

Biological activity is reported to be the result of ubiquitous microbial populations. Microbial products may or may not be added to encourage or speed up establishment of these populations but “adding biology” has not proven necessary in order to establish microbial populations in many container operations. This has proven that adequate crop results can be achieved in container growing without adding compost, compost tea, or any of the commercially available products alleged to contain beneficial microorganisms.

Criteria Used for Characterizing Systems

The first question is whether we can accept container growing as qualifying as organic. If we can accept the possibility of container growing, then a second question is how to ensure that container growing systems still adhere to the basic principles of organic farming. Following are seven criteria that were considered by the 2010 Subcommittee.

1. Source of Fertility

Even with a minimum soil volume requirement, without specific requirements for the source of fertility there is nothing to prevent a grower from running what is, in effect, a hydroponic growing system, in which virtually all of the nutrients are supplied in the liquid nutrient solution, thus bypassing the soil food web. The British Soil Association has implemented a rule to address this, limiting the amount of nutrients that can be added after planting to no more than 50% of the total nutrients required. The Soil Association requires all crops to be grown in the ground, so this requirement applies to soil grown crops in both field and greenhouse. These same requirements are recommended by the IFOAM EU 2010 Recommendation for Greenhouse Standards, as well as limiting the nutrients supplied in a liquid form to no more than 25% of the total nutrients supplied to the crop. While we will discuss other possible approaches, this is a verifiable way of insuring that fertility is coming from the soil mixture. We suggest that the NOSB develop this type of approach of limiting the plant available fertilization to 20% of a plant's nutritional needs on an annual basis in an effort to follow the intent of the 2010 recommendation (akin to the manner by which NOP regulates the use of sodium nitrate, which is an immediately available source of nitrogen fertility) (See Appendix I).

2. Growing Media / Compost

The type of growing media will help determine the amount of water and nutrients supplied by the growing media versus directly from water applied nutrients. The height of the growing media in a container will impact the proportion of the pore space filled with water or air; short containers hold more water than tall containers. The media in short containers (flats) used for transplants is made more porous to increase air space. The same high porosity media is used for larger/taller containers for finished crops, but doing so is not essential. One measure of growing media nutrient retention capacity and porosity is the bulk density or weight per unit volume. Non-organic peat-based or coir-based container growing media have approximately one-tenth the bulk density of mineral soils (0.13 gram/cubic centimeter compared to 1.3 gram per cubic centimeter). Using compost and composted mineral soils, growing media can be designed with both the capacity to provide adequate aeration and nutrient retention. With compost or high organic matter based media, as the bulk density increases (range of 0.3 to 0.9 gram per cubic centimeter) typically so will the nutrient holding capacity. We recommend that the organic growing media must have a minimum of 20% composted plant and animal material.

3. Biological Activity of Growing Media

The presence of biological activity that allows conversion of ammonium to nitrate nitrogen and the digestion of organic nutrient sources, as is the case for bioponic and aquaponic systems, does not qualify the system as suitable for organic certification. The 2010 recommendation distinguishes hydroponic systems from allowed container systems, using the assumption that greenhouse and container systems use compost-based growing media, or soil in which "all typical soil-dwelling organisms can thrive". The extent to which soils can support diverse soil ecology varies drastically based on texture, structure, density, temperature etc. This requirement would be very challenging for certifiers to apply consistently, so we are not recommending a standard based on the measured biological activity. This task force has not been provided evidence that biological activity contributes significantly to providing fertility in a system that primarily provides soluble nutrients to the crops. We also are finding that some of the currently certified container production systems feeding via approved organic liquid fertilizers do not find it necessary to "add biology", and are still quite successful in producing crops. This would indicate that adding biology is not a necessity for producing crops with allowed organic fertilizers. It raises the question whether adding biology is a necessity. Without specific limits on the use of liquid fertility, a farm could add compost tea or small amounts of compost in order to satisfy the requirement of having an active biology while actually relying primarily on the liquid fertilizers to supply the needed nutrients. A more easily verified regulation could be based on the amount of added fertilizer. The amount of fertility needed to be added would reflect the amount of fertility not supplied by the soil (see The Soil Association Greenhouse Standards, Appendix D and the IFOAM recommendations, Appendix B).

A recent study by the Oregon Department of Agriculture discovered that many of the commercial products being sold to growers to supply microorganisms are failing to meet their claims. "Some products have met the claim [that they contained viable microorganisms] and have passed, but the percentage is very low," says Oregon Dept. of Agriculture fertilizer enforcement specialist Toby Primbs.

4. Consumer Awareness of Growing Method

For many centuries, agriculture has included growing seedlings in containers for transplant into the field. It has also included growing plants, such as ornamentals and herbs, for taking into people's houses for their pleasure and, in the case of herbs, for their consumption.

Organic farming around the world has always accepted these kinds of container growing, and there is little controversy around this. In the European standards, permitting this kind of container growing is explicitly stated, and is justified on the basis that the consumer can always tell that the seedlings or herbs they are purchasing are grown in pots (See Appendix A). In the case of seedlings, it has been justified in that the plants will spend the majority of their lives growing in the ground as part of a full soil system. But to ensure that consumers are not mislead, even for the stated exceptions of seedlings, ornamentals and herbs, any products grown in containers must also be sold in the same containers. That way it will be clear how those plants were produced.

5. Annual Seedling Transplants or Finished Crops

Methods for organic annual seedling production have included the range of Growing Methods from Type A to E listed above since the start of the USDA organic regulations. Methods of using peat-based and other light weight media and water soluble fertilizer have been accepted for annual seedlings. Apparently what has been allowed to happen is that these methods of production for annual seedlings are now being used for full season organic crop production. In order to align with OFPA, either a clear distinction between transplants and crops needs to be made, or more restrictive methods for transplant production requiring compost-based growing media similar to Types A to B need to be required.

6. Container Size

By making the containers large enough, it is possible to rely on the nutrients contained in the soil and the complex soil biology therein to supply the majority of nutrients that a plant requires. These systems are an attempt to adhere to the organic principle of feeding the soil instead of the plant, while at the same time allowing growers to avoid some of the challenges of growing in the ground, such as a buildup of disease and growing on very infertile or stony ground, or, in urban settings, even on concrete. Requiring a minimum soil volume per ft^2 of growing area is a step in the right direction.

To go further we could follow the recommendation of Dr. Martine Dorais of Laval University and the Agassiz Research and Development Centre to grow in 100 to 180 liters of soil per m^2. At this volume she has demonstrated that no liquid feeding is necessary, and fertility can be provided by the biological activity of the growing medium in the beds.

However, container size alone does not ensure the soil and organic matter as the primary source of fertility and the necessary restriction on routine liquid nutrients.

7. Adherence to All Applicable Aspects of the USDA Organic Regulation

A significant problem with allowing a container system in America is its departure from the section §205.203(a) of the USDA organic regulations- "The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of the soil and minimize erosion." Although it can be required to use soil as the growing medium in a container, it would be difficult to say that growing in a container is maintaining or improving the soil. It is our concern that if NOSB accepts growing a crop to maturity in containers, an amendment to the USDA organic regulation may be required.

Section 4. International Standards

It is helpful to look at the standards in the rest of the world, to see how they have addressed these certifying challenges. The US is alone in NOT having created rules around greenhouse growing for organic certification.

There are three basic groupings.

1. The Canadian standards. [7]In the first group, Canada and Sweden are the only countries that we know of which have taken the approach of permitting container growing while requiring minimum soil volumes based on growing area. Both countries prohibit hydroponic production.
2. The standards for most European countries prohibit hydroponic production. They allow container production for very limited exceptions. They require that organic crops be grown in the ground except for transplants, ornamental potted plants, and potted herbs, which can be grown in containers.
3. The Scandinavian standards allow growing in containers. The four countries take different approaches to this, but all permit some kind of container growing to maturity. An approved biodegradable substrate is permitted, but they all prohibit soil-less growing such as NFT or aquaponics.

The Canadian Standards

Discussion:
In November 2015, the Canadian greenhouse standards were amended. The standards were strengthened, greatly increasing the amount of soil mixture required per square foot of growing area for staked crops such as tomatoes, cucumbers, and peppers. This was a huge change which will have a strong impact on the Canadian greenhouse industry. Existing certified operations have been given one year grace period to change their growing practices in order to meet the new standards.

The new standards (see Appendix C) continue to prohibit hydroponic and aquaponic growing for organic certification, but they go much further in stating explicit requirements for container growing. The old standards had no minimum required soil volume, much like the Scandinavian standards.

The new standards require a minimum soil volume of 70 liters per m^2 of growing area. They state:

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[7] See Appendix C.

"**7.5.4** Soil used in a container system, with the exception of transplants, shall provide nutrients to plants continuously. The soil (growth media) shall contain a mineral fraction (sand, silt or clay) and an organic fraction; it shall support life and ecosystem diversity."

They go on to have stricter requirements for long season, tall "staked" crops, such as tomatoes, cucumbers, and peppers:

"**7.5.5** The following conditions apply to containerized, staked crops (for example, tomatoes, sweet peppers, cucumbers, eggplant):

- a) at the start of production, the total volume of soil shall consist of at least 10% compost;
- b) compost shall be included in the fertility program;
- c) containers shall be at least 30 cm (12 in.) high; and
- d) the soil volume shall be at least 70 L/m² (15.4 gal./10.8 ft^2), based on the total growing area."

To give an example of how much soil this would be, here is a description of a typical greenhouse set up for tomatoes. The plants are grown in a bed that is approximately 4 feet wide, with a path on each side. In the bed there will be two rows of plants. If 5 gallon buckets were used to hold the soil blend, there would be two rows of five gallon buckets, filled to the brim, pressed together bucket to bucket, for the length of the bed. The standards don't specify the shape of the container or raised bed. If it is a raised bed, it can be demarcated from the ground underneath by a sheet of poly, or some other kind of barrier.

As listed below, the current Canadian standards ban all NFT and hydroponic growing systems from organic certification.

- **7.5.3**: "Hydroponic and aeroponic production are prohibited."

- **7.5.4: "**Soil used in a container system, with the exception of transplants, shall provide nutrients to plants continuously. The soil (growth media) shall contain a mineral fraction (sand, silt or clay) and an organic fraction; it shall support life and ecosystem diversity."

- **7.5.12: "**Soil regeneration and recycling procedures shall be practiced. The following alternatives to crop rotation are permitted: grafting of plants onto disease-resistant rootstock, freezing the soil in winter, regeneration by incorporating biodegradable plant mulch (for example, straw or hay), and partial or complete replacement of greenhouse soil or container soil, provided it is re-used outside the greenhouse for another crop."

The way that the current Canadian standards are written, there is no limitation on artificial lighting, and if a grower could satisfy the soil requirements, they could technically be permitted to grow in 100% artificial lights.

In the current Canadian standards, no rotation is required in a greenhouse crop, either in the ground or in a container. (See above 7.5.12).

Aquaponics can be certified as organic in Canada through a non-government certification program for Aquaculture. Products certified under this label do not qualify for export to the US, nor can they bear the official Canadian organic seal.

The following are some key challenges that this subcommittee sees with the current Canadian standard:

1. The way that the standard is written, there is no minimum requirement for % of compost in the soil mixture for a lettuce crop, and there is no minimum requirement for the % of a mineral fraction in the soil mixture in any kind of crop. So theoretically, an operation could throw in a handful of sand into their coconut coir mix and satisfy the letter (if not the spirit) of the law. The current Canadian standard requires at least 10% compost in a staked crop at the start of the crop.
2. The required minimum soil volume is only at the start of the crop, but this could easily be greatly reduced by breakdown and settling by the end of the crop, resulting in a reduced soil volume of up to 50%. There perhaps should be clear requirements for both mineral fraction and compost fraction. There perhaps should be a requirement to maintain minimum soil volumes during the growing season, to avoid a single measurement when the soil mixture is fluffy and filled with air at the beginning of the season. This might well require topdressing with compost during the crop cycle.
3. It is unclear how certifiers would measure these required soil mix fractions.
4. There is no limitation on the amount of nutrients that could be supplied as a liquid, so even though an operation might be growing in a container with 70 liters/m^2 of growing area, it would still be quite possible to be running a 99% hydroponic operation, in which virtually all of the nutrients that the crop takes up are in fact supplied in a nutrient solution.
5. They do not address the use of the newer hydrolyzed liquid fertilizers that, in effect, provide soluble N to the crops, thus bypassing the need for a complex soil microbiology to transform the N from a complex organic form into a mineral form. **Hydrolyzed protein** is protein that has been hydrolyzed or broken down into its component amino acids. While there are many means of achieving this, two of the most common are prolonged boiling in a strong acid (acid-HVP) or strong base, or using an enzyme such as pancreatic protease to simulate the naturally occurring hydrolytic process.
6. If the goal is to require the producer to create a soil system which will provide the bulk of the nutrients through the normal biological interplay of a complete soil system, then there should be a limitation placed on the % of liquid feed that could be provided.

7. There is no clear definition of the "growing area". "Growing area" needs to be clearly defined. In most greenhouse production, "growing area" includes the paths between the growing beds, and sometimes the concrete walkway at the end of the house is included as well. This should be defined if the NOSB chooses to go in this direction.
8. There is no restriction on swinging back and forth between conventional and organic. As no transition period is required, this opens the way to an operation choosing whichever system seems most profitable for that season. It even permits a grower to use a prohibited substance to "clean up" an insect problem at the end of the crop cycle, and then return a week later to "certified organic" production.
9. Certifiers struggle with certifying for "ecosystem diversity". That is a statement of principle, but it is beyond the capabilities of most certifiers to evaluate such a criterion. Certifiers felt that this was obvious in an in-ground system, but had no idea how to evaluate it in a container system. Certifiers expressed to us the desire to have more clear criteria that reflected the principle of "ecosystem diversity". There are mechanisms for evaluating ecosystem diversity, such as measuring the diversity of soil life (both microbes and animals).
10. Although the question of 100% artificial light is not addressed in the standards, inspectors that we spoke with felt it should be, as none of them accepted 100% artificial light as qualifying for organic certification. It is true that the Canadian standards insistence that crops must be grown in a soil mixture would make 100% artificial light unlikely, it still could happen, for example in a marijuana crop growing in a locked facility.

The EU Standards

Most of the European countries are members of the EU, and EU organic standards are set by the European Commission. These standards are the basis for the standards of the member countries, which can then create their own standards, based on the EU standards. Individual countries may make stricter standards, but cannot allow practices that are prohibited by the European Commission.

The European Commission is advised by the EGTOP (Expert Group for Technical Advice on Organic Production) in creating standards. The EGTOP is composed of scientists, academics, and policy advisors from various member states. The EGTOP makes recommendations, which are then acted on by the European Commission. The EGTOP is respected in the European organic community as a sincere group of scientists who know a lot about their field of expertise, and are also connected to the organic sector.

In 2013 the EGTOP released a report with proposed organic greenhouse standards. See Appendix A.

Earlier in 2013, the IFOAM EU also released a report on organic growing in greenhouses. This report was the result of years of work. On the question of soil and hydroponics, the EGTOP report agreed with the IFOAM report, concurring that organic production in greenhouses should be grown in the ground, with the allowed exceptions of seedlings, ornamentals, and herbs. To see this report, go to Appendix B.

The approach of the EU Commission is quite different from that taken by the NOP. The basic standard of ALL of the countries in Europe says that hydroponic production is prohibited. The basic EU rule is that organic means grown in the soil, and that growing hydroponically (in an inert substance (like rockwool, or in a Nutrient Film Technique) is clearly forbidden. But the definition of "soil" is up to each country. 23 (including England, Germany, Holland, France, Spain, Belgium, Austria, and Italy) out of 28 member states forbid growing on natural substrates (such as coconut coir and peat moss) as well as inert substrates. They require that organic growing happen in soil that is continuously connected with the subsoil and bedrock. This means that is must be grown in the ground. An accepted exception is that seedlings, ornamentals, and herbs are allowed to be grown and sold in containers. If herbs are harvested prior to sale, then they must also be grown in the ground. As an example, the Dutch interpretation of the EU standard, laid down in Article 4 of the Council Regulation (EC) No 834/2007 is that crops that are normally grown in the soil, must be cultivated in the soil. And soil is defined as the outer layer of the earth's crust.

The 23 EU countries are very clear that the exceptions are exceptions, and that all other organic production must happen in the ground. Some of these countries do not have explicit language in their standards describing that the production must be in the ground, as they take the approach that growing in the soil is self-evident for organic growing, and only the exceptions must be specified. Some other countries have language that clearly states that organic production must happen in the ground.

For example, the language from Germany as stated is the Bioland standards:

5.1.2 Soils and Substrates
Growing vegetables on stone wool, hydroponics, nutritional film technology, thin layer culture and similar systems are not permissible neither the production in bags and containers. Permissible is the growing of herbs in pots and similar products, whereas the container is sold together with the plant.

But in all of these 23 countries, the enforced standards are that organic produce must be grown in the ground.

The rationale for the exceptions are specified by some countries, such as Holland and Germany.[8] We have discussed with policy advocates of European groups the rationale for

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[8] This justification is put in official writing in some countries, for example in Germany on the webpage with the official explanations of the European regulation for organic production:https://www.oekolandbau.de/fileadmin/pah/loek_protokolle/
The same for the Dutch official interpretation of the regulation: http://www.skal.nl/assets/Wetgeving/Skal-R4.pdf

allowing exceptions for containers for seedlings, ornamentals, and herbs.[9] They have said that as seedlings still spend most of their life in the soil before harvest, this is still in keeping with the principle of grown in the ground. This is the traditional way that growing has always happened. The containers are still required to be filled with acceptable potting mixture based on Annex 1. All countries allow soil in the potting mixture except Austria, which prohibits it because it means removing soil from the farm.

The justification for an ornamentals or herbs to be grown and sold in a pots is that then the consumer can see exactly how it was grown, and not mistake it for something grown into the soil. The standard is that organic produce harvested out of sight of consumers must always come from plants grown in soil, and not from horticultural substrate cultures. We have heard from policy advocates that the goal in Europe is complete transparency with the consumer. They want the consumer to understand and be able to trust what they are buying.

There is one Dutch group of growers that is certified only by the NOP, called Pura Natura. They grow somewhere between 8 and 15 hectares of hydroponic peppers and tomatoes. There has been some concern that they might try to sell their produce in Holland, using the equivalency agreement with the US, but that hasn't been attempted so far. Of course, the substrate grown "organic" produce from Holland is not considered organic in Holland. It can only be certified organic by the NOP, not by the Dutch certifiers. It is all exported to the US.

At the moment aquaponics are not certified organic in Europe. Growing in the soil is a foundational principle of European organics. The belief system of organic is based on the principle of feeding the soil, and thus supporting the whole biological system that transforms the minerals in the soil into food for the plant in a very steady, slow-release way.

The EU makes an effort to limit the fertilization of crops to the natural process of a healthy soil. The British Soil Association specifies that at least 51% of the nutrition for the crop must come from the soil at the time of planting. The belief is that the major source of the fertility has to be the soil. This standard takes work to enforce, but all the certifiers are working with this. Almost all European countries have held fast on the question of growing only in the soil.

Looking at the standard in England and Belgium, they do allow continuous cropping in a greenhouse of a single crop, as long as other soil health issues are addressed. In the rest of Europe there is a variety of approaches. Many growers in Holland have a very minimal rotation in the greenhouse. Perhaps tomatoes are followed by peppers, often grafted onto the same rootstock, and then back to tomatoes.

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[9] Private conversations with Marian Blom, a Regulation Officer for Bionext and former Council member for IFOAM EU, Chris Atkinson of Soil Association, and Alan Schofield of Soil Association and Organic Growers Alliance.

The Four Scandinavian Countries

The three northern countries of the EU (Sweden, Finland, and Denmark) plus Norway allow "substrate growing," meaning they allow growing in containers or isolated beds. They took a different approach from the rest of Europe in defining "grown in the soil."

In Sweden they follow the KRAV standards. Here is the relevant section regarding soil requirements for growing in a substrate:

4.6.2 When you Cultivate in a Delimited Substrate- A substantial portion of the plant nutrients a plant takes up must come from the soil the plant is grown in. Therefore, you cannot cultivate exclusively in biologically inactive material or cultivate in excessively minimal soil volumes. If you cultivate in a delimited substrate, e.g. in a pot, and you add plant nutrients after planting, each plant must have at least 30 litres of soil. This applies to annual vegetable crops with a long cultivation time, e.g. tomatoes, cucumbers, red peppers and eggplants. Other cultivations must have at least 0.2 litres substrate per pot. (K) Other cultivations include mainly herbs and lettuce, though berry cultivations such as strawberries can be included. For bedding-plants that are then cultivated on open land there are no size requirements for pots, but they must be grown in a biologically active material.

4.6.3 Hydroponics- Hydroponic cultivation is when plants are grown in a water solution. You can only cultivate aquatic plants with this technique. Sprouts must be sprouted and rinsed in clean water. (EU)

So Sweden allows container growing on the Canadian model, with specific requirements on the minimum soil volume per plant. They do not permit aquaponic nor NFT style growing.

Section 5. 2010 Recommendations Not Directly Related to Hydroponics

“The charge of the task force is to inform the National Organic Standards Board (NOSB) of our findings and advise on what practices should be allowed or restricted in organic hydroponic and aquaponic production.” (Federal Register, March 9, 2015))

A key document that that was developed to provide guidance and context for hydroponic and aquaponic is the NOSB Crops Committee Recommendation for ***Production Standards for Terrestrial Plants in Containers and Enclosures (Greenhouses)*** published January 23, 2010.

That recommendation for rulemaking addressed certain aspects of greenhouse production that are commonplace in indoor cropping methods, such as container based root media (potting mixtures), hydroponics, and aeroponics.

If growing in containers is to be certified, the discussion points below should be included in development of additional standards to the USDA organic regulations. The information presented here is a summary of parts of the 2010 recommendation that were questioned and critiqued by this subcommittee as well as proposed revisions and discussion to include in any future recommendations and rulemaking.

The document includes eight points of discussion including

1. Enclosures
2. Lighting
3. Natural Resources
4. Containers
5. Container Growing Media
6. Land Use and Soil management
7. Rotations
8. Compost

Eight Point Summary

Clarification and proposed edits of the 2010 recommendation has been provided by addressing:

1. **Enclosures:** The term enclosure was more clearly defined by differentiating greenhouses and controlled indoor environments. Greenhouses have transparent roofs and walls to collect sunlight and are used for transplants, in-ground crop production and container crop production. Controlled indoor environments use electrical lighting and should only be considered acceptable for transplant production.
2. **Lighting:** The term “electrical light” is proposed as a preferred term over artificial or full-spectrum light. The use of lighting for transplant production is differentiated from crop production. We suggest a clarification that electric light as a “sole source” may be allowed for transplant production, but electrical lighting should only be allowed for supplemental use in crop production.
3. **Natural Resources:** It is the opinion of this subcommittee that if container production is permitted, then this must include management of both soil/growing media within the containers as well as soil underneath and surrounding the container system. This would ensure that land is maintained, or improved for future in-ground production and overall protection of natural resources. The NOSB should consider limiting use of land where crops could be grown in the soil from being converted to container production. This subcommittee rejects the notion that covering the soil with plastic is maintaining the fertility.
4. **Containers:** Proposed change to the definition for the term “container” by differentiating between container growing methods for transplants (seedling annuals, planting stock) and containers for crop production.
5. **Container Growing Media:** The term “container growing media” is proposed to replace the current term “growing media”. To provide more clarity, container growing systems and container growing media are defined for 1) transplants and 2) food production in the context that the first is currently allowed and the second is currently allowed and under review. To be consistent with OFPA, container growing media fertility must primarily come from compost based growing media and not from liquid sources, which is contrary to / more restrictive than current interpretation and certification allowed by the NOP. We accept the recommendation of the 2010 Committee that compost is the equivalent of soil for container crop production.
6. **Land Use and Soil management:** Transition and tillage issues.
7. **Rotations**: The 2010 recommendation allows for exemption of the use of rotations in greenhouses, containers and protected cultivation by allowing use of alternative methods of maintaining soil and plant health. Some members of the subcommittee propose rejection of

this exemption on the grounds that the alternative methods could also be used for field production and no rationale or justification is given for why crop rotation is not economically viable in a greenhouse or container production system. Other members support it.

8. **Compost:** Compost was primarily defined in the OFPA and NOP regulation by how it must be made without providing characteristics of the final product. A more detailed description of required compost characteristics for container growing media is recommended with the intent of expanding and extending the various roles of compost beyond that as a soil amendment. Compost for use as a container growing media needs to be defined. Questions are raised about vermicompost and compost from anaerobic digestion.

Eight Point Details

1. Enclosures

Starting Point From the 2010 Recommendation:
Greenhouse- Permanent enclosed structure that allows for an actively controlled environment used to grow organic crops, annual seedlings or planting stock used in organic production.

What are the questions?

- What is a greenhouse?
- What other types of permanent enclosed structures are allowed for transplant production and crop production?
- Do non-permanent high tunnel structures used for protected cultivation of in ground organic crops without heating need to be defined in the recommendation?

Analysis and Clarification
To define a greenhouse, the term ***"transparent"*** is used to describe the roof and walls of the structure. The absence of the word transparent in the 2010 recommendation definition is not accurate and is allowing the consequence of organic crops to be grown in buildings with only electrical lighting (see the **Lighting** discussion).

Currently a greenhouse can be used to produce: 1) organic annual seedlings or planting stock, 2) organic crops grown in the ground, and 3) organic crops grown in containers.

Differentiation is needed between a Greenhouse and a Controlled Indoor Environment. Many smaller scale diversified vegetable producers do not have greenhouses and instead rely on electric lights above transplants growing on shelves or tables in homes, basements, garages or other places. Our committee perception is that use of controlled indoor environments to produce annual seedlings as transplants is a common and acceptable practice for an OSP.

Larger indoor production facilities with only lighting have been in use for over 30 years to grow crops such as leafy greens and herbs. The use of such facilities is likely increasing in response to changing transportation costs, food security concerns, and climate and water availability. Some of these facilities have succeeded in getting certified organic (approved OSP). The production of organic crops in controlled indoor environments is questionable in terms of alignment with OFPA, the organic regulations and the founding principles of organic agriculture. Our committee perspective based in part on historical organic practices and perceived consumer expectation is that use of controlled indoor environments for organic crop production is not an acceptable practice for an OSP.

Summary of Committee Recommended Revisions
Greenhouse- Permanent enclosed structure ***with transparent roof*** and walls that allow for sunlight as the primary source of light for plant growth and an actively controlled environment used to grow transplants (annual seedlings, planting stock) or organic crops.

New Definition - Controlled Indoor Environment– Permanent enclosed structure, room or area with electrical lighting as the sole or primary source of light for plant growth.

Controlled Indoor Environments are allowed for organic transplant production but not allowed for organic crop production.

Currently no recommendation relative to non-permanent high tunnel structures.

2. Lighting

Starting Point from the 2010 Recommendation:
(c) Producers may use full-spectrum light sources.

What are the questions?
- What types of lights are allowed?
- How can the lights be used?
  - Supplement photosynthetic lighting?
  - Sole source photosynthetic lighting?
  - Photoperiodic lighting to alter the day length for flower initiation out of season?

Analysis and Clarification
By definition, use of the term "full spectrum" lighting would imply a mixture of wavelengths/colors in the 400 to 700 nanometer visible light range. This definition would disallow the use of high pressure sodium lamps, currently the most commonly used lamp for greenhouse photosynthetic lighting, and metal halide or LED lights used for controlled (indoor) environments. Initially the term "artificial" lighting was used. "Artificial" lighting is an inaccurate or incorrect term. In some cases, the term "supplemental" lighting would be

appropriate for use of lighting in a greenhouse setting. However, for the purpose here, lighting may also be used in a controlled environment with no additional sunlight. The term “electric” lighting encompasses all types.

A member of the NOSB involved in development of the 2010 recommendation verbally confirmed at the Task Force San Diego meeting (January 2016) that the intention of the Crops Committee was for supplemental lighting in greenhouses or for transplant production but not for crop production in controlled indoor environments.

Operations using 100% lighting from electrical light sources are being certified. For example, crops growing in a shipping container outfitted with electrical light sources. It is questionable whether this practice is consistent with the perceptions or expectations of production of organic crops in an OSP.

European standards do not allow certification of crop production without sunlight.

Summary of Committee Recommended Revision:

(c) Producers may use electrical light sources such as high pressure sodium, metal halide, fluorescent or light emitting diodes (LED) as supplemental electric light sources in greenhouses for providing photosynthetic light or for photoperiod alteration for crops harvested for food. Transplants may be produced with complete electric lighting in controlled indoor environments. Organic crops are not to be produced in controlled indoor environments with electrical lighting as a single source of light.

Electric lighting - fixtures and lamps used to provide photosynthetically active radiation (PAR) primarily in the visible light wavelengths (400 to 700 nm) for plant growth. Examples include but are not limited to high pressure sodium, metal halide, fluorescent, and light emitting diodes (LED).

For a more detailed discussion of lighting standards, review the EGTOP report in Appendix A.

3. Natural Resources

Starting Point from the 2010 Recommendation:
The 2010 recommendations do not specifically address natural resource requirements as they relate to crop production within containers and enclosures. The majority of this subcommittee feels that was an oversight, and that there should be specific requirements in order to have a robust certification process for these systems.

What are the Questions?
- What are the natural resource implications for an operation that does not grow in the ground?
- Is the soil underneath a container system impacted by production practices which occur in the containers?
  - If yes, how are those impacts assessed, monitored and mitigated to ensure natural resources are maintained or improved?
- Is soil impacted by covering with permeable or impermeable coverings such as weed cloth, plastic or pavement?
  - Should paving over soil be allowed as an ongoing management practice within an organic system?

