

Organic Vegetable Production¹

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This document serves as a general introduction to organic production. For additional information on organic crop or livestock production, contact your county Extension office or an accredited certifying agency. For complete regulations, refer to the USDA's National Organic Program.

Economics of the Organic Industry

The original philosophy that guided organic farming emphasized the use of on-farm or local resources and avoided the use of synthetic fertilizers and pesticides (Treadwell et al., 2003). The prevailing approach was to rely on biological and ecological processes for soil fertility and pest control, and was accomplished through the use of crop rotations, the addition of crop residues and animal manures to the soil and the use of biological pest control to maintain soil productivity and tilth, supply plant nutrients, and regulate insects, weeds and diseases. Original organic farmers saw these strategies as a way to produce food for their community in a manner that was in synchrony with nature. Due to the efforts of these pioneers and the support and advocacy of a diverse group of consumers, scientists, and policy makers, the practice of organic farming is now widespread.

Organic farming is practiced in approximately 120 countries throughout the world and more than 31 million hectares are currently under organic

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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.

management (Willer and Yussefi, 2006). Countries with the largest land area under organic production are Australia (10 million hectares), Argentina (3 million hectares) and Italy (1.2 million acres) (Willer and Yussefi, 2006). In the U.S., there are over 10,500 certified organic farms comprising one million hectares or 0.3% of the total domestic agricultural production area (Willer and Yussefi, 2006). In 2003, the United States and the European Union (EU) market accounted for 95% of the global organic foods market (Dimitri and Olberholtzer, 2005). Although the U.S. market is slightly larger than the EU, the proportion of organically managed land is greatest in the EU compared to the United States and other comparable countries due in part to governmental price supports, economic incentives for land conversion, and increased funding for research, education, and marketing (Dimitri and Olberholtzer, 2005).

Since 1990, the U.S. organic market has grown, on average, 20% a year (Dimitri and Green, 2003). The USDA AMS (2004) reports that organic foods are now sold in 73% of all conventional food markets. Revenues from the sales of organic food and beverages were 14.5 billion dollars in 2005 (Willer and Yussefi, 2006). Fresh market organic fruits and vegetables account for 4.58 % of the total domestic market. Many of the organic products sold in the United States are imported from Australia and New Zealand (kiwifruit, 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 United States Department of Agriculture (USDA) National Organic Program (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 when market saturation may occur.

In Florida, over 100 operations totaling over 12,500 acres are certified under the NOP. Approximately 6,000 of those acres are in citrus production with the remainder in mixed vegetables, herbs, and ornamentals. In addition, there are several

certified organic livestock and poultry (layers and pullets) operations in the state. Due to the demonstrated market demand for organic meat and dairy products in the state, opportunities exist for market expansion. Sales of organic products by Florida producers exceeded 4 million dollars in 2002 (Austin and Chase, 2004; USDA NASS, 2003). Approximately 33 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 increased consumer demand, direct sales opportunities have increased in recent years and include farmers markets, subscription sales (community supported agriculture, or CSA) 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.

The National Organic Program

The National Organic Program (NOP) and the National Organic Standards Board (NOSB) were created under the authority of the Organic Foods Production Act of 1990 to establish organic production standards for the purpose of consumer protection and providing a uniform standard of production for all products labeled organic in the U.S. marketplace. The NOSB, composed of 15 members appointed by the Secretary of Agriculture from across the U.S., provides recommendations to the Secretary regarding the implementation of the NOP. 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.

Certification Process in Brief

Certified organic production is the process of satisfying and maintaining the stringent production

standards established by the NOP and validated by an accredited certifying agency. These 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 advertising their products as organic is required 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.

