

Introduction to Organic Crop Production¹

D.D. Treadwell²

This document is written for commercial producers who are transitioning to or beginning organic production. Home gardeners should refer to EDIS publication HS1215, Organic Vegetable Gardening in Florida, available at <http://edis.ifas.ufl.edu/hs1215>.

The National Organic Program

Organic farming can generally be described as a method of production that utilizes non-synthetic inputs and emphasizes biological and ecological process to improve soil quality, manage soil fertility, and optimize pest management. The industrialization of agriculture in the 1940s served as a point of departure from conventional agriculture to shape a new production paradigm that avoided chemical inputs. As consumer demand for organic food increased, organic industry stakeholders requested the creation of United States federally regulated standards to facilitate national and international trade (Treadwell et al. 2003). As a result of this significant grassroots effort, the National Organic Standards Board (NOSB) was created under the authority of the Organic Foods Production Act of 1990, to establish uniform organic production standards and to ensure consumer protection for all products labeled organic in the marketplace. The NOSB, composed of 15 members appointed by the Secretary of Agriculture from across the United States, provides recommendations to the

Secretary regarding the implementation of the National Organic Program. The NOP resides in the Agricultural Marketing Service, an arm of the United States Department of Agriculture (USDA). The process to develop national standards for the organic industry took over a decade, with multiple revisions occurring before the final rule became fully implemented in October 2002. A wealth of information for consumers and producers, including the complete regulations, are located on the NOP website: <http://www.ams.usda.gov/AMSv1.0/nop>.

Certification Process in Brief

Certified organic production is the process of satisfying and maintaining the stringent production standards established by the NOP rule and validated by an accredited certifying agency (Figure 1). Accredited agencies include private for-profit and non-profit agencies, as well as public state-run certifying agencies. The standards are dynamic, and minor revisions are ongoing through a transparent process involving public notification, public comment, and federal rulemaking. All producers, handlers, and processors who are certified are required to be compliant with the specific sections of the Final Rule that apply to their operation.

Any farmer with gross organic sales greater than \$5,000 a year and who advertises products as organic is required

1. This document is HS720, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date June 1995. Revised April 2014. Please visit the EDIS website at <http://edis.ifas.ufl.edu>.

2. D.D. Treadwell, associate professor, Horticultural Sciences Department, UF/IFAS Extension, Gainesville, 32611.

The use of trade names in this publication is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named, and does not signify that they are approved to the exclusion of others of suitable composition. Use pesticides safely. Read and follow directions on the manufacturer's label.

The Institute of Food and Agricultural Sciences (IFAS) is an Equal Opportunity Institution authorized to provide research, educational information and other services only to individuals and institutions that function with non-discrimination with respect to race, creed, color, religion, age, disability, sex, sexual orientation, marital status, national origin, political opinions or affiliations. For more information on obtaining other UF/IFAS Extension publications, contact your county's UF/IFAS Extension office. U.S. Department of Agriculture, UF/IFAS Extension Service, University of Florida, IFAS, Florida A & M University Cooperative Extension Program, and Boards of County Commissioners Cooperating. Nick T. Place, dean for UF/IFAS Extension.

to be certified. If gross sales are less than \$5,000 a year, certification is optional, and although farmers are allowed to verbally communicate that they are following organic standards, regulations prohibit the use of the USDA seal or the words “certified organic” on any label or advertisement. False claims are subject to a \$10,000 fine and possible legal action for every violation.

The basic steps to certification are listed in Figure 1. Producers are required to design and adhere to an organic system plan (OSP) to ensure they are managing all aspects of agricultural production and handling in accordance with the organic regulations. In brief, land is eligible for certification once it has been free of prohibited substances for at least 36 months. Certification is available for a fee from a number of third-party independent certifying agencies. Producers have the right to select any certifying agency that is accredited by the USDA NOP. A current list of accredited agencies is located at the NOP’s website. When selecting an agency, producers should consider cost of certification, accessibility, and experience among other factors.

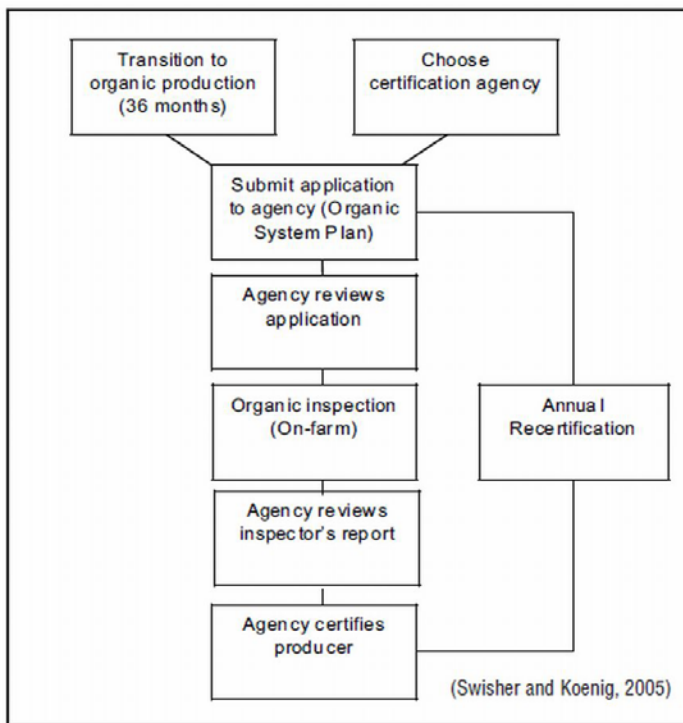


Figure 1. Flow chart of the process of organic certification for farmers. Costs are calculate either by acreage or by anticipated gross sales.

Once an operation is certified, its organic status never expires unless it is suspended, revoked, or surrendered. The operation must be visually inspected and the organic system plan recertified annually by the agency. Growers may be certified by any USDA-accredited certifier, and they may switch to another certifier if they are not satisfied with

the service or fees associated with their current certifier. There are costs for the initial certification as well as the annual recertification. The cost of certification varies from agency to agency, and growers should explore different accredited certifiers to determine which one fits their needs. An average initial fee for a production system less than 100 acres is around 500 dollars, and subsequent annual fees are less than the initial fee. The producer typically pays for the inspector’s travel costs to the farm for inspection.

The Organic System Plan

In organic production, management strategies are selected to restore, maintain, and enhance ecological harmony among the components of the farming system. A common misconception is that organic farming merely involves the substitution of approved inputs for prohibited inputs. However, the misapplication of organic materials or poorly executed cultural pest-control strategies will effectively disrupt the function of ecological and biological cycles and may lead to detrimental outcomes (Lampkin 1990). To ensure natural cycles are managed in a proactive manner, the NOP requires producers to complete a soil and pest management plan (OSP). The OSP, or farm plan as it sometimes called, is unique to each operation and is submitted to the certification agency for review and approval. Producers can get assistance with the development of their plan from a county Extension agent or other service providers. It is important to note that certifying agencies cannot provide *consultation* services to a producer on matters of production, including recommendation of specific input products or service providers, because that would be a conflict of interest. Rather, the responsibilities of certifying agencies are to make *decisions on compliance of an operation in accordance to the national standards* of the NOP and to provide information about their certification process, including fees. Certifying agencies are allowed to direct producers to publicly available information resources such as Extension publications, lists of crop consultants,



Figure 2. USDA Organic Seal.

and approved materials, but they are not allowed to recommend a specific one.