Analysis and Clarification

Natural resources requirements under NOP § 205.200 state that "…Production practices … must maintain or improve the natural resources of the operation, including soil and water quality." Natural resources are defined under NOP § 205.2 as "the physical, hydrological, and biological features of a production operation, including soil, water, wetlands, woodlands, and wildlife." Additionally, NOP Guidance 5020 "Natural Resources and Biodiversity Conservation" clarifies specific practices that can be included with an organic system plan in order to meet § 205.200 and certifier responsibilities for ensuring compliance. It is the opinion of this subcommittee that for container production systems this includes management of both soil/growing media within the containers as well as soil underneath the container system. This would ensure that land is maintained or improved for future in-ground production and overall maintenance of natural resources.

Container systems could meet natural resource requirements in ways which are similar to perennial in-ground crops. Within an organic system, some of the many functions of crop rotation and cover cropping is to provide species diversity, creating habitat and food sources for beneficial insects. For container systems, this function could be achieved in ways similar to those practices utilized in perennial systems including cover cropping/interplanting between crop rows; adding hedgerows around the crop production area or enclosed growing area/greenhouse; utilizing insectary plantings, which can be interspersed with crop plants, etc.

Summary of Committee Recommended Revisions

In the opinion of some of this subcommittee, the land underneath the container system must be considered a natural resource which must be maintained or improved.

1) Impacts on soil due to use of weed cloth, other permeable cover, or application of any material must be considered and mitigated.
2) Although erosion may not be an issue for covered ground, a soil's ability to regenerate biological activity and soil organism populations must be considered. It is important to consider impacts on a soil covered with weed cloth during, for example, the 3-10 year lifespan of some perennial crop container systems.
3) For enclosed or outdoor systems on impermeable surfaces such as concrete, cement or pavement, it is important to consider whether paving over soil in order to place a container system should ever be allowed as a regular practice within an organic system plan.
4) The NOSB should consider limiting use of land where crops could be grown in the soil from being converted to container production. This subcommittee rejects the notion that covering the soil with plastic is maintaining the fertility.

4. Containers

Starting Point from the 2010 Recommendation:

Containers- Any vessel and associated equipment used to house growing media and the complete root structure of terrestrial plants and to prevent the roots from contacting the soil or surface beneath the vessel, such as, but not limited to, pots, troughs, plastic bags, floor mats, etc.

Transplant. A seedling which has been removed from its original place of production, transported, and replanted. (From final rule, not 2010 recommendation)

What are the Questions?

- Containers are allowed for transplants. Is any change or clarification needed regarding transplant production?
- Are organic food crops grown and sold in a container suitable for an OSP?
- Should containers be allowed for organic crops?
    - If yes, should there be regulations or boundaries on size, volume, etc?
    - Are there different regulatory implications for the production of perennial crops in containers versus annual crops?

Analysis and Clarification

For the current definition, it appears that there are no boundaries. A container for growing a plant or plants can range from a plastic flat composed of over 100 cells of 0.5” cubed volume or a raised bed covering some fraction of an acre up to 12” deep or more.

The size of a growing container relative to the crop being grown should be regulated in order to meet the premise that organic crops be grown in a biologically active supportive soil. The expectation is to provide long term water and fertility without constant / routine applications.

Internationally, approval for the use of containers for organic certification varies by country. The majority of European standards allow containers for a) transplants and b) for sale of finished product still in the container to the consumer but not for organic crops.

Canada and some Scandinavian countries allow organic crop production in containers. Canada provides a minimum container volume.

Summary of Committee Recommended Revisions

Containers- Any vessel and associated equipment used to hold growing media and the complete root structure of terrestrial plants and to prevent the roots from contacting the soil or surface beneath the vessel, such as, but not limited to, pots, hanging baskets, boxes, buckets, barrels, plastic crates, troughs, plastic bags, floor mats. etc. If necessary landscape fabric, weed-cloth or polyethylene film may be required to prevent root contact with soil not approved for an OSP.

If requirements related to compost-based container growing media expectations to provide long term soil biology, water and fertility without constant / routine applications of water soluble nutrient sources (see container growing media) are included, container growing of organic crops can continue to be allowed.

5. Container Growing Media

Starting Points Extracted from the 2010 Recommendation:
Growing media- Material which contains sufficient organic matter capable of supporting the plant root system and a natural and diverse soil ecology.

"Although the regulations do not specifically state 'soil only production', the exclusion of soil from organic production of normally terrestrial, vascular plants violates the intent of the regulations."

"Since all typical soil dwelling organisms, such as earthworms, protozoa, fungi, bacteria, actinomycetes, etc. can thrive in a properly designed compost based growing media, producing the beneficial symbiotic ecological relationships found in soil, such growing media should be rightfully considered soil."

What are the Questions?

- Should container growing media that are compost based be considered 'soil'?
- Does the definition of and type of container growing media allowed need to change from what is currently allowed? If so, how?
- Should a minimum amount of media per plant be required to assure that the crop nutrients are coming from the soil based organic matter interactions rather than from periodic feeding of available nutrients?
- If compost is a suitable substitution for soil, how do we amend the definition of compost to include what is acceptable as growing media?

Analysis and Clarification
Growing media are defined by approved component materials and the absence of non-allowed substances such as synthetic nutrients or wetting agents. Growing media should also be defined by required characteristics that must be present. Transplant and container growing methods would have more clarity if container growing media had a defined initial and temporal water and nutrient holding capacity and biology carrying capacity.

An emphasis has been placed on soil organic matter and desired limitations on the amount of soluble or supplemental fertility added to soil during crop production. Therefore, it is recommended that container growing media for an OSP be specified to be the primary source of fertility for crop production without routine additions of water soluble fertility. Compost based growing media can be prepared with the necessary high porosity / low bulk density to provide adequate aeration and water holding capacity when used in containers of limited depth/height. The same growing media can also provide adequate fertility for weeks or months of annual plant growth or years of perennial plant growth.

For a greenhouse, indoor or container plant system, there are farming practices that provide for long term container *growing media* fertility, water conservation and diverse microbiology. These practices are often dependent on the production and use of growing media containing compost that can include mineral soil as a component of the compost. The compost can also be produced with allowed mineral amendments. As with field soils, organic matter in a variety of forms and stages of decomposition are essential for maintaining water and air balance necessary for plant roots and microorganisms, and for nutrient retention (CEC), reserves and availability (primarily based upon pH management).

The size of a growing container relative to the crop being grown can be defined as a function of expectations to provide long term water and fertility without constant applications of plant nutrients. A point of discussion has been that in ground systems with sandy soil may rely on routine applications of fertility. Perhaps the question should be asked whether such sandy soils should be allowed in or approved for an OSP?

An emphasis on the use of compost as the basis for container growing media will likely have a positive impact on cultivating a greater degree of recycling of on and off farm organic matter. The definition of compost can be expanded as a way to increase options for organic crop production. This topic is addressed separately in the compost section.

Why should soil or compost based container growing media be used for transplant and crop production?

1. Source of diverse minerals for plant growth and health of those consuming the plants.
2. Microbiology interactions with plant roots that impact the biology of the plant and contribute to the resiliency of the system and the tolerance or resistance of the plant to insect infestation or disease infection. Based on recently published research from Cornell University, the biology present in compost used for transplant media was present in the root rhizosphere of roots distant from the original transplant roots.
3. Recycling of on and off farm organic matter and resources.

Two common plant based organic materials that meet the definition of “organic matter” are sphagnum peat moss and coconut husk residue (coir). Depending on the source and the handling of the material, the organic matter present is primarily of a type that will not support “natural and diverse soil ecology” for extended periods of time (months) unless blended with other organic matter or compost. The difference needs to be recognized.

Currently a root medium made up of primarily sphagnum peat or coir mixed with perlite or vermiculite is allowed for transplant / annual seedling production with the fertility coming from routine application of liquid sources. Should such options no longer be acceptable for an organic systems plan for transplants? This is important if requirements for container crop production are put in place. Is consistency needed for transplant and crop production?

One perspective is that container growing media need to be an exception / exemption to OFPA requirements related to soil properties and management for organic certification. Not all the methods described in the OFPA that ***"must"*** be used to maintain soil organic matter (cover crops, tillage, etc.) are necessary to maintain compost based container media. A field or perennial plant system that relies on constant use of mulch does not require tillage and hay mulch can provide many benefits of cover crops. Is it possible that compost based container growing media could meet the requirements without being an exception?

Another perspective that has been offered is that not all crops are tolerant of or provide the desired quality grown in a nutrient rich environment generally associated with perceptions of compost. Compost based container media can be produced with a wide range of fertility levels including limited fertility.

Summary of Committee Recommended Revisions
Container Growing media- Compost based organic material with sufficient water and nutrient holding capacity and living microorganisms capable of supporting normal plant growth without frequent applications of supplemental plant or microbial nutrients or food.

6. Land Use and Soil management

Starting Point from the 2010 Recommendation:
The 2010 Recommendation states that in §205.209 (a) that "Container and enclosure (Greenhouse) operations must meet all applicable requirements of subparts B (205.105) and C (205.200 - 205.206) except that: (1) The producer operating a greenhouse with crops grown in containers using a growing media that does not contain soil is exempt from 205.202 (b) and 205.203 (a)...".

205.202 (b) refers to the requirement for 3 years of no prohibited materials applied in order to be eligible for organic certification. In addition to issues regarding the use of the word "exemption", the 2010 recommendation does not address specific requirements or considerations for transition of the container crop itself.

What are the Questions?
- Is there an allowance for transition of non-organic container crops to organic?
- Can a non-organic container crop be repotted into allowed media and be considered organic without a 3 year transition?
- What happens to a container crop in the event of an unintended application of prohibited substance?

- o Can the media retransition?
- o Can the crop retransition?

Analysis and Clarifications
As per §205.202 Land management, soil within a growing media must meet the 3 year transition in order to be used to grow organic crops. The remaining components, such as compost, peat, perlite etc., must be allowed substances under the USDA organic regulations. In the opinion of this subcommittee, when discussing transition, it is appropriate to consider that a container system, where applicable due to use of prohibited inputs or applications, must transition in the same manner as land. Plants themselves should not be allowed to be "up-sized" from use of prohibited materials or media into allowed growing media in order to eliminate transition periods. This would be analogous to digging up a plant and putting in another field after an application of prohibited materials. The only exception that applies the same standard for containers and in ground systems is where transplants or planting stock (such as bare root, or allowed non-organic planting stock or equivalents) are placed in allowed media/soil. Transition requirements should be clear in cases of drift or application of prohibited materials. We see no distinction between prohibited materials used on the plant or in the media with respect to transition of containers.

Summary of Committee Recommended Revisions
In the opinion of this subcommittee, if container production systems are to be permitted, they must take into account impacts to the soil and land underneath and around their crops, including monitoring and mitigating impacts due to covering the soil, applying materials, and runoff from the container. This could include a prohibition or limitation on waste to drain systems. An application of a prohibited material to a container that is not on a closed loop system would affect the transition date of the underlying ground.

Suggested update to the wording in the 2010 Recommendation 205.209 (a) to state:
"For a producer operation a greenhouse or other location with crops grown in containers, any soil used as growing media must meet the requirements of 205.202 (b), 205.203(a)."

7. Rotation

Starting Point from the 2010 Recommendation:
205.209(2) "In addition, the growing container based producer is exempt from the crop rotation and cover cropping requirements in section 205.203(b) and 205.205. In lieu of crop rotation and cover cropping, soil regeneration and recycling practices shall be implemented and documented for the certification agent in order to demonstrate that the required functions/goals of crop rotation and cover cropping listed in 205.205(a, b, c, d) have been achieved through these alternate practices, as applicable to the operation.

What are the Questions?

- Should organic crops grown in native or amended soil covered by a greenhouse or a protected environment (high tunnel) be allowed without a requirement for rotation?
- Should container growing media reuse be allowed without a requirement for rotation?
- Are there appropriate comparisons to be made between management of long term annual crops in a greenhouse and perennial crop production in a field setting?
- Can container media recycled by composting be considered to have met a rotation requirement by essentially doing a restart? If yes, how?
- How many crops of different botanical family, genus or species must be grown before replanting a particular crop? Needs to not be based on “years” but on crops or cycles.

Analysis and Clarification

Crop rotation is considered essential to maintain a natural and diverse soil ecology. A number of alternatives to maintain natural and diverse soil ecology in a greenhouse setting were provided in the 2010 recommendation. Any of those alternatives could also be used in an outdoor field setting at a small scale. Does this open the door for loss of emphasis on crop rotation?

A number of alternatives to maintain a diverse soil ecology were provided in the 2010 recommendation. The justification for the exemption was that the economic cost of managing the structure could only be met by producing a very limited number of high value crops. The diverse soil ecology could be maintained by managing crop residues, ground covers, mulches, compost applications, intercropping, etc. The task force subcommittee is divided on this issue. Allowing greenhouses to only grow high value crops such as tomatoes in repeated succession with no rotation is in conflict with organic regulations, but is commonly permitted.

Long term perennial crops such as fruit and nut trees are maintained without crop rotation but are required to use practices such as alley cropping, mulching, intercropping, or hedgerows to meet the same intended benefits provided by crop rotation. Ground covers, mulches, and compost applications are used to increase the diversity of organic matter needed to support diverse soil biology.

Summary of Committee Recommended Revisions

We are divided on whether rotations for in-ground annual greenhouse production and for containers should be required.

Define how a container growing media can be recycled by composting to allow reuse in a container without crop rotation.

Define what constitutes appropriate or minimal rotation based on crop number and not based on years or the seasonal cropping cycle of a field production setting.

Suggested update to the 2010 recommendation:

205.209 2) ***In lieu of crop rotation and cover cropping requirements in section 205.203 (b) and 205.205, container producers shall implement soil building and recycling practices*** so that the required functions/goals of crop rotation and cover cropping listed in 205.205 (a,b,c,d) have been achieved through these alternative practices, as applicable to the operation…"

8. Compost

Starting Point from the 2010 Recommendation:
Compost. The product of a managed process through which microorganisms break down plant and animal materials into more available forms suitable for application to the soil. Compost ***must*** be produced through a process that combines plant and animal materials with an initial C:N ratio of between 25:1 and 40:1. Producers using an in-vessel or static aerated pile system **must** maintain the composting materials at a temperature between 131°F and 170°F for 3 days. Producers using a windrow system must maintain the composting materials at a temperature between 131°F and 170°F for 15 days, during which time, the materials **must** be turned a minimum of five times.

What are the Questions?
- Is the definition of compost used in the 2010 recommendation adequate to allow certifiers to make necessary decisions relative to the use of compost based container growing media? Given compost guidelines that have been provided by the NOSB and NOP (5021), does more need to be said or referenced in the recommendation?
- Can the "green waste" information in the Handbook be used to adequately provide certifiers with the necessary information for decision making?
- Is the NOP compost definition contrary to most other definitions of composting relative to whether nutrients become less or more available? If so, why?
- Is the NOP aware that the vermicomposting recommendation does not provide any guidance for a required minimum worm population density for vermicomposting?
- Is the NOP aware of the growing use of anaerobic digestion (wet and dry methods) that produces large volumes of solid and liquid output not addressed by current compost guidelines with potential for nutrient recycling for an OSP?
- Does the NOP have plans to address any future review or changes relative to compost?

Analysis and Clarification
The original definition of compost was perceived to be overly prescriptive and narrow since the introduction of the NOP rule. The NOSB and certifiers have attempted to address the issue through recommendations and Guidelines, many of which are available in the USDA Organic Handbook. The NOSB Compost Task Force Recommendation of April 2002 and Final Report provide important details about composting for an OSP that are not referenced.

Compost based container growing media are currently allowed but not clearly defined. Additional clarification or expanded guidelines of allowed and prohibited methods of making compost and of finished compost characteristics would provide more consistency and confidence in the certification process.

Defining the product compost by describing the composting process of how it can be made continues to be a limitation on more accurately describing and promoting organic agriculture practices that use compost.

The current definition states that the process of composting makes "materials into more available forms suitable for application to the soil". Most all other definitions (Rynk, 1992; Cooperband, 2002) of composting emphasize that the process of composting takes available forms of nutrients such as in high moisture manure or food scraps for example and converts them to ***less available forms***.

Defining compost as only a thermophilic process limits the use of other successful methods of processing organic matter (manure, green waste) into less available/more stable forms suitable for application to soils. Perceptions of compost are often narrow and based on experience with either a dairy or poultry manure based compost high in nutrients or a municipal leaf and grass based compost low in nutrients. There are many other options or types of compost.

Compost is most often defined as a soil amendment. It is also frequently pointed out that compost should not be considered a "fertilizer" or source of soluble nutrients. This line of presentation was necessary in the early decades of organic farming when academics tended to dismiss compost as a potential strategy for soil management based on applying NPK thinking.

Compost can be produced to serve the function of a growing medium or a major component of growing media by intentionally formulating the feedstocks to achieve a desired final C:N ratio and a balanced nutrient profile. This can also be accomplished by mixing a variety of mature composts that are high or low in total nutrients. Doing so may require starting C:N ratios of higher than the 40:1 currently allowed for blended compost feedstocks.

One approach to avoid the current limitations of the compost definition is to use the definitions associated with "green waste" in the Handbook. Decomposition of organic materials without animal manure are suitable for use as mulch and soil amendments without meeting the heating requirement. Can it also be assumed therefore that such non-manure organic matter is also allowed for container growing media assuming no prohibited substances are present?

Recommendations for mesophilic (low temperature) composting or vermicomposting have been published. The current recommendation defines oxygen, moisture and composting times but lacks any reference to a minimum necessary worm population or density, for example worm biomass/unit area or volume of feedstocks.

Anaerobic digestion (AD) may prove to be a viable composting method to recover energy, organic matter and nutrients from organic materials. The rule currently does not address or define necessary characteristics to allow the use of AD solids and liquids in organic agriculture systems.

The current rule has no guidance or description of target or acceptable range of end product C:N ratio, bulk density, particle size distribution, total or soluble nutrient content or biological profile. To define appropriate or acceptable compost based growing media will require or benefit from some expanded guidance or definitions related to characteristics of *finished compost*. These characteristics might include:

- Dry Bulk Density, Particle size distribution
- Percent organic matter, Percent Nitrogen, C:N Ratio
- pH, soluble salts or electrical conductivity, mineral analysis
- Biological respiration (Solvita test), Biological Diversity

Most of these characteristics have already been described as part of the Compost Quality Assurance program or seal. (Woods End Laboratory, US Composting Council).

Summary of Compost Related Committee Recommended Revisions

Assuming the 2010 Recommendation will be amended or edited; the continued development of compost guidelines by the NOSB compost task force needs to be referenced so more than just the initial definition of compost is included.

Guidelines describing characteristics of finished compost suitable for use in container growing media can be developed and provided. The compost guidelines can support or be a part of guidelines for compost based growing media that are also needed.

At some point issues related to alternative methods of composting can be addressed by the NOSB or possibly a new compost task force. Some issues to be addressed might be:

Vermicomposting:

- The current guideline of 70 to 90% moisture during composting may be too high for on-farm composting methods.
- Vermicompost final quality is influenced by the density of worms present during the active composting phase and some guideline as to desired worm density could be provided.

Anaerobic Digestion

- Wet and dry anaerobic digestion methods are available for commercial and on-farm use.

- These additional composting methods can provide solid and liquid products that can be useful tools in an OSP that should be made available to organic farmers / producers.

Cited Literature

Cooperband, L. 2002. The Art and Science of Composting; A resource for farmers and compost producers. Center for Integrated Agricultural Systems, University of Wisconsin, Madison. 17 pgs.
Rynk, R. (editor) 1992. On-Farm Composting Handbook. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY. NRAES-54. 204 pages.
USDA Organic Handbook

Examples of other compost definitions:

- Rynk, pg 1 Composting is a biological process in which microorganisms convert organic materials such as manure, sludge, leaves, paper, and food wastes into a soil-like material called compost. It is the same process that decays leaves and other organic debris in nature. Composting merely controls the conditions so that materials decompose faster.
- Rynk, pg 5 The nutrients in compost are mostly in a complex organic form and must be mineralized in the soil before they become available to plants. For example, less than 15% of the total nitrogen in compost is typically available in the first cropping season.
- Cooperband, pg1 Composting is controlled decomposition, the natural breakdown process of organic residues. Composting transforms raw organic waste materials into biologically stable, humic substances that make excellent soil amendments. Compost is easier to handle than manure and other raw organic materials, stores well and is odor-free.

Section 6. Definitions

Aeroponic Production--a variation of hydroponics in which plant roots are suspended in air and misted with nutrient solution
Aquaponic Production -- A system of growing plants in the water that has been used to cultivate aquatic organisms
Compost -- The product of a managed process through which microorganisms break down plant and animal materials including allowed feedstock materials (either nonsynthetic substances not prohibited at § 205.602, or synthetics approved for use as plant or soil amendments), into more available forms suitable for application to the soil. Compost must be produced through a process that combines plant and animal materials with an initial C:N ratio of between 25:1 and 40:1 and processes it to a low final C:N ratio (in the range of 5:1 to 20:1). Producers using an in-vessel or static aerated pile system must maintain the composting materials at a temperature between 131 °F and 170 °F for 3 days. Producers using a windrow system must maintain the composting materials at a temperature between 131 °F and 170 °F for 15 days, during which time, the materials must be turned a minimum of five times.
Compost tea -- A water extract of compost produced to transfer microbial biomass, fine particulate organic matter, and soluble chemical components into an aqueous phase, intending to maintain or increase the living, beneficial microorganisms extracted from the compost.
Vermicompost -- Vermicomposts are organic matter of plant and/or animal origin, consisting mainly of finely-divided earthworm castings, produced non-thermophilically with bio-oxidation and stabilization of the organic material, due to interactions between aerobic microorganisms and earthworms, as the material passes through the earthworm gut.
Diverse Soil Ecology -- An incredible diversity of organisms make up the soil food web. They range in size from the tiniest one-celled bacteria, algae, fungi, and protozoa, to the more complex nematodes and microarthropods, to the visible earthworms, insects, small vertebrates, and plants.
Ecology -- Agricultural ecology is the study of agricultural ecosystems and their components as they function within themselves and in the context of the landscapes that contain them. Application of this knowledge can lead to development of more sustainable agricultural ecosystems in harmony with their larger ecosystem and ecoregion.
Growing media -- Material which contains sufficient organic matter capable of supporting the plant root system.
Hydroponic production-- the production of normally terrestrial, vascular plants in nutrient rich solutions or in an inert, porous, solid matrix bathed in nutrient rich solutions.
Organic matter --The remains, residues, or waste products of any organism which may include living, recently dead microorganisms & plant materials, slowly decaying organic matter decades old and stable and humus organic matter that exists for decades to centuries.
Organic production--A production system that is managed in accordance with the ACT and regulations in this part to respond to site-specific conditions by integrating cultural biological and mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity.

Soil -- The upper layer of earth that may be dug or plowed and in which plants can grow. Soil consists of four important parts: mineral solids, water, air, and organic matter. Mineral solids are sand, silt, and clay and mainly consist of silicon, oxygen, aluminum, potassium, calcium, and magnesium. A typical agricultural soil has 1% to 6% organic matter. It is the interaction between the soil organisms in the organic matter that release the mineral nutrients from the soil minerals in plant available forms.

Soil food web -- The soil food web is the community of organisms living all or part of their lives in the soil. A food web diagram shows a series of conversions (represented by arrows) of energy and nutrients as one organism eats another.

Thrive -- to grow vigorously

Section 7. Appendices

Appendix A: EGTOP Report on Greenhouse Production

http://ec.europa.eu/agriculture/organic/eu-policy/expert-advice/documents/final-reports/final_report_egtop_on_greenhouse_production_en.pdf

3.9.2. When should growing plants in substrate be authorized? In general, organic growing and the production of organic plants should take place in soil, and 'soil' means that the upper soil is in contact with the subsoil, so that roots can grow into the subsoil. As an exception from this principle, the Group accepts cultivation in substrates for seedlings and transplants, and for plants which are sold to the consumer together with the pot/container in which they grow (e.g. herbs in pots, ornamentals). In these cases, production in horticultural substrate is obvious to consumers and there is no risk that they are misled regarding the production method of the plants. By contrast, organic produce harvested out of sight of consumers should always come from plants grown in soil, and not from horticultural substrate cultures. This would also be important if a shorter conversion period is established for substrate cultures to avoid unfair competition between substrate-grown and soil-grown crops (see Section 3.10.2).

3.9.2.1. Growing organic vegetables in demarcated beds as an exception for growing in soil Authorities in Finland, Sweden, Norway and Denmark, have authorised a practice of growing organic vegetables in 'demarcated beds', which is a form of substrate culture, where the plants are grown in large containers, bags or beds surrounded by plastic sheets/fleece where the roots may or may not be in contact with the soil. The total area is very small (about 18 ha). The Group strictly opposes to any enlargement of such practices in organic farming because it is not in line with the objectives and principle of organic farming. Some urban organic production systems (e.g. rooftop production) may not comply with the requirement of growing in soil. These systems may be encouraged as private initiatives, they are outside the scope of the organic farming rules and will need to be addressed separately.

3.9.2.2. Side remarks on special cases, where the principle of growing in soil is not applicable for biological / technical reasons
There are some plants, fungi and algae which naturally do not grow in the soil. For such plants, the principle of growing crops in the soil obviously does not apply.

- Exceptions for mushroom culture are defined in Art. 6 of the Reg. (EC) 889/2008.
- Sprouts are young seedlings, which are produced by moistening of seeds. Production of sprouts in the soil would raise hygienic concerns, and it would not make sense, because at this stage of development, seedlings utilize exclusively the reserves in the seed and

do not take up nutrients from the environment. Sprout production therefore does not fall under the definition of 'hydroponics', given in Art. 2(g) of the Reg. (EC) 889/2008. The same argument applies also to the 'forcing' of vegetative materials, e.g. chive bulbs (Allium schoenoprasum). EGTOP/6/13 Final Report on Greenhouse Production (Protected Cropping) 31

- Freshwater plants such as watercress (e.g. Rorippa amphibia) and freshwater algae (e.g. Spirulina) naturally grow in water and are often certified as organic. However, there is some doubt as to whether freshwater plants and algae can strictly be grown organically, because under the Organic Regulation their cultivation may be considered as hydroponics, and they do not fall under the Reg. (EC) 710/2009. A distinction could be made between stream bed production and greenhouse production. In greenhouses, they could be used in combined systems, where freshwater plants or algae are used to recycle nutrients originating from freshwater fish production.

The Group concludes that the circumstances under which the production of such freshwater plants and algae can be authorized should be clarified, possibly in the framework of revision of the Reg. (EC) 710/2009. However, the Group does not want to set a precedent for any kind of hydroponic cultivation of plants which would normally grow in the soil.

3.9.2.3. Conclusion on when growing plants in substrates should be authorized

The Group recommends that growing in substrates is accepted for seedlings and transplants, and for plants which are sold to the consumer together with the pot/container in which they grow (e.g. herbs in pots, ornamentals), while harvested organic vegetables or fruits (e.g. strawberries) should come from plants grown in the soil, and not from substrate cultures. However, the Group recognised that in Finland, Sweden, Norway and Denmark a practice was authorised where vegetables are grown on growing media in demarcated beds but strictly opposes to any enlargement of such practices in organic farming because it is not in line with the objectives and principle of organic farming. Therefore, the Group recommends that only those farms which have used demarcated beds in the past (i.e. before 2013) should be allowed to use them in the future and that there should be no expansion of the use of demarcated beds neither on these holdings nor in the rest of the EU. The Group recommends that any excess or spent growing media or plastic used in organic greenhouse production and farming in general should be reused or recycled.

As regards plants, fungi and algae which naturally do not grow in the soil, e.g. water plants (e.g. water cress), some mushroom species and sprouts, the Group recommends that the production of such organisms should be authorized

Appendix B: IFOAM EU Position Paper on Organic Greenhouse Production

http://www.ifoam-eu.org/sites/default/files/page/files/ifoameu_reg_greenhouse_production_position_201302.pdf

Growing in greenhouses is a longstanding horticultural practice. Greenhouses are used to lengthen the growing season and to protect vulnerable crops. Organic greenhouses exist in many Member states. Organic greenhouse production falls within the scope of Regulation EC 834/2007. The general rules for plant production apply.

This means in particular that also for organic greenhouses the basis is that: soil fertility is based on the use of crop rotations which include legumes and other green manures and the application of organic manures. If these methods are insufficient, products listed in annex 1 of Regulation EC 889/2008 may be used in addition. Rapidly soluble fertility amendments should be allowed only as a last resort when other fertilization techniques have proved insufficient.

But in greenhouse production, due to its character, growing measures are applied that are not possible in arable farming or non covered cropping such as heating, lighting or cooling. Furthermore other growing measures that are common practice in arable farming are more difficult in greenhouse production, such as a wide crop rotation.

Due to harmonization of organic rules and increase in demand for organic products, trade between Member states has increased. The producers that are confronted with different practices and interpretations in the Member states demand a level playing field. At the same time differences in climatic conditions and the demand for local produce should be respected. Finally, the energy input in greenhouses can be such a considerable part of that specific plant production system that it needs to be addressed in an organic regulation.

Regulating organic production in greenhouses touches upon many issues. It should be noted that some of the issues addressed are relevant for more types of production than only for greenhouses but we are proposing the measures only for greenhouses. Next to production of food crops this does include seedling production and production of ornamentals.

In this paper we have taken a position on conversion, soil, fertility, use of peat, CO_2 use, water use, steam sterilization, energy use and urban farming.