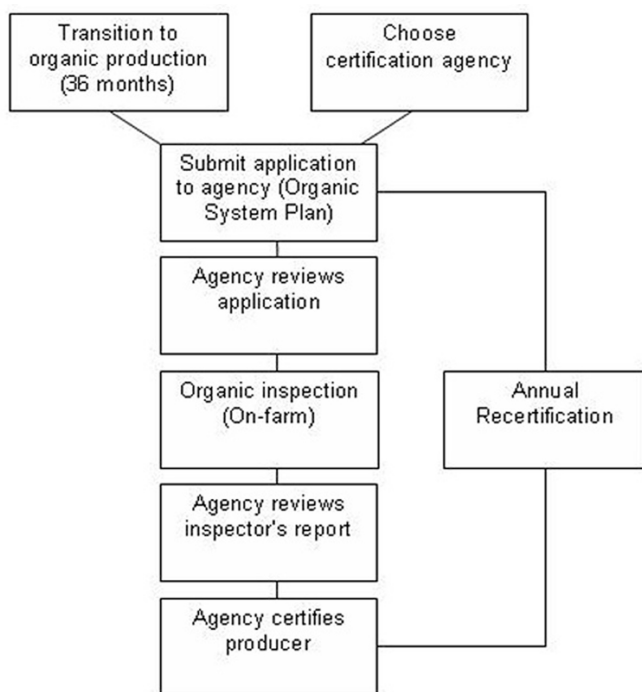


Figure 1. Flow Chart of the Process of Organic Certification

The basic steps to certification are listed in Fig. 1 (Swisher and Koenig, 2006). Producers are required to design and adhere to an Organic System Plan 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 list of accredited agencies is located at the NOP's website <http://www.ams.usda.gov/nop/indexIE.htm>. When selecting an agency, producers should consider cost of certification, accessibility and experience among other factors.

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. Costs are calculated either by acreage or by anticipated gross sales.

Applying the Organic Label

Labeling of organic products in the marketplace is regulated by the NOP. The use of the organic seal is not a requirement, but producers are obligated to identify their certifying agency with a written statement on processed products. There are a number of labels that can be used to designate organic products depending on the amount of organic agricultural ingredients and approved nonagricultural ingredients a processed product contains. For single-ingredient agricultural products including raw fruits and vegetables, the product claim is clear: if it is certified and labeled as organic, then it is 100% organic. However, when products contain multiple ingredients, product labeling may be confusing for the consumer. The use of the word “Organic” as

well as use of the USDA seal (Fig. 2) and seal of the certifying agency (Fig. 3) depends primarily on the percentage of organic ingredients by weight or volume in the product (Table 1). Among multi-ingredient packaged products, there are four general categories of marketing claims:

100 % Organic = 100% of ingredients are certified organic, excluding salt and water.

Certified Organic = 95% of ingredients are certified organic, excluding salt and water.

Made with Organic Ingredients = At least 70% of ingredients are certified organic, excluding salt and water.

No Label Claims = Less than 70% of ingredients are certified organic.



Figure 2. USDA Organic Seal

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 organic for mineral fertilizers and biological and cultural pest controls for synthetic pesticides. However, the misapplication of organic materials or pest control strategies will effectively disrupt the function of ecological and biological cycles and may lead to detrimental outcomes (Lampkin, 1990). To help producers manage these natural cycles in a proactive manner, the NOP requires them to complete a soil and pest management plan unique to their operation called the Organic System Plan (OSP). The OSP, or Farm Plan as it sometimes called, is submitted to the certification agency for review and approval. Producers may get assistance with the

development of their plan from a county Extension agent or other service providers. It is important to note that certifiers cannot provide consultation services to a producer. They cannot consult on matters of pest control strategies or rotations, nor suggest particular products, nor recommend a crop consultant. These things would constitute 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 provide information about their certification process, including fees. Agencies are allowed to provide publicly available information and resources such as Extension publications, lists of crop consultants and approved materials to producers, but they are not allowed to recommend a specific one.



Figure 3. Seal of a certifying agency

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 that 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.

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 be 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 the 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 hydrologic 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 non-organic), 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 nonorganic 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 Florida Organic Growers (FOG) at www.foginfo.org. For a

comprehensive guide to completing the Organic System Plan, please refer to the National Sustainable Agriculture Information Services (ATTRA) Organic Crops Workbook available at no charge on their Web site www.attra.org.

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 their 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, refer to Lampkin (1990) and visit the ATTRA website, www.attra.org.

Approved Amendments

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. The NOSB continually reviews and recommends substances to be included on the National List. The NOP regulation includes the National List, and amendments to the list are updated through a federal register process. The National list and amendments to the list are available from any certifying agency or the NOP Web site. In general, all synthetic substances are prohibited and all natural products are allowed unless they appear on the allowed or 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 from 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 in the proper manner.