Figure 3. Seal of a certifying agency.

The two main components of the OSP are the soil management plan and the pest management plan. Producers are required to design and subscribe to a *soil management plan* to ensure they are managing plant and animal materials in a manner that does not contribute to the contamination of crops, soil or water by crop nutrients, pathogens, heavy metals, or residues of prohibited substances. Rotation, tillage, irrigation, fertility management, and a soil- and plant-nutrient monitoring program are all factors that affect soil and water quality and should be included in the plan. The *pest management plan* provides producers with a road map to manage pests through mechanical, physical, and cultural control methods. Approved non-synthetic biological, botanical, or mineral inputs may be used to manage pests only if preventative methods fail to provide sufficient control. A producer's certifying agency will confirm when it is appropriate to use additional inputs for pest management.

Because the National Organic Standards characterizes the rules and regulations in general terms, the OSP provides producers an opportunity to develop a detailed approach to organic management that is appropriate for their operation. The OSP is required to contain a description of all farm practices and procedures and the frequency with which they will be implemented. Records need to be kept for at least five years and made available for authorized federal, state, and/or agency service providers. Changes to the plan should be discussed with the certifying agency prior to implementation. Specifically, the plan must document items 1–4, and items 5 and 6 are typically required by the certifying agent:

1. A description of the **record keeping protocols**.
2. A plan of **all inputs** to be used, including documentation of their composition, source, and location and date used.

3. The **monitoring practices** to verify the plan is effectively implemented.
4. A description of **practices and physical barriers used to prevent commingling** of organic and conventional products on farms with split production. Also, to prevent organic products from contamination with prohibited substances.
5. An **accurate map** of the farm including permanent structures, field boundaries, non-crop areas, and hydro-logic features such as wells, irrigation ditches, and ponds.
6. **Field histories** documenting production methods (conventional, transitional, organic), crops, cover crops, all inputs, and field sizes or production area (if greenhouse or beds).

For operations with split production systems (organic and nonorganic), the plan must define adequate buffer zones (physical structures or natural features) to prevent the possibility of unintended contact with a prohibited substance, establish protocols to prevent commingling of unpackaged organic and noncompliant products, and outline an equipment cleaning protocol for shared equipment.

Information about the NOP regulation, certification, marketing, and technical production assistance may be obtained locally from your local UF/IFAS County Extension agent or a staff member at Florida Organic Growers (FOG) at <http://www.foginfo.org>. Several electronic tools are available to assist farmers to complete an Organic System plan—the National Sustainable Agriculture Information Service's website (ATTRA) in the Organic Farming resource area (<http://www.attra.org>), and Rodale Institute's Organic System Plan Tool (<http://rodaleinstitute.org/farm/organic-system-plan/>). These tools are available at no charge.

Due to the substantial impact of crop rotation on soil fertility, soil physical structure, soil, organic matter, and pest management, organic producers must implement a crop rotation that provides for some or all of these functions and include this crop rotation plan with the OSP. Crops can include but are not limited to sod, cover crops, green manures, and catch crops, in rotation with harvested crops. The length and design of the rotation is dictated by climate cycles, production needs, and market opportunities. For a more complete discussion of rotation and its effects on the production system, visit the ATTRA website or refer to Lampkin (1990).

Approved Inputs

The NOP's National List of Allowed and Prohibited Substances (commonly referred to as the "National List") specifies the inputs that are allowed for use in organic production, handling, and processing, and is part of the NOP regulation. Substances proposed for use in production, handling, and processing are subject to a rigorous technical review process by the NOSB to determine if the substance satisfies the legal criteria in the Organic Food Protection Act and Final Rule of the NOP. Amendments to the list are updated through a federal register process. A current National List is available from any certifying agency or the NOP website. In general, all synthetic substances are prohibited and all natural products are allowed unless they appear otherwise on the Allowed and Prohibited Substances List.

According to the NOP, the term *synthetic* is defined as "any substance that is formulated or manufactured by a chemical process." Substances that are created as the "result of naturally occurring biological processes" are referred to as non-synthetic or *natural*. The National List of allowed synthetic substances is a list of synthetic inputs that are allowed for use in organic production and handling operations, and non-synthetic substances that are prohibited for use in organic production and handling systems. For example, although arsenic is a natural substance, it is prohibited for use in organic systems. Plastic mulch, a synthetic, is allowed for use, provided the material is not made of polyvinyl chloride and the mulch is removed and disposed of according to local waste management guidelines. Further, all substances approved by the NOP must be used as indicated on the National List. The List is organized in specific use categories such as "Insect Control" and "Soil Amendment." In some instances, a substance or material may be approved for use in one application (sanitation), but prohibited in another (soil amendment).

A second resource that lists allowable synthetic and non-synthetic products for organic producers is the Organic Materials Review Institute (OMRI) Products List. OMRI is a private, not-for-profit organization that serves the organic community by determining if brand name products are compliant with the NOP regulation. Because product labels do not provide complete information about active and inert ingredients, the OMRI Products List is a reliable resource and contains a current and rather complete inventory of allowable products. Companies pay a fee and fully disclose their formulations and other necessary proprietary information to OMRI for a thorough review. Thus, OMRI provides a needed service for manufacturers

who do not wish to disclose trade secrets to the general public but desire to sell their products to organic producers. However, because inclusion on the OMRI list is voluntary, omission from the OMRI List does not necessarily mean the substance is prohibited.



Figure 4. OMRI Label.

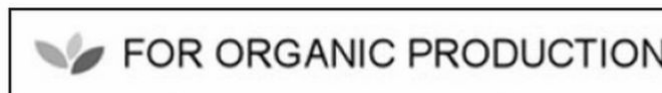


Figure 5. Optional NOP Label for EPA approved pesticides.

Products that have been listed by OMRI as approved for use in organic production carry the label (Figure 4). OMRI makes no claims to product effectiveness; they only verify that the product is approved for use under the NOP. The OMRI Products list is available to the public at no cost on their website at <http://www.omri.org>.

Products labeled for use as a pesticide in organic production are also subject to state and federal labeling laws as well as tolerance criteria established by the Environmental Protection Agency. In pesticide products, substances added to improve the efficacy of the active ingredient are referred to as inert ingredients. Primarily, inert ingredients included in EPA's List 4 (Inerts of Minimal Concern) are allowed for use by the NOP. According to the Federal Insecticide Fungicide and Rodenticide Act (FIFRA), companies are not obligated to list the inert ingredients on the package, but they must disclose the total percentage of inert ingredients. Companies that register pesticides for use in organic production may voluntarily apply the NOP pesticide label to the package for consumer benefit (Figure 5) or voluntarily apply for OMRI certification.