	Subject	Position	Rationale
1	Definition of greenhouse	A greenhouse is a structure in which plants are grown. For the purpose of this regulation, a greenhouse is a covered structure which stays for several years at the same place.	Specific provisions are required for protected cropping under permanent structures as this is considered as a system rather different from arable farming. As a consequence of this definition the proposed provisions do not apply to moveable structures like fleece covering, part season tunnel or netting.
2	Definition of waste heat	Waste heat is heat generated in a process, e.g. an industry, that can be utilised as a resource.	This is relevant for the position on the use of renewable energy
3	Definition of renewable energy	Renewable energy means renewable non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, landfill gas, sewage treatment plant gas, biogases and wood products.	This is almost similar to the existing definition in reg. 889/2008, art. 2.K, with one addition, namely wood products. Biofuels are not included in the definition for the moment.
4	Definition of natural substrate	A mixture of soil and/or soil improvers that are mentioned in Annex I.	If we accept that we can use pots for seedlings, herbs and ornamentals we need to have a description of what can go in the pots. Soil is not included in Annex I but is in practice used for some of the mixtures that go in the pots. This definition does justice to practice. We do not need to adapt Annex I. The article should be read as: "soil and/or [soil improvers that are mentioned in Annex I].

5	Conversion of production in natural substrates	Substrates used in a conventional system cannot be converted to organic.	This line is to clarify that in accepted practices where you grow plants in pots (seedlings, herbs and ornamentals), you can only convert between batches. You cannot convert the plant in the pot to organic.
6	Production in soil	The main principle of organic greenhouse production: greenhouse production must be in living soil (mineral soil mixed and/or fertilised with materials and products included in Annex I of Regulation (EC) No 889/2008) in connection with the sub-soil and bedrock.	
7	Production in pots	Only seedlings, ornamental plants and herbs can be produced in substrates authorised by the organic regulation and sold in pots.	
8	Systems that were allowed before the EU regulation came into force	In some Northern countries , growing in demarcated beds is an accepted organic practice, due to local, climatic, traditional and environmental specificity and historical* development and approaches. Only existing organic greenhouses certified until 31st December 2012 in these countries using demarcated beds can continue the existing practise. No extension of the practice to other member states or countries would be acceptable.	

		* historical means that this practise was accepted before the very first EU organic regulation came into force in that country.	
9	Plan on soil fertility	Operators need to prepare a plan to develop soil fertility in the greenhouse, which should be updated regularly. This plan should demonstrate that the greenhouse production system: - enhances the efficiency of nutrient use - builds soil health and fertility - optimises sustainability of fertility inputs.	
10	Fertilization	The main principle of fertilisation in organic greenhouse production for all systems, excluding production in pots is that **nourishing of plants works primarily through the soil ecosystem** In practice this means that in greenhouse production: * A maximum of 50% of nutrients are provided after planting. * A maximum of 25 % of fertilisation is allowed in liquid form.	This is already a basic principle for agriculture in Article 5a of EU Regulation (EC) No 834/2007. It is elaborated now for greenhouse production.
11	Use of peat	Use of other material is preferred to peat.	Although we ackowledge that there is a diversity of systems all over Europe we think that for those MS where peat is scarce other materials should be used first.
12	Re-examination of use of peat	The use of peat should be re-examined at the latest 4 years after this regulation comes into force.	

13	Steam sterilization of the soil	Steam sterilization of soil, of natural substrates and of compost made on the farm is only allowed in exceptional circumstances and only to combat or regulate soil borne diseases. No routine or systematic use is accepted and the need should be documented.	Steam sterilization should be considered an exceptional instrument.
14	Use of CO2	Carbon dioxide is accepted in protected cropping only if it has been produced as a by-product of another process. Fuel must not be burned solely to produce carbon dioxide.	As there seemed to be different understandings on the use of CO2 as a growth stimulator IFOAM EU feels it necessary to make a clear position on this.
15	Water collection	If climatic conditions allow it, rainwater must be collected from greenhouses if the total size of structures on one operation site is 5000 m2 or more. New structures must be build so that rainwater is collected.	As water is a scarce resource it needs to be addressed.
16	Annual energy analysis	Holdings using non renewable energy/ fossil fuels above 130 kWh/m2 per year for heating must make an annual energy analysis. The annual energy analysis must record the energy use for lighting and climate control (climate control includes heating,	In the future this topic should be further developed to become more complete and it should cover the whole farm. But as it is the first time energy is regulated in the EU organic regulation, we take a careful approach. We only want to target the heavy users and not create extra bureaucracy, so <u>only</u> the holdings that exceed the use limit of 130 kWh/m2/year will need to make an analysis.

		dehumidification and ventilation). The energy analysis must be calculated on quantity harvested crop and per cropping area in m2. For potted plants, it is sufficient to calculate energy consumption per cropping area in m2. The energy analysis must record the source of energy.	The number of 130 kWh/m2/year was chosen after exchange of information among experts that were consulted by the IFOAM EU.
17	Plan to increase energy use efficiency	Based on the energy analysis an energy use efficiency plan must be elaborated. The plan must describe how: (1) to reduce total amount of energy; (2) to improve energy efficiency; (3) to reach a limit of either a maximum in fossil fuel use or a minimum requirement on the use of renewable energy sources. 4 years after the regulation enter into force the Commission must present an evaluation on the functioning of this paragraph and if needed formulate additonal rules.	The plan in itself will raise awareness among the farmers. We need to collect experiences and learn from experience before eventually introducing a more specific common regulation. In Sweden this system is in place on a voluntary basis since early 2010 and also inspected. The energy efficiency plan is part of the inspection and growers have to show what they have improved since the last control.
18	Urban farming	Many currently operating urban farming initiatives claim to follow organic production principles. Some of them	

		produce only for own use thus no certification is needed. Those which produce for sale but do not follow the principle of production "in soil with connection with sub-soil/on bedrocks" cannot be certified as organic. However urban farming is a valuable way of delivering fresh food to cities. The organic sector and the urban gardening sector should work together and support each other in their development .	

Appendix C: Canadian Soil Fertility and Crop Nutrient Management and Greenhouse Standards

National Standard of Canada Organic Production Systems
http://www.cog.ca/uploads/GeneralPrincipelsandManagemetnStandards_2015.pdf

5.4 Soil fertility and crop nutrient management

5.4.1 The main objective of the soil fertility and crop nutrient management program shall be to establish and maintain a fertile soil using practices that maintain or increase soil humus levels, that promote an optimum balance and supply of nutrients, and that stimulate biological activity within the soil.

5.4.2 Where appropriate, the soil fertility and biological activity shall be maintained or increased, through: a) crop rotations that are as varied as possible and include plough-down, legumes, catch crops and deep-rooting plants; b) incorporation of plant and animal matter in compliance with this standard and with Table 4.2 of CAN/CGSB-32.311, including the following: 1) composted animal and plant matter; 2) non-composted plant matter, specifically legumes, plough-down crops or deep-rooting plants within the framework of an appropriate multiyear rotation plan; and 3) unprocessed animal manure, including liquid manure and slurry, subject to the requirements of 5.5.1.

5.4.3 Tillage and cultivation practices shall maintain or improve the physical, chemical and biological condition of soil, and minimize damage to the structure and tilth of soil, and soil erosion.

5.4.4 Plant and livestock materials shall be managed to maintain or improve soil organic matter content, crop nutrients, and soil fertility, and in a manner that does not contribute to the contamination of crops, soil or water, by plant nutrients, pathogenic organisms, heavy metals or prohibited substances residue.

5.4.5 The organic matter produced on the operation shall be the basis of the nutrient cycling program. It may be supplemented with other organic and non-organic nutrient sources. Non-organic sources shall be listed in Table 4.2 of CAN/CGSB-32.311. Manure is also subject to the requirements of 5.5.1.

7.5 Greenhouse crops

7.5.1 In a permanent, in-ground soil system, prohibited substances shall not have been used for at least 36 months before the harvest of an organic crop.

7.5.2 In a container system, soil shall be free of prohibited substances.

Note: The Canadian *Organic Products Regulations* require operators to document that they have not used prohibited substances. The Regulations also require that, in the case of an initial application for organic certification of crops grown in greenhouses with a permanent, in-ground soil system, the application for certification must be filed 15 months before the day on which the product is expected to be marketed. During that period of time, compliance with this standard will be assessed by the certification body and this assessment must include at least one inspection of the production unit, during production, in the year before crops may be eligible for certification and one inspection, during production, in the year crops are eligible for certification. This requirement does not apply to greenhouses built on land that is part of an existing organic operation.

7.5.3 Hydroponic and aeroponic productions are prohibited.

7.5.4 Soil used in a container system, with the exception of transplants, shall provide nutrients to plants continuously. The soil (growth media) shall contain a mineral fraction (sand, silt or clay) and an organic fraction; it shall support life and ecosystem diversity.
7.5.5 The following conditions apply to containerized, staked crops (for example, tomatoes, sweet peppers, cucumbers, eggplant):

- a) at the start of production, the total volume of soil shall consist of at least 10% compost;
- b) compost shall be included in the fertility program;
- c) containers shall be at least 30 cm (12 in.) high; and
- d) the soil volume shall be at least 70 L/m^2 (15.4 gal./10.8 ft^2), based on the total growing area.

7.5.6 Supplemental heat, with proper exhaust of burnt gasses, and supplemental lighting, are permitted. Supplemental nutrition with substances listed in Table 4.2 of CAN/CGSB-32.311, is permitted.

7.5.7 Plants and soil, including potting soil, shall not come into contact with prohibited substances, including wood treated with prohibited substances.

7.5.8 For crop production, the operator shall:

- a) use reusable and recyclable pots and flats whenever possible;
- b) use substances listed in Tables 4.2 and 4.3 of CAN/CGSB-32.311;
- c) use appropriate equipment cleaners, disinfectants and sanitizers listed in Tables 7.3 and 7.4 of CAN/CGSB-32.311.

7.5.9 Full-spectrum lighting is permitted.

7.5.10 The following procedures, processes or substances are permitted to:

- a) enrich carbon dioxide levels:
    - 1) flaming;
    - 2) fermentation;
    - 3) composting; and
    - 4) compressed gas (CO_2);
- b) clean and disinfect plant containers, pots and flats:
    - 1) substances listed in Tables 7.3 or 7.4 of CAN/CGSB-32.311; and
    - 2) steam-heat sterilization;
- c) stimulate growth or development:
    - 1) substances listed in Tables 4.2 or 4.3 of CAN/CGSB-32.311; and
    - 2) control of daily temperature and light levels;
- d) prevent damping-off:
    - 1) low-temperature baking;
    - 2) hot-water treatment; and
    - 3) steam treatment.

7.5.11 The following procedures or substances are permitted for the prevention and control of disease, insects or other pests:

- a) substances listed in Table 4.3 of CAN/CGSB-32.311;
- b) pruning;
- c) rouging;
- d) vacuuming;
- e) pest exclusion from greenhouses with air filters, screens or other physical devices; and
- f) biological control methods.

7.5.12 Soil regeneration and recycling procedures shall be practiced. The following alternatives to crop rotation are permitted: grafting of plants onto disease-resistant rootstock, freezing the soil in winter, regeneration by incorporating biodegradable plant mulch (for example, straw or hay), and partial or complete replacement of greenhouse soil or container soil, provided it is re-used outside the greenhouse for another crop.

7.5.13 Greenhouse crop product preparation

Wherever organic product preparation takes place, 8.1 and 8.2 apply.

7.5.14 Facility pest management

Subclause 8.3 applies to pest management practices in and around crop facilities.

Appendix D: Soil Association Greenhouse Standards

Soil Association Organic Standards Farming and Growing
https://www.soilassociation.org/media/1220/sa-farming-and-growing-standards.pdf

4.6 Managing soil (p. 65)
4.6.1 You should maintain a protective cover of vegetation, such as green manure or growing crops, to protect surface-living organisms and soil structure from exposure to dry conditions, heavy rain or strong winds.

4.6.2 Your cultivation for crop production should:

- be well-timed to get a suitable tilth whilst avoiding damage to the soil structure
- cause minimal disruption of the soil profile by shallow ploughing or no-till systems, and
- enable deep loosening of the sub-soil to break plough or compaction pans.

4.6.3 You should monitor the levels of organic matter, available plant nutrients and nutrient reserves in your soil by analysing them and nutrient budgeting. You should try to do this at the same time each year.

4.6.4 You must manage your soil to prevent erosion.

4.6.5 You must manage your soil with the aim of developing and protecting an optimum soil structure, biological activity and fertility. To do this you must:

- maintain humus levels, biological activity and plant nutrients for instance by regularly applying organic manure or compost and plant remains
- make sure your soil has enough microbial activity to start the decay of organic materials
- make sure your soil has enough microbial activity to breakdown non-soluble minerals to make them available to plant roots, and
- make sure your soil conditions encourage the continual activity of soil fauna and other soil stabilising agents. They will improve and stabilise soil structure by producing granular casts, deep burrows and mixing the organic matter.

5.1.13 If your rotation does not meet the requirements of standard 5.1.10 above and relies on brought-in inputs for crop production, you must:

- show us you are balancing your fertility building and fertility depleting management
- make optimum use of legumes, green manures and/or composted materials, and
- reduce or minimise your reliance on brought-in inputs.

5.1.14 When you cannot produce crops within a rotation your methods of nutrient supply, weed, pest and disease control must still comply with sections 4.6 - 4.11. Below are the main examples of such production systems:

- permanent pastures, including upland habitats
- perennial crops such as orchards, vineyards and plantation crops
- wild harvested plants growing naturally in uncultivated areas (please see chapter 9).

5.1.15 You must not use:

- any cropping system we have not defined in standard 5.1.14 or 5.2.1 that relies on outside inputs for nutrient supply, weed, pest and disease control, or
- continuous arable rotations.

5.2 Additional standards for protected cropping (p. 96)

5.2.1 You may produce crops without a rotation in a protected cropping system (polytunnel or glasshouse). You must:

- demonstrate that your system builds and maintains the health of your soil and crops;
- demonstrate that your system is not reliant upon routine use of restricted products for pest, disease and weed control, and;
- comply with standard 5.1.13.

5.2.2 You must produce a fertility management plan for your protected cropping system. The plan must demonstrate that your system:

- maximises the efficient use of nutrients
- builds soil health and fertility, and
- optimises sustainability of fertility inputs.

The table below outlines steps to best practice to inform your fertility management plan. Your plan must outline your options for movement towards more sustainable fertility sources over time.

Management of fertility inputs Progress in best practice					
	1	**2**	**3**	**4**	**5**
Distance the fertility input has travelled	Imported	From the UK	From within 100 miles	From within 20 miles	Produced on the holding
Are nutrients recycled?	Nutrients from mined sources	Purpose-produced organic fertiliser	From a waste stream	From a local farm	Fertility derived from the holding
Contribution to soil health	Liquid feeds	Granular fertilisers	Pelleted plant material or pelleted manure	Non-composted organic matter	Composted organic matter
Reliance on non-organic systems	Entirely from non-organic sources	25% from organic sources	50% from organic sources	75% from organic sources	Entirely from organic sources

Note - your fertility management plan will help you to comply with standard

5.2.3 If you use fuel or electricity to heat your protected cropping structure, you must record the energy you use for heating in kWh per metre2 per week. You must also record the type and source of energy used.

5.2.4 If you heat your protected cropping structure and use more than 100kWh per metre2 per year for heating, you should produce an energy plan outlining how you will progress towards renewable energy or combined heat and power over the next five years.

Note - following a review in 2016, we will set targets for renewable energy use and a date for making this standard a requirement.

5.2.5 You may use carbon dioxide in your protected cropping structure only if it has been produced as a by-product of another process. You must not burn fuel solely to produce carbon dioxide.

5.2.6 You should collect and use rainwater run-off from your protected cropping structures.

Note – see sections 4.5 and 4.16 for additional standards on water management.

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5.2.6 You should collect and use rainwater run-off from your protected cropping structures.

Note – see sections 4.5 and 4.16 for additional standards on water management.

5.3 Using seed and propagation material 5.3.1 Where appropriate you should use bare root transplants raised on your own organic unit.

5.3.2 Revised 2014 (applies from June 2014) When buying seed and plant material (including potato tubers, onion sets, strawberry runners, fruit tree root stock and bud material), you must, in order of preference: use organic seeds and plant material when a suitable variety is available. Use in-conversion seeds and plant material when a suitable variety is available. Obtain our permission to use non-organic seed and plant material. You must send us a completed seed derogation form before we can give you permission. You must apply for permission every season. Note - seed derogation forms are available from us on request. You can also submit them on-line, and find details of available organic varieties, at www.organicxseeds.co.uk.

5.3.3 Revised 2014 (applies from February 2014) You may use non-organic treated seed or seed potatoes if: Defra advise so for plant health (phytosanitary) reasons. It must not be treated with anything that is not allowed under section 4.11 unless Defra prescribe chemical treatment for all varieties of a species in a defined geographical area. Defra approve its use for research, for small-scale field trials or for variety conservation purposes.

5.3.4 Revised 2014 (applies from February 2014) Except for the purposes outlined in standard

5.3.3, you must not use seed treated with anything that is not allowed under section 4.11.

5.3.5 To produce organic seeds you must grow the mother plant to organic standards for at least one generation, or for perennial plants, two growing seasons.

5.3.6 To produce organic propagating material you must grow the mother plant to organic standards for at least one generation or, in the case of perennial plants, two growing seasons.

5.3.7 If you use transplants (bare root, blocks, modules) they must have been grown to organic standards by a registered organic producer.

5.3.8 You must use organic propagating material (sets, root stock and bud material) when available.

5.3.9 With our permission, you may use non-organic propagating material (not including transplants) when organic material is not available.

5.3.10 In propagating substrates you may use: clay, including bentonite and zeolites, and vermiculite and perlite. These must not have been treated with materials we do not allow. Growing transplants

5.3.11 To produce transplants for use in organic growing, you may only use substrates made from materials in section 4.7 and supplementary nutrients in section 4.8. 5.3.12 You may describe these transplants as, for example, 'plants suitable for organic growing' or 'transplants suitable for organic production'.

5.3.13 You must have all labels and marketing literature approved by us before you use them.

5.3.14 You must not describe transplants as organic. Growing plants in pots and containers to sell as organic

5.3.15 The only plants that you can grow in pots or other containers are ornamentals or herbs (including salad cress). You may sell them as organic only if: the substrate is made of at least 51% (by fresh weight of the end product) of materials from organic farming origin no more than 49% of the substrate is made up of non-organic materials listed in standards 4.7.8 and 4.7.9, which you must treat according to standard 4.7.19 ***the substrate provides more than 50% of their nutrient needs, until the point of sale you make sure the substrate is biologically active*** (emphasis added)***,*** for example by including composted material you meet all other relevant standards the entire plant and the pot are sold together you do not use peat or slaughterhouse wastes, and you do not use soil from organic farms.

5.3.16 You must not harvest parts of herbs or ornamentals that have been grown in pots and sell them as organic.

Appendix E: Language for the EU rule on growing in the ground

Council regulation 834/2007. This is the basis for all legislation in the EU for organic production
http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32007R0834

Article 4

Overall principles
Organic production shall be based on the following principles:

(a) the appropriate design and management of biological processes based on ecological systems using natural resources which are internal to the system by methods that:

  (i) use living organisms and mechanical production methods;

  (ii) practice land-related crop cultivation and livestock production or practice aquaculture which complies with the principle of sustainable exploitation of fisheries;

(b) the restriction of the use of external inputs. Where external inputs are required or the appropriate management practices and methods referred to in paragraph (a) do not exist, these shall be limited to:

  (i) inputs from organic production;

  (ii) natural or naturally-derived substances;

  (iii) low solubility mineral fertilisers;

Article 5

Specific principles applicable to farming

In addition to the overall principles set out in Article 4, organic farming shall be based on the following specific principles:

(a) the maintenance and enhancement of soil life and natural soil fertility, soil stability and soil biodiversity preventing and combating soil compaction and soil erosion, and the nourishing of plants primarily through the soil ecosystem;

1. In addition to the general farm production rules laid down in Article 11, the following rules shall apply to organic plant production:

a. organic plant production shall use tillage and cultivation practices that maintain or increase soil organic matter, enhance soil stability and soil biodiversity, and prevent soil compaction and soil erosion

b. the fertility and biological activity of the soil shall be maintained and increased by multiannual crop rotation including legumes and other green manure crops, and by the application of livestock manure or organic material, both preferably composted, from organic production;

c. the use of biodynamic preparations is allowed;

d. in addition, fertilisers and soil conditioners may only be used if they have been authorised for use in organic production under Article 16;

e. mineral nitrogen fertilisers shall not be used;

Appendix F: Bioland Standards on Soils and Substrates and Growing of Seedlings, Transplants, Sprouts and Potted Herbs in Greenhouses (Bioland - the leading association for organic farming in Germany)

http://www.bioland.de/fileadmin/dateien/HP_Dokumente/Richtlinien/Bioland_Standards_2016-03-14.pdf

5 Horticulture and Permanent Crops

The general parts of these standards apply also to horticulture and permanent crops in as far as no exceptions are specified in the following. In farming without animals the supply of nitrogen must be effected as far as possible by leguminous growing in the operation itself. The amounts of nitrogen fertiliser which is additionally required and permissible may be purchased in the form of external, organic additional fertilisers.

5.1 Vegetable production

5.1.1 Fertilising

The total amount of fertiliser from the operation and organic supplemental fertiliser to be used in free range vegetable gardening may not exceed 110 kg of nitrogen per ha and year. In greenhouses, the quantity of the nitrogen fertilization shall be matched to the length of the growing period and the yield expectations. In free range vegetable gardening, at annual average for a total period of 12 weeks, 20 % of the arable area has to be cultivated with green manure during growing season, the assessment period for accounting the green manure areas is 2 years. In general, in vegetable gardening, art. 3.4.5 is of particular importance. In order to control the nitrogen dynamics in the soil it is urgently recommended that N-min-tests be carried out on a regular basis.

5.1.2 Soils and Substrates

Growing vegetables on stone wool, hydroponics, nutritional film technology, thin layer culture and similar systems are not permissible neither the production in bags and containers. Permissible is the growing of herbs in pots and similar products, whereas the container is sold together with the plant.

The production of chicory sprouts in water is possible.

The use of peat to enrich the soil with organic substance is not permitted. It is also forbidden to use styrol mull and other synthetic materials in soils and in substrates.

5.1.3 Steaming Soil and Substrates

Soil and substrates may be steamed. Flat steaming of the soil for the purpose of weed regulation is permissible. Depth steaming to de-pollute the soil may only be permissible, if the plant protection problem may not be solved by other measures, e.g. change of crop, and requires express approval by the BIOLAND association.

5.1.4 Crop production in Greenhouses (Glass and Plastics)

Heating greenhouses is – in general - limited to the reasonable extension of the growing period in autumn and to earlier starting in spring. In winter, the crops should merely be kept free of frost (approx. 5°C). The growing of seedlings and transplants, forced sprouting and potted herbs are excepted. When choosing the system of heating and the kind of fuel, the environmental compatibility should be taken into account. The buildings should be well insulated thermally.

Appendix G: 1980 USDA Report on Organic Agriculture

http://pubs.nal.usda.gov/sites/pubs.nal.usda.gov/files/Report%20and%20Recommendations%20on%20Organic%20Agriculture_0.pdf

"Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests...

The concept of the soil as a living system which must be "fed" in a way that does not restrict the activities of beneficial organisms necessary for recycling nutrients and producing humus is central to this definition....

...(3) Motivations for shifting from chemical farming to organic farming include concern for protecting soil, human, and animal health from the potential hazards of pesticides; the desire for lower production inputs; concern for the environment and **protection of soil resources**." (p. xii)

2.4 ORGANIC AGRICULTURE: SOME BASIC TENETS (p. 8-9)

Despite the range of agricultural practices followed by organic farmers, most of them are guided by certain basic values and beliefs which may be called the "organic ethic." Some of the principal tenets of this ethic are summarized below. However, not all organic farmers would place equal weight on these tenets.

<u>Nature is Capital</u> -- Energy-intensive modes of conventional agriculture place man on a collision course with nature. Present trends and practices signal difficult times ahead. More concern over finite nutrient resources is needed. Organic farming focuses on recycled nutrients.

<u>Soil is the Source of Life</u> -- Soil quality and balance (that is, soil with proper levels of organic matter, bacterial and biological activity, trace elements, and other nutrients) are essential to the long-term future of agriculture. Human and animal health are directly related to the health of the soil.

<u>Feed the Soil, Not the Plant</u> -- Healthy plants, animals, and humans result from balanced, biologically active soil.

<u>Diversify Production Systems</u> -- Overspecialization (monoculture) is biologically and environmentally unstable.

<u>Independence</u> -- Organic farming contributes to personal and community independence by reducing dependence on energy-intensive agricultural production and distribution systems.

<u>Antimaterialism</u> -- Finite resources and Nature's limitations must be recognized.

In summary, organic farmers seek to establish ecologically harmonious, resource-efficient, and nutritionally sound agricultural methods.

3.2 CROP PRODUCTION (p. 12)

3.2.1 Cropping Practices A legume-based rotation with green manure or cover crops was an integral part of the management system on most of the organic farms studied. Legume crops frequently comprised 30 to 50 percent of the cultivated acreage. However, in some cases legumes were not used; for example, on vegetable farms receiving heavy applications of manure and in low rainfall areas. Other crops in the rotation were generally similar to those grown on neighboring farms. However, in areas where farm size was smaller, organic farmers seemed more inclined than their neighbors to produce vegetable crops for fresh markets.

The Rodale survey disclosed that about 50 percent of the farmers grew legume hay, mixed hay, or pasture in their rotations. A high percentage (50 percent) of these organic farmers were vegetable and/or small fruit producers that grew only limited amounts of small grains and cultivated field crops. As the farm size increased, the percentage of farmers growing meadow increased sharply (15 percent for farms of 9 acres or less, 71 percent for farms of 100 acres or more). The survey also showed that the percentage of farmers growing vegetables and small fruits decreased sharply with increasing farm size. These data emphasize the importance of legumes in rotation with small grains and cultivated field crops on organic farms.

Organic farmers on non-irrigated land followed crop rotations similar to those used on farms 30 to 40 years ago. A typical pattern was to follow a heavy green manure crop with a high nitrogen-demanding crop such as corn, sorghum, or wheat. For example, in a corn-soybean area such as the Midwest a rotation might be: oats - 3 years of alfalfa - corn (or wheat) - soybeans - corn - soybeans. On more productive soils, there might be an additional corn or wheat and soybean crop after 3 years of alfalfa. Vegetable crops grown with or without legumes are rotated so that the same crops are not followed sequentially. Organic vegetable farmers alternate deep and shallow rooted crops, root crops, and above-ground crops throughout the growing season by careful crop selection and consideration of planting and maturity dates. Organic farmers using irrigation often did not follow rotations systematically but instead based their cropping patterns on short-term demand for produce, plant disease problems, and availability of land and water.

3.7 ORGANIC AGRICULTURE IN JAPAN (p. 19)

Some guiding principles and objectives of the organic agricultural movement in Japan include:

1) To achieve self sufficiency;
2) To recycle organic wastes back to the land (cited as being commensurate with Buddhism and

its principles);
3) To protect and maintain human health; and
4) To achieve a mutually beneficial relationship between the farmer, the consumer, and the environment. The importance of a close and cooperative relationship between the farmer and consumer in the production and marketing of organically grown produce was emphasized.

4.3 ORGANIC FARMING AND ORGANIC WASTES (p. 35)

Organic farmers are well aware that the proper management of crop residues, green manures, and animal manures on their land is essential for protecting soils from wind and water erosion, and for preventing nutrient runoff. Certainly, they recognize that efficient and effective use of their residues and manures is essential for maintaining the productivity of their soils and for recycling plant nutrients. **A 1978 USDA report, Improving Soils with Organic Wastes** (1), is particularly relevant to the needs of organic farmers and some of the problems with which they must deal. 4.3.1 USDA Report, Improving Soils with Organic Wastes (1978) The Food and Agriculture Act of 1977 (P.L. 95-113) directed the U.S. Department of Agriculture to prepare a report to the Congress on "the practicability, desirability, and feasibility of collecting, transporting, and placing organic wastes on land to improve soil tilth and fertility." The urgency for this information stems from the increased cost of energy, fertilizers, and pesticides that confronts U.S. farmers, and the problems of soil deterioration and erosion associated with intensive farming systems. This report is now available upon request from the Office of the Secretary of Agriculture in Washington, D.C. 20250. It contains detailed information on the availability of seven major organic waste materials for use in improving soil tilth and fertility: (a) animal manures, (b) crop residues, (c) sewage sludge, (d) food processing wastes, (e) industrial organic wastes, (f) logging and wood manufacturing wastes, and (g) muni ci pat refuse. For each waste, information is reported on the quantity currently generated, current usage, potential value as fertilizers (based on major plant nutrients contained), cost of land application, competitive uses, and problems and constraints affecting their use. The report points out that this kind of information is absolutely essential for sound agricultural planning and successful implementation of organic recycling programs.

Appendix H: Moratorium Letter

February 17, 2016

Mr. Tom Vilsack
Secretary of Agriculture
U.S. Department of Agriculture
1400 Independence Ave SW
Washington, DC 20250

CC: Elanor Starmer, Acting Administrator, USDA Agricultural Marketing Service
Miles McEvoy, Deputy Administrator, USDA National Organic Program
Tracy Favre, Chair, National Organic Standards Board

Re: Ending the Organic Certification of Hydroponics

Dear Secretary Vilsack,

This letter serves as a formal request for the U.S. Department of Agriculture (USDA) to institute an immediate moratorium on the organic certification of all new hydroponic and aquaponic operations, until the agency enacts a final rule. We believe that it is incumbent upon USDA to accept the NOSB's 2010 recommendations to prohibit soilless hydroponic vegetable production as certified organic. The recommendation specifically states that hydroponic and aeroponic "cannot be certified as organic growing methods...." NOP's written response to the NOSB's recommendations acknowledges the completion of their work on greenhouse standards and that "the NOP will develop a proposed rule based on the NOSB final recommendations."[1]

The NOP's decision to allow organic certification of hydroponic systems, in direct opposition to the 2010 NOSB recommendations, and without formal proposed standards, violates the program's legal responsibility to follow the established due process in setting organic standards. Moreover, the harsh reality of the extreme variations that exist in how such operations are being certified (or not) is creating consumer confusion and undermining the integrity of the organic label that is relied upon by the organic sector for its market success.