Substances proposed for use in production, handling and processing are subject to a rigorous review process by the NOSB that includes a technical review by experts who determine whether or not the substance satisfies the legal criteria in the OFPA and Final Rule of the NOP. All substances approved by the National Organic Program must be used as indicated on the National List which is organized in specific use categories such as an insect control or a 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 allowed and prohibited synthetic and non-synthetic products for 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. Many products used by organic producers and handlers contain multiple ingredients rather than individual (generic) substances. Companies pay a fee to OMRI and voluntarily disclose their formulations and other necessary proprietary information for a thorough review of their brand name products. 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. Because product labels do not provide information about inert ingredients in pesticides, the OMRI Products List is a reliable resource and contains a current and rather complete inventory of allowable products. However, because inclusion on the OMRI list is voluntary, omission from the OMRI list does not necessarily mean the substance is prohibited. Products that have been listed by OMRI as approved for use in organic production carry the label shown above (Fig. 4). OMRI makes no claims to product effectiveness; they only confirm the product is approved for use under the NOP. Producers find this list easy to use because OMRI provides several search options including by “brand

name” as well as “generic ingredient.” The OMRI brand name materials list is available to the public at no cost on their Web site www.omri.org, and additional publications are available for a fee.



Figure 4. OMRI Label.

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, additional substances other than the active ingredient are referred to as inert ingredients. Only inert ingredients included in the EPA's List 4 (Inerts of Minimal Concern) are allowed for use by the NOP, and some inerts in the EPA's List 3 (Inerts of Unknown Toxicity) are permitted if specifically included on the National List of approved synthetic ingredients. 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 (Fig. 5).



Figure 5. Optional NOP Label for EPA approved pesticides.

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 to control Med Fly in citrus were applied to organic oranges, then the producer would not be able to market the oranges as organic for that harvest cycle. However, if the oranges were Valencia, then a two-year waiting period may be necessary since it takes 2 years for fruit to mature and therefore to complete the harvest.

Soil Quality and Fertility Management

In organic cropping systems, advance planning of rotations, the addition of organic matter, and suitable tillage practices are necessary to enhance the nutrient management plan 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 root 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 plant materials on the soil surface or shallow-incorporated animal-based inputs. 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, 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 and 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 and cultivation during the growing season to control weeds and reduce insects. However, tillage disturbs soil structure and decreases the amount of organic matter in the soil. 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
- Suppressing some soil-borne pathogens
- Increasing predation of weed seeds by soil microbes
- 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 prior to each rotation when the rotation is short (less than three years), and at least every two to three years for longer rotations.

To avoid contamination of surface and groundwater associated with over application 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. 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 nitrogen, boron and sulfur. 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.

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. Most plant nutrients are supplied by natural sources of fertility including compost, animal manures, and leguminous cover crops. These natural sources may be supplemented by the application of mined sources of mineral nutrients and various formulations of minor nutrients.

Because 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. Most fertigation products are fish meals and emulsions that can be purchased as wettable powders. These products typically have a low nitrogen analysis and can be expensive, so providing a substantial fraction of the necessary nitrogen through fertigation may not be economically feasible. To prevent nutrient losses associated with leaching and volatilization, a number of strategies should be employed, including but not limited to:

- Splitting fertilizer applications
- Incorporating nitrogen into moist but not saturated soil
- Using precision irrigation for site-specific irrigation
- Covering the surfaces of beds with plant or plastic mulches

- Submitting organic materials to a laboratory for analysis prior to use to avoid over application
- Avoiding the application of materials during periods of heavy precipitation
- 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 (FLDACS). These products come with a guaranteed analysis clearly stated on the product label. Materials not registered with FLDACS 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 product 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 to nitrogen 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 15 days (and five turnings) for windrow systems. Compost can be

formulated to meet the site-specific needs of the system. For instance, some compost formulations can reduce incidence of plant disease, while composts containing crushed egg or oyster shells can provide a valuable source of calcium. There are many possibilities, but producers should have a firm understanding of soil biology and chemistry to avoid potential complications.

