Organic Vegetable Gardening in Florida[1]

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Florida's climate allows homeowners to grow their own delicious vegetables nearly year-round. Basic vegetable gardening information, planting dates, reliable varieties, and much more can be found in the *Florida Vegetable Gardening Guide*, available from your county Extension office or online at http://edis.ifas.ufl.edu/vh021.

This publication is meant to be a companion document to the *Florida Vegetable Gardening Guide*. It is intended for the home gardener who prefers to use natural and organic materials as well as methods that are compatible with the philosophy of organic gardening. Commercial organic producers should refer to *Introduction to Organic Crop Production* (http://edis.ifas.ufl.edu/cv118).

What Is "Organic"?

The term *organic gardening* is of fairly recent origin. The word *organic* describes the "natural method of gardening and farming" and is commonly attributed to J. I. Rodale, founder of the Rodale Institute and publisher of *Organic Gardening* magazine, although the first documented use of the term was by Lord Northbourne in his 1940 publication *Look to the Land*. Today's organic gardeners acknowledge their debt to these promoters of good husbandry of the land.

The National Organic Program (NOP) was formalized in 2002 in response to the need for uniform production standards among commercial organic farms. The NOP is managed by the USDA and is a federally regulated consumer protection label for agricultural products. Commercial producers who want to advertise crops as organic must be certified if they gross more than $5,000 a year. Part-time market gardeners who gross less than $5,000 a year from organic products are not required to be certified, but they are required to comply with all regulations established by the NOP. Home gardeners who consume or freely share the bounty with friends and family are not required to be certified and, in fact, are not allowed to use any NOP labels or organic logos. For more information, visit the NOP website (http://www.ams.usda.gov/AMSv1.0/nop), also listed in the Additional Resources section at the end of this document.

Be careful when buying garden supplies with the term *organic* on the label. Organic does not necessarily mean the product is approved for use in organic production, but rather that the product contains organic material, or material that is high in carbon. The term *certified organic* is used only for commercial agricultural outputs—namely food, fiber, and seed, but not for inputs such as compost, manure, or soil. For products approved for use in commercial organic production (such as pesticides and fertilizers), look for the NOP seal (Fig. 1) or the OMRI (Organic Materials Review Institute) seal (Fig. 2). The OMRI seal can also be found on numerous garden products sold at nurseries and home supply stores. For more information, see *Understanding the 'USDA Organic' Label* (http://edis.ifas.ufl.edu/hs397).

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Figure 1. Optional USDA National Organic Program Label for products that are approved by the Environmental Protection Agency (EPA) for organic production

Figure 2. OMRI label

Seeds and Transplants

Organically produced seeds are now available from many online or mail-order catalogs as well as local garden centers. Organically produced transplants are not as widely available, but may occasionally be purchased at farmers markets or from a certified organic producer. Currently, the demand for organic seeds and transplants exceeds supply, so these organic products can be more expensive than nonorganic products.

No matter the approach (organic or nonorganic), it's important to use a quality soil mix (medium) when growing transplants from seed. Sterilized soilless mixes are readily available and minimize the risk of soilborne diseases and weeds. However, many commercially available mixes have synthetic wetting agents and starter fertilizers that are prohibited in commercial organic production. Therefore, purist organic gardeners should look for mixes approved for use in organic production or make their own by buying bulk ingredients and mixing by hand. A large trash can with a secure lid is an inexpensive container for mixing and storing soil mixes. Be advised that aluminum or plastic cans are probably much more acceptable than galvanized cans, which can impart zinc (Zn) to the soil.