Unlawful and Extreme Variations in Certification Requirements Weaken Organic Markets

Due to the lack of formal organic greenhouse standards, organic certification agencies have been acting independently and creating and recreating their own rules to address public concerns, particularly with respect to the organic soil requirement. While some certifiers allow crops to be grown in an undefined "biodegradable substrate," others do not. Some certifying organizations such as Vermont Organic Farmers, OneCert, and New York NOFA do not permit any form of hydroponic certification. They require crops to be grown in the soil, in keeping with the European standards. Other organizations have certified hydroponic crops for many years.

One of the central tenants of the Organic Foods Production Act of 1990 (OFPA) is to “assure consumers that organically produced products meet a consistent standard” (7 U.S.C. § 6501(2)). This lack of a consistent standard with respect to hydroponic systems is exactly the type of problem that OFPA and the NOP were specifically designed to avoid.

Consumers Have a Right to Know How Their Organic Food is Grown

All produce sold under these disparate organic hydroponics certification standards use the same USDA seal without differentiation. Therefore, there is no way for customers to identify which food is grown hydroponically and which is not. Indeed, most consumers have no idea that hydroponic growing is permitted under existing USDA organic standards.

Public Notice and Comment on Hydroponics Regulations is Required by Law

The NOP hydroponics rule must be subjected to public notice, review, and comment and specifically address the January 23, 2010 formal National Organic Standards Board (NOSB) Recommendations on the “Production Standard for Terrestrial Plants in Containers and Enclosures (Greenhouses).” NOSB passed this recommendation by a majority vote -- twelve to one -- after six years of hard work and public hearings. The recommendation unequivocally states that hydroponic production should not be permitted in organic certification and that organic production of terrestrial plants must be soil-based.[2]

U.S. Organic Rules Must be Consistent with International Hydroponic Rules

Strong international support for the 2010 NOSB Recommendations already exists. The recommendations are consistent with the vast majority of world organic standards, including twenty-four countries in the European Union (EU). It is also worth noting that Canada prohibits hydroponically grown produce to be certified organic, a situation that has forced the U.S. to create a specific hydroponics exception in its trade agreement with Canada.

The 2013 position papers of both the International Federation of Organic Agriculture Movements European Union (IFOAM EU) and the Expert Group for Technical Advice on Organic Production (EGTOP) offer well-researched recommendations on organic hydroponics that are in accord with the organic standards of twenty-four EU countries. IFOAM EU has also produced a position paper calling for USDA to regulate organic hydroponics based on the NOSB’s 2010 recommendations.

As an influential participant in global organic trade, it is incumbent upon the U.S. to join the international community in maintaining strong and consistent organic standards.

“Soil is the Source of Life” and the Foundation of U.S. Organic Farming Systems

Soil fertility and soil management are prerequisites for organic certification of crop production. Hydroponics systems do not meet this mandate. Both the OFPA and the NOP final rule describe organic agricultural production as being much more than substituting approved inputs for non-approved ones.

The 2010 NOSB Recommendation strongly reinforces foundational principles and descriptions of "organic," as practiced on U.S. organic farms. The 1980 *USDA Report and Recommendation on Organic Farming,*[3] clearly states:

- "Soil is the Source of Life—Soil quality and balance (that is, soil with proper levels of organic matter, bacterial and biological activity, trace elements, and other nutrients) are essential to the long-term future of agriculture. Human and animal health are directly related to the health of the soil.

- Feed the Soil, Not the Plant—Healthy plants, animals, and humans result from balanced, biologically active soil."

Hydroponic operations on the market do not enhance the biological diversity of plant/soil system or meet other essential requirements inherent in organic soil and ecosystem-based agricultural systems.

OFPA also makes clear that managing soil health is central to organic agriculture systems, as evidenced by the inclusion of details about what is expected by organic farmers as they design their annual crop and animal production system plans. In the discussion of what constitutes an Organic Plan (6513) it states:

(b) Crop Production Farm Plan.

(1) Soil Fertility. An organic plan shall contain provisions designed to foster soil fertility, primarily through the management of the organic content of the soil through proper tillage, crop rotation, and manuring.

The Rule also outlines a practice standard for soil fertility and crop management that is impossible to meet in a hydroponic system. In the *Soil fertility and crop nutrient management practice standard* (§ 205.203):

(a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.

(b) The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials.

(c) The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. Animal and plant materials include:

(1) Raw animal manure, which must be composted unless it is:

(i) Applied to land used for a crop not intended for human consumption;

(ii) Incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or

(iii) Incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles;

No language exists in either OFPA or the rule which outlines requirements for soilless hydroponic systems. In contrast, clear language exists to justify the prohibition of hydroponics in organic given the fact that they cannot meet the minimum standards described above. This conflict with OFPA makes it impossible to allow the universal organic certification of hydroponic production.

NOP Allowance of Hydroponic Certification is Unjustified

NOP's rationale for allowing hydroponic certification is based on a single sentence taken from the 1995 *NOSB Recommendation for Specialized Standards for Hydroponic Production in Soilless Media*. It states: "Hydroponic production in soilless media to be labeled organically produced shall be allowed if all provisions of the OFPA have been met." This recommendation was not included in the final rule and so it has no legal basis for current organic certification.

No provision in OFPA or the NOP regulations justifies the certification of hydroponics. In fact, in its written response to the NOSB recommendation in 2005 the NOP implies that standards need to be developed before hydroponic operations can be certified. It states that:

NOP concurs with the NOSB and agrees to proceed with additional rulemaking for mushrooms, apiculture and honey, and greenhouse operations and their products, and not to propose hydroponic standards until the NOSB has submitted a final recommendation.

Hydroponics Task Force Must Uphold and Clarify NOSB Recommendations

A stated primary objective of the USDA/NOP-created Hydroponics Task Force is to clarify the NOSB’s 2010 Recommendation (80 Fed Reg. 12,422, Mar. 9, 2015). Yet, widespread concern exists regarding the actual purpose of this task force, which appears to be to rewrite rather than to clarify the recommendation. Justification for this concern is based upon the composition of this task force, the majority of which seem to have a vested interest in advancing organic certification of hydroponics rather than in clarifying the 2010 NOSB recommendations.

It is troubling that taskforce membership was initially limited to those with at least three years of experience in hydroponic or aquaponic production. This restriction was later amended to include those with experience in soil-based organic systems of production. Nonetheless, the initial Federal Register notice gave an accurate foreshadowing of the affiliation of those who would be chosen to join. Several highly qualified task force applicants known to support the exclusion of hydroponic from organic were not chosen. This unfortunate situation created an unfairly biased task force which, coupled with USDA's allowance of hydroponics certification in the absence of clear and consistent regulations, has sparked increasing discontentment with the NOP by the wider organic community. Opaque decision-making runs counter to the practices that the organic sector expects from USDA and the NOP.

Conclusion

We must not take trust in organic for granted, either from the organic community as a whole, or from organic agriculture producers. It took decades to build trust in the organic label, and we must not squander it by ignoring due process. Yet, disturbing signs of eroding public trust in organic are evident. In 2015, the Consumers Union (CU) downgraded the rating of USDA's Organic Seal from "highly meaningful" to "meaningful," based upon extensive survey research of organic consumers. While we have heard from the NOP that it is not overly concerned about the study's results, we view CU's research (which did not specifically ask about hydroponics) as a first alarm. To us, it sends a powerful warning signal of the urgent need for course corrections to be taken by the USDA/NOP. Stopping the organic certification of hydroponic operations is a correction that is urgently and sorely needed.

To allow the entire organic industry to suffer public mistrust due to unnecessary confusion regarding basic greenhouse standards is short-sighted public policy. We must not compromise the organic standards in an effort to increase sales and open new markets at the expense of the public confidence.

For the reasons outlined above, the undersigned urge USDA to uphold the integrity of the organic label for farmers, handlers, and consumers by instituting an immediate moratorium on the organic certification of all new hydroponic and aquaponic operations until the agency enacts a final rule. We believe that it is incumbent upon USDA to accept the NOSB's 2010 recommendations to prohibit soilless hydroponic vegetable production as certified organic and have the details of that recommendation flushed out and reflected in the final rule.

This is the only way to ensure that *all* products carrying the organic label and USDA organic seal have met rigorous organic standards, and that organic farmers are protected from harm arising from inconsistent certification practices.

Respectfully yours,

Dave Chapman, Long Wind Farm, Vermont
David Miskell, Miskell's Premium Organics, Vermont
Anaïs Beddard, Lady Moon Farms, Pennsylvania, Georgia, and Florida
Dru Rivers, Full Belly Farm, California
Eliot Coleman, Four Season Farm, Maine
Pete Johnson, Pete's Greens, Vermont
Margit Kaltenekker Hall, Prairie Star Farm, Kansas

(On behalf of the diverse organic stakeholders who have signed the attached position statement calling for an immediate moratorium on new certified organic hydroponic operations)

US Organizations

National Organic Coalition

NOFA VT

NOFA NH

NOFA NY

NOFA NJ

NOFA CT

NOFA MA

NOFA RI

MOFGA (Maine Organic Farmers and Gardeners Association)

Center For Food Safety

Beyond Pesticides

Food and Water Watch

Northeastern Organic Dairy Producers Association

Organic Consumers Association

Organic Seed Growers and Trade Association

NOFA Interstate Council

Cornucopia Institute

Carbon Underground

Agrarian Elders

Forrest and Frances Lattner Foundation

Biodynamic Association

Demeter Association

Organic Crop Improvement Association

Deep Root Growers Cooperative

New England Farmers Union

Food Democracy Now!

Tuscagora Organic Growers Cooperative

International Organizations

Soil Association (Great Britain)

Organic Growers Alliance (Great Britain)

French National Organic Farmers Federation (France)

Bionext (Holland)

Biohuis (Holland)

Study Network of Organic Greenhouse Growers of the Dutch Federation of Agriculture and Horticulture (Holland)

Study Network of Organic Arable Farmers in Southwest Netherlands (Italy)

Nautilus Organic (Dutch Organic Growers Association-Holland)

BDEKO (Federation of Biodynamic and Organic Farmers-Holland)

AIAB (Associazione Italiana per l'Agricoltura Biologica- Italy)

AIAB Liguria (Italy)

BOLW (Bund Ökologische Lebensmittelwirtschaft e.V.)

CAPE (Cooperative pour l'Agriculture de Proximite Ecologique- Canada)

Amis de la Terre Estrie (Canada)

Former NOSB members

Michael Sligh - NOSB 1992 to 1996. Founding Chair.- Executive Director Rafi

Fred Kirschenmann- NOSB 1995 to 1999- Farmer. President Stone Barns Center For Food and Agriculture, Distinguished Fellow for Leopold Center For Sustainable Agriculture, Professor of Religion and Philosophy at ISU, Cofounder Farm Verified Organic, Inc.

Dr. Joan Gussow- NOSB 1996 to 2000 - Professor Emeritus Columbia University, Author.

Dave Carter - NOSB 2001 to 2005 - Executive Director National Bison Association, USDA Agricultural Trade Advisory Committee on Animals and Animal Products, Consultant with Crystal Springs Consulting Inc.

Jim Riddle - NOSB 2001 to 2005. Former Chair.- Farmer at Blue Fruit Farm, Inspector, Trainer, Policy Specialist, Co-author of OTA's American Organic Standards, Outreach Coordinator University of Minnesota Southwest Research and Outreach Center, Cofounder International Organic Inspectors Association, former University of Minnesota Extension Organic Outreach Coordinator, Ceres Trust.

Dr. Hubert Karreman - NOSB 2005 to 2009. - Former Chair of the Livestock Committee Organic veterinarian, member Biodynamic Educators Collaborative.

Jeff Moyer - NOSB 2005 to 2010. Former Chair. - Executive Director and former Farm Director Rodale Institute, Board Chair for the Seed Farm, Founding and current member of the Pennsylvania Certified Organic, past board member of the Organic Farming Research Foundation, Project member of the Noble Foundation's Soil Renaissance project.

Joe Smillie - NOSB 2006 to 2010- Former Vice President of Quality Assurance International. Former President and board member of the Organic Trade Association.

Kevin Englebert - NOSB 2006 to 2010 - Farmer at Englebert Farms.

Dr. Barry Flamm - NOSB 2008 to 2012. Former Chair - Farmer, Founder and Vice-Chair of the Montana Organic Association, Former Director of the USDA Office of Environmental Quality, Former Senior Staff Member for natural resources and agriculture at the President's Council For Environmental Quality, former teacher of environmental policy at the University of Montana, Former Chief Forester at the Wilderness Society.

Nick Maravell - NOSB 2011 to 2015 - Farmer at Nick's Organic Farm.

Jennifer Taylor - NOSB 2011 to 2015 - Associate Professor Florida A&M University.

Colehour Bondera - NOSB 2011 to 2015 - Farmer at Kanalani Ohana Farm.

Goldie Caughlan - NOSB 2001 to 2005 - Nutrition Education Manager at PCC Natural Markets, Board member Cornucopia Institute.

Jay Feldman - 2010 NOSB. Later Chair of crops subcommittee. - Executive Director Beyond Pesticides.

Farmers and Organic Advocates

Dr. Stuart Hill Retired professor of soil zoology, McGill University

Elizabeth Henderson Co-chair NOFA NY Policy Committee

Edward Maltby Farmer, Executive Director NOFPA

Terry Shistar Beyond Pesticides

Bob Scowcroft Cofounder and former Executive Director of the Organic Farming Research Foundation, First Executive Director of the California Certified Organic Farmers

Tom Beddard Farmer Lady Moon Farm

Bart Hall P. Ag. Farmer, former inspector

Bill Duesing Executive Director NOFA CT

Enid Wonnecott Executive Director VT NOFA

Jack Kitteridge Farmer Many Hands Organic Farm, Editor The Natural Farmer

Julie Rawson Farmer Many Hands Organic Farm, Editor The Natural Farmer

Mitch Blumenthal Farmer and Founder/President of Global Organic Specialty Source

Ronnie Cummins Co-founder and International Director of The Organic Consumers Association, Author

Lisa Bunin Former Organic Policy Director for Center For Food Safety

Jim Gerritsen Farmer Wood Prairie Family Farm, President of Organic Seed Growers And Trade Association, named an Organic Food Champion by the Utne Reader, Agrarian Elder

Megan Gerritsen Farmer Wood Prairie Family Farm, Agrarian Elder

Alan Schofield Farmer Growing With Nature, Chairman of the Horticultural Standards Committee for the Soil Association, Chairman of the Organic Growers Alliance

Steve Gilman Farmer, Policy Coordinator NOFA Interstate Council

Tom Newmark Farmer Finca Luna Nueva, Co-Founder and Chair Carbon Underground, Founder Sacred Seeds, Trustee American Botanical Council, Founder New Chapter

Patty Lovera Assistant Director Food & Water Watch, former Deputy Director at Public Citizen

Paul Hawken Environmentalist, Entrepreneur, journalist, and author. Founder of Natural Capital Institute. Former board member of Point Foundation, Center For Plant Conservation, Conservation International, Trust For Public Land, Friends of the Earth, and National Audubon Society.

Karl Hammer Farmer, Founder and President Vermont Compost Company

Will Allen Farmer Cedar Circle Farm

Liana Hoodes Former Executive Director NOC

Tom Page Farmer Page's Organics

Frank Morton Farmer Shoulder To Shoulder Farm, Agrarian Elder

Clara Coleman Four Season Farm Consulting

Zoe Bradbury Farmer Valley Flora Farm, Agrarian Younger

Amigo Bob Cantisano Consultant, Founder Ecological Farming Conference, Steward of Sustainable Agriculture, Agrarian Elder

Jack Algiere Farmer Four Season Farm at Stone Barns Center, Agrarian Younger

Dan Pullman Manager of Fresh Source Capital, Board of Food and Environment Reporting Network, Board of Yale Sustainable Food Project, Founding President of Sprout Lenders, Board of FarmPlate

Dr. Will Brinton President Woods End Laboratories

Will Raap Founder Intervale Foundation, Cofounder Gardeners Supply

Barbara Damrosch Farmer Four Season Farm, Journalist Washington Post, Author

Dr. William Liebhardt Emeritus UC Davis , Former Director UC Sustainable Agricultural Research and Education Program 1987-2001, Former chief scientist Rodale Institute 1981-1987, professor U of Delaware 1970 to 1981

Frederic Jobin-Lawler Farmer Abri Vegetal (Canada)

Thea Maria Carlson Co-director Biodynamic Association

Robert Karp Co-director Biodynamic Association, founder New Spirit Farmland Partnerships, Former Executive Director of Practical Farmers of Iowa, former board chair of Michael Fields Agricultural Institute.

Stephan Schneider Farmer, Board member Biodynamic Association, President Hawthorne Valley Farm

Daphne Amory Board member Biodynamic Association, Inspector for Demeter USA

Gregory Georgaklis Board member Biodynamic Association, Founder Farmers To You

Peter Littell Board member Biodynamic Association, President of Biodynamic Farmland Conservation Trust

Terry Brett Board member Biodynamic Association, Co-owner Kimberton Whole Foods

Jim Fullmer Co-Directer Demetor USA

Dr. Larry Phelan Professor of entomology at Ohio State University

Jean-Paul Courtens Farmer Roxbury Farm, former president of the Biodynamic Association, Teacher

Jim Crawford Farmer New Morning Farm, Agrarian Elder

Jake Guest Farmer Killdeer Farm, Agrarian Elder

Betsy Hitt Farmer Peregrine Farm, Agrarian Elder

Gloria Decater Farmer Live Power Community Farm, Agrarian Elder

Stephen Decater Farmer Live Power Community Farm, Agrarian Elder

Carly Delsignore Farmer Tide Mill Organic Farm, Agrarian Elder

Andrea Hazzard Farmer Hazzard Free Farm, Agrarian Elder

Zachary Wolfe Farmer Farm at Locusts on Hudson, Agrarian Elder

Tom Willey Farmer T&D Willey Farms, Agrarian Elder

Bavo van den Idsert Director, Bionext, The Netherlands

Lisa Stokke Cofounder Food Democracy Now!

Dave Murphy Cofounder Food Democracy Now!

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[1] September 30, 2010,
[2] 80 Fed Reg. 12,422, Mar. 9, 2015
[3] US Department of Agriculture Study Team on Organic Farming. (1980) *USDA Report and Recommendation on Organic Farming*, section 2.4, “Organic Agriculture, Some Basic Tenets,”

Appendix I: USDA Regulations of the use of Chilean Nitrate in Organic Agriculture

http://www.ecfr.gov/cgi-bin/ECFR?page=browse

§205.602 Nonsynthetic substances prohibited for use in organic crop production.

The following nonsynthetic substances may not be used in organic crop production:

(g) Sodium nitrate—unless use is restricted to no more than 20% of the crop's total nitrogen requirement; use in spirulina production is unrestricted until October 21, 2005.

Appendix J: Letter from Michael Sligh

I am Michael Sligh, and was a founding member of the NOSB from 1992-1997and served as the founding chair and vice-chair to the second chair. I did publish, A Guide To The Development of US. Organic Standards, in 1997, that contains all of the Original NOSB recommendation to USDA for the development of the US Organic Regulations.

This record records that the Board did pass a three line recommendation on April, 25, 1995:

Hydroponic production in soilless media to be labeled organically produced shall be allowed, **if all provisions of the OFPA have been met.**

We had been required to make some recommendations on a wide range of specialized subjects prior to submitting our final recommendation to USDA for the development of US NOP regulations. The Hydroponic discussion was very short and consisted of only a few minutes of full board discussion during our April, 25, (1995) meeting. USDA's own transcripts from the period of 1992 - 1995, also only records this same one reference from that April 25th meeting, but it does add that:

"*Kahn concluded his report by reading the hydroponics recommendation that would allow organic labeling for products from soilless media if all other National Program requirements are satisfied. Baker expressed his concerns about the philosophical problems associated with soilless production. Kahn noted that the recommendation only allows for the possibility of an organic hydroponics industry developing. Kahn recognized that hydroponics is a practice that is dependent on synthetic inputs and wants to open up dialogue with its proponents."

* Gene Kahn was the chair of the Crops during that period and wanted a "place-holder" for future discussions.

On a personal note, my understanding of that statement, that "all provisions of OFPA have been met", was the key to my voting for that very brief recommendation. As one that both worked on the OFPA and as the founding chair and a founding board member; I understood OFPA to be about organic farming, which meant that the goal,(as our NOSB definition of organic farming stated and was also adopted at that same April meeting in Orlando, states" …based on management practices that restore, maintain and enhance ecological harmony….The primary goal of organic agriculture is to optimize the health and productivity of **interdependent communities of soil life, plants, animals and people."**

Additionally, the OFPA refers to soil about ten times:

and specifically;

"(b) Crop production farm plan.
(1) Soil fertility. An organic plan shall contain provisions designed to foster soil fertility, primarily through the management of the organic content of the soil through proper tillage, crop rotation, and manuring.
(2) Manuring.
(A) Inclusion in organic plan. An organic plan shall contain terms and conditions that regulate the application of manure to crops."

So, in conclusion, in my opinion OPFA includes the "following key provisions that must be met" - "would include a farm plan; that fosters soil fertility, includes crop rotations, is compatible with a system of sustainable agriculture, does not harm soil organisms and does not include any production practices that are inconsistent with this chapter."

Hope this helps,

all the best,

Michael

2. Hydroponic & Aquaponic Subcommittee Report

Preserving a philosophy while embracing a changing world

Colin Archipley
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<u>Please note</u> - this document was prepared under very tight time constraints. The Hydroponics and Aquaponics Subcommittee was tasked with both providing specific information about growing systems, supported by scientific research and case studies, as well as reviewing and answering other questions regarding coordination with organic production standards and the 2010 NOSB Recommendations. The full Task Force, now split into three subcommittees, was initially to be a full year project. It began in November 2015 with preliminary discussions. The first and only in-person meeting was January 2016. The project deadline was shortened by five months to June 2016 and then a slight extension to mid-July 2016. As such, it was not possible to complete all the tasks of the Hydroponics and Aquaponics Subcommittee with the detail and specific information, supported by research, as initially intended, due to the lack of adequate time to address all matters.

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Introduction

The words organic farming conjure not just a set of guidelines for agricultural practices, but also often are associated with a deep philosophy rooted in the concept of improving and maintaining our environment, promoting life beyond just the crop and staying true to preserving nature's life processes. For as far back as history has recorded, societies worked with limited resources and flourished or failed based on their ability to innovate and adapt to changing environments, resources and conditions. Humans farmed in the basic sense of "organically" since the time we learned to sow a seed. However, it is not until recent decades that synthetic materials have become widely available for use in agriculture, and thus specific legal guidelines have emerged to identify and certify "Organic" growing under U.S. Department of Agriculture guidelines.

Challenges in the farming industry such as drought, food safety, limited arable land, climate change and rapid population growth constantly evolve, and with it, the farming industry continually adapts as well. One part of a solution to these challenges is use of growing techniques such as hydroponics and aquaponics, as addressed in this report.

It is important to note that extensive documentation shows that ancient civilizations practiced innovative growing techniques similar to hydroponics and aquaponics, including the Aztecs with Chinampa "floating gardens" and the Babylonians and their famed "hanging gardens of Babylon." These historic techniques are still in practice and are continually expanding today to be an active part of U.S. agriculture.

In 2010, the NOP conducted a survey and reported that there were 8 certifiers who were certifying hydroponic operations as "organic", and only 39 hydroponic growers. A second survey in 2016, which asked about certification of hydroponic and aquaponic as well as other types of container operations reported an 88% increase in certifiers who certify hydroponic and aquaponic operations and an increase of over 33% in these operations.

In 2010, the National Organic Standards Board (NOSB) recommended that hydroponic systems not be eligible for organic certification "… due to their exclusions of the soil-plant ecology intrinsic to organic farming systems…" (NOSB may 2009).

It is this Subcommittee's intent, via this report, to among other tasks, provide additional information, background and clarification about hydroponic and aquaponic growing systems that likely were not available to the NOSB at the time of their 2010 recommendation.

Specifically, the description of "hydroponic" systems in the NOSB's 2010 recommendations addresses a traditional method of hydroponics that is sterile and inert. This Subcommittee agrees with the NOSB's 2010 position that such systems should not be eligible for organic certification. However, there are other container growing systems that may resemble traditional hydroponic systems, but are fundamentally and completely different. Such systems require and contain rich, diverse and complete soil-plant ecology that symbiotically work with plants to biologically process animal, plant and mineral inputs. This subcommittee has termed such “organic hydroponic” practice as “bioponic” – this report will discuss in detail how bioponic growing practice works and its alignment with current organic regulations.

As will be discussed in detail below, it is critically important to consider hydroponic and aquaponic production systems as eligible for organic certification, because these practices conserve incredible amounts of water, dramatically reduce food safety risks and pose very low environmental impacts – while at the same time holding soil-plant biology and the use of the same animal/plant-based inputs, as soil-field farmers, at the core of their practice.

Definitions

Hydroponic production - The growing of plants in mineral nutrient solutions with or without an inert growing media to provide mechanical support

Bioponic production - A contained and controlled growing system in which plants in growing media derive nutrients from natural animal, plant and mineral substances that are released by the biological activity of microorganisms

Aquaponic production - A type of bioponic system in which wastes produced from the life cycle of fish or other aquatic animals supplies nutrients for plants grown in container systems. As plants absorb nutrients, the water is purified for reuse

Aeroponics - A type of growing system in which plant roots are suspended in an enclosed space and at regular intervals are moistened with nutrient solution or microbial solution, which is then returned to the reservoir and re-used

Soil - The outermost layer of the earth comprised of minerals, water, air, organic matter, fungi and bacteria in which plants may grow roots

Growing media - Material which provides sufficient support for the plant root system and a diverse ecosystem of soil-borne microorganisms

Compost Tea - A water extract of compost produced to transfer microbial biomass, fine particulate organic matter, and soluble chemical components into an aqueous phase, intending to maintain or increase the living, beneficial microorganisms extracted from the compost.

Nutrient solution - Growing solution used in traditional hydroponic production which is commonly composed of immediately plant-available soluble synthetic mineral salts in water

Microbial solution - Growing solution used in bioponic production which is commonly composed of organic substances and a diverse ecosystem of beneficial microorganisms in water

Container - any vessel and associated equipment used to house growing media and the complete root structure of terrestrial plants and to prevent the roots from contacting the soil or surface underneath the vessel (per the 2010 NOSB Recommendations). Containers may range from pots to plastic grow bags, to mats, to PVC channels, to large troughs containing nutrient-rich water.

Brief Review of the Organic Food Productions Act (OFPA) and USDA Organic Regulations

History

In 1990, Congress passed the Organic Foods Production Act (OFPA)[10]. This is the main federal law regulating organics in the United States. Congress delegated authority to the United States Department of Agriculture through the Secretary of Agriculture[11] to make specific regulations to manage and implement organic production and set standards for which products are eligible for organic regulation through a regulatory, rule-making process. This law also created the National Organic Standards Board (NOSB)[12], a federal advisory committee, which makes non-binding recommendations to the USDA for potential final approval and implementation through the official legal rule-making process. Public input and participation are required in the process as well, and USDA considers public comments in approving and enacting final rules. Notices related to USDA rules are published in the Federal Register and final rules are eventually codified in the Code of Federal Regulations.

The USDA's first organic regulations were created as a Proposed Rule in 1997, a second Proposed Rule in March 2000 and the Final Rule was enacted in December 2000.

In the Second Proposed Rule in March 2000, the preamble discusses removing the term "organic agriculture" and replacing it with "organic production" to "provide a more encompassing term, which may come to include such diverse activities as hydroponics, green house production and harvesting of aquatic animals."

The final legal definition in the new rules for organic production was "[a] production system that is managed in accordance with the Act and regulations in this part to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity."[13] These rules went into effect in October 2002. **This remains the current legal definition of organic production today.**

This definition requires that organic methods include the use of biological practices that foster the cycling of resources, but does not mention or require "soil" for organic production.

In 2003, the NOSB prepared a guidance document for hydroponics and other "soil-less" growing systems, but did not present any final recommendations to USDA for approval.

A 2008 NOSB meeting included a discussion regarding hydroponics. The Crops Subcommittee of the NOSB led a discussion on guidance statements relative to limiting hydroponic systems to naturally aquatic plant species, but it was never voted on by the full NOSB.

In 2009, the Crops Subcommittee presented a discussion item at the spring meeting which noted:

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[10] 7 U.S.C. § 6501 *et seq.*

[11] 7 U.S.C. § 6503.

[12] 7 U.S.C. § 6518 (governed by the Federal Advisory Committee Act (FACA), 5 U.S.C. App. 2).

[13] 7 C.F.R. § 205.2.

"Hydroponics ...certainly cannot be classified as certified organic growing methods due to their exclusion of the soil-plant ecology intrinsic to organic farming systems ..." However, the NOP did not adopt this recommendation, but rather stated that further information and review was necessary due to the complexity and diversity of production systems, making it difficult to develop guidance with the limited information.

At the September 2009 NOSB meeting, the NOSB presented a recommendation for federal rulemaking – the addition of specific rules for Greenhouse Production Systems. The recommendation again stated a prohibition of hydroponic systems. After public comment was received, the Crops Subcommittee wrote a new recommendation, *Production Standards for Terrestrial Plants in Containers and Enclosures*.[14] The full NOSB approved the document, and made a formal recommendation for approval by the USDA, which was submitted to the NOP on April 29, 2010. The recommended regulations state, in part: "Growing media shall contain sufficient organic matter capable of supporting natural and diverse soil ecology. For this reason, hydroponic and aeroponic systems are prohibited."[15]

Although the full NOSB developed a recommendation to prohibit hydroponics and aeroponics in 2010, as discussed above, the **NOP/USDA has not adopted nor implemented this recommendation and therefore it is not current law**.