If waste material is not composted according to the standards, 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 of the crop 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 manures, 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. This precaution should allow them to avoid accumulation of phosphorus, zinc and copper in production areas. For example, stockpiled turkey litter applied at a rate of 5 tons to the acre to a crop of sweet corn could supply 180 pounds of total N or approximately 90 pounds of plant available N. However, phosphorus (as P_2O_5 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 zinc 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
- 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
- Frequency and type of tillage during the current cropping season

For animal wastes and cover crops, the current UF/IFAS recommendation is to estimate that 50% of the total nitrogen 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. Much of it is lost in grazing or used in on-farm applications 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. For additional information on handling of poultry litter, please refer to the EDIS publication "Guidelines for Purchase and Application of Poultry Manure for Organic Crop Production" <http://edis.ifas.ufl.edu/HS217>. 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.

Mined and Other Natural Products

Nonanimal 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 input procedures that would not be

eligible for use in organic production include certain methods 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 $\text{Ca}(\text{OH})_2$) 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 3.

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 nitrogen 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 nitrogen rock such as sodium nitrate (NaNO_3 , Chilean nitrate, or bulldog soda) may be used for up to 20 percent of a crop's total N requirement. Regular applications of sodium nitrate are not allowed due to the risk of increasing soil sodium concentrations. Further, sodium nitrate is prohibited under some foreign National Standards (European Union - EEU, Japan - JAS) 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 phosphorus, potassium, calcium, magnesium, copper, sulfur, manganese and zinc 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 zinc, copper, iron, manganese, molybdenum, selenium, and cobalt.

Commercial Formulations

Recently, a number of manufacturers have released 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. A cover crop is a crop used for 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. A good cover crop is easy to establish with minimal to no inputs, satisfies the objective, does not compete with the primary crop, can be managed with extant equipment and labor resources, and performs well under various environmental conditions.

In Florida, cover crops that have been used successfully for partial nitrogen supply are sunhemp (*Crotalaria juncea* L.), cowpea (*Vigna unguiculata* L.), velvetbean (*Mucuna deeringiana* L.), hairy vetch (*Vicia villosia* L.), crimson clover (*Trifolium incarnatum* L.) and jointvetch (*Aeschynomene* spp.). Other species such as sorghum sudangrass (*Sorghum bicolor* X *S. bicolor* var. sudanese (Piper) Stapf) and cereal rye (*Secale cereale* L.) are effective catch crops and are used for biomass production. Leguminous species should be inoculated with an approved inoculum to ensure colonization by nitrogen fixing bacteria, unless the native soil has an adequate population. The majority of nitrogen 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, weed suppression is attributed to a preemptive use of 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 kill and vegetable planting or using transplants rather than direct seed may reduce negative effects of plant chemicals. Many species of cover crops do an excellent job of suppressing weeds; however care must be taken to manage the crop properly to avoid undesired regrowth.

Some species of cover crops including sorghum sudangrass and sunn hemp are known to suppress nematode populations, while others such as hairy vetch (*Vicia villosia* L.) are associated with nematode population increases. More information on cover crops, including estimates of available nutrients, can be found for free in the online publication “Managing Cover Crops Profitably” by USDA Sustainable Agriculture Research and Education (SARE) at their Web site, <http://www.sare.org>.

Seeds and Transplants

Seed, including cover crop seed, inoculum, 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 nonsynthetic material (i.e., clay) may be used. 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 and inoculant 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 produce their own transplants must also satisfy regulations regarding the use of pressure treated wood in greenhouses and related structures, and use of organic materials in soil mixes and other inputs. The National List has a section that lists products that can be used. 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 then 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 nonorganically 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 nonorganically produced seed or stock to ensure compliance.

Pest Management

In order to demonstrate an adequate pest management strategy for certification, producers need to know which pests they are likely to find on their crops, the life cycles of those pests, and other important factors like alternate plant hosts, approximate time of emergence, method of dispersion, and the like. 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, timing of plant, selection of pest-resistant 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 to manage pests provides flexibility and strength to the pest management plan.

A three-tiered 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 producer 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 to eliminate pests using the management practices in 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 category “One” or “Two,” but rather 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 plants with different 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 is 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 online for free, or in print for \$18.00 plus shipping (<http://www.sare.org/publications/weeds.htm>).