Organic growers are obligated to comply with mandatory pest or disease treatment programs authorized by federal, state, or local agencies for the purpose of eradicating a pest or disease. In this rare instance, producers may appeal to the agency initiating the treatment program and offer an alternative pest control program. Producers may also request that synthetic sprays be withheld from land under organic production. The producer's certifying agency should be notified immediately if this situation occurs. If the treatment includes prohibited pesticides and those substances are used on crops under organic production,

those agricultural products cannot be marketed as organic for that season; however, producers are allowed to maintain certification of their land without penalty. For example, if insecticides were mandated by the state to control medfly in all Florida citrus, and those insecticides were applied to organic oranges, the producer would not be able to market the oranges as organic for that harvest cycle but would not necessarily lose his or her certification.

Soil Quality and Fertility Management

In organic cropping systems, it is necessary to plan rotations in advance, add organic matter to soil, and employ suitable tillage practices to ensure crop fertility and preserve soil and water quality. Because plants vary in their nutrient requirements and in their ability to extract nutrients from the soil, rotating crops with different nutrient needs and plant architecture in the field can increase the efficiency of nutrient use and decrease the potential for nutrient leaching or runoff. For example, plants with shallow fibrous root systems are more efficient at utilizing nutrients mineralized from decomposing organic matter on or near the soil surface. Deep-rooted plants such as winter cereals are efficient at extracting nutrients that have moved downward in the soil profile.

Organic production systems rely on biological processes to convert organic forms of nutrients to mineralized, plant-available forms; therefore, nutrients are released slowly over time. In Florida, many soils are low in organic matter content, so the addition of organic materials is important to stimulate the growth and reproduction of soil microorganisms. Regular additions of organic matter increase the size and stability of soil aggregates as well as reduce soil erosion. Larger aggregates are not as easily moved by wind or rain, and less crusting means more water can infiltrate the soil rather than move over the surface. In rotations, organic matter can be added by including sods, catch crops, plant mulches, and green manures, supplemented by compost or other stable organic materials.

Most cropping systems require tillage to prepare the soil for planting, as well as cultivation during the growing season to control weeds and reduce insects. However, tillage disturbs soil structure and decreases the amount of soil organic matter. To minimize negative effects on soil water-holding capacity and soil fertility, and to prevent losses of topsoil that could occur with an excess of mechanical cultivation for weed control, tillage should be employed judiciously. Employing a combination of practices including crop

rotation, appropriate tillage, and the addition of organic amendments can improve soil quality by

- maintaining soil fertility,
- improving soil tilth (physical condition),
- reducing soil compaction and erosion,
- increasing soil water-holding capacity (namely, field capacity),
- suppressing some soil-borne pathogens,
- increasing predation of weed seeds by soil microbes, and
- providing a source of slow-release plant available nutrients.

Planning and Monitoring a Nutrient Management Program

Due to the broad range of soil types in Florida, the best way to plan for future crop nutritional needs is through periodic soil tests to monitor soil nutrient concentrations.

In general, the rotation schedule will influence the soil sampling schedule. Samples should be collected annually, or at least prior to the start of each rotation when the rotation is short (less than three years). To avoid contamination of surface and groundwater associated with overapplication of fertility inputs, producers are advised to submit samples of soil amendments to a reputable laboratory for analysis if a guaranteed analysis is not available from the supplier.

Crop fertility recommendations are the same in organic as they are in conventional systems, and materials must be applied at rates compliant with existing nutrient-management guidelines and in a manner that minimizes environmental degradation. However, the number of allowed inputs is limited in organic systems. Therefore, producers need to be resourceful when selecting inputs to provide sufficient fertility. The majority of plant nutrients is supplied by natural sources of fertility—including compost, animal manures, and leguminous cover crops—and is supplemented by the application of mined sources of mineral nutrients and various formulations of minor nutrients.

Because the organic fertility sources listed above are slowly available in the soil, nutrient amendments are typically preplant incorporated, with occasional side dressing or fertigation, depending on crop production recommendations. To meet the criteria for Florida's Best Management Practice (BMP) program, no more than 50% of a crop's recommended nitrogen (N) requirement should be applied at seeding or transplanting (FDACS 2005). When plastic

mulch and drip irrigation are used, remaining fertility applications are practically limited to soluble forms. Most fertigation products are fish meals and emulsions that can be purchased as a wettable powder. These products typically have a low N analysis and can be expensive, so providing a substantial fraction of the necessary nitrogen through fertigation may not be economically feasible.

During the growing season, plant tissue analysis is the most accurate method to assess fertility levels. Plant tissue analysis can also provide information on nutrients that are not easily measured in soil analysis, such as N, boron (B), and sulfur (S). Sufficiency ranges for N and potassium (K) content from petiole sap and twelve nutrients from whole leaf samples are available in EDIS publication HS710, *Vegetable Production Handbook for Florida* <http://edis.ifas.ufl.edu/cv100> (Olson and Santos 2012). Should nutrient content be less than sufficient, fertility programs can be adjusted accordingly. The UF/IFAS Extension Soil Testing Laboratory (ESTL) offers six types of analysis, including soil and tissue analyses, for a modest fee. Interested producers should contact their county Extension office or visit <http://soilslab.ifas.ufl.edu/> for more information. In addition to the ESTL, a number of private laboratories offer similar services. A list of these laboratories is located on the ATTRA Web site.

Recommended steps to a nutrient management plan include (1) using the IFAS recommendation for nutrient application rate; (2) knowing the nutrient analysis of the materials you are applying; (3) accounting for estimated nutrient contributions from pre-season compost applications and legume cover crops; (4) subtracting the estimated nutrient contributions from the seasonal recommended fertilizer rate, while accounting for N, phosphorus (P), and K as well as secondary nutrients if soil tests indicate a deficiency; and (5) planning to apply nutrients in a manner that will not pose a risk to water quality (Ozores-Hampton 2012).

To prevent nutrient losses associated with leaching and volatilization, a number of strategies should be employed, including but not limited to

- splitting fertilizer applications over time,
- incorporating N into moist but not saturated soil,
- using precision irrigation for site specific application,
- covering the surface of beds with plant or plastic mulches,

- submitting organic materials to a laboratory for analysis prior to use to ensure accurate calculation of application rates,
- calibrating application equipment,
- avoiding application of material during periods of heavy precipitation, and
- planning for effective tillage.

Nutrient Sources

Nutrient sources typically used in organic production are discussed below, and a summary of sources is presented in Table 2. All materials sold as “fertilizers” in the state of Florida must be registered with Florida Department of Agriculture and Consumer Services (FDACS). These products come with a guaranteed analysis clearly stated on the product label. Materials not registered with FDACS are sold as “soil amendments” even though they are commonly used in organic systems to improve soil fertility. The nutrient concentrations in soil amendments vary depending on the method of production and source of materials. Average concentrations of commonly used soil amendments are listed below in Tables 2–4. In general, bulk fertilizers and soil amendments are allowed in organic production if they are natural or mined. Some synthetic micronutrients are allowed with a documented nutrient deficiency. Because some forms of these materials may be prohibited, producers should request written confirmation of approval for organic use (request a copy of the OMRI label or validate with the certifying agency). Additional information on use and sources of soil amendments in organic production is available from ATTRA.