In 2015, the NOP appointed the Hydroponic and Aquaponic Task Force to prepare a report to the NOSB to provide additional information and industry expertise that may have not been available to the NOP/NOSB in the past.

Discussion

In May 2014, NOP published in its Organic Integrity Quarterly, a piece explaining organic hydroponics, including a statement regarding NOP's position of current law and its corresponding policy with respect to hydroponics, and arguably, other non-traditional soil-based growing techniques. It stated, "[o]rganic hydroponic production is allowed as long as the producer can demonstrate compliance with the USDA organic regulations." This statement is not law, but offers the USDA/NOP interpretation of existing law regarding organic production, which is under the legal jurisdiction of the USDA. This serves as guidance to growers and certifiers who wish to certify hydroponic production systems as USDA Organic. In this statement, NOP/USDA notes that crop production can be considered organic even when terrestrial plants are grown in pure microbial solution, as may be the case with hydroponics and aquaponics.

Several provisions within existing regulations mention the word soil, but as reviewed below, do not explicitly prohibit soil-free production from organic certification.

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[14] *See* Production Standards for Terrestrial Plants in Containers and Enclosures, *available at* https://www.ams.usda.gov/sites/default/files/media/NOP%20Final%20Rec%20Production%20Standards%20for%20Terrestrial%20Plants.pdf
[15] *Id.*

7 CFR §205.202 states: "Any field or farm parcel from which harvested crops are intended to be sold, labeled, or represented as organic," must: (a) Have been managed in accordance with the provisions of §§ 205.203 through 205.206." Those sections within these requirements (§§ 205.203 through 205.206) that mention soil are discussed following:

Section 205.203 covers "soil fertility and crop nutrient management practice standards." Later in this report, the Subcommittee explains that while what is considered traditional soil may not be used in bioponic systems, soil ecology fully exists in bioponic systems, and all of these provisions may be met. For the purposes of this section, we review the legal requirements of these provisions.

7 CFR § 205.203, it states: "(a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion." This provision does not expressly say soil must be used. Rather, it appears to suggest that if there is soil, then the producer must follow these particular practices.

Even if this provision is interpreted in the most strict sense, "OR" creates two potentially mutually exclusive possibilities. An organic facility must either 1. maintain the physical, chemical, and biological condition of soil, OR 2. it must improve the physical, chemical, and biological condition of soil.

There is no definition for "soil" in the OFPA nor in the USDA organic regulations. A definition of "soil" can be found in the USDA Agricultural Handbook:

> The collection of natural bodies on the earth's surface, in places modified or even made by man of earthly materials, containing living matter and supporting or capable of supporting plants out-of-doors. Its upper limit is air or shallow water. At its margins it grades to deep water or to barren areas of rock or ice. Its lower limit to the not-soil beneath is perhaps the most difficult to define. Soil includes the horizons near the surface that differ from the underlying rock material as a result of interactions, through time, of climate, living organisms, parent materials, and relief. In the few places where it contains thin cemented horizons that are impermeable to roots, animals, or marks of other biologic activity. The lower limit of soil, therefore, is normally the lower limit of biologic activity, which generally coincides with the common rooting depth of native perennial plants.

For the purposes of this report, the Task Force defined soil as "the outermost layer of the earth comprised of minerals, water, air, organic matter, fungi and bacteria in which plants may grow roots."

As hydroponic and aquaponic growing methods generally do not rely on the use of what traditionally is considered "soil" for providing nutrients to the plants being grown within the system, such systems will not deplete the physical, chemical, and biological condition of soil, and thus falls within the text of 7 CFR §205.203. When there is no depletion, there is the status quo, thus maintenance. By the same logic then, there would be no soil erosion at all, as also required by the same provision.

Section 205.203(b) states that "[t]he producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials." Again the discussion hinges on the context of “soil”. This section could be interpreted to mean that if there is traditional soil in a growing system, producers must follow these requirements. Or it could be read that this hinges on “soil fertility”, which is not the same as soil. In bioponics, the soil ecology, and thus fertility in the system is maintained through various methods including changing crop variety over time and the application of plant and animal materials, as is similarly done in field crops.

Section 205.203(c) states “[t]he producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances.” In bioponics, the soil ecology is maintained within the contained system. Producers can manage plant and animal materials in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances in the system, just as field producers do. Again if this is read most strictly, that producers must maintain or improve organic matter in “soil”, then as stated above, bioponic growing methods generally do not rely on the use of what traditionally is considered “soil”, so such systems will not impact soil, thus will “maintain” it and fall within the requirements of the text of 7 CFR §205.203(c).

Section 205.203(d) states “[a] producer *may* manage crop nutrients and soil fertility to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances by applying [various substances].” The word “may” indicates that this provision is optional, and therefore just like for field crops, may or may not be utilized in bioponic production, based on the producer’s preference.

Section 205.203(e) lists substances that producers may not use, and would apply to bioponic production.

Section 205.205 concerns crop rotation practice standards and requires “[t]he producer must implement a crop rotation including but not limited sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation: (a) [m]aintain or improve soil and organic matter content.” The use of the words “including but not limited to” infinitely expands the options to achieve this requirement. Again the “maintain or improve” language appears here. Bioponic production maintains traditional soil as discussed above pertaining to §205.203(a) and the similar requirement to “maintain or improve soil.”

Finally, § 205.206 (a) states that “[t]he producer must use management practices to prevent crop pests, weeds, and diseases including but not limited to: (1) Crop rotation and soil and crop nutrient management practices, as provided for in §§ 205.203 and 205.205” As discussed above, the words “including but not limited to” provide for infinite methods to comply with this requirement. See the above discussion regarding the requirements of §§ 205.203 and 205.205.

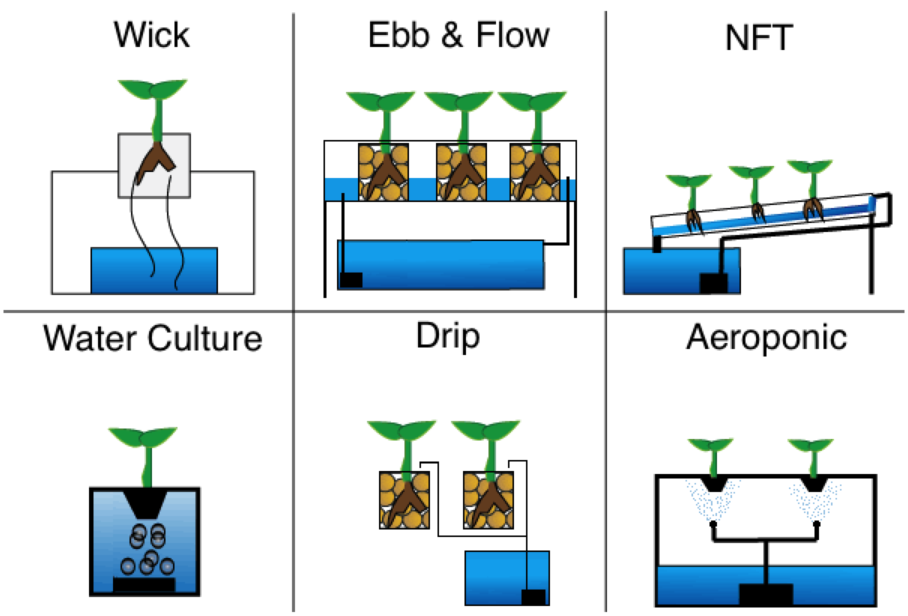
Conclusion

Under current law and clarification from NOP/USDA, hydroponic and aquaponic production methods are legally allowed for certification as USDA Organic as long as the producer can demonstrate compliance with the USDA organic regulations.

Traditional (non-organic) Hydroponic Systems

Hydroponics is the growing of plants in a container with mineral nutrient solutions, with or without an inert growing media to provide mechanical support. Traditional hydroponic systems are inorganic systems that do not rely on biological organisms to make minerals available to the plants. Instead, the plants are fed nutrients in their basic ionic forms (ex. nitrate, potassium, iron) that can immediately be taken up through their roots. The growing media is considered inert because it has little to no cation exchange capacity (a measure of the ability of nutrients to be adsorbed and later released to the plants) compared to typical soils and because of the lack of microbiology, the media itself is stable and does not readily decompose or contribute nutrition to the plants.

There is wide variety of hydroponic systems. The most common systems will be described below. However, despite the variety of system configurations, the systems typically only differ in their mechanical setup, but the underlying science is virtually identical. The following diagram illustrates some of the most common systems. (Note: the design of a system is not relevant for determination of whether it is hydroponic or bioponic, rather it is the function and microbial content of the system that is relevant, and in fact some of the typical designs below may be the same or similar for a bioponic system).



Hydroponic growing systems may be categorized by where the roots are located in the system:

1. **Water-based systems** - roots are directly in the liquid nutrient solution or somehow regularly moistened by it
2. **Aggregate culture** - roots grow into an inert medium such as sand, perlite, vermiculite, peat moss, or coconut coir, and are irrigated with a complete nutrient solution

Systems may also be categorized by what happens to the nutrient solution:

1. **Open** - the nutrient solution is distributed from a reservoir to the plants and is then "drained to waste" (i.e. not used again).
2. **Recirculating**- the nutrient solution is distributed from a reservoir to the plants. After passing through the root zone, it is collected and reused. The recycled nutrient solution may or may not be sterilized (UV light, ozone etc.) to eliminate plant pathogens so they are not re-introduced to the plant roots.

There are many different types of hydroponic systems. However, the majority of small farms and commercial growers use the following water-based and aggregate systems. For the clarity of this report, container systems include hydroponic production, aquaponic plant production and greenhouse production. (Note: many of these same systems are used in bioponic production).

a) Water-based Systems

1. **Deep water culture(DWC)/raft** - Plants are suspended through foam boards which float on the surface of the nutrient solution. Oxygen must be supplied to the roots using an air pump and air stones, or using a venturi system. This is a closed system where the nutrient solution remains within the same enclosed container throughout the growing cycle.
2. **Nutrient Film Technique (NFT)** - Plants are suspended through holes in the top of a long tube or channel that is slightly slanted. Nutrient solution is pumped to the higher end, constantly flowing as a thin film across the plant roots to the lower end where it is collected and then recirculated.
3. **Ebb and Flow (Flood and Drain)** - Used for propagating seedlings and growing plants in pots. Seedlings and potted plants are placed in a drain table. Nutrient solution is periodically pumped into the drain table from a reservoir below, flooding the media for a short time before draining back into the tank below.
4. **Aeroponics** - Roots are suspended in an enclosed space and at regular intervals are moistened with nutrient solution, which returns to the reservoir and is re-used.

b) Aggregate culture

Inert media is placed in some type of container where nutrient solution is fed to each plant through a top-drip system (main irrigation line with emitters and spaghetti tubing going to each plant head). Because the nutrient solution consists of dissolved minerals, these minerals can build up in the media, necessitating some excess watering (leaching) to flush salts. These systems typically require 10-30% excess watering, which is re-circulated, re-directed to outdoor cropping systems, or sent to waste to septic or sewer. Aggregate systems are used primarily for vining crop production (ex. tomato, cucumber, pepper) or other fruiting crops such as strawberries.

1. **Slab** - This is the traditional method for commercial hydroponic tomato growers. Plants are grown in 3ft long x 3 or 4-inch-thick polyethylene lay-flat bags (or slabs) filled with coconut coir or similar natural fibers.
2. **Upright bag or Dutch Bucket** - Another common method for commercial growers is 3 or 5-gallon upright polyethylene bags, or 3-gallon square hard plastic buckets called Dutch buckets or Bato buckets. These systems typically use coconut coir sometimes mixed with perlite and vermiculite.

3. **Trough** - A long above-ground container where a large amount of plants are sharing growing media. Troughs can be made of plastic, PVC, metal, wood, concrete or even on a plastic cover on top of a soil trench. Most troughs are closed off to the ground so roots and water cannot penetrate the soil surface, but drainage is collected to be recycled or re-used.
4. **Tower** - Plants are grown in hard plastic or Styrofoam pots containing a media mix that are stacked into a tower. Nutrient solution from a reservoir is pumped to the top of the tower where it drips or sprays onto the top pot, trickling through subsequent pots until it is collected into a reservoir at the bottom to be drained to waste or recirculated.
5. **Pots** - Round or square pots usually made of plastic are sometimes used to grow smaller or short cycle plants, such as starter seedlings or herbs. These are usually used with a drip irrigation system or ebb and flow table.

Traditional (non-organic) hydroponic systems place a great deal of importance on sterility. The goal is to keep biology out of these systems, namely soil-borne pathogens that are ubiquitous in soil-based growing systems. Plant fertilization is based on chemistry. Plant nutrition comes in the form of inorganic minerals that become available through solubilization with water. Because nutrients are not bound within organic molecules, these systems do not require the work of microorganisms to free up the nutrients for uptake by the plants.

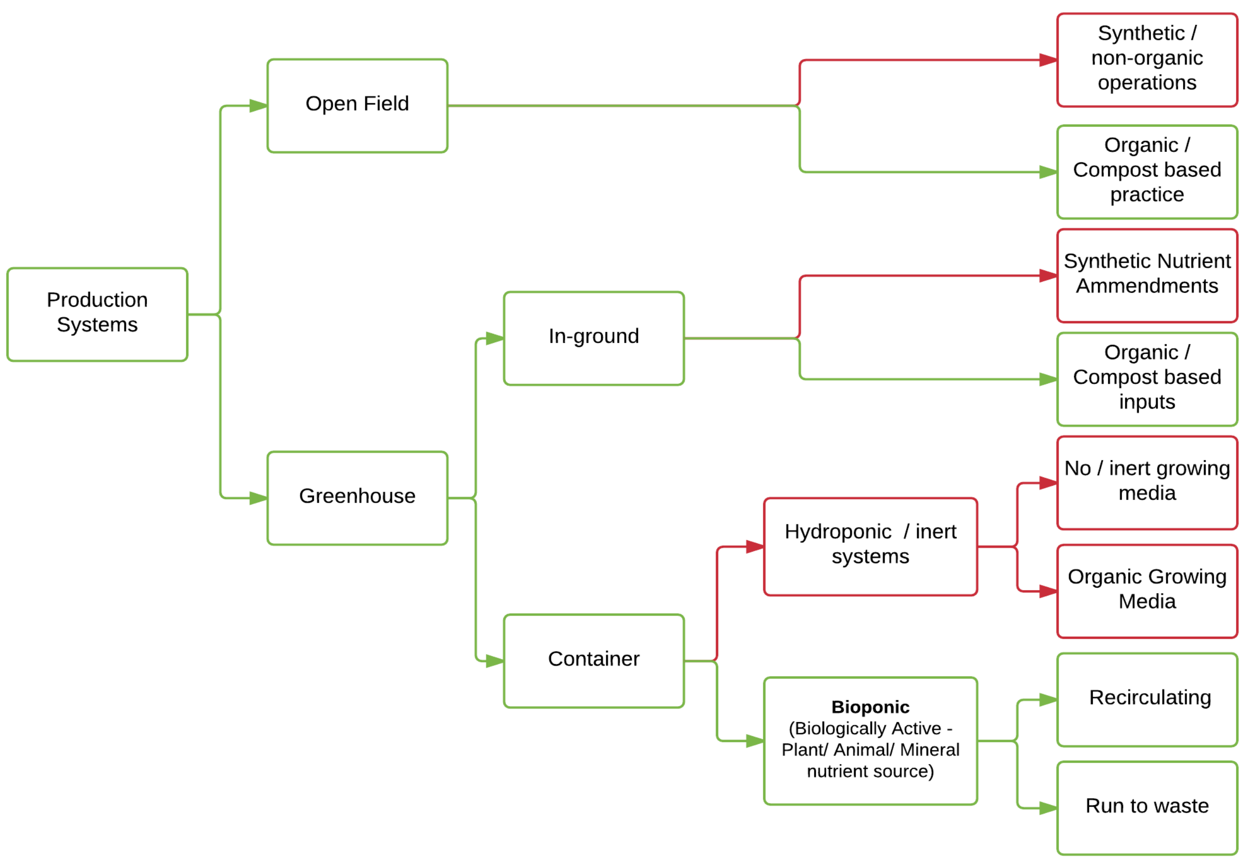
The media in traditional hydroponic systems is typically inert. This means that the media itself does not readily degrade or contribute significant nutrition to the plant nor does it significantly interact chemically or biologically with the nutrient solution. Rockwool, historically the most popular media used in the hydroponic industry, fits this definition. However, it is important to note that the U.S. hydroponic industry has now moved to the use of alternate media, such as coconut coir instead of rockwool, as its base media for growing. Coconut coir (also called coco coir, cocopeat, fiber, husk, pith) is the outside fiber of the coconut which is a waste product of the coconut industry. While coconut coir is organic in nature and has a cation exchange capacity similar to typical mineral soils (sand, clay), it is considered inert when used in traditional hydroponic systems because the lack of biology in hydroponic systems keeps the material from decomposing readily. However, it is important to note that when significant organic matter and microbiology are added to coconut coir, it is capable of maintaining biology and decomposing the coconut husk into humus (Prabhu, S.R. and Thomas, G.V.; Suresh Kumar and Ganesh, 2012;).

Organic Hydroponics - Bioponics

a) Why Bioponics is Relevant to the NOSB/NOP

Organic hydroponics, or bioponics, as this Subcommittee has termed it, is fundamentally and entirely different from conventional (non-organic) hydroponics. Bioponics is a growing method that completely relies on a soil food web micro-biological ecosystem to provide nutrients to a crop. All inputs come from animal, plants and minerals and require biology to convert these raw inputs into plant-usable form. This is the opposite of conventional hydroponics, where synthetic/inert nutrients are fully provided to a crop without the need for any biology.

In the 2010 NOSB recommendation, the NOSB addresses the specific growing practice of conventional hydroponics. Rightfully, the NOSB determined that this production practice should not be eligible for organic certification "due to their exclusion of the soil-plant ecology intrinsic to organic farming systems…" (NOSB May 2009). However, due to the relatively new emergence of bioponics, this form of organic production system was not addressed in the 2010 NOSB recommendation. Specifically, because bioponics relies entirely on soil-plant ecology, it is technically the opposite concept of a sterile traditional hydroponic system. This section describes in detail how bioponic systems work.



b) How is Bioponics different from Hydroponics

The simplest and most fundamental difference between hydroponics and bioponics is that bioponics uses plant-based, animal-based and mineral inputs that require a biological eco-system to make nutrients available to plants, whereas conventional hydroponics uses inert already soluble nutrients that require no biology for plants to use the nutrients.

In the past 10 to 15 years, advances in research and technology allowed growers to minimize the use of natural resources, decrease soil and water contamination, increase production, and maintain or improve fruit and vegetable quality while growing using organic substrates, organic nutrition, and natural microbial nutrient cycling. We define these systems as "bioponic"**.** The term "bioponic" is a recent concept that is used frequently in practice, but is not yet common in research literature. Just as hydroponics means "water-working", bioponics mean "life-working". More than one person has been credited with developing or "coining" the term. David Yarrow (1997) as one of the first to use the concept of bioponics to describe aquaponic growing. There is no record of patents or trademarks with the U.S Patent and Trademark Office regarding "bioponics." In any case, bioponics combines the philosophies of organic farming with the efficiencies of hydroponics to create a new organic farming model that can address modern day resource conservation, food safety, food availability and social justice issues.

After gathering and reviewing information in the public domain and from those in the industry practicing bioponics, this Subcommittee has adopted a definition for bioponics:

> **Bioponics -** A contained and controlled growing system in which plants in growing media derive nutrients from plant-based, animal-based and mineral natural substances which are released by the biological activity of microorganisms.

Bioponic systems use the same organic inputs, processes, and principles as field growers. Only NOP-compliant growing media and inputs are used in such systems. Organic matter (plant and animal material) is added to the system to provide nutrition for the soil microbiology to flourish and thus provide nutrients to the plants. NOP-compliant minerals may be added as needed. A natural soil ecology is cultivated in the system by adding microbes through compost, compost-tea, liquid nutrient products, or specific consortiums of microbes from commercially produced products, as do certified organic field growers. This microbial community must be carefully maintained in order for nutrients to become available to the plants to uptake. If the microbial community is not sufficient in numbers and diversity, the plants will suffer or not be able to grow.

Bioponic systems evolved from conventional hydroponic systems, but can also look more like a traditional container growing system (for example, growing berries in a compost/potting soil mix). The most common form of bioponics is aquaponics, where the waste produced from farmed fish, or other aquatic animals, supplies nutrients for plants grown in container systems, which in turn purifies the water for reuse. An example of a bioponic tomato system is described in a case study appended to this report. The system consists of plants in containers of growing media, fertilizer, added microbiology, and earthworms which cycle nutrients to make them available to the plants. Just like in field growing, periodic solid and liquid additions may be necessary to maintain crop growth and yields. However, with container systems, it is easier to maintain optimal conditions for microbial growth and nutrient cycling as well as being better able to control soil moisture and temperature, especially if used in a greenhouse environment. In addition, any excess drainage can be captured and recycled or reused so as not to contribute to surface or groundwater contamination or soil erosion.

Another type of bioponic system for growing lettuce and greens is described in a second appended case study. This system uses a Nutrient Film Technique (NFT) design, and uses carbon-based plant and animal materials and NOP-compliant minerals as the fertilizer which is mineralized by soil microbiology in the system.

Bioponics systems will be described in the following 4 components:

1) Container and container systems
2) Growing media
3) Biology
4) Nutrition

c) Containers and Container Systems

A **container** is any vessel and associated equipment used to house growing media and the complete root structure of terrestrial plants and to prevent the roots from contacting the soil or surface underneath the vessel (2010 NOSB Recommendations). Containers may range from pots to plastic grow bags, to floor mats, to PVC channels, to large troughs containing nutrient-rich water.

A **container system** includes all components connected to the containers which enable the system to function in order to grow the plants. The container system may include things such as clarifiers, bio-filters, mechanical filters, pumps, plant support structures, irrigation plumbing, drainage collection apparatus, etc.

Just as with field growing systems, a container system may rely on a separate system (on-farm or off-farm) to create nutrient amendments to be added to the growing system. For example, compost tea created on the farm site may be produced in a brewer not hydraulically connected to the growing system, but the tea will be added to the system as needed. Similarly, a commercial company may biologically produce an NOP-compliant liquid fertilizer that will be purchased by the grower and applied to the crop as needed.

d) Growing Media

In a conventional hydroponic system, growing media is sterile, whereas in a Bioponic system, growing media is designed to promote and sustain biology in order for the system to function. A simple definition of growing media is “a substance through which plant roots grow and extract water and nutrients” (Landis et al., 2014). Growing media often is primarily made up of solid particles (aggregate) such as soil or potting mix. However, growing media can also be water based. In water-based media systems, seeds are typically started in a solid medium, and are then transplanted into the bioponic system where the roots are grown out of the solid medium and placed directly into contact with water that contains nutrients, oxygen and microbial ecosystem. In bioponic systems, the media, whether aggregate or water-based, must contain sufficient carbon, minerals, plant/animal-based nutrients, oxygen and a diverse and complete microbial ecology so that biology can thrive and provide plants nutrition to thrive. Therefore, this committee will use the same definition of growing media as given by the 2010 Committee “material which contains sufficient organic matter capable of supporting the plant root system and a natural and diverse soil ecology,” which may include water as a type of growing media. The sources of carbon, nutrition, and microbiology in each of these media will be discussed in the next sections. This section will further describe the different types of growing media.

Seedling ready to be transplanted into water-based bioponic system.

1. Solid (aggregate) growing media

In bioponic systems, seedlings are often started in solid media. A single type of media or a mix of media may be used for seedling production and to be added to containers to grow the plant to harvest.

Examples of solid growing media used in bioponic systems include:

- Soil
- Potting Soil Mix
- Compost
- Vermicompost
- Coconut coir
- Peat moss
- Bark
- Saw dust
- Rice hulls
- Perlite
- Vermiculite

In a conventional hydroponic system, the growing media is inert and sterile. Whereas, in a bioponic systems, biology and carbon sources are added to the media, which promotes the growth of microorganisms and decomposition of solid media with a release of its minerals and nutrients.

For example, potting mixes, bark, sawdust, and coconut coir have a high resistance to decomposition (high C:N ratio), but when they are inoculated with beneficial organisms (bacteria, fungi, protozoa, nematodes, earthworms and microarthropods), degradation is accelerated. Also, naturally occurring microbes on each material are activated when given favorable conditions for reproduction and activity, thus releasing nutrients from the organic materials and starting mineralization. When growing media is inoculated and fed with microbial foods (such as molasses and kelp), a sufficient level of decomposition and a diminished C/N ratio can be reached, creating an environment where enough water and air capacity is maintained for roots to develop.

An example from a study in India using a fungi such as *Pleurotus platypus* inoculation on coconut coir resulted in 58.6% reduction in cellulose, and 78% reduction in lignin after 35 days of inoculation. The C:N ratio was reduced to 18:1 versus the uncomposted coir pith of 104:1. In addition, the study found that earthworms and bacteria enhance coir decomposition (S.R. Prabhu and George V. Thomas Indian Institute Agricultural Research, 2002). Another study showed when coconut coir was inoculated with the earthworm *Eudrilus sp*. at a rate of 1000/ton of organic material, protected from direct sunlight and maintained moisture level over 50%, a granular vermicompost can be obtained with a 16.7:1 C:N ration in two months, (K.V.Peters,2008). Earthworms and microarthropods also help keep air passages intact for optimal root health and to avoid soil compaction which fosters anaerobic conditions.

Therefore, solid growing media in bioponic systems is by design, not inert. Through the additions of carbon and soil-microorganisms, the solid growing media goes through the same decomposition processes as field soil. In fact, this decomposition can occur at a faster rate because the soil moisture and temperatures of the media can be more closely controlled for optimal microbial conditions.

Methods of adding biology are addressed in subsequent sections.

In some cases, soil from the ground may be added, but the growing media is usually not 100% soil. Soil is not often used due to the risk of soil pathogens and non-ideal water holding and transmission properties. If soil is used in container systems, it is commonly disinfected first by solarizing or steaming methods. If the soil is sterilized, it will be necessary to add biology back into the soil. Compost or compost tea is often added or applied to establish an adequate number of organisms to inoculate the media. Also, it is necessary to assure organic matter is present in the soil for biology to establish (minimum 3% organic matter). If compost is added to the media, whether for nutrition or biology, it typically will not make up more than 50% of the media because it holds too much water (Grubinger, 2012). Because only a limited amount of compost can be added to the growing media, and because the nutrients in compost are slow to release, there are usually not enough nutrients to grow a crop for an entire season. Therefore, supplemental amendments of organic fertilizer may need to be added throughout the growing season.

2. Liquid growing media

By definition, water can be a growing media when it "contains sufficient organic matter capable of supporting the plant root system and a natural and diverse soil ecology", which is the case in bioponic liquid media growing systems. In these systems, organic plant and animal material and microorganisms are added to the water to create a liquid compost. In aquaponic systems, fish waste is decomposed by aerobic microorganisms that can be in the biofilter and throughout the growing system. In other liquid bioponic systems, such as NFT or deep water culture systems, compost teas or commercially produced liquid organic fertilizers (as described below under nutrition) are added to the water. Microbiology is present within these products naturally or from the biological processing which it goes through. This microbiology or added microbial inoculants are the catalyst for the decomposition of the organic material within the growing system.

Source water in these systems primarily come from municipalities, well water, or through rain water collecting. Water should be tested to ensure it does not contain heavy metals or pollutants at levels detrimental to plant growth, and to ensure that human pathogens are at or better than drinking water standards.

e) Biology

1. Soil-Food Web in Bioponics

There are 16 elements that are essential for plant growth: Carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, boron, zinc, copper, molybdenum, and chloride (Hoagland, 1947), although nickel has now become thought of as a 17th (K-state). Whether nutrients are derived from inorganic or organic sources, plants need them to be in ionic form. An ion is a positively or negatively charged atom or group of atoms that can be taken up by plant roots.

In soil, plant nutrients are bound up in organic molecules and rock material. Dead and decaying organic material decomposes through physical, chemical, and biological processes. As this material is broken down into smaller and smaller fractions, minerals may be dissolved into soil solution and soil microorganisms can use the organic matter as food sources, releasing plant nutrients into soil solution. These soil organisms make up the soil food web, or the community of organisms living all or part of their lives in the soil (Ingham). Bacteria, fungi, nematodes, protozoa, earthworms, arthropods, and living roots are dependent on each other to live and reproduce. Exudates from plant roots and decaying plant and animal material feed bacteria and fungi. Bacteria and fungi incorporate some of the nutrients into their bodies but release any excess nutrients they cannot incorporate into their own cells. Higher level organisms such as protozoa eat the bacteria and fungi, again releasing excess nutrients into the soil that will dissolve into water. Nematodes and larger organisms such as earthworms eat the protozoa. When any of these organisms die, they release the nutrients that were stored inside their cells. Some of the nutrients that are released will be available immediately to plants because they go into soil/water solution. This process of microbes decomposing and releasing plant nutrients from organic matter is called mineralization. In optimal environmental conditions and with enough food sources, plants and microbes are able to regulate the processes so that they each get what they need at the rates needed (Bot and Benites). The microbes decompose carbon sources to create soil organic matter which enhances soil structure and creates available nutrients for plant growth.

Soil is highly variable in the amount of organic matter and number and diversity of microorganisms it contains, decreasing over time and with multiple plantings. Most soil growers must amend their fields with manure, compost, compost teas, and organic fertilizers to increase carbon content, microbial activity, and nutrient availability.