Small seeded annuals can be depleted with repeated shallow tillage, soil inversion, and the use of 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. Cover crop species including rye and sunhemp are known to exude chemical toxins that help suppress weeds (including nutsedge) during the season they are grown. Targeted (drip) irrigation that is directed 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 its 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 pests 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) provide food and habitat for populations of beneficial insects that attack insect pests (Altieri et al., 2005). Insect pests can be managed with appropriate fertilizer use, cover crops, rotation, and tillage. Although more research is needed on the effect of excess nitrogen and insect proliferation, most studies investigating mites and aphids found a positive correlation between excess nitrogen and population densities (Altieri et al., 2005). Rotating cover crops 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 Anne'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 because it may take up to 4 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 such as disinfecting tools after use should be followed during crop production. A number of materials including hydrogen peroxide, chlorine 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. Copper is commonly used in a number of formulations depending on the crop and disease organism, but reports indicate that the effectiveness of copper varies with the site. In addition, the over application of copper on some sites can lead to copper toxicity. 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.

Biological controls are increasingly becoming an important tool to manage disease in organic systems. Products such as PlantShield HC[®], made from *Trichoderma harzanium*, 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.

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 crop varieties should be selected, and if resistant varieties are not available then 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 strategies listed above with some special considerations. Because many fungal organisms can remain in the soil 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*) disease in potato. Brassica can be incorporated as a green manure before potatoes are planted (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.

Additional Information

To view the entire National Organic Standards, see the following website: National Organic Standards: <http://www.ams.usda.gov/nop/indexIE.htm>

For a list of OMRI approved materials, see the following website:
http://www.omri.org/OMRI_brand_name_list.html

To obtain recommendations and information on organic production visit:

IFAS/UF Small Farms and Alternative Enterprises: <http://smallfarms.ifas.ufl.edu/>

Florida Organic Growers:
<http://www.foginfo.org/>

Growing Small Farms:
<http://www.ces.ncsu.edu/chatham/ag/SustAg/>

Appropriate Technologies Transfer for Rural America (ATTRA) <http://www.attra.org>

USDA's Sustainable Agriculture Research and Education Program: <http://www.sare.org>

For more information on the economics of the organic industry:

USDA's Briefing Room:
<http://www.ers.usda.gov/Briefing/Organic>

International Federation of Organic Movements (IFOAM): <http://www.ifoam.org>

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<http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/>

Table 1. Summary of Product Label Regulations Under the NOP Rule.

Product Category	Must identify ingredient as organic in the ingredient panel	Must display the phrase "Certified organic by" (name and contact information of certifying agency)	Display the USDA Organic Seal (Fig. 1)	Display the certifying agency seal (Fig. 2)
100% Organic	YES	YES	OPTIONAL	OPTIONAL
95% Organic	YES	YES	OPTIONAL	OPTIONAL
+ 70% Organic	YES	YES	OPTIONAL	OPTIONAL
- 70% Organic	OPTIONAL	NO	NO	NO

Table 2. Average Nutrient Content of Common Animal Manures used in Organic Production (Pounds per Ton on a Wet Weight Basis)¹

MANURES	TKN	P ₂ O ₅	K ₂ O	Comment
	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 1,000lbs liquid)	23	14	21	10% Ca, 5% Mg, 3% S
Beef				
Fresh	12	7	9	5% Ca, 2% Mg, 2% S
Paved surface, scraped	14	9	13	5% Ca, 3% Mg, 2% S
Unpaved feedlot	26	16	20	14% Ca, 6% Mg, 5% S
Horse				
Fresh	12	6	12	11% Ca, 2% Mg, 2% S
Broilers				
Fresh	26	17	11	10% Ca, 4% Mg, 2% S
House litter	72	78	46	41% Ca, 8% Mg, 15% S
Stockpiled litter	36	80	34	54% Ca, 8% Mg, 12% 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 thousand 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	%P₂O	%K₂O	Comments
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	0.0	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 Production (Percentage on a Dry-Weight Basis)¹

MINERALS	%N	%P ₂ O ₅	%K ₂ O	Comment
Nitrogen Materials				
Sodium Nitrate NaNO ₃ (R)	16	0	0	Maximum allowable use is 20% of total N for a crop.
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)	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 HO)	0	0	0.5	22% Ca, 17% S
Magnesium Materials				
Magnesium Sulfate (Epsom Salt) (MgSO ₄ H 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, Knotts 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).