Compost with Animal Manures

Composts made of plant materials are allowed and encouraged; however, to minimize risk of contamination by human pathogens associated with handling animal byproducts, producers must follow specific NOP guidelines for compost made with animal manures. Compost must be manufactured with raw materials that have an initial carbon (C) to N ratio between 25:1 and 40:1. An internal temperature between 131°F and 170°F must be maintained for at least three days for in-vessel or static-aerated systems or for at least fifteen days (and five turnings) for windrow systems. Compost can be formulated to meet the site-specific needs of the system. For instance, some compost formulation can reduce incidence of plant disease, while composts containing crushed egg or oyster shells can provide a valuable source of calcium (Ca). There are many possibilities, but producers should have a firm understanding of soil biology and chemistry to avoid potential complications.

If animal waste is not composted according to the NOP rule, then it is treated as raw animal manure. Raw animal manure can be applied to a crop that is not for human consumption, applied 90 days prior to the crop harvest date if the edible portion does not touch the soil, or applied 120 days prior to the harvest date if the edible portion does come into contact with the soil. Municipal waste is prohibited in organic production.

The average nutrient analysis of common animal manures used in organic production is summarized in Table 2. When using animal manure, there are two important considerations. First, in addition to regular soil tests, producers are strongly encouraged to submit samples of compost and animal waste for analysis prior to application to avoid accumulation of P, zinc (Zn), and copper (Cu) in production areas. For example, stockpiled turkey litter applied at a rate of 5 tons per acre to a crop of sweet corn could supply 180 pounds of total N or approximately 54 to 90 pounds of plant available N. However, phosphorus (as P₂O₅ equivalent) would provide 400 pounds per acre, while crop removal would be roughly 4% of applied P, or about 16 pounds for a yield of 114 cwt. Similarly, 2.8 pounds of Zn would be added, but crop uptake would be less than 5% or 0.15 pound per acre. Due to the risk of over-applying P and heavy metals, producers should apply animal manures sparingly, and rely instead on legume cover crops or other N sources to supply nutrients. Second, repeated applications of animal manures can increase the pH over time. Finally, it is difficult to predict the amount and timing of nutrient availability due to the many environmental factors that influence the rate of biological processes. These factors include

- soil temperature,
- soil moisture,
- soil water-holding capacity (i.e., field capacity)
- method of irrigation,
- percent soil organic matter,
- previous field history (tillage),
- concentration of nutrients currently in the soil relative to previous applications,
- current crop's uptake efficiency, and
- frequency and type of tillage during the current cropping season.

For animal wastes and cover crops, the current IFAS recommendation is to estimate that 50% of the total N in the material will be available to the plant during a

typical growing season. However, the actual amount of nutrients available depends on the previously mentioned environmental factors. Although the animal industry is of considerable size in Florida, much of the manure is not recoverable due to acreage in grazing or on-farm application on other crops. There are a number of poultry operations that will sell stockpiled litter for a nominal price; however, shipping can be prohibitively expensive. Spent mushroom compost, a by-product of the mushroom industry in Florida, may be a source of compost for organic producers. If compost or manure is purchased in bulk and stored on site, the storage area must be designed to prevent runoff and leaching during periods of heavy rain. Producers should contact the certifier to make sure that any new information regarding commercial compost sources is properly reviewed and approved. The average nutrient content of meals and compost materials used in organic production is summarized in Table 3.

Mined and Other Natural Products

Non-animal fertility inputs approved for use in organic farming systems are applied in their natural, unprocessed state and have a range of solubility rates. Some mined inputs that would not be eligible for use in organic production include certain types of synthetic processing or the addition of a prohibited substance after mining (such as certain pelletizing agents). For example, although most agricultural lime is allowed for use in organic systems, hydrated lime (slaked lime Ca(OH)₂) and burnt lime (calcium oxide CaO) are prohibited due to their method of manufacture. The average nutrient analysis of common mined or natural amendments used in organic production is summarized in Table 4.

Nitrogen is frequently the most limiting nutrient in vegetable production systems, and N management can be challenging in organic production systems due to the variability of N concentrations in organic amendments. Furthermore, because the rate of N release depends on many environmental factors, even the best estimate may not always reflect the actual release rate. Nitrogen is typically supplied in sufficient concentrations to support crop growth in organic sources, but naturally occurring nitrates present in mined N rock—such as sodium nitrate (NaNO₃), Chilean nitrate, or bulldog soda—may be used. Sodium nitrate contains approximately 27% sodium (Na), and therefore applications of sodium nitrate should be carefully monitored to avoid the risk of increasing soil or water sodium concentrations. Pending future rules regarding the use of sodium nitrate, the previous limit of 20% of a crop's total N requirement has been lifted as of October 2012.

Sodium nitrate is prohibited under some foreign national standards (European Union, Japan) so if the crop is for export (such as citrus juices) then producers will need to refrain from using sodium nitrate. Other plant nutrients including P, K, Ca, magnesium (Mg), Cu, S, manganese (Mn), and Zn are typically found in ample quantities in lime, organic amendments, and mined products. If producers can document a soil deficiency, then certain synthetic materials with relatively high solubility may be used with approval from their certifying agent, including sulfates, carbonates, oxides, or silicates of Zn, Cu, iron (Fe), Mn, molybdenum (Mo), selenium (Se), and cobalt (Co).

Commercial Formulations

A number of manufacturers have formulated fertilizers for organic cropping systems that are composed of dehydrated granular by-products of animal production. These products are typically composed of materials such as feather meal, bone meal, and poultry litter, plus other mined sources of P, K, and some micronutrients. Examples of available formulations are 8-5-5, 4-2-2, and 4-2-3. Analysis is guaranteed and the dry granulated forms are easy for producers to calibrate and apply, but these materials can be expensive.

Cover Crops

Cover crops are an integral part of organic production systems and are any crop used for any other purpose other than to harvest as a food product. They are used to improve soil physical properties, add organic matter, reduce erosion, prevent sandblasting, supply nutrients, suppress weeds, and interfere with pest life cycles. Producers should identify specific objectives in the farming system and consider the potentially negative consequences (alternate host to insect or disease, leaches compounds that may be toxic to small seeded annuals) prior to selecting cover crop species. The cover crop should be easy to establish with minimal to no inputs, satisfy the producer's objective, not compete with the primary crop, be managed with existing equipment and labor resources, and perform well under various environmental conditions.

In Florida, cover crops that have been used successfully for partial N supply are sunn hemp (*Crotalaria juncea* L.), cowpea (*Vigna unguiculata* L.), velvetbean (*Mucuna deeringiana* L.), hairy vetch (*Vicia villosa* L.), crimson clover (*Trifolium incarnatum* L.) and jointvetch (*Aeschynomene* spp.). Other species such as sorghum sudangrass (*Sorghum bicolor* × *S. bicolor* var. *sudanese* (Piper) Stapf) and cereal rye (*Secale cereale* L. 'FL401') are effective catch crops and are used for biomass production.