The same is true of bioponic systems. Bioponic systems start out with growing media that may or may not have a sufficient amount and diversity of carbon and microbial population. Just like with soil, nutrients may be added in solid or liquid form. Solid soil amendments may include compost, manure, bone meal, alfalfa meal, magnesium sulfate, gypsum, potassium sulfate, kelp, bat guano, etc., all of which are NOP-compliant (see list in Table 1). Commercial liquid organic fertilizers which are NOP-compliant or homemade liquid organic fertilizers made from organic-compliant substances such as compost tea, may also be applied at varying frequencies depending on the nutrition added to the media, the same method as in organic soil-field farming. Solid amendments must be decomposed by soil microorganisms in the media for the plants to make use of them. The majority of liquid organic fertilizers are composed of complex proteins and carbohydrates which contain plant nutrients that only become available upon the action of microbiology within the growing system.

2. Where Microbiology Comes from in a Bioponic System

As stated earlier, bioponic nutrition is supplied as complex organic compounds that need to be decomposed and mineralized so that nutrients can become available to the plants. This decomposition may occur in-line with the container system or outside the growing system in an on-farm or off-farm system. In the case of field growing, the organic matter is applied in the soil and decomposition must occur primarily locally at the root zone. In the case of container growing, biological decomposition and mineralization of organic matter can occur in controlled environments to enhance its efficiency. The decomposition of organic matter outside the growing system is by no means complete, as it would be too time-intensive and costly a process. However, some organic material (such as produce and plant material wastes) can be biologically processed or fermented to make them partially digested and easier for soil microbes to process completely within the growing system. For example, compost teas can be made in a separate brewer and then added to the system. These teas add biology and some nutrients, but organic matter in the teas still need to be further broken down within the growing system. This added biology is used to break down other solid nutrients that are added within the system. Commercially produced liquid fertilizers do not decompose organic matter completely to the ionic form of nutrients that the plants can take up. These products need to be further decomposed in the growing system by microbes in the system. The key point is that in a bioponic system, biology is required to break down organic material into plant available nutrients, either completely within the growing system or partially outside the growing system. In either case, biology is the engine that drives a bioponic system, just as in an organic soil/field growing system.

The data shown at the end of the appended case study of bioponic tomatoes illustrates the diversity and numbers of soil microbes that can be found in bioponic systems. The numbers of bacteria, fungi, protozoa, and nematodes are at least as much, if not higher than would be expected in good soil. These numbers and diversity indicate a high ability to cycle nitrogen.

3. Where Microbial Activity Takes Place in a Bioponic System

Water based growing media contains particulate organic matter (POM) and dissolved organic matter (DOM). Bacteria typically aggregate onto solid surfaces such as soil particles, particulate organic matter, or biofilters that are designed to have a high surface area. Biofilms are microorganisms attached to a surface and embedded in an extracellular gel-like matrix of polymeric substances. Dissolved organic matter absorbs and diffuses into the biofilm, the microbes release enzymes to decompose the organic matter, and then microbes can take up the released nutrients. Microbes can still aggregate or “floc” together without the aid of a solid surface. Microorganisms such as Pseudomonas sp. and Bacillus sp. excrete extracellular polymeric substances (EPS) that allow the microbes to aggregate together within the water column (Guibad (2010); Sheng; Subramanian, 2010). These aggregates and EPS material attracts and adheres POM and DOM to it. Therefore, microbes are actively cycling nutrients within the water-based growing media as well as on surface of the containers and in biofilters.

The biological processing of organic nutrition occurs throughout bioponic systems. In aggregate systems, the processes occur throughout the growing media and rhizosphere. In liquid systems, microbes in the nutrient-rich water are constantly decomposing suspended and dissolved organic materials within the water column. The microbes congregate at the root zone in the rhizosphere, in both solid and liquid growing media where they also assist in chelating metals to increase uptake of nutrients into the plant roots. It is very common for bioponic systems to have a component in the system which adds high amounts of surface area to provide biology a place to attach, such as biofilters, growing media, etc.

4. How can you demonstrate that a bioponic system has enough biology?

A commonly asked question is how to demonstrate that a bioponic system has enough microorganisms and/or if they are diverse enough to create a true soil-plant ecology intrinsic to organic farming. The answer is, in fact, very simple; it involves observing the system inputs and the final crop health. If the inputs used are in such a form that require microbial breakdown and the grower is able to achieve a healthy final crop, then it must be true that there is sufficient biology and biological diversity in the system, otherwise the nutrients would not have been fully microbially processed and the crop would show signs of deficiencies. As with any organic farming operation, the farmer is directly punished or rewarded with the quality of his/her crop based on the quality of the microbiological activity and organic content in their growing system.

f) Nutrition

In bioponic systems, nutrition comes in many forms. Nutrition may be added to the growing media itself or to the water in the system. Nutrient sources may be in solid or liquid form as long as they are NOP-compliant. Providing enough organic nitrogen and phosphorus to these growing systems is the greatest challenge. Nitrogen is typically provided by compost, bat guano, sugar beet molasses, and/or soy proteins. Nitrogen is also provided through some commercially available liquid organic fertilizers derived from fermented plant material (see table below). Phosphorus can be provided using rock phosphate, bat guano, and commercial NOP-compliant organic liquid fertilizers. The table below shows a variety of other organic inputs that provide different nutrients for plant growth. Because most of these materials are in rock form or are organic molecules containing the various nutrient elements, the same soil microbiological processes must occur in these growing systems as in soil-based growing systems. Without the action of microorganisms, nutritional ions would not be available for the plant to uptake.

Examples of Organic Inputs and Associated Nutrients

Input	Associated nutrients
Animal Based Compost	N,P,K
Soy protein	N
Fish Emulsion	N,P,K
Kelp	N,P,K
Seaweed	N,P,K, Mg, S, Ca, Na, B, Fe, Mn, Cu, Zn
Molasses	K, P, S, Ca, Mg
Gypsum	Ca, S
Humic acid	Biostimulant
Fulvic acid	Biostimulant
Epsom salt	Mg, S
Bone meal	N,P
Fulvic acid	Chelator
Alfalfa meal	N,P,K
Potassium sulfate	K,S
Potassium Chloride	K, Cl
Fish Water	N,P,K, S
Worm Tea	N, Ca, Fe
Plant based compost	N, P, K
Hydrolyzed animal protein	N
Hydrolyzed plant protein	Biostimulant, chelator
Composted poultry manure	N,P,K
Bird/Bat Guano	N,P,K
Insect frass	N, dependent on host plants
Dairy manure	N,P,K
Blood meal,	N,P,K
Rock phosphate	P
Volcanic rock dust	P, K, Ca, Cu^{2+}, Zn^{2+}, Mn^{2+}, Fe^{3+}, Co^{2+}, Ni^{2+}, V^{4+}
Cotton seed meal	N,P,K
Limestone	Ca, Mg
Calcium carbonate	Ca
Oyster shell lime	Ca
Langbeinite	K, Mg, S
Fish meal	N,P
Neem seed meal	N,P,K
Worm castings	N,P,K
Molasses	Carbon

In bioponic systems, nutrients primarily come from plant and animal material that must be decomposed by biological processes either in the growing system or in a separate decoupled container. The extent to which these materials are decomposed before they are placed into a growing system will dictate how much biology is required by the growing system to make nutrients available to the plants.

Advantages of Bioponic Systems

In general, the advantages to bioponic growing practices are centered on the concept of precision control of inputs, reducing waste, and controlling growing conditions in order to reduce environmental impact and conserve resources such as water and arable land. While there are many additional practical advantages such as improved ergonomic conditions for workers, this section focuses on the overarching advantages of bioponics.

a) Water Conservation

Water conservation is one of the greatest advantages to bioponic growing. A recirculating bioponic system can use up to 80% less water than field grown crops. This is achieved due to the design of a bioponic system where no water is lost to evaporation, runoff or leaching. The grower can virtually use only the exact amount of water needed by each individual plant to grow.

In a state such as California that has suffered from an almost a decade long severe drought, this is of extreme importance. California is the number one producer, by volume, of organic produce in the United States. This is a strong example for the reasoning behind evolving growing practices to adapt to changing environments and resource scarcity.

b) Food Safety

Increased food safety is another major advantage of bioponics. The greatest food safety risk is contamination of crops with human pathogens such as E. coli and Salmonella. These risks are generally high in crops such as leafy greens (lettuces) where the edible portion of the crop is in contact with the ground. Animal feces, including bird droppings, and downstream rain water runoff pose huge food safety risks for any farm. However, a bioponic system greatly mitigates such risks because crops are grown off the ground using a closed loop watering system. This virtually eliminates the runoff and ground animal intrusion risk and, coupled with a greenhouse, also mitigates the overhead risk of bird droppings. Furthermore, pathogen testing is very easy to test for by sampling water circulating in the system at any point will indicate if there is any human pathogen present in the entire operation.

c) Disease Suppression

Bioponic systems are effectively a container growing system where the grower has ultimate control over growing media, nutrient and biological inputs. There is a significant advantage to being able to guarantee that the growing media, nutrient and biology are free of disease prior to starting a crop. This is achieved by testing inputs prior to use.

Furthermore, if the grower maintains a balanced soil-food web ecology in the system, then no single organism can overpopulate and take over. A good example of this is how a properly designed compost tea can help suppress disease when it is applied to soil or bioponic container systems. Because a bioponic system is a containerized biological system, there is the ability to better control specific microbial populations by controlling inputs, system environment and inoculum.

d) Nutrient Conservation & Retention

In a bioponic system, inputs can be precisely measured and added to the system with a high degree of certainty for the quantity of inputs required based on the system size and crop. Furthermore, bioponic systems are completely contained and therefore do not lose any inputs or resources to the environment thereby eliminating the chance of runoff contamination, leaching and soil erosion.

e) Soil Conservation

Growers who implement a bioponic growing practice are not limited to setting up their operation on fertile soil. Because the system is completely containerized, it is able to be placed on any type of ground – for example areas where farming would otherwise not be possible such as rocky areas, paved areas, sand and urban sites such as rooftops. Therefore, by growing in areas that are otherwise not farmable, this is the ultimate level of soil conservation and an added tool for farmers to be able to keep up with increasing population, but limited arable land.

Aquaponics

Over the past three decades, aquaponic systems have continued to increase in number and scale. Pioneer systems were developed in arid regions such as Australia and the Caribbean where fresh water was limited. Typically, the systems supply both plants and protein (fish), however many systems focus on the plant production and may never harvest the fish. Aquaponics depends on a biologically active water-based ecosystem, allowing for consistent nutrient availability without the use of synthetic fertilizers. Besides the input of fish food, very few other inputs are used in aquaponic food production systems. Research at the University of the Virgin Islands (UVI), St. Croix, produced a balanced integrated fish and plant system that has been a model for much of the small commercial aquaponic industry in the U.S. Currently, some aquaponic farms are being organically certified for their crops by various certification agencies. No organic rules for fish exist in the U.S. to date, so only plant crops are being certified as organic.

a) Water-based production

Most aquaponic systems recycle greater than 98% of their water daily. As the water is continuously recycled, a microbial-based ecosystem develops. Research in Alberta, Canada has shown that as aquaponic systems mature over time, a more diverse ecosystem develops and crop production increases (Savidov et al, 2007). The same researchers have shown that aquaponics can out-produce conventional hydroponic growers that are using synthetic fertilizers. The protagonist microbes are also believed to fend off diseases that would otherwise attack a sterile, non-biologically active system. For any aquaponic facility to succeed, a water source with good quality and quantity is required.

b) Types of aquaponic systems

Aquaponic systems may be categorized as balanced or de-coupled. A balanced system is a system where the fish provide the nutrients for the plants and the plants purify the water for the fish. A balance is achieved following recommended daily feed to plant area rates. If a balance is achieved, the water quality stays optimal for the fish and the nutrient quantity stays optimal for the plants. Many current systems are balanced systems.

De-coupled systems are becoming more common. In these systems, there is separation in some manner between the fish and the plants. The use of fish waste that has been mineralized into dissolved nutrients for a separate plant culture system would be an example. De-coupled systems are used in temperate climates where the plant greenhouse is only used seasonally. The greenhouse can be isolated during the winter and shut down, while the fish system is designed to operate with other filtration methods. In these regions de-coupled systems also allow the integrated production of cold-water fish and tropical vegetables.

c) Fish waste and mineralization in aquaponic systems

Fish are cold-blooded animals and do not harbor pathogenic E. coli strains. All published food safety data has shown no risk, and more work is being done in this field (Chalmers 2004). The waste consists of dissolved nutrients and nutrients bound in the solids. Some systems discharge solids, while others digest or mineralize the solids in a side loop, then return the dissolved nutrients back to the system after a certain digest time. A digester, or bio-reactor, is heavily aerated allowing aerobic bacteria to mineralize the fish solid waste. Systems utilizing this technique have become nearly-zero discharge systems.

Nitrification and mineralization occurs whether in soil or water. The water processes typically occur in the soil matrix, but outside the soil matrix it is not well researched or published. In a sense, water-based mineralization is aquatic composting. Nitrification in the water is well researched and published as it is the biological process that allows for Recirculating Aquaculture Systems (RAS) to convert toxic ammonia to less toxic nitrites to even less toxic nitrates. Typically, RAS fish farmers utilize a biofilter which supports nitrifying bacteria (Nitrobacter, Nitrosommonas, Nitrospiria esp) using a media that is designed for high surface area for the billions of bacteria that thrive in the ammonia and oxygen rich environment.

Aquaponic systems provide surface area for nitrifying bacteria on the side walls of the containers used (tanks, troughs, etc.), in the root zone, in the filtration system and also on fine particles suspended in the water column. Some aquaponic systems incorporate a denitrification zone where solids are allowed to accumulate for a short period of time between cleanings. As water passes through this zone of no oxygen, denitrification occurs, stripping N from the system. This would be preferential when a grower wants to produce fruiting crops. The process of denitrification will produce alkalinity as a byproduct, raising pH or buffering acid produced via the nitrification process.

The mineralization process is being researched in areas of de-coupled aquaponics, or dual-loop aquaponics. When fish are fed, approximately 70% of N is excreted by the fish (most in the soluble form) and 70% of P (most bound in the solid waste). Growers are removing the non-available solids from the system and using a separate bioreactor to mineralize the solids creating dissolved nutrients over time. We refer to this as bioponics. Now the nutrients are dissolved and able to cross cell walls into the plant. Other researchers have identified a very diverse microbial community in bioponic systems including plant growth promoters, and other beneficial enzymes the serve as facilitators for nutrient uptake as well as a probiotic to pathogen attack.

Referenced is a paper about this mineralization process as it pertains to the breakdown of fish effluents in water (Rakocy, et al 2007). Many other producers are using this idea now on much larger systems to extend use of the original fish food input.

d) Aquaponic System Factors

Aquaponic systems can be sited at any location, allowing arable land to be saved for soil crop production. Current certified organic aquaponic producers did not have to adhere to a transition period like is required by a soil producer. Breaking in an aquaponics system is referred to as a transition period, or an acclimation period. This allows the microbial population to develop and flourish.

Most certified aquaponic growers use conventional fish feeds. The feeds have been formulated to provide complete nutrition for the species being reared. To take pressure off wild fish stocks, alternatives to fish meal are being researched including insect and plant based proteins. One USDA Organic fish feed exists currently, but is not required as the fish are not certifiable. Like most livestock feed in the US, most conventional fish feed contains GMO corn and soybean.

e) Aquaponic System Designs

Any hydroponic plant production method can be integrated into a fish-based system to remediate the nutrients released by the fish.

Deep Water Culture (DWC) is the most commonly used method in the commercial setting. Nutrient Film Technique (NFT) is also used. Smaller systems, or systems that use a low fish stocking/feeding rate, often use the flood and drain (ebb/flow) method. Aeroponics is not commonly used since the microbial solution can lead to clogs in the misters. Vertical towers are sometimes used. Often, a hybrid system is designed using more than one of these techniques.

f) Fish

Many options exist for fish in an aquaponic system. Temperature requirements and tolerance to recirculating aquaculture conditions often dictate which fish to choose. Growers select fish and plants that have similar temperature requirements (i.e. Warm-water fish with warm-weather crops). Regulatory issues also dictate when fish may or may not be used legally. The most common fish being used across the US are Tilapia, Catfish, Bass, Sunfish, Koi, Sturgeon, Perch, Trout and Ornamentals. Fish health is maintained through Best Husbandry Practices, quality diet, selective breeding for disease resistance and maintaining optimum water quality.

g) Crop Production

Virtually every type of plant can be grown in some variation of an aquaponics system. Pest control is accomplished through IPM, biological controls, and as a last resort, an organic compliant spray. Some organic compliant pesticides are toxic to aquatic life and are not recommended for use in aquaponic systems. Some commonly used organic pesticides toxic to fish are: copper sulfate, Rotenone, and sulfur.

h) Nutrients

Research from UVI, using rainwater and conventional fish feed, showed three elements lacking for optimal growth of lettuce. The nutrients Ca, K, and Fe may be required as a supplement in an aquaponic system, depending on source water quality. Many systems supplement only Fe. The form of Fe has been a bottleneck in organic certification for some. pH is often near neutral in an aquaponics system. At that pH, Fe particularly is not available. Aquaponic growers may supplement with a chelated iron, allowing the Fe to remain in solution. One product that is used is chelated with citric acid (Biomin Iron, OMRI) and is allowable, but does not promote a healthy system. The addition clouds the system water for 24 hours and lowers the pH. Operating systems at a lower pH can lead to more Fe availability, however the health of the fish should be considered when deciding on a system pH level. Iron chelated with DTPA is by far the most common form used by non-certified organic aquaponic growers. Producers may identify other deficiencies (perhaps Mg). Some producers will supplement micronutrient products. These could be organic compliant or not depending on the producer's goals.

i) Growing media

Many planting media options exist for aquaponic growers. Growers are looking for a certified organic plug that uses an organic polymer to hold it together, preventing wash out in the water based systems. Coconut media is preferred over peat for most growers. Many also use a coconut/vermiculite mix to start seedlings. Ebb and Flow systems often use clay pellets, expanded shale, or lava rock. Worm castings and compost are sometimes incorporated into the planting media.

Considerations and Analysis

a) Bioponics and Organic Certification

Bioponics and other types of container production which rely on biological activity are in a unique category of crop production systems that allow for increased conservation of land and water resources, a growing area of concern and attention given diminishing resources, rising populations and arable land.

These production systems can conserve land resources as they don't involve tillage, require less acreage to produce crops and minimize erosion when the systems are recirculating (closed loop). These types of systems can also exist in places where traditional soil-based production cannot, like rooftops, land unsuitable for field crops due to soil toxicity or type and areas with seasonably unsuitable climates.

Recirculating systems allow for increased water conservation, as water is added to the system only to replenish what's evaporated and the nutrients and water in the system are constantly recirculated and reused by the plants rather than in single applications as in in-ground production.

With regard to bioponics and container production and current USDA regulations, this Subcommittee believes that most areas of the standards can be followed as currently written, including implementing and maintaining an Organic System Plan, maintaining and providing records at inspection and using all organic-compliant inputs. This question of alignment is limited to production practices surrounding crops grown in the ground versus those grown in containers and whether those systems align with regard to the ecological focus of organic production, OFPA and the USDA organic regulations.

Citations below (Table 2) address those areas where this Subcommittee believes that bioponic systems align with the USDA organic regulations, particularly in terms of environmental/ecological aspects of the regulation, such as cycling of nutrients, promoting ecological balance and conserving biodiversity. Within these citations, we also address areas where we see that bioponics doesn't align with the current regulations, because the described practices are soil-specific or as otherwise noted.

b) Areas of alignment

NOP 205.2 Terms defined.

Natural resources of the operation. The physical, hydrological, and biological features of a production operation, including soil, water, wetlands, woodlands and wildlife.

When considering the natural resources of a bioponic farm, bioponics aligns with this requirement as soil is conserved due to lack of tillage and cultivation of plants.

Nutrients are not removed from the soil when a bioponic farm is active above it. The bioponic system can be removed from the area and the land, if arable to begin with, can be returned to traditional agricultural production. For bioponic systems on non-arable land, as is often the case in urban farming, this is not applicable.

Water is actively conserved in bioponic farming, particularly in recirculating systems which add water in measured amounts to make up only for that which is lost to evaporation and plant uptake. Bioponic systems are designed to maintain their microbial solution indefinitely, rather than be emptied and restarted, as in conventional hydroponics.

Further accounting for conservation could include a requirement for the use of only recirculating systems or ecologically sound methods for managing water runoff from non-recirculating systems. One example of water run-off management could be irrigating in-ground crops, other container crops, landscaping, hedgerows or orchards with discharged microbial solution.

Organic Matter: The remains, residues, or waste products of any organism.

The organic matter in a bioponic system include compost inputs (teas, solid matrix), some types of growing media, some nutrient inputs and the active biology present in the system. While there isn't a constant variable for amount, concentration or combination of compost (whether tea or solid matrix), growing media, nutrient inputs or active biology from system to system, all bioponic systems incorporate some of these elements. For example, growing media components such as coco fiber, nutrient inputs like molasses, and the remains, residue and waste of biological organisms are considered organic matter.

Organic Production. A production system that is managed in accordance with the Act and regulations in this part to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.

The site-specific conditions of a bioponic farm can vary drastically from a warehouse to a greenhouse on a traditional farm to a kitchen in a restaurant, but all can comply with the regulation.

Bioponics interprets the cycling of resources as the system's reliance on biological activity to function and, in some cases, the incorporation of plant material back into the production process. Nutrient cycling occurs as the microorganisms, bacteria, protozoa and fungi interact and proliferate in the microbial solution, mineralize nutrients for plant uptake and release nutrients held in their physical bodies into the solution as remains, residue and waste. In some cases, excess plant material from bioponic systems can be incorporated into compost and/or compost tea to be reintroduced to the system, though this is site-specific and differs from farm to farm. Additionally, microarthropods like earthworms are sometimes employed within substrate bioponic systems, which represents another integration of biological and mechanical practices, fostering of cycling of resources and promotion of ecological balance.

Bioponics relies on the careful balance of the biological ecosystem to produce healthy crops. The intention of a bioponic system is to establish active biology and maintain this ecosystem indefinitely for the benefit of the crop, diversity of ecology and conservation of resources and inputs. While specific levels may vary from farm to farm, bioponic systems require attention to oxygen levels, temperatures and food sources in order to keep the biological ecosystem in balance.

§205.200 General.

"...Production practices implemented in accordance with this subpart must maintain or improve the natural resources of the operation including soil or water quality."

While formal scientific analysis has not been conducted on the effects of bioponic production on soil or water quality, based on field experience, soil quality is maintained at levels that existed prior to the bioponic operation as bioponic production doesn't remove soil nutrients or till the soil for crop production. Experiential evidence demonstrates how crops planted in ground previously covered with weed cloth for bioponic production were equally productive compared to in-ground crops and did not exhibit increased disease pressure or nutrient deficiency once being uncovered and amended with standard pre-planting amounts of compost and then tilled.

Similarly, it is expected that water quality would also be maintained at existing levels, particularly in cases of recirculating bioponic systems where the microbial solution is contained within the system indefinitely or rarely or minimally discharged. In the cases of drain-to-waste bioponics, analysis would have to be conducted to determine what effects the discharged microbial solution may have on overall water quality in comparison to the effects of soil-based fertilization of in-ground agriculture.

As bioponic production can take place in locations without arable soil, a determination should be made to identify relevant resources to be evaluated for their maintenance or improvement resulting from production practices. Water quality would continue to be a relevant resource to evaluate.

§205.203 Soil fertility and crop nutrient management practice standard.

(a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.

Similar to §205.200, this subsection also can mean that the lack of tilling and extraction of nutrients from the soil and minimal microbial solution discharged from bioponic systems to demonstrate alignment with cultivation practices that maintain the physical, chemical and biological condition of soil and minimize soil erosion. Based on the same experiential evidence mentioned in response to §205.200 and the lack of formal scientific analysis to the contrary, likely the physical, chemical and biological condition of the soil would be unaffected by covering the soil to facilitate a bioponic system and that minimal soil erosion would occur.

(b) The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials.

This can be applied to bioponic production, specifically to mean that management of crop nutrients and growing media fertility are maintained or improved without contributing to contamination of crops or growing media in the containers as well as the surrounding ground soil and groundwater.

Crop nutrients and growing media fertility are maintained or improved through the maintenance and monitoring of the biological ecosystem's environment to ensure optimal ranges are met to allow the proliferation of active biology throughout the crop and system. The active biology, or organic matter as it is interpreted by this subcommittee, would be maintained or improved as the system is established and brought into balance.

As bioponic systems have not been shown to affect the soil fertility or crop nutrient management of surrounding in-ground agricultural production, it is expected that the requirement of rotations, cover crops and application of plant and animal materials to surrounding soil to manage or improve such soil organic matter would be satisfied by alternative practices applicable to the operation as detailed in the 2010 Formal Recommendation by the National Organic Standards Board (NOSB) to the National Organic Program (NOP), "Production Standards for Terrestrial Plants in Containers and Enclosures", part 205.205(a,b,c,d) as it is in the cases of organic transplant container production and other container systems.

(c) The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances.

The management of bioponic systems to avoid contributing to the contamination of crops, soil or water by plant nutrients, pathogenic organisms, heavy metals or residues of prohibited substances is achieved by maintaining a healthy biological ecosystem within the system and further by minimizing discharge into ground soil or groundwater, discharging in a compliant manner when it is necessary to discharge microbial solution, maintaining a regular water testing schedule to ensure no human pathogens are present in the microbial solution and the use of only organic-compliant inputs in organic-compliant ways. Some of these safeguards are enforced further in those operations that are also GAP (Good Agricultural Practices) certified.

§205.205 Crop rotation practice standard.

The producer must implement a crop rotation including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions that are applicable to the operation:

> **(a) Maintain or improve soil organic matter content;**
> **(b) Provide for pest management in annual and perennial crops;**
> **(c) Manage deficient or excess plant nutrients; and**
> **(d) Provide erosion control.**

In a bioponic system, rotation is accomplished with the renewal of growing media at the time when it is appropriate for the specific crop. Typically, this occurs at the end of the crop cycle and the growing media is not reused to prevent the buildup of pests and because, in some types of container production, the accumulation of roots in the growing media prevents its reasonable reuse. In some cases, the roots and remaining growing media are composted in accordance with the regulation and can be reincorporated into the production cycle to generate some fertility, but is not currently a common practice.

As bioponic systems do not impact the soil organic matter below the system as would an in-ground crop, it is expected that the requirement of rotations and cover crops to maintain or improve such surrounding soil organic matter would be inapplicable to bioponic production.

Table 2

NOP Section	**Aligns**	**Does not align**
NOP 205.2 Definitions		
Natural resources of the operation: The physical, hydrological, and biological features of a production operation, including soil, water, wetlands, woodlands and wildlife.	The definition speaks to the "features of the production operation" meaning the applicable features. Woodlands and wildlife may not be applicable for enclosed systems, as it is not always applicable to in-ground field production. Bioponic and container operations conserve the soil beneath their production by not tilling or extracting nutrients and minimally discharging water solution. Water is conserved in recirculating systems which enable greatly reduced overall water use. *Recommendations could include requirement that operations use recirculating systems or account for any water run-off in drain-to-waste systems.*	
Organic Production: A production system that is managed in accordance with this Act and regulations in this part to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster **cycling of resources, promote ecological balance, and conserve biodiversity**	**Cycling of Nutrients**: Wikipedia defines Nutrient cycle as "the movement and exchange of organic and inorganic matter back into the production of living matter. The process is regulated by food web pathways that decompose matter into mineral nutrients."	

	Within biologically active container systems like Bioponics, microorganisms decompose matter into mineral nutrients enabling them to be used by the plants. Container systems which contain a greater diversity of growing media volume and components may include significantly more decomposition within the growing season. Container based systems for annual crop production would likely not include decomposition of plant material back into the system	
	Promote ecological balance: Ecological balance as defined by the WWF "a state of dynamic equilibrium within a community of organisms in which genetic species and ecosystem diversity remain relatively stable, subject to gradual changes through natural succession" or "A stable balance in the numbers of each species in an ecosystem." Bioponics relies on the stability of the biological ecosystem for the health of their system and crops.	It may not contribute to long term ecological stability, but rather stability within their production cycle.
	Conserving biodiversity is described by the WWF as "... ensuring that natural landscapes, with their array of ecosystems, are maintained and that species, populations, genes, and the complex interactions between them, persist into	

	the future." This includes diversity at all trophic levels, birds, beetles, butterflies, soil microbes, earthworms, mammals and vegetation. Wild Farm Alliance adds that "It encompasses diversity found at all levels of organization, from genetic differences between individuals and populations to the types of natural communities found in a particular area." While not all trophic levels will be found in every agricultural system, particularly controlled environments, bioponic systems contain diverse ecology within their growing media and/or nutrient solution	
Organic Matter: The remains, residues, or waste products of any organism	Bioponic systems which use solid matrix, liquid compost products or microbial products align with the definition of organic matter.	The question of how much OM is present to distinguish bioponic systems should be clarified.
Production practices implemented in accordance with this subpart must maintain or improve the natural resources of the operation including soil or water quality. (§205.200)	Container and bioponic systems align with this requirement. Particularly those with recirculating systems. Because soil on the site is not tilled, it could be considered to be maintained, although not improved.	

The producer must manage plant and animal materials to maintain soil organic matter content in a manner that does not contribute to contamination of crops, soil or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. (§205.201c)	If soil (as defined by the task force) is used as part of the growing media, bioponic and container systems would appear to maintain soil OM levels for perennial systems if additional media is added over time. For short season crops, additions of microbial rich nutrients would be maintaining the OM in the container.	For systems that do not use soil in their growing media: recirculating systems would have to manage the discharging of microbial solution in a compliant manner when the system is purged and cleaned. For container systems where the water drains through the container to surface soil, we would have to consider if the concentration of nutrients is significantly different than that used in an in-ground system sufficient to warrant additional oversight measures.
Crop pest, weed, and disease management (§205.206) **(a) The producer must use management practices to prevent crop pests, weeds, and diseases including but not limited to:**		
(1) Crop rotation and soil and crop nutrient management practices, as provided for in §§205.203 and 205.205;	Rotation is accomplished with the renewal of the growing media when appropriate. Cover crops are not appropriate when the rotation includes the removal of soil and growing media. Applying plant and animal materials is required to generate fertility. As in in-ground soil systems, the mineralization of the animal/plant/mineral materials requires a healthy balanced microflora/macroflora.	This could be considered a soil-specific production requirement and an exemption for crop rotation could be granted for all types of container production.
(2) Sanitation measures to remove disease vectors, weed seeds, and habitat for pest organisms.	Managing the nutrient solution's healthy biological activity (climate, active bacteria levels, oxygen	

	levels...) manages water pathogens and boosts plant immune system to resist disease. Greenhouse ground is commonly tarped or covered to inhibit weeds and majority of pests are excluded by protected structure.	
(3) Cultural practices that enhance crop health, including selection of plant species and varieties with regard to suitability to site-specific conditions and resistance to prevalent pests, weeds, and diseases.	Selection of varieties suitable to container and site and system-specific conditions for production satisfy this requirement.	
(b) Pest problems may be controlled through mechanical or physical methods including but not limited to:		
(1) Augmentation or introduction of predators or parasites of the pest species;	Use of biologicals is common practice in organic greenhouse container production. Biological pest management in water systems is also used in container systems, as it is in in-ground systems.	
(2) Development of habitat for natural enemies of pests;	Containerized banker and insectary crops can be used for pest management and habitat for biologicals. Similarly, microbial solution conditions that favor biologicals are used.	
(3) Nonsynthetic controls such as lures, traps, and repellents.	Use of nonsynthetic lures, traps and repellents is common in organic greenhouse container production.	
(c) Weed problems may be controlled through:		

(1) Mulching with fully biodegradable materials;	Floors could be tarped with biodegradable materials.	
(2) Mowing;	N/A	
(3) Livestock grazing;	N/A	
(4) Hand weeding and mechanical cultivation;	Greenhouse edges are commonly managed with hand weeding	
(5) Flame, heat, or electrical means; or	Greenhouse weeds are sometimes managed with handheld torches	
(6) Plastic or other synthetic mulches: Provided, that, they are removed from the field at the end of the growing or harvest season.	Greenhouse floors are commonly covered with plastic or other weed-blocking covering during time of cultivation.	
(d) Disease problems may be controlled through:		
(1) Management practices which suppress the spread of disease organisms.	Managing the nutrient solution's healthy biological activity with climate, active bacteria levels and oxygen levels satisfies this requirement.	
(2) Application of nonsynthetic biological, botanical, or mineral inputs.	In bioponics, with the exception of aquaponics, horticultural oils and other non-synthetic and biological inputs can be used without harming biological activity in nutrient solution. In the case of aquaponics, inputs must also be determined to be safe for the fish in the system before use. To be avoided are any inputs or treatments that indiscriminately kill bacteria unless nutrient solution is inoculated after application to	

	maintain healthy bacteria levels.	
(e) When the practices provided for in paragraphs (a) through (d) of this section are insufficient to prevent or control crop pests, weeds, and diseases, a biological or botanical substance or a substance included on the National List of synthetic substances allowed for use in organic crop production may be applied to prevent, suppress, or control pests, weeds, or diseases: Provided, That, the conditions for using the substance are documented in the organic system plan.	In bioponics, with the exception of aquaponics, horticultural oils and other non-synthetic and biological inputs can be used without harming biological activity in nutrient solution. In the case of aquaponics, inputs must also be determined to be safe for the fish in the system before use. To be avoided are any inputs or treatments that indiscriminately kill bacteria unless nutrient solution is inoculated after application to maintain healthy bacteria levels.	
(f) The producer must not use lumber treated with arsenate or other prohibited materials for new installations or replacement purposes in contact with soil or livestock.	Adequate alternative materials exist to satisfy this requirement.	

Proposed Changes to USDA Standards

Relevant Sections of the USDA Organic Standards

§205.2 Terms defined.

Aquaponics – A type of bioponic system in which the waste produced from farmed fish, or other aquatic animals, supplies nutrients for plants grown in container systems, which in turn purifies the water for reuse

Bioponic production – contained and controlled growing system in which plants in growing media derive nutrients from natural animal, plant and mineral substances that are released by the biological activity of microorganisms

Container – Any vessel and associated equipment used to house growing media and/or the complete root structure of plants and to prevent the roots from contacting the soil or surface beneath the vessel, such as but not limited to, pots, troughs, plastic bags and liners, etc.

Growing media - Material which provides sufficient support for the plant root system and a diverse ecosystem of soil-borne microorganisms

Hydroponics - The growing of plants in mineral nutrient solutions with or without an inert growing media to provide mechanical support

Soil - The outermost layer of the earth comprised of minerals, water, air, organic matter, fungi and bacteria in which plants may grow roots

§205.208 Bioponic Production Standard

Any container system from which harvested crops are intended to be sold, labeled, or represented as "organic", must meet all applicable requirements except: §205.202(b), §205.203(a and b), §205.205. In lieu of §205.202, §205.203, §205.205, container systems must meet the following requirements:

(a) *Growing media.*
1. Growing media may include soil that has been managed in accordance with §205.202 through §205.206 and other substances in accordance with 205.105, 205.601 and 205.602.
2. Growing media must be composted, recycled, or reused.
3. The containment system must prevent plant roots from contacting underlying soil.

(b) *Growing media fertility and crop nutrient management.*
1. The producer must manage crop nutrients within the system through the addition and/or maintenance of soil-dwelling micro- and macro-organisms and the application of plant, animal, and mineral materials in accordance with 205.105, 205.203(c, d and e), 205.601 and 205.602

2. Excess drainage of plant nutrient water must be captured and reused within the containment system or used on a crop outside the system.

(c) *Crop rotation functions.* The producer must implement a system to provide the following functions to the container system:
1. Maintain or improve organic matter content;
2. Provide for pest management in annual and perennial crops;
3. Manage deficient or excess plant nutrients.

Organic Systems Plan Considerations for Bioponics

For a bioponics system to be certified organic, a certifier needs to be able to:

> "Evaluate an OSP and look for straightforward evidences that a bioponics producer is managing crop nutrients within the system through the addition and/or maintenance of soil-dwelling micro- and macro-organisms and the application of plant, animal, and mineral materials not listed as prohibited in §205.105."

The following are some suggested ways that an OSP can demonstrate the above by providing evidence of organic material microbial cycling:

1. Frequency and types of plant, animal, mineral material additions
2. Frequency and types of microbial and macro-organism additions (ex. Compost, commercial inoculants, worms) and reasons for use (ex. nutrient cycling, biocontrol)
3. Provide the insoluble and soluble nutrient breakdown of the plant and animal materials added to the system.
4. Provide lab analysis of the nutrient concentrations in growing media or microbial solution in the middle and end of a growing cycle, particularly looking at nitrogen conversion from ammonia to nitrite to nitrate. Nitrifying bacteria are necessary to convert nitrogen to nitrate.
5. Provide lab analysis of the plant tissue nutrient levels.
6. Records of dissolved oxygen over time and the need to add oxygen to the system (microbes use up oxygen as they decompose organic matter).
7. Records of biological oxygen demand (BOD). BOD would be high when organic matter is not yet degraded, lower after degradation.
8. Records of Oxidation Reduction Potential (ORP). ORP will be lower when organic materials are not yet mineralized, higher after mineralization.
9. Records of pH over time (biologically active media usually has natural pH fluctuations and mature aquaponic systems will have a decrease in pH over time due to nitrification).
10. Laboratory analysis of growing media using Formazan Test (measures respiration by microorganisms as they decompose organic matter. The higher the Formazan rating, the more biological activity in the soil).
11. Laboratory analysis of actual microbiology in growing media or microbial solution, throughout the system (ex. numbers of active bacteria, fungi, protozoa, nematodes)

12. Laboratory analysis of C:N ratio of the growing media overtime (C:N decreases as microbes decompose carbon).
13. Microscope records of microbes in growing media or microbial solution.
14. If compost tea is used, microscopic analysis records of microbial activity.
15. If aquaponics, plant to fish ratio, feed inputs over time.

Clarifications of 2010 NOSB Recommendations

Purpose and Context for this Analysis

Over the past 20 years, the NOSB has addressed and provided recommendations and formal comments to the NOP regarding greenhouse, container and hydroponic growing methods including:

1. 1995 – NOSB states that hydroponic systems can be certified if they can comply with OFPA
2. October 2001 – NOSB Final Recommendation Greenhouse Production Systems
3. April 2008 – Crops Committee Discussions on Guidance Statements Relative to Soil-less Growing Systems
4. May 2009 – NOSB Crops Committee Soil-less Growing Systems Discussion
5. September 2009 – Crops Committee Recommendation Greenhouse Production Systems
6. April 2010 – Production Standards for Terrestrial Plants in Containers and Enclosures

Over this time, container, greenhouse and hydroponic growing practices have significantly increased and intensified as commercial growing methods. In a survey conducted by the NOP in 2010 and another in 2016, the results are the following:

	2010	2016	% Change
Certifiers certifying hydroponic/aquaponic	8	17	112% increase
Certified hydroponic/aquaponic operations	39	52	33% increase
Certified Container-based operations	n/a	69	

* NOP 2010 & 2016 survey to certifiers

The increasing industry movement towards controlled growing systems has further created the need for USDA guidance on this matter. The challenges for developing standards that address container, greenhouse and hydroponic growing practices primarily stem from the limited amount of public information that has been available to the NOSB/NOP regarding these subjects, especially as it relates to hydroponics.

This report section has a primary objective of providing additional information and clarification regarding these specific methods and emerging technologies that was not previously available to the NOP/NOSB.

NOSB 2010 Recommendation Summary

Introduction
Recommendation addresses rulemaking for container based media, hydroponics, aeroponics and protection against commingling.

Background
States that the NOSB provided a clarifying document on its soil-less growing position in May 2009, attached as an appendix to the 2010 Recommendation; and, that although the 2010 recommendation focuses on greenhouse production, it is based on the same criteria and principles outlined in the 2009 document.

Task Force Analysis

Introduction
No comments.

Background
The Appendix referred to as the May 2009 NOSB discussion has two (2) primary messages:

1. Hydroponic systems should not be certifiable "… due to their exclusion of the soil-plant ecology intrinsic to organic farming systems…" (NOSB May 2009)
2. Properly designed compost based growing media "…producing the beneficial symbiotic ecological relationships found in soil, such growing media should be rightfully considered soil." (NOSB May 2009)

Regarding point number 1 above – that hydroponic systems exclude soil-plant ecology. This is true for the first generation of hydroponic systems that first emerged, where inert, synthetic nutrients are used as the plant nutrition source. However, there are a variety of different hydroponic growing systems that do not use any synthetic nutrients at all, but rather use plant, animal and mineral inputs only that rely on soil-plant microbial action (such as nitrifying bacteria, protozoa and fungi found in soil) to convert such inputs into plant usable form. This is described in more detail in other areas of this report.

Regarding point number 2 above – the NOSB establishes the concept of equivalency between compost and soil because compost is capable of achieving the same functions as soil. By the same logic, a properly designed bioponic system is capable of achieving the same functions as compost would beneficial biology, then a bioponic system should rightfully be eligible for organic certification.

NOSB 2010 Recommendation Summary

Discussion
"Organic farming" refers to the practice of maintaining or improving carbon containing organic matter in soil through various methods – the organic matter itself is not what is necessarily important but rather the diverse microbial populations that it proliferates. The organic farmer "is not just a tiller of the soil, but a steward of the soil ecology" (NOSB 2010). Thus, hydroponic systems that eliminate such soil ecology, cannot be acceptable organic practices.

Task Force Analysis

Discussion
The discussion by the NOSB in the 2010 recommendation defines the following key principles:

1. It is not the physical soil that is necessarily important, but the biological ecosystems that it fosters.
2. "The organic farmer is not a tiller of soil, but a steward of soil ecology" (NOSB 2010).
3. Growing systems that eliminate soil ecology should not be certifiable.

The NOSB 2010 discussion provides emphasis that the core principal of organic farming is the concept of fostering soil biology to create symbiotic relationships with the plant. Physical soil itself is not necessary so long as the soil ecosystem can be fostered and achieved – this is clarified further by the statement that a properly designed compost based growing media (which is not soil) where typical soil dwelling organisms can thrive, should rightfully be considered soil – demonstrating the NOSB's 2010 position that if proper soil functions can be achieved, the physical soil itself is not necessary, such as the case with compost-based container systems.

Based on these principles of achieving equivalent soil functions, as does a properly designed compost container growing system, there also exist specific types of organic hydroponic growing systems that also achieve such equivalent soil functions by integrating plant, animal and mineral inputs with organic growing media and high levels of soil microbiology. It is important to differentiate that hydroponic systems can be fundamentally different from one to the next with respect to inputs and biology, as can any open field farm. For the purpose of this analysis, it is important to understand that the hydroponic systems that should be considered for organic alignment are only those that specifically achieve, promote and maintain a soil-microbial ecosystem that soil or a compost-equivalent would achieve.

NOSB 2010 Recommendation Summary

Relevant Areas in the Rule
OFPA §6513(b) requires an organic plan designed to foster soil fertility. The resulting NOP regulations are:

- §205.203(a) – producer must implement tillage and cultivation practices that maintain or improve the physical, chemical and biological condition of the soil;
- §205.203(b) – producer must manage crop nutrients and soil fertility through rotations, cover crops and the application of plant and animal materials;
- §205.203(c) – producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination

Reiteration that compost is a soil-equivalent and should be rightfully considered soil because it achieves the same functions of fostering soil ecology.

Task Force Analysis

Relevant Areas in the Rule
NOSB's 2010 recommendation that compost be considered soil is acceptable because OFPA §6513(b) requires an organic plan to foster soil <u>fertility</u> – but not necessarily contain soil, thus consistent with the concept that properly designed compost that achieves all soil functions should be considered soil.

NOP §205.203(a-c) describes required practices to help foster soil fertility which is directly applicable for open field operations. The NOSB has addressed the need for NOP to modify the rule to create additional guidance and exceptions where necessary for greenhouse and container growing systems in 2001, 2003, 2008, 2009 and 2010, specifically with respect to §205.203 – tilling, crop rotations and cover crops. The specific modifications recommended by the NOSB is described in the next section.

Hydroponic growing systems are a type of container growing system that would require the same rules applicable to greenhouse container systems.

NOSB 2010 Recommendation Summary

Terms Defined:

Greenhouse – permanent enclosed structure… used to grow crops… in organic production

Hydroponics – the production of normally terrestrial, vascular plants in nutrient rich solutions or in an inert, porous, solid matrix bathed in nutrient rich solutions

Aeroponics – a variation of hydroponics in which plant roots are suspended in air and misted with nutrient solution

Containers – any vessel and associated equipment used to house growing media and the complete root structure of terrestrial plants and to prevent the roots from contacting the soil or surface beneath the vessel, such as, but not limited to, pots, troughs, plastic bags, floor mats., etc.

Task Force Analysis

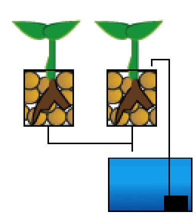
Terms Defined:

Greenhouse – no comment

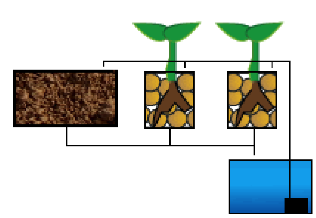
Hydroponics – this NOSB's 2010 definition captures the description for a conventional/non-organic hydroponic system. As explained in other areas of this report, there are organic hydroponic systems that are fundamentally different than the non-organic system described to the left. A more appropriate definition for an organic hydroponic system could be: <u>A container production system that derives the majority of nutrients from animal and plant based organic matter and relies on soil food web microbiology to make nutrients available to plants.</u>

Aeroponics – this is a mechanical variation of a hydroponic container system where water, nutrition and biology is sprayed onto plant roots, as opposed to being in direct contact.

Containers – this definition is consistent with classifying hydroponic systems as a type of container system.



Recirculating System



Recirculating System with additional growing media in separate container

NOSB 2010 Recommendation Summary

Growing Media – Material which contains sufficient organic matter capable of supporting the plant root system and a natural and diverse soil ecology

Task Force Analysis

Growing Media – In a container system, materials are mixed together to achieve the equivalent properties of soil including materials that provide support, nutrition and biology. The base substrate can be/include coco-fiber, peat, perlite, water, compost, etc. Some systems use water exclusively as the growing media – with properly designed aeration, inputs and biology, water can be a very good host for soil microorganisms.

Similar to the concept of a properly designed compost achieving soil equivalency, a properly designed growing media can also achieve the same properties.

It is impossible to determine a universal volume of growing media that is necessary to support plant root systems. Rather, the inputs/contents of the growing media should be measured to determine adequacy rather than volume. A well-designed growing media versus a poorly designed growing media will vary tremendously in volume to achieve equivalent results; therefore, the makeup is more important than the volume.

In a recirculating container system where water and nutrition are shared by all plants in the system, the entire system must be considered as a single “container” as opposed to individual plant sites because all resources are shared and biology flows and distributes freely among the plant sites. In many systems, there are often large containers with organic material and significant amounts of biology where water continuously recirculates along with all plant sites adding additional biological holding capacity beyond the individual plant sites. Thus, the entire system must be considered as a single container. See illustration:

NOSB 2010 Recommendation Summary

Recommendation - § 205.209

NOSB 2010 recommendation for additional rule(s) and exception(s):

§205.209(a)(1) – greenhouse container systems with growing media that does not contain soil is exempt from 205.202 (b) and (a)

§205.209.a.2 – container systems are exempt from crop rotation and cover cropping requirements in 205.203(b) and 205.205.

In lieu of crop rotation and cover cropping, soil regeneration and recycling practices shall be implemented to "demonstrate that the required functions/goals of crop rotation and cover cropping in 205.205(a,b,c,d) have been achieved through these alternate practices, as applicable to the operation" (NOSB 2010)

Task Force Analysis

Recommendation - § 205.209

In NOSB's 205.209(a)(1) recommendation, it is explicitly recommended that container systems that do not contain soil are [should be] exempt from cover cropping and tillage requirements. This is specifically important to note that the 2010 NOSB recommendation, and virtually all other 2001, 2003, 2005, 2009 recommendations, align with the principal that soil is not required if the functions can be achieved by other methods/organic materials.

This same reasoning is used throughout the rest of the recommendations provided by the 2010 NOSB where the concept of achieving equivalency or "functions/goals" of required practices are acceptable alternate practices.

This is specifically important because as stated in NOP §205.2: "Organic production [is] a production system that… respond[s] to site-specific conditions by integrating cultural, biological, and mechanical practices that foster the cycling of resources, promote ecological balance and conserve bio diversity." The key is that farming is, by nature, site-specific and the grower must be able to uniquely adapt to his/her environmental constraints/resources.

NOSB 2010 Recommendation

§205.209(b) – growing media ingredients shall be verified by certifying agent and shall not include prohibited materials. Growing media shall contain sufficient organic matter capable of supporting natural and diverse soil ecology. For this reason, hydroponic systems should be prohibited.

§205.209(c) – producers may use full-spectrum light sources.

Task Force Analysis

§205.209(b) – The 2010 NOSB recommendation makes an important distinction that the growing media "shall contain sufficient organic matter capable of supporting natural and diverse soil ecology." The emphasis is on supporting the soil ecology, not the plant, which allows the grower the important flexibility to make soil/nutrient amendments, as needed, to the growing media based on environmental conditions and crop requirements – i.e. the ability to "feed the soil."

The statement that hydroponic systems should be prohibited because they do not contain growing media that can support soil ecology, again, is true only for inorganic hydroponic systems that are based on sterile/inert synthetic solutions. On the other hand, organic hydroponic systems (a form of bioponics) contain substantial soil biology including large numbers of bacteria, fungi, protozoa and nematodes, found in soil – in many cases, organic hydroponic systems use the same organic potting soil mixes used in common organic pot containers.

§205.209(c) – this issue is not specific to hydroponic growing, but rather greenhouse growing in general. Supplemental lighting is an important tool for both ornamental and vegetables growers alike to extend day length during the winter and grow during times of the year that would otherwise be impossible.

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Appendix

Greenhouse technology to promote soil life

Life in soil and growing media is a huge contributor to nutrient availability, good structure, plant, soil and growing media health. Biological farms can use technology or practices that help increase this biology, and ideal conditions are reached, for biology to thrive.

pH that is not too low or too high

In general, bacteria prefer slightly acidic environments, or low pH. Fungi prefer slightly more basic environments or higher pH. Earthworms do best at a neutral pH. If the pH is too far toward either extreme, none of the organisms that help the crops will do well.

In a greenhouse environment, pH control can be achieved very precisely since there is no influence from heavy rain that could leach elements like Ca and Mg and create acidic environments. The pH value of a soil is influenced by the kinds of parent materials from which the soil was formed. In a container the volume of media allows changes to pH to be made and levels kept in check with adjustments allowable if needed. (Clemson University, Cooperative Extension.)

Stable Temperatures of Soil or Growing Media

In order for roots and soil life to survive, the temperature has to stay relatively moderate, which is why it is recommended to keep soil covered with growing plants or residues of plants, and to avoid bare ground. Bare soil would be too cold in winter and too hot in the summer. Even on covered soil, the influence of winter to the top layer of the soil will cause biology to be dormant or not active enough and a slowdown of processes like mineralization and nutrient cycling would be expected.

In container growing, conditions of temperature of media and water can be controlled very accurately, using technology (heating and cooling systems) that keeps ideal conditions of temperatures inside the greenhouse. Also water temperature can be regulated to better fit the conditions for biology to thrive.

Soil life wants a Carbon source to feed on

Carbon is food for microorganisms. They need a blend of slow and fast released carbon sources, with the slow released carbon sources feeding fungi and the fast releasing materials feeding bacteria. Diversity of food is important in order to have diversity of organisms.

Some container growers are able to grow plants in growing media that is rich in organic matter of slowly released carbon, like peat, coco coir and bark. These materials are good fungal carbon sources and provide excellent pathogen-free growing media. These growing systems require continuous fast release carbon sources to feed the biology and the crops.

When growing in low organic matter content soils (<2%) biology would never reach full potential of activity and it could take several years to increase organic matter in soil by 1%.

Why does it take so long for organic matter levels to increase? An acre of soil six inches deep weighs about 1000 tons, so increasing the proportion of organic matter from two to three percent is actually a 10-ton change. However, you cannot simply add 10 tons of manure or residue and expect to measure a one percent increase in soil organic matter. Only ten to twenty percent of the original material becomes part of the soil organic matter. Much of the rest is converted over several years into carbon dioxide. (University of Minnesota extension).

Fine-textured soils can hold much more organic matter than sandy soils for two reasons. First, clay particles form electrochemical bonds that hold organic compounds. Second, decomposition occurs faster in well-aerated sandy soils. A sandy loam rarely holds more than 2% organic matter.

Low, poorly-drained areas have higher organic matter levels, because less oxygen is available in the soil for decomposition. Low spots also accumulate organic matter that erodes off hilltops and steep slopes. (University of Minnesota extension).

Case study 1 - Bioponic Tomato Growing

The container system consists of multiple three-gallon plastic containers with four tomato heads in each. These containers are placed on a metal trough. There are holes in the containers to allow water to drain out and be collected and partially recycled. The growing media consists of a coarse mix of coconut husk which comes pre-washed to reduce salt content. This media must be mixed with fertilizer and soil microbes to establish sufficient soil ecology and nutrient cycling before seedlings are planted. This takes approximately one month. Biology is introduced to the media through compost tea or solid compost application. Between ten to fifteen earthworms are added to each container to enhance media structure, increase microbiology, and increase nutrition through processing of organic material into fertilizer. Nutrition is also added to enhance the growth of soil microbes and add nutrition for plants. Approximately 50% of the nutrition needs of the plant can be added at this point. During the month long incubation period, this media mix is exposed to optimal temperature and water content to allow the microbial population to increase and diversify as they decompose the solid fertilizers and coconut husk itself.

After planting the seedlings in this growing media, it is necessary to add supplemental nutrition throughout the growing cycle (approximately one year). About once per week, solid and liquid nutrients are added to the growing media. Some fertilizer can be applied through the irrigation lines because they are soluble enough and will not clog the lines. The use of soluble nitrogen fertilizers is limited because of their high costs, for instance for plant-based amino acids. As long as the sodium nitrate rule continues to apply, it will be used as a lower cost nitrogen source. Soluble organic-compliant inorganic minerals are also added through the irrigation system, such as potassium and magnesium sulfate. Other liquids which can clog the irrigation lines are added as a drench, such as fish emulsion, certain fulvic acids, kelp, rock phosphate and gypsum in liquid form, and any products which are oil in nature or contain biology. Solid fertilizers will also be applied to the growing media to provide continuous slow-release of nutrition. Organic granulate products with higher concentrations of multiple elements are top- dressed on the growing media but are manually worked into the media so that the soil biology can access it readily.

The biological analysis shown below is from a sample taken of growing media about halfway through a crop cycle. The number of bacteria, fungi, protozoa, and nematodes is above expected levels to be found in a typical organic soil. This means it has a high capacity to cycle nutrients, equivalent to over 300 lbs. nitrogen per acre. This level of nutrient cycling is achieved even with a small container size of three gallons.

The irrigation cycles are dependent on many environmental variables, including amount of solar radiation, humidity, and continual measurements of soil moisture within the containers. During radiation peak hours, plants are irrigated three times per hour. Every time they are irrigated, it includes the soluble nutrients in the line. The collected drain water is filtered through 5-micron silica media filters to reduce solids suspended in the water which could potentially clog the system. The water is then ozonated to eliminate any pathogens that might be present. After a short time, ozone (O_3) converts to oxygen (O_2). This increases the dissolved oxygen level in the irrigation water to 13 – 15ppm which keeps the irrigation lines cleaner and promotes biology in the root zone.

While ozone oxidizes any organic matter in the water, including beneficial microbiology, data from this system shows very high concentrations of soil microbes in the growing media and relatively lower microbial levels leaving the system through drainage. As long as plant and microbial foods are being added to the containers, the microbes stay in the container doing their work. Therefore, the “sterile” water being re-circulated into the system is not killing the critical microbial workers of the system. Continued monitoring of the microbiology in the growing media is necessary in case replenishment is needed. For example, on a cloudy weather week, the plants would not be as photosynthetically active and have little energy left over to produce exudates for root microorganisms. On colder days, the root zone is colder, decreasing reproductive rates of the microbes.

After a year-long growing season, the same container of growing media can be reused to grow a cucumber crop. After growing cucumbers, the growing media is then incorporated into the soil at the site and used for cover crop or summer crops like squash, eggplant, and cucumbers. A fraction of the earthworms will be harvested and transferred to new containers for the next container crop.
This system has been designed and adjusted for a decade based on the advice of biological and plant nutrition experts. It has consumed much time and money to be able to achieve this commercially viable organic system of tomato production.

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Biological Analysis
Soil

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Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacteria (µg/g)	Total Bacteria (µg/g)	Active Fungi (µg/g)	Total Fungi (µg/g)	Hyphal Diameter (µm)
Results	**0.140**	502	3787	111	3116	2.95
Comments	Below Range	Above range	Above range	In range	Above range	
Expected Range Low	0.45	75	300	75	300	
Expected Range High	0.85	150	600	150	600	

	Protozoa (Numbers/g)			Total	Mycorrhizal Colonization (%)	
	Flagellates	Amoebae	Ciliates	Nematodes #/g	ENDO	ECTO
Results	30457	410971	99	86.2	Not Ordered	Not Ordered
Comments	Good	High	Good	High		
Expected Range Low	10000	10000	0	10	10%	10%
Expected Range High	100000	100000	200	20	50%	50%

Organism Biomass Ratios	Total Fungi to Tot Bacteria	Active to Total Fungi	Active to Total Bacteria	Active Fungi to Act Bacteria	Nitrogen Cycling Potential (lbs/ac)
Results	**0.82**	**0.04**	**0.13**	**0.22**	300+
Comments	Low	Low	Low	Low	
Expected Range Low	1	0.25	0.25	1	
Expected Range High	2	0.95	0.95	2	

Nematode detail (# per gram or # per mL)
Classified by type and identified to genus.
(If section is blank, no nematodes identified.)

Bacterial Feeders	80.01	
Butlerius		32.31
Cuticularia		35.39
Rhabditidae		12.31
Fungal/Root Feeders	4.62	
Aphelenchoides	Foliar nematode	4.62
Predatory	1.54	
Mononchoides		1.54

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Case study 2 - Decoupled Bioponic NFT

The system consists of 900 NFT channels, divided into three systems of 300 channels each, with 20 flat channels dedicated to nursery production in each system. These channels are placed on a raised platform and connected to the underground portion of the system with spaghetti tubes at the head of each channel and a return channel at the foot of the channels.

The water solution recirculates constantly and receives supplemental water to account for evaporation via an autofill valve connected to the system's return tank and onsite well. The system's plumbing includes multiple oxygen sources and gravity fed tanks designed to introduce oxygen throughout the system. Filters are installed throughout the system to prevent clogging from loose debris.

The growing media consists of coco fiber, perlite, and two species of trichoderma. Basil seedlings are produced in standard plastic nursery trays and grown in the nursery channels within the recirculating system until the seedlings are root bound. At that point, they are transplanted into the NFT channels, allowed to grow to maturity and then either harvested as living plants or cut as loose bunches. Roots and growing media are then incorporated into the site's soil for production of other organic vegetable and herb crops.