Leguminous species should be inoculated with an approved inoculum to ensure colonization by N fixing bacteria, unless the native soil has an adequate population. The majority of N that is returned to the soil following incorporation of a green manure is typically water-soluble nitrate. To moderate the potential for nitrate losses, producers can plant a mixture of cereal grains and legumes.

In most cases, when cover crops are present, weed suppression is attributed to increased competition for light, water, and nutrients. Some species, including rye, exude toxic substances through roots or incorporated stems and leaves into the soil. These substances are effective in killing some species of small seeded annuals and grasses, but may also be toxic to small seeded vegetable crops such as carrot and onion. In this instance, increasing the time between cover crop termination and vegetable planting, or using transplants rather than direct seed, may reduce the negative effects of plant chemicals. Many species of cover crops do an excellent job of suppressing weeds, though the crop must be managed properly to avoid undesired regrowth.

Some species of cover crops, including sorghum sudan grass and sunn hemp, are known to suppress nematode populations, while others such as hairy vetch (*Vicia villosa* L.) are associated with nematode population increases. More information on cover crops, including estimates of available nutrients, can be found on EDIS. See Annual Cover Crops in Florida Vegetable Systems, Parts 1–3 (HS387, HS389, and HS390; Treadwell et al. 2012 a,b,c) and in the online publication “Managing Cover Crops Profitably” by USDA Sustainable Agriculture Research and Education (SARE) at no charge on their website.

Seeds and Transplants

Seed (including cover crop seed), annual vegetable transplants (annual seedlings), and perennial plants must be certified organic unless the desired variety is commercially unavailable. “Commercially available” is defined by the NOP as any production input in an appropriate form, quality, or quantity to fulfill an essential function in a system of organic production. If no organic variety is available, then conventionally produced untreated seed or seed treated with an approved synthetic or non-synthetic material (i.e., clay) may be used with approval from your certifying agency. Seed used for the production of edible sprouts must be organic; the “commercially available” clause does not apply. Methods used to genetically modify organisms that are not possible under natural conditions or processes are prohibited in organic production. Prohibited methods include recombinant DNA technology, cell fusion,

and micro- or macroencapsulation. Examples of allowable natural methods include traditional breeding, fermentation, hybridization, in vitro fertilization, and tissue culture.

Producers should make a reasonable effort to locate organic seed and plants, and they will be required to document their attempts on record. Producers are encouraged to save seed labels with documentation of commercial unavailability. Currently, the demand for organic seed and transplants frequently exceeds supply. The frequently higher cost of organic seeds and plants is not considered a valid reason to purchase conventional equivalents. As the demand for organic seed and plants continues to increase, it is anticipated that over time the availability will increase and costs will decline.

Planting stock is defined as either annual or perennial, and the rules governing each are different. *Annual seedlings* are plants grown from seed that will complete their life cycle or produce harvestable yield in the same year they were sown. When the seedlings are removed from their original production location, transported, and replanted, they are considered transplants. Producers who grow their own transplants must also satisfy regulations regarding the use of pressure-treated wood in greenhouses and related structures, use of organic materials in soil mixes, and other inputs. Two exceptions exist for the purchase of organic annual seeds and seedlings: (1) if federal or state regulations require seed treatment for phytosanitary reasons, then producers are allowed to use seeds or seedlings treated with prohibited substances; and (2) if original organic transplants were destroyed by an act of nature, fire, or other business interruption, conventional replacement transplants may be used.

Perennial plants are those that will be maintained and harvested for more than two harvest cycles, or sold as a plant. If it is necessary to use non-organically produced planting stock for perennial crops, then produce from that plant, or the plant itself cannot be marketed as organic for at least one year following transplanting. For example, blueberries from nonorganic replacement trees or shrubs in an organically produced area can only be sold on the conventional market until all the fruit is harvested from that plant. As always, consultation with your agency is highly recommended prior to purchasing non-organically produced seed or stock to ensure compliance.

Pest Management

Successful pest management strategies will reflect the producers' knowledge of the pests most likely to occur on

crops, the life cycles of those pests, alternate plant hosts, approximate time of emergence, method of dispersion, and more. The challenge is to manage the interacting factors of the ecological environment to minimize pest damage to crops. Due to the limited number of approved substances for pest control, this is achieved largely through prevention. Regardless of the pest, organic farmers emphasize pest prevention through avoidance strategies, including sanitation, rotation, the timing of planting, resistant crop varieties, and similar best management practices. In addition to avoidance strategies, producers can employ tactics that exaggerate naturally occurring control mechanisms, such as attracting beneficial insects. Using many complimentary strategies or "many little hammers" to manage pests provides flexibility and strength to the pest management plan.

A three-level approach is used to ensure producers are managing pests using physical, biological and cultural means prior to relying on approved substances. Although the distinction between the levels is not always clear, the levels are defined by the NOP as follows:

Level One—Management practices that reduce the potential for the development of pests. These are proactive measures the producers must take to eliminate the need for additional management.

Level Two—Involves the use of traditional management practices, primarily cultural and mechanical steps or the use of natural products.

Level Three—Allows for the use of a wider array of biological and botanical products, including allowable synthetics.

Producers must document their efforts toward compliance on the first two levels. Because some proactive measures are also traditional management practices, the distinction between Levels One and Two is often minimal. Producers should not concern themselves too much with placing practices in Level One or Two, and rather should develop a pest management strategy to ensure all steps are taken to avoid reliance on Level Three controls. Examples of Levels One and Two practices include alternating plant families or plant growth habits in time and space (rotation, intercropping), establishing predator populations in border crops, selecting resistant varieties, and using row covers. Level Three controls are the producer's last line of defense and should only be used when all other options have been exhausted. If a producer anticipates the need for curative controls (Level Three), then that information should be included in the Organic System Plan. This may occur

when the sum of preventative practices are predicted to be insufficient for adequate control.

Weed Management

Weeds are frequently cited as the primary pest in organic cropping systems. Due to the limited number of effective herbicide controls, prevention is the best strategy. When devising a weed management plan, producers should consider the weed density and spectrum of species present, and avoid locating crops in fields known to have heavy infestations of weeds. Weed populations can be decreased over time with cultural and mechanical practices. An excellent discussion of mechanical weed control implements and their use is found in the SARE publication “Steel in the Field” and is available on the SARE website at no cost.

Small-seeded annuals can be depleted with repeated shallow tillage, soil inversion, and plant and plastic mulches. Large-seeded annuals and perennial weeds often require additional methods such as rotation or solarization. Weed species that propagate vegetatively, such as nutsedge, are difficult to control in organic systems. Research has demonstrated that solarization has been effective in reducing nutsedge populations. Some cover crop species, including rye and sunn hemp, are known to exude chemical toxins that help suppress weeds (including nutsedge) during the season they are grown. Targeted (drip) irrigation that is direct to the crop minimizes the water and nutrient resources available to the weeds and helps to inhibit germination of some species.

Insect Management

On the organic farm, ecological pest management is virtually site-specific. An understanding of insect life cycles is critical to avoid infestation and risk of crop failure. Each operation will develop a pest management plan that is effective and appropriate to their needs. Three key strategies to ecological pest management are (1) select, grow, and rotate a variety of crops that have natural pest resistance or are unattractive to the pest typical of your operation, and provide crops with adequate nutrition to alleviate plant stress and optimize growth; (2) stress the insects by interrupting their life cycles, remove alternate food sources, and confuse them with various visual cues or pheromones; and (3) enhance populations of beneficial insects that attack insect pests by providing them food and habitat (Altieri et al. 2005). Although more research is needed on the effect of excess N and insect proliferation, most studies investigating mites and aphids found a positive correlation between excess N and population densities (Altieri et al. 2005).

Cover crops in rotation with primary crops can interrupt insect life cycles and confuse some pests, discouraging colonization. Cover crops also attract many predatory and parasitoid beneficial insects that reduce pest populations. An alternative to cover cropping in rotation is to plant a strip or border of flowering plants known to attract natural enemies, such as sunflower (*Helianthus* spp.), mustards (*Brassica* spp.), alfalfa (*Medicago sativa*), and Queen Ann’s lace (*Daucus carota*). Beneficial insects can also be purchased from commercial suppliers and released on site and can be used to colonize an area for the first time or to augment existing populations. Beneficials should have adequate food and shelter in the field if released prior to immigration of their preferred host (insect pest), and this can be accomplished using strips or borders of suitable plant species. Orders should be made in advance, as it may take several weeks for the order to arrive.

Disease Management

As with insect pest management, an understanding of the disease cycle is precursory to developing a control plan. Sanitation, crop diversification through rotation, biological controls, and other cultural practices are common approaches to disease prevention. Sanitation practices during crop production should be followed, such as disinfecting tools after use. A number of materials, including peracetic acid, hydrogen peroxide, chlorine, chlorine dioxide, and sodium hypochlorite (bleach) are included on the National List of Synthetics allowed for use in organic production systems for sanitation purposes, pending the certification agencies’ approval. Few curative controls are available.

Diseases caused by bacteria, such as bacterial spot on tomato and pepper (*Xanthomonas campestris* pv. *vesicatoria*) and common scab on potato (*Streptomyces scabies*), are controlled mostly with cultural practices. Resistant varieties should be selected, and if not available, seed can be treated with hot water prior to planting. Because bacterial diseases can be spread by splashing water, drip irrigation is preferred. Furthermore, scab can be suppressed by maintaining a pH below 5.6.

Diseases caused by fungi and similar organisms are avoided by using the strategies listed above, with some special considerations. Because many fungal organisms can remain in the soil for many years, rotation is especially important. Rotating with Brassica species that have high concentrations of glucosinolates can be effective in reducing black scurf (*Rhizoctonia solani*) when incorporated as a green manure prior to potato (Caldwell et al. 2005). Crops that are alternate hosts to the disease organism should be

avoided, with special attention to removing weedy hosts. Avoid crop-to-soil contact by staking or mulching, and manage soil moisture with raised beds and drip irrigation to prevent excess soil water retention.

Biological controls are increasingly becoming an important tool to manage disease in organic systems. Products such as PlantShield HC made from *Trichoderma harzianum* were effective in suppressing early blight in tomato in recent research (Caldwell et al. 2005). A beneficial fungus *Coniothyrium minitans* (Contans) reduces the survival rate of sclerotia (*Sclerotinia sclerotiorum*) when applied preplant or during an infection of white mold in solanaceous crops (Caldwell et al. 2005). In addition to commercially available products, compost may contain organisms that reduce some pathogens.

Copper is commonly used in a number of formulations depending on the crop and disease organism, but reports on the effectiveness of copper varies with the site. In addition, the over-application of copper on some sites can lead to copper toxicity in crops as well as copper resistant pathogens. To avoid this, the EPA is currently soliciting comments from organic producers to learn about their copper application practices for a revision of copper application rates and restrictions.

Food Safety

The ongoing national dialogue on food safety has increased consumer's concerns over food safety risks, both real and perceived. The National Organic Program defines production methods and ensures that organic products reach consumers without cross-contamination with prohibited substances and non-certified products. However, it is not specifically a food safety program. Commercial organic producers are held to the same standards of food safety as non-certified producers. Due to the vigorous record-keeping protocols required for USDA-certified organic producers, obtaining additional certification for a farm food-safety program may not require an additional significant time investment. Based on current research data, organic production systems are subject to many of the same risks as conventional systems, and it is not possible to generalize that food safety risks due to contamination by enteropathogens such as *E. coli* are greater in one system compared to the other (Winter and Davis 2006; Smith-Spangler et al. 2012; Forman and Silverstein 2012). However, use of compost, manure, and other biologically active inputs does require additional care to ensure consumer safety. Strategies to minimize food safety risks on organic farms are reviewed in EDIS FCS8872 (Simonne and Treadwell 2013).

Economics of the Organic Industry

Organic farming is practiced in approximately 160 countries throughout the world, and more than 91 million acres are currently under organic management (Willer and Kilcher 2011). The largest land areas under organic production are in Oceania (30 million acres), Europe (23 million acres), and Latin America (21 million acres). In comparison, the United States has 5 million acres in organic management in all 50 states. The latest figures released by the USDA in December of 2010 reported 12,941 organic crop and livestock farms (USDA ERS 2010).

The domestic organic industry continues to expand despite a stagnant economy. In 2010, the organic industry grew 7.7%, over 7% more than the rest of the industry, and it generated over 28 billion in sales. Total organic food sales account for 4% of the US market, but fresh market organic fruit and vegetable sales is the top selling retail category and accounts for 12% of the total domestic market (Organic Trade Association 2011). Statistics on US imports and exports of organic products are inconsistent, because the organic product codes have not been added to the US and international harmonized system of trade codes, but the USDA estimated the value of organic imports from \$1–\$2 billion and exports at \$125 million in 2002 (USDA ERS 2013). Many of the organic products sold in the United States are imported from Australia and New Zealand (kiwi-fruit, apples, and meat) and Latin America (coffee, bananas, sugar, cereal, and meat). Other nations have similar organic programs, but all imported organic agricultural products must satisfy criteria established by the USDA's NOP before they can be marketed as organic in the United States. Similarly, exported organic agricultural products must also satisfy the organic regulations of the importing country. Industry experts predict the organic industry will continue to expand at the current rate in the United States and there is no consensus about when market saturation may occur.

In Florida, over 130 operations totaling over 12,500 acres are certified under the NOP. Much of this crop acreage is in citrus production, with the remainder in mixed vegetables, herbs, and ornamentals. In addition, there are several certified organic livestock operations in the state. Due to the demonstrated market demand for organic meat and dairy products in the state, opportunities exist for market expansion. Approximately 33 certified handlers are certified in Florida, and that number includes operations that increase the value of their products with minimal on-farm processing such as bagged salad mix, as well as larger industrial processors (sugar). Due to the increased consumer demand, direct sales opportunities have increased in recent years and

include farmer's markets, subscription sales (Community Supported Agriculture or CSAs), and a minor share to restaurants. Traditional wholesale market opportunities account for the majority of gross sales for producers. However, because the Florida Department of Agricultural Statistics does not take data on the proportion of sales that are sold directly to the consumer, it is not possible to assess how much of Florida's organic fresh market produce is consumed within the state.