The balanced water solution consists of a microbial inoculated molasses-based fertilizer, bacillus species, nematode species and well water. When starting the system for the first time, the system's return tank is filled with water and the microbial inoculated fertilizer. At addition, the microbial population in the fertilizer is dormant. As the water, fertilizer and microbiology circulates through the oxygenated system, the biology is activated, resulting in a stable pH and mineralization of the fertilizer's nutrients. This process can take anywhere from one day to one week depending on the plant load and age.

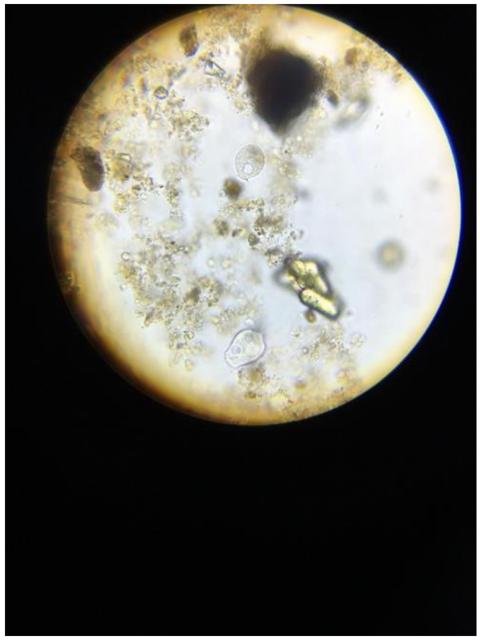
Once the system is balanced, plants are grown and harvested constantly and the system runs continuously with additions of the same microbial inoculated molasses-based fertilizer added automatically to maintain a preset EC level, bacterial food source and active biology. Nematode species and bacillus species are added to the system via the nursery channels and growing channels, respectively, for disease suppression and overall plant health.

Dissolved oxygen, water temperature, EC, pH and water solution levels are monitored and recorded twice daily. Active biology is observed under a 400x microscope when disease symptoms are present, before and after inoculation with nematode or bacillus species and at random intervals for observation.

This system has been designed and adjusted for two years to minimize water, fertility, media, seed and labor inputs and to maximize the health and yield of various types of organic basil production.

Case study 3 - Bio Digestion within a Water Culture System

This process begins with brewing a compost tea with additional protein inputs for approx. 36 hours, or until samples under microscope shows a diverse level of microbial activity. We are specifically looking for bacteria, protozoa, and hyphae. Aeration is constant and temperature is maintained at or around 75 deg. Observing bacteria and Protozoa help identify if nitrification is or will be occurring. When the desired biology is observed, the tea is then added to the greenhouse reservoir of recirculating irrigation water feeding an NFT system. This typically occurs twice per week, but the environment, systems, and crop dictate actuals.



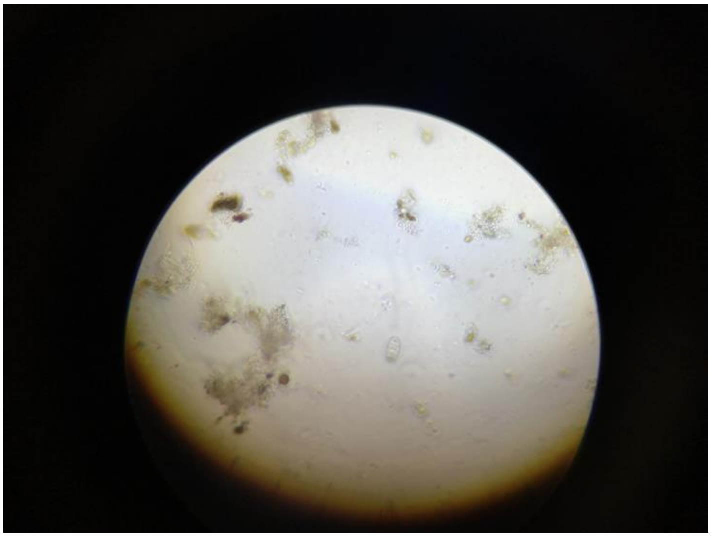
The crop is produced in a 4,200 sq. ft. greenhouse with a 1,500 gal reservoir for the recirculating water and produces over 60,000 plants per year with each plant weighing about 1/3-1/2 lbs. (without roots attached). The plants are seeded using a common organic potting mix consisting of peat, perlite, and compost, in a flood and drain system, using the same fertility, at lower rates, and methodology.

After 3-5 weeks, when the roots begin to bind in the tray and they are easy to remove from the tray, they are planted in the NFT system where they will be grown to maturity over approximately three weeks. The growing environments temperature is regulated, as well as the temperature and oxygen content of the irrigation water of the recirculating system to ensure the metabolism of the system is hyperactive to digest the organic matter and synthesize nutrients.

The metabolism of the system is monitored by measuring pH, EC, and observing plant development of both the leaf tissue and root structure. There is typically organic matter built up in the roots and slight discoloration, but the plants have primarily white roots with green and well developed leaf tissue and favorable growth rates.

Monitoring has shown that, after compost tea was added, the pH decreases several hours later, as insoluble nitrogen converts to ammoniacal nitrogen. Then the pH stabilizes for a period of time, but, as the pH begins to rise, this is considered as a sign that the available nitrogen has been depleted and it is time to add more tea to the system. This occurs typically twice per week, but the system and its ability to metabolize dictate actuals. It can take several weeks to get the nitrogen content built up to adequate levels.

A vital component of the system is the biological digester. A digester, in this case, is essentially a media filter, but using a volcanic stone as a media. The more surface area of the media, the more biological activity, which is why the volcanic rock is chosen to be the media of the digester. As the inoculated water (from compost tea) passes through the digester, the organisms colonize the volcanic rock, creating a "microbial field" containing the same organisms found in healthy organic soils including bacteria, protozoa, mycorrhizae, nematodes, earthworms, etc. As organic matter in the water passes through the digester, the organisms consume the organic matter causing nitrification and other biological processes to occur. The organisms also inoculate the plants roots zones, creating an even larger microbial field in the NFT system and increasing the metabolism of the system as a whole. Samples are taken from both the digester and the plant root zones to observe and ensure biological activity.

The plant roots provide stimulants to the organisms to encourage their activity. This system can show that there is as much or more biological activity in bioponic systems than in many healthy soil or compost samples observed. However, each system, environment, soils and compost, used to compare are different.

By providing an ideal environment for both the plants and the organisms, the organisms live in harmony with the plants and do work on their behalf. Controlled environments and recirculating irrigation systems like the NFT provide the grower with certain levels and capability of control, but also put more responsibility on the grower to create a habitable and productive environment not having any buffers.

Why: Reasons why this system is used include but are not limited to:

- Water - Recirculating systems have shown to use much less water than conventional production systems since the water is contained, some say up to 90% water savings, although there are many variables between various production systems. In San Diego, for example, the cost of water is now above $2,100/acre foot, more than double the cost than just 10 years ago. The reality of it is that the access to available free water will only become more limited, which will continue to encourage and upward pressure on water pricing. Also, irrigation water has caused massive environmental damages, whether it be the brine that fill the Salton Sea which is a designated agricultural sump or the degradation of the Great Coral Reef, and although organics may mitigate that exposure, it doesn't guarantee exclusion of salt runoff to groundwater.

- Yields - Because a containerized system provides a unique level of environmental control that allows for an ideal environment for plants and biology to thrive, an increase in yields can be achieved. The system described here produces 17 turns per year with losses of less than 5%.
- Land Use - This system, and other containerized systems, allow growers to put into production small plots of land that may not have been the right scale to provide the needed returns, land that is contaminated and land that urbanized.

Case study 4 - DWC Aquaponics

Three replicated, balanced Deep Water Culture (DWC) Aquaponic systems have been in continuous operation for 6 years producing tilapia fish and primarily lettuce, herbs and other leafy green crops. During this time only city water, fish feed and supplemental iron have been added. The water solution is fully recycled through one water pump running 24 hours/7 days per week. Top-off city water is added weekly, with the systems using approximately 0.5% system volume per day (due to transpiration and evaporation). Each system holds approximately 18,000 US gallons of water. The components of each system include 2 fish rearing tanks, 4 tanks used for solids removal and mineralization of fish effluents, and two deep water hydroponic troughs (8’x75’x1’), one water pump and one air blower. Air stones deliver air to the fish tanks as well as the hydroponic troughs. Simple hoop house structures are used to protect the plants from the elements. Poly material is used in the winter, replaced with shade cloth during the extreme summer heat.


Fish

Young 1g tilapia fish fry are purchased and reared in protective recirculating aquaculture systems until they reach 50g, in about 4 months. At that time fish are released into the Aquaponic system tanks. 1250 fish are stocked into each 3000 gallon fish tank. After another 6 months, the tilapia are ready for harvest (approximately 900g). When a fish tank is harvested completely, the next cohort of 50g fish is stocked into the tank. Feed is complete nutrition for tilapia from Cargill Feed.
Snails are a persistent problem along surfaces of the container system. They multiply rapidly and graze fixed film bacteria, including beneficial nitrifying bacteria. To combat this pest, the farm uses the biological control fish, the “shellcracker” (aka, pumpkinseed, red-ear sunfish, *Lepomis* sp.). The

sunfish are stocked at 10 fish per hydroponic trough and have completely eliminated the snails and their reproduction.

Fish Health is ensured through optimal water quality conditions for tilapia and good husbandry practices. Genetics and diet also contribute greatly to fish well-being. Tilapia survival is greater than 99%.


Plants

Seedlings are started in a mix of coconut coir/vermiculite outside of the main aquaponic systems using approved organic seedling production methods. After 2-3 weeks, seedlings are transplanted into the DWC aquaponic systems. The seedlings are placed into of nest of long-fiber coconut coir in 3" net pots on a food-grade plastic floating raft. With a three week grow out period, 1800 plants are harvested, transplanted and seeded weekly. Plants including flowers, cucumber and herbs may be harvested multiple times before replanting.

Common plant pests are caterpillars and aphids. Besides a well-developed IPM plan, biological controls may be used occasionally and organically approved sprays when required are used. Other diseases like mildews, molds, viruses, etc… are controlled using organic methods. Root rot (*Pythium* spps.) is common in water based systems and is exacerbated when temperatures rise above 27C. During these hot months, crops are rotated to resistant plants such as cucumber, basil, and other herbs and vegetables. During the mild winters the farm produces primarily kale, bok choi, lettuce and herbs.

The produce is primarily sold via wholesale to a local grocery chain. Food is also regularly donated to the local food bank in the community. Most plants are sold as living plants, others like kale and beet greens are sold as cut leaves.

Shared Water Quality

Water quality parameters are optimized for fish health, including high oxygen, low ammonia and nitrite nitrogen, and low total suspended solids (TSS). Plants are then selected that produce well under these conditions. Most plants produced have shown iron deficiencies from lack of inclusion in fish feed. Options for iron supplementation are currently being trialed on the farm and Fe levels are maintained at 2ppm. Included at the end of this case study is a water nutritional analysis from two current systems (Sample A and B). An analysis of source water (city water) is also included (Sample S). Farm staff monitors water quality 3x weekly for pH, Temp, EC, Ammonia, and Nitrite.

Effluent Management

The systems grow fish at a rate of approximately 0.5lbs/gallon of fish tank at final biomass. Feed is given at a rate of 35g/m^2 of plant area/day. Consistent nutrient input balanced with consistent nutrient uptake, by staggering fish and plant production, creates a system that provides optimum water quality for the fish and plants.

Large solids are collected at the bottom of a cylindro-conical clarifier tank and discharged from the system. Approximately 3 US gallons are discharged from each system daily. This effluent is incorporated into the soil around the farm, either directly or applied to an active compost pile. Three additional solids removal tanks follow, allowing for the microbial mineralization of fine suspended solids into usable plant nutrients. Each tank has fine filter screens on the outlets that trap the fine solids preventing them from entering the deep water hydroponic troughs.

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FERTILIZER ANALYSIS

Lab ID: 161449-2
Received: 06/10/16
Completed: 06/13/16
Phone: [redacted]
Fax:

Sample Description: A

	--ppm-
Sulfate (SO4)	66.61
Chloride	18.46
MAJOR NUTRIENTS: *	**--ppm-**
Nitrate (NO3-N)	37.40
Ammonium (NH4-N)	1.02
Phosphorus (P)	7.22
Potassium (K)	20.21
Calcium (Ca)	54.95
Magnesium (Mg)	20.23
MINOR NUTRIENTS	**--ppm-**
Iron (Fe)	2.42
Manganese (Mn)	0.04
Boron (B)	0.11
Copper (Cu)	0.08
Zinc (Zn)	0.82
Molybdenum (Mo)	0.00
Sodium (Na)	12.59
Nickel (Ni)	0.08
Aluminum (Al)	0.13
Silicon (Si)	1.74
	--ppm-
pH	6.82
Conductivity (mmho/cm)	0.56

* Urea not determined

Conversions: To convert P to P205 multiply by 2.29
To convert K to K20 multiply by 1.20

This analysis is based upon the sample received and does not guarantee the uniformity of the lot sampled.

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FERTILIZER ANALYSIS

Lab ID:	161449-3
Received:	06/10/16
Completed:	06/13/16
Phone:	[redacted]
Fax:	

Sample Description: B

	--ppm-
Sulfate (SO4)	82.45
Chloride	24.71
MAJOR NUTRIENTS: *	**--ppm-**
Nitrate (NO3-N)	49.30
Ammonium (NH4-N)	2.11
Phosphorus (P)	4.18
Potassium (K)	15.59
Calcium (Ca)	57.78
Magnesium (Mg)	21.32
Carbonates(CO3)	0.00
MINOR NUTRIENTS	**--ppm-**
Iron (Fe)	1.56
Manganese (Mn)	0.10
Boron (B)	0.11
Copper (Cu)	0.10
Zinc (Zn)	0.79
Molybdenum (Mo)	0.00
Sodium (Na)	11.97
Nickel (Ni)	0.20
Aluminum (Al)	0.10
Silicon (Si)	0.65
	--ppm-
pH	6.15
Conductivity (mmho/cm)	0.60

* Urea not determined

Conversions: To convert P to P205 multiply by 2.29
To convert K to K20 multiply by 1.20

This analysis is based upon the sample received and does not guarantee the uniformity of the lot sampled.

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MMI DOMESTIC WATER REPORT

Lab ID: 161449-1
Received: 06/10/16
Completed: 6/27/2016
Phone: [redacted]
Fax:

Sample Description: S

pH: 7.54	(Desired level 6.5 to 8.5)		EC: 0.49	(<1 mmho/cm)	
Element	Concentration in Sample	EPA Maximum Level*	Element	Concentration in Sample	EPA Maximum Level*
Alkalinity	220.18		Magnesium (Mg)	15.06	No Set Maximum
Lead(PB)	0.00	0.015 ppm	Manganese (Mn)	0.00	0.05 ppm (S)
Aluminum(AL)	0.07	0.2 ppm (S)	Molybdenum (Mo)	0.00	No Set Maximum
Ammonium(NH4-N)	1.28	No Set Maximum	Nitrite (NO2)	0.00	1.0 ppm (P)
Boron(B)	0.02	No Set Maximum	Phosphate (PO4)	0.75	
Bromide(Br)	0.00		Potassium (K)	2.63	No Set Maximum
Cadmium(Cd)	0.00	0.005 ppm (P)	Silica (SiO2)	3.66	No Set Maximum
Calcium(Ca)	70.39	No Set Maximum	Sodium (NA)	11.29	No Set Maximum
Chloride(Cl)	22.51	250 ppm (S)	Sulfate (SO4)	25.82	250 ppm (S)
Chromium (Cr)	0.00	0.005 ppm (P)	Sulfur (S)	8.52	
Copper(Cu)	0.01	1.0 ppm (S)	Total Dissolved Salts (TDS)	313.60	550 ppm (S)
Fluoride(F)	0.00	2.0 ppm (S)	Zinc (ZN)	0.00	5.0 ppm (S)
Iron(Fe)	0.01	0.30 ppm (S)	Carbonates (CO3)	0.00	
Nitrate(NO3-N)	1.37	10.0 ppm (P)	Bicarbonates (HCO3)	268.49	< 2.0

The letter (P) is an EPA primary drinking water standard, the letter (S) is an EPA secondary water standard for this element.

PPM: Stands for parts per million. One part per million is equivalent to 1 pound of an element dissolved in 1,000,000 pounds of water. One part per million is the same as one milligram per liter (mg/L).

NOTE: This test does not imply that this water is safe from bacteria or other chemicals that may be present.

Case study 5 - Container production systems

As a growing sector of agriculture, container production has increased and diversified considerably within the past 5 years. Responding to increased variability of climatic conditions, including droughts in western states with limited access to quality water as well as increased land prices, innovation in this sector has led to, and continues to increase adoption of these production practices. As innovation increases, it is important that regulatory processes take into consideration not only production practices in place today, but also development over the coming years. As resource restrictions and production systems evolve, operations and certifiers are looking to the 2010 recommendation and future clarification to understand what systems are allowed under USDA organic regulations.

Perennial crops grown in containers

This section provides a case study of 2 certified organic container perennial berries and is presented as a real-life example of container systems currently within our organic agricultural universe. These systems highlight specific regulatory challenges for certifiers as well as specific production benefits realized by the growers. The information in this section was provided by Ian Justus, Driscoll Strawberry Associates Sr. Manager Controlled Environment Production. This is presented in order in order to further the dialogue about container production, and is not intended as an endorsement of this system or its alignment with OFPA or the USDA organic regulations.

The photos below show two certified organic perennial container systems for blueberries and raspberries in California. The systems are a rapidly growing sector of organic agriculture in the West and range in terms of their specific production practices including: Crop, growing media, container size and fertility program. These systems have been developed over the past 3-4 years and have not yet reached the end of lifecycle for these crops which is expected to be 8-10 years. This is an active time for research and system refinement.

Blueberries do particularly well within this type of system due to the low pH of the peat based growing media and consistent delivery of water and nutrients. Tunnels are not enclosed, and the metal hoops will be covered with plastic to create warmer temperatures and diffuse light. Weed cloth covers the soil. This system could be in place for 8-10 years.

This photo shows Raspberry production in containers. No weed cloth has been used at this site, however this system uses similar practices to the blueberries such as high tunnels covered with plastic and other specific production methods.

Container size ranges from 10-40 liter pots. The size of the container is based on the eventual size of the root mass of the plant, lifespan of the crop and the volume of growing media needed.

Growing media consists mainly of peat, coconut coir and perlite. Some growers may also include compost, wood chips or solid fertilizer such as guano. The analogous non-organic system uses pure coconut coir because the increased surface area and organic matter content provided with the peat is not needed due to the highly available nutrients used in the non-organic system. Blended media is more common in the organic systems because it provides better buffering for moisture and fertility retention (increased CEC) and higher organic matter, and therefore surface area for needed to support biological activity.

Fertility is derived predominantly from liquid fish and with some operations using hydrolyzed (and other) soy products (less common due to high cost) fed through the irrigation lines. Some growers also use compost or other solid-state fertilizers as part of the growing media, but this is not typical.

Biological Activity is mostly the result of microbial populations in the air which colonize growing media under the right moisture and temperature levels. Microbial products may or may not be added to encourage of speed up establishment of these populations but research with these systems has shown that is isn't necessary in order to establish microbial populations. Additionally, the organic systems outperform comparable non-organic systems which these growers attribute to the benefits the organic systems see from the established microbial populations.

Production benefits found with container perennial crop production

Producers report specific production benefits using container production which is increasing interest and conversion to these systems. In addition to the 3 benefits discussed below, producers report higher yields, extended growing season and improved conditions for workers due to the cleaner conditions, higher plant height and consistent production.

A. Precision

The key benefit these growers find when using container production for these perennial systems is **precision**. These systems are extremely water and fertility efficient. Plants are watered several times a day with very precise amounts and little to no run-off. Liquid fertility is also delivered in very precise amounts down to ppm of fertility needed by the plant. In terms of both water and fertility, plants are given "exactly what they need exactly when they need it." This has allowed plants to thrive and produce fruit more quickly when coupled with specific varietal selection.

B. Reduced resource use

Even with planting densities much higher than in-ground systems, producers see a 40-70% reduction in water use (depending on the crop), and reduction in fertilizers compared with the same crops grown in ground. This is an important consideration for agricultural areas reliant on summer irrigation, as is common throughout the West. Importantly, due to the low level, consistent watering, these systems require vigilant and constant monitoring. If water is not delivered correctly for one day, the entire crop could be lost.

C. Utilizing non-ideal growing locations

Container systems have opened up production areas which, due to soil or water quality issues, may not be suitable for in-ground growing. This could lead to increased agricultural production in urban areas, on rooftops, as well as on contaminated or other marginal ground if the sites can meet requirements outlined in the USDA organic regulations.

Conclusion

In a time of increasing climatic instability and variability, systems that are resource efficient will become increasingly important in order to maintain a consistent food supply. However, the fact that growers find benefits using these methods is not sufficient justification for their allowance in USDA organic regulations. The challenge still remains in determining if these methods align with OFPA and current USDA organic regulations, and can/should the USDA organic regulations be updated to specify requirements for crops produced in containers to ensure adherence to fundamental organic agricultural methodology.

3. Alternative Labeling Subcommittee Report

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Alternative Production Methods and the Benefits and Challenges of Alternate Labeling Strategies

In addition to the original objectives laid out for the Hydroponic and Aquaponic Task Force, the task force was also asked to explore alternative labeling concepts that could be applied to hydroponic, aquaponic and/or other container based production methods. To carry out this task, the task force created the Alternative Labeling Subcommittee. The tasks of the subcommittee was two-fold:

1. Consider labeling options for hydroponic and container production systems both within the existing USDA organic standards and outside them based on a request by the NOSB Crops Committee.
2. Additionally, this report attempts to assess benefits and challenges of alternate labeling categories for container based/soil-less/hydroponic production systems within the current NOP organic standards.

There is not consensus among members of the committee regarding these alternatives. Rather, the alternatives are being presented to represent the range of ideas shared by members of the committee.

A limitation of the suggestions below is that currently there are neither clear, agreed upon definitions for these systems nor finalized standards on which to base a distinction. Adoption of any alternate strategy, requires a clear production standards as a starting point to develop clear labeling standards. Since there are already significant differences among certifiers regarding the certification of hydroponic systems, some members of the task force feel that it is premature to suggest any alternative labeling.

The goal of developing an alternate labeling category (for the benefit of writing and reading this report, we use Alternate Label as a placeholder name for any specific alternate labeling strategy) is to create transparency within the organic marketplace; enabling producers to distinguish their crops/products and consumers to make informed choices. This report discusses mainly alternate labeling strategies *within* the USDA organic regulations, however, it is the opinion of some members of this subcommittee that requirements in OFPA and the USDA organic regulations would not allow a container/soil-less/hydroponic label to be included under the organic label and would therefore necessitate separate standards development. Therefore, an alternate label outside of USDA organic regulations is also listed, however details of a separate standard are not discussed within this report.

Goals of an alternate label within *or* outside of USDA organic regulations:

1. Provide a transparent label to consumers.

2. Enable clear communication regarding what is the distinguishing characteristic of this set of production systems.

Challenges of alternate labeling within the USDA organic regulations:

1. Determining authority within OFPA to include container/soil-less/hydroponic production within USDA organic regulations.
2. Dependent on clear standards to distinguish and define the productions systems included/excluded in the label.
3. The label distinction will, by design, group a variety of production practices together into the same category. This is a challenge due to the wide variety of production practices in use, including future industry innovation, and would require agreement as to the core difference between in-ground/soil-based systems and container/soil-less/hydroponic systems.
4. The use of an alternate seal (a seal's use being optional under § 205.303) and the associated phrase (phrase being required under § 205.303) for single vs multi ingredient products would require significant changes to the USDA organic regulations and create additional complexity during the certification process. Changes to § 205.303 Packaged products labeled "100% organic" or "organic" would be needed to define use of the additional modifier to organic.
5. If transparency is the goal, an Alternate Label would need to be used on all products and through all labeling scenarios. This would necessitate a % cut-off of Alternate Label ingredients to be able/required to use an Alternate Label label
   a) For example, an USDA organic tomato sauce using Alternate Label tomatoes. Would the sauce need to be identified as Alternate Label Tomato Sauce"? What if only 2 % of the tomatoes used the Alternate Label? Could a product use a portion of regular Organic and Alternate Label tomatoes in the same sauce? What if the sauce was from 100% Alternate Label crops?
6. Challenges for multi-ingredient products:
   a) Would the producer *have* to use the seal? (not required under current NOP organic standards)
   b) If the phrase-only is required as it is under §205.303 (b) 1 (ingredients) &2 (COB statement) does it only need to be on ingredient panel or will it also be required on front label?
   c) Would a product be required to use the Alternate Label only if a defined % of the product is Alternate Label (herbs are very commonly grown in containers and are often only a small % of a recipe)

d) What is the cut-off? 5%? 25% 75% of a recipe?
e) Anywhere the word Organic is used, will it need to be modified? If no, then the transparency being sought will be lost.
f) What about Made with Organic claims?

7. Given the added complexity for multi-ingredient products, an alternate label may only be realistic if used only for fresh produce or single ingredient products and therefore would not create consistent transparency.
8. Creates what is in effect a "2nd-class" product category which is unlikely to be seen as a value added label and may not be beneficial to the Organic label overall.
9. Could open the door to request for additional alternate labeling strategies for other production systems in the future.
10. Not in line with international organic standards, such as Canadian, who have specific production standards for container production within their current organic label.

Discussion on alternate labeling within USDA organic regulations:

The ability or willingness for consumers to understand what is behind the Organic label is always a challenge. Consumer understanding of the production standards behind the label vary widely. Alternate labeling will require adding layers to an already confusing labeling environment. Creating additional labeling categories based on specific production systems would require easy-to-understand definitions and requirements as well as continued education efforts by the NOP and ACAs.

An alternate label within the USDA organic regulations may be more feasible for single ingredient crops/products in the produce aisle, however when considering the impact on multi-ingredient products, it is the opinion of this subcommittee that developing alternate labeling categories within the USDA organic regulations will lead to considerable challenges during the certification process and even greater confusion for consumers.

Additionally, creating an alternate label may take the pressure off of developing and ensuring high integrity production requirements. It may be more motivating to develop stricter requirements and ensure production practices are held to a high standard when using the same label for all production systems.

Alternatives to Organic Certification:

Given the challenges to creating a label for hydroponic crops within the USDA organic regulations, it may be more feasible to create a separate standard for those who want to distinguish container/soil-less or "Bioponic" production from standard hydroponic systems. Two possible paths for creating a separate standard include: a) establishing a separate labeling program--similar to but separate from the NOP; b) creating a Process Verified Program (PVP). Creating a new labeling program may require an act of Congress and would take significant time and resources. Alternatively, creating a PVP would be much easier, as the USDA's Agricultural Marketing Service (AMS) already offers this service to the industry. The USDA's PVP is a verification service that offers industry groups a unique way to market their products to customers using clearly defined, implemented, and transparent processes. PVP applicants work with USDA to establish clear standards for production and, once the program is approved, the USDA provides independent verification by a qualified AMS auditor.

Aquaponic:

Some aquaponic growers have stated that they can market their crops successfully without using the organic label. An aquaponic system will appeal to some consumers because it is a closed system based on efficient use of fish waste for growing crops.

Alternate labeling suggestions within the USDA organic regulations:

When considering alternate label options below, in addition to production standard updates needed to define these systems, sections of the regulation that would need to be updated include **§ 205.300 - § 205.311**. Specifically:

a. **§ 205.301** Product Composition, to distinguish soil grown and container grown ingredients.

b. **§ 205.303 to define usage of alternate labeling phrases**

c. **§ 205.310(b)** –would container grown need to be identified on ingredient panel as such.

d. **§ 205.312 to specifically outline design and use requirements of a new seal.**

Additionally, it may be necessary to amend OFPA to provide authority for alternate labeling options under USDA organic regulations.

A. LABEL : USDA Organic - Container Grown

1. Systems include any system under USDA organic regulations where terrestrial plants are grown to maturity in an enclosed container. Would include rooftop gardens, perennial container systems, herbs in pots, annual greenhouse container systems. Would *not* include transplants, mushrooms, aquatic plants and sprouts for reasons discussed in the 2010 Subcommittee report.

   a. Could include hydroponic or aquaponic systems once determination is made by the NOP regarding their inclusion/exclusion in the USDA organic regulations.

2. Definitions required in order to apply this label change include those needed to define and implement certification for container and hydroponic production systems as discussed in 2010 hydroponic/aquaponic taskforce including – soil, container, growing media, hydroponic, container production.

B. LABEL: USDA Organic - Soil-Less

1. Systems include any allowed system where terrestrial plants are grown to maturity in an enclosed container or otherwise not planted in the ground. Would include rooftop gardens, perennial container systems, herbs in pots, annual greenhouse container systems.
   a) Could include hydroponic systems once determination is made by the NOP regarding their inclusion/exclusion in the USDA organic regulations.
   b) Would include systems that use some percent soil within their growing media.
2. Definitions needed include those required to define and implement certification for container and hydroponic production systems as discussed previously– soil, container, growing media, hydroponic and soil-less production.

C. LABEL - USDA Organic - Hydroponic

1. Systems include those determined to be hydroponic under (possible future) USDA organic regulations.
2. Definitions needed include those used to define and implement certification for container and hydroponic production. Most importantly, Hydroponic, and including soil, container, growing media etc

D. LABEL - USDA Organic - Bioponic

1. Systems included:
   a. Systems defined as Bioponic under (future) USDA organic regulations
2. Definitions needed include those required to define and implement certification for container and hydroponic production. Most importantly, Bioponic, and including hydroponic, soil, container, growing media etc