Additional Information

To view the entire National Organic Standards, see the following website: The National Organic Program (NOP): <http://www.ams.usda.gov/AMSV1.0/nop>

For a list of OMRI approved materials, see the following website: <https://www.omri.org/>

To obtain recommendations and information on organic production, visit the following websites:

- IFAS UF Small Farms and Alternative Enterprises: <http://smallfarms.ifas.ufl.edu/>
- Florida Organic Growers and Consumers, Inc.: <http://www.foginfo.org/>
- eXtension's Organic Agriculture Resource Area: http://www.extension.org/organic_production
- Appropriate Technologies Transfer for Rural America (ATTRA): <http://www.attra.org>
- USDA's Sustainable Agriculture Research and <http://www.sare.org>
- The Rodale Institute's Farm Resource Area: <http://rodaleinstitute.org/farm/>

For more information on the economics of the organic industry, visit the following websites:

- USDA's Economic Research Service, Organic Agriculture: <http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture.aspx#.UdL1wvnVB1Y>
- International Federation of Organic Movements: (IFOAM) www.ifoam.org

Literature Cited

Altieri, M. A., C. I. Nicholls and M. A. Fritz. 2005. Manage Insects on Your Farm: A Guide to Ecological Strategies. Sustainable Agriculture Network, SARE. Beltsville, MD.

Caldwell, B., E. B. Rosen, E. Sideman, A. Shelton and C. Smart. 2005. Resource Guide for Organic Insect and

Disease Management. Cornell University. New York State Agricultural Experiment Station, Geneva, NY. 169 pp.

Dimitri, C. and C. Green. 2003. Recent growth patterns in the U.S. foods market. Agriculture Information Bulletin No. AIB777. United States Department of Agriculture, Economic Research Service. 23 March 2006. <http://www.ers.usda.gov/publications/aib777/>

Dimitri, C. and L. Oberholtzer. 2005. Market-Led Growth vs. Government-Facilitated Growth: Development of the U.S. and EU Organic Agricultural Sectors. USDA-ERS Outlook Report No. (WRS0505) pp. 26. August.

Florida Department of Agriculture and Consumer Services. 2005. Water quality/quantity best management practices for Florida vegetable and agronomic crops. Florida Department of Agriculture and Consumer Services, Office of Agricultural Water Policy. http://www.floridaagwaterpolicy.com/PDF/Bmps/Bmp_VeggieAgroCrops2005.pdf

Forman, J. and J. Silverstein. 2012. Organic Foods: Health and Environmental Advantages and Disadvantages. Pediatrics. 130 (5): E1406-E1415.

Lampkin, N. 1990. Organic Farming. Farming Press Books, Ipswich, UK. 701 pp.

Olson, S. and B. Santos (Eds.) 2012. Vegetable Production Handbook for Florida EDIS CV100: <https://edis.ifas.ufl.edu/cv100>

Organic Trade Association. 2011. U.S. Organic Industry Overview. Accessed June 19, 2013. <http://www.ota.com/pics/documents/2011OrganicIndustrySurvey.pdf>

Treadwell, D., S. Park Brown, J. Stephens and S. Webb. 2013. Organic Vegetable Gardening in Florida. EDIS HS1215 <http://edis.ifas.ufl.edu/hs1215>

Simonne, A. and D. Treadwell. 2013. Minimizing Food Safety Hazards for Organic Growers. EDIS FCS8872. <http://edis.ifas.ufl.edu/pdffiles/FY/FY106200.pdf>

Smith-Spangler, C., M. Brandeau, G. Hunter, C. Bavinger, M. Pearson, P. Eschbach, V. Sundaram, H. Liu, P. Schirmer, C. Stave, I. Olkin, and D. Bravata. 2012. Are Organic Foods Safer or Healthier than Conventional Alternatives? Annals of Internal Medicine. 157:348-366.

Sullivan, P. 2001. Alternative Soil Amendments. NCAT ATTRA Publication #IP054. Accessed online 14 February. <http://www.attra.org/attra-pub/altsoilamend.html>

Swisher, M.E. and R. Koenig. 2005. The National Organic Standards: What Service Providers Need to Know. In Press (EDIS).

Treadwell, D.D., D.E. McKinney, N.G. Creamer. 2003. From philosophy to science: A brief history of organic horticulture in the United States. *HortScience*. 38: 1009-1014.

Treadwell, D.D., W. Klassen and M. Alligood. 2012a. Annual Cover Crops in Florida Vegetable Systems. Part I. Objectives: Why Grow Cover Crops? EDIS. <http://edis.ifas.ufl.edu/HS387>

Treadwell, D.D. W. Klassen and M. Alligood. 2012b. Annual Cover Crops in Florida Vegetable Systems. Part II. Production. <http://edis.ifas.ufl.edu/HS389>

Treadwell, D.D. W. Klassen, M. Alligood and S. Shewey. 2012c. Annual Cover Crops in Florida Vegetable Systems. Part III. Buying and Sourcing. <http://edis.ifas.ufl.edu/HS390>

[USDA ERS] United States Department of agriculture and Economic Research Service. 2006. Data sets: Organic production. Table 2. U.S. certified organic farmland Acreage, livestock numbers, and farm operations, 1992-2008. Accessed online 2 July 2013. <http://www.ers.usda.gov/data-products/organic-production.aspx#25762>

[USDA ERS] United States Department of agriculture and Economic Research Service. Organic Trade. Accessed online June 19, 2013 <http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-trade.aspx#.UdMt7PnVB1Y>

Willer, H. and L. Kilcher (Eds.). 2011. The World of Organic Agriculture. Statistics and Emerging Trends 2011. International Federation of Organic Agriculture Movements (IFOAM), Bonn, Germany, and Research Institute of Organic Agriculture (FiBL), Frick, Switzerland.

Winter, C.K. and S.F. Davis. 2006. Scientific Status Summary: Organic Foods. *J. Food Science* 71(9): R117-R124.

Zublena, J.P., J.V. Baird and J.P. Lilly. 1997. Soil Facts: Nutrient Content of Fertilizer and Organic Materials. North Carolina Cooperative Extension Service. Pub. # AG-439-18, Accessed online June 19, 2013. <http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/AG-439-18.pdf>

Table 1. Summary of product label regulations under the National Organic Program rule

Product	Must identify ingredient as organic in the ingredient panel	Must display the phrase "Certified organic by" and contact information for the certifying agency	Display the Organic Seal (Figure 1)	Display the certifying agency seal (Figure 2)
100% Organic	YES	YES	OPTIONAL	OPTIONAL
95% Organic	YES	YES	OPTIONAL	OPTIONAL
70% or more Organic	YES	YES	OPTIONAL	OPTIONAL
Less than 70% Organic	OPTIONAL	NO	NO	NO

Table 2. Average nutrient content of common animal manures used in organic production¹

MANURES	TKN	P_2O_5	K_2O	Comment
		$P \times 2.2910 = P_2O_5$	$K \times 1.2047 = K_2O$	
		Lb/ton wet basis		
Dairy				
Fresh	10	5	8	4% Ca, 2% Mg, 1% S
Paved surface, scraped	10	6	9	5% Ca, 2% Mg, 2% S
Liquid manure (lbs per 1,000 lbs liquid)	23	14	21	10% Ca, 5% Mg, 3% S
Beef				
Fresh	12	7	9	5% Ca, 2% Mg, 2% S
Unpaved feedlot	26	16	20	14% Ca, 6% Mg, 5% S
Fresh	12	7	9	5% Ca, 2% Mg, 2% S
Broiler				
Fresh	26	17	11	10% Ca, 4% Mg, 2% S
Stockpiled litter	36	80	34	54% Ca, 8% Mg, 12% S
Fresh	26	17	11	10% Ca, 4% Mg, 2% S
Horse				
Fresh	12	6	12	11% Ca, 2% Mg, 2% S
Layers				
Fresh	26	22	11	41% Ca, 4% Mg, 4% S
Undercage, scraped	28	31	20	43% Ca, 6% Mg, 7% S
Deep pit	38	56	30	86% Ca, 8% Mg, 9% S
Liquid (lbs per 1,000 lbs liquid)	62	59	37	35% Ca, 7% Mg, 8% S
Turkey				
Fresh	27	25	12	27% Ca, 2% Mg
House litter	52	64	37	35% Ca, 6% Mg, 9% S
Stockpiled litter	36	72	33	42% Ca, 7% Mg, 10% S
Other				
Bat guano	5.5	8.6	1.5	
Seabird guano	12.3	11.0	2.5	

¹Adapted from J.P. Zublena, J.V. Baird and J. P. Lilly, Soil Facts: Nutrient Content of Fertilizer and Organic Materials, North Carolina Cooperative Extension Publication # AG-439-18 (1997) and P. Sullivan, Alternative Soil Amendments, NCAT/ATTRA Publication # IP054 (2001).

Table 3. Average nutrient content of meals and compost materials used in organic production (percentage on a dry-weight basis)¹

MEALS and COMPOST MATERIALS	%N	%P ₂ O ₅ P x 2.2910 = P ₂ O ₅	%K ₂ O K x 1.2047 = K ₂ O	Comment
Alfalfa meal	2.5	0.5	2.0	Commonly used as animal feed.
Blood meal	12.0–15.0	2.0	0.8	High in ammonia, can burn. Expensive.
Bone meal, raw	4.0	21.0	0.2	22% Ca, 0.3% Mg
Citrus pomace	1.0	0.1	1.0	Heavy and wet. Best composted prior to use.
Cottonseed meal	7.0	3.0	1.5	Most certifiers restrict or prohibit use due to pesticide residues in the seeds.
Crab meal	2.0–10.0	0.2–3.5	0.2	Slow release. Also used for nematode suppression
Egg shells	1.2	0.4	0.2	
Feather meal	15.0	0	0	
Fish meal	10.0–13.0	4.0	0	Available in wettable powder. Also a source of sulfur.
Fish emulsion	4.0	1.0–4.0	1.0	Acid digest (4-1-1), enzyme digest (4-1-1).
Kelp meal	1.0	0.5	2.0–10.0	Provides up to 60 trace elements. May have high salt concentration.
Mushroom compost (spent)	2.0	0.74	1.46	
Oak leaves	0.8	0.4	0.2	Readily available from municipalities, however often contaminated with unwanted trash. Private commercial sources may be an alternative. May acidify soil over time.
Oyster shell siftings	0.4	10.4	0.1	
Peanut hull meal	1.2	0.5	0.8	
Peanut meal	7.0	1.5	1.2	
Pine needles	0.5	0.1	0	
Sawdust	0.2	0	0.2	
Seaweed, dried	0.7	0.8	5.0	
Shrimp heads	7.8	4.2	0	
Shrimp waste	2.9	10.0	0	
Soybean meal	7.0	1.2	1.5	Protein supplement for animals. Can be expensive.
Spanish moss	0.6	0.1	0.6	
Worm castings	1.5	2.5	1.3	

¹Adapted from J. P. Zublena, J.V. Baird and J.P. Lilly, Soil Facts: Nutrient Content of Fertilizer and Organic Materials, North Carolina Cooperative Extension Publication # AG-439-18 (1997) and P. Sullivan, Alternative Soil Amendments, NCAT/ATTRA Publication # IP054 (2001).

Table 4. Average nutrient content of mined or natural amendments used in organic production¹

MINERALS	%N	%P ₂ O ₅ P x 2.2910 = P ₂ O ₅	%K ₂ O K x 1.2047 = K ₂ O	Comment
Percentage on a Dry-Weight Basis				
Nitrogen Materials				
Sodium nitrate NaNO ₃ (R)	16	0	0	Recommended use is 20% of total crop N; however, more can be used with approved plan for managing sodium
Phosphorous Materials				
Colloidal phosphate	0	16.0	0	Availability moderately faster than phosphate rock.
Phosphate rock	0	2-35	0	Slow availability.
Granite (ground)	0	0	4.5	Mostly feldspar. Slow availability.
Greensand (Glauconite)	0.0	1.5	5.0-7.0	Used as a soil conditioner, rich in iron, magnesium, silica and trace minerals. Slow availability. Expensive.
Potassium Materials				
Potassium chloride (muriate of potash) KCl	0	0	60-62	
Potassium magnesium sulfate (sulfate of potash magnesia, or Langbeinite) (K ₂ SO ₄ • 2MgSO ₄ / MgSO ₄ K ₂ SO ₄ 6H ₂ O) ₄	0	0	22	11% Mg, 23% S
Potassium sulfate (K ₂ SO ₄)	0	0	50	18% S
Calcium Materials				
Calcitic limestone (CaCO ₃)	0	0	0.3	32% Ca, 3% Mg.
Dolomitic limestone (CaCO ₃ + MgCO ₃)	0	0	0	21%–30% Ca, 6%–12% Mg
Gypsum (CaSO ₄ • H ₂ O)	0	0	0.5	22% Ca, 17% S
Magnesium Materials				
Magnesium sulfate (Epsom salt) (MgSO ₄ • 7H ₂ O)	0	0	0	10% Ca, 14% S
Magnesium sulfate (Kieserite) (MgSO ₄ • H ₂ O)	0	0	0	17% Ca, 23% S
Boron Materials				
Solubor (Na ₂ B ₈ O ₁₃ • 4H ₂ O)	0	0	0	20.5% B

¹Adapted from Donald N. Maynard and George J. Hochmuth, Knott's Handbook for Vegetable Growers 4th Edition (1997) and J.P. Zublena, J.V. Baird and J.P. Lilly, Soil Facts: Nutrient Content of Fertilizer and Organic Materials, North Carolina Cooperative Extension Publication # AG-439-18 (1997).