There are several reliable recipes for organic soil mixes, but trial and error is the only way to know which blend works best for the crops you grow. For vegetable transplants, one simple recipe is two parts compost, six parts peat moss or small pine bark chips, and two parts perlite or vermiculite. For best results, the mix should have a pH between 5.5 and 6.5; otherwise, some nutrients may not be accessible to the plant. If perlite is used, adjust the pH with dolomitic limestone (dolomite), which provides magnesium (Mg) as well as calcium (Ca). Since Mg is already present in vermiculite, regular agricultural limestone is sufficient to raise the pH if necessary. Add the liming material at a rate of 5 lb. to every cubic yard of mix. Be sure to mix the media in a well-ventilated area, and wear gloves and a mask designed to trap fine particulates to avoid inhaling potentially harmful dust. If using the trash can approach, simply alternate the addition of ingredients until the can is no more than ¾ full, secure the lid, and roll until mixed. For a list of organic potting media suppliers and more media recipe ideas, see *Potting Mixes for Certified Organic Production* on the National Sustainable Agriculture Information Service (ATTRA) website (http://www.attra.org). Table 2 summarizes selected media ingredients allowed in organic production.

Fertilize transplants 10–14 days after germination with a soluble fertilizer such as liquid fish emulsion or liquid kelp; mix and apply according to product directions. Gardeners with an interest in using compost tea should refer to that section below. Transplants grown indoors need to be prepared for the more stressful conditions outdoors. Move the transplants outside for about a week before planting them in the garden. Transplant stems should be checked daily while outside and planted in the ground once they are firm but not woody. Woody stems are a sign that growth has slowed, and these plants may have difficulty resuming active growth. Transplants should be planted prior to flowering to ensure rapid growth and establishment.

Soil Organic Matter

One key tenet of organic gardening is to increase the soil's organic matter content. Soil organic matter consists of living microorganisms plus plant and animal organic residues that are either fresh or partially or fully decomposed. Florida soils typically contain less than 1.5% organic matter. It is possible to increase the soil organic matter in Florida's subtropical environment, but it takes regular additions of organic amendments over several years before an increase can be documented.

Organic matter is central to many beneficial ecological processes. Over time, organic matter is slowly transformed by earthworms and microorganisms, such as fungi, algae, bacteria, and beneficial nematodes, into soluble nutrients that plants use for growth and development. Organic matter also provides the following additional benefits:

- Improves soil structure.

- Improves the ability of soil to hold water, nutrients, and air.
- Improves the "buffering" capacity of soil (i.e., improves the soil's resistance to sudden changes in pH).
- Provides a source of carbon to sustain the biological life in the soil.
- Natural microbial processes help convert insoluble natural additives, such as ground rock, into plant-usable forms.
- Suppresses nematode populations.
- Recycles organic waste products.

Organic matter is applied to the soil in the form of animal manures, plant manures (cover crops), compost, or mixed organic fertilizer. Before adding any nutrients or amendments to the soil, all gardeners should submit a soil sample for analysis to a licensed soil laboratory.

Fertilizer Recommendations

UF/IFAS Extension encourages all gardeners to use appropriate rates of fertilizer and amendments in the garden, and to follow local ordinances on the use of nitrogen (N) and phosphorus (P) to protect Florida's natural resources. The University of Florida offers a soil test for home gardeners for a nominal fee. Visit the UF/IFAS Extension Soil Testing Laboratory's (ESTL) website (http://soilslab.ifas.ufl.edu/ESTL Home.asp) or check with your county Extension office (http://solutionsforyourlife.ufl.edu/map/) for more information about how to collect and submit a soil, manure, or compost sample, as well as to obtain additional guidance about fertility management. Soil test results include a recommendation for fertilizer application based on the planned crops. The UF/IFAS ESTL can determine the percentage of soil organic matter for an extra fee. The sections below provide an overview of the most common fertilizers and soil amendments used in the home garden.

Animal Manures

When animal manures are available, they are a very good source of nutrients and organic matter for the organic gardener. When animal manure can be obtained from a local source, transportation costs are minimized, a waste product is recycled, and the gardener learns firsthand about animal diets and litter materials. However, there are disadvantages of using raw manure, including its strong odor, plant damage resulting from its high salt and N concentration, and risks to human health. Manure from pigs, dogs, and cats should never be used in gardens because of the risk of contamination by parasites, such as roundworm or tapeworm. Please refer to the section on compost below to avoid many of the pitfalls of using raw manures.

The National Organic Program has strict rules regarding the use of manure to grow edible crops. In certified organic systems, raw manure must be applied at least 90 days before harvesting a crop where the edible portion is not in contact with the soil (e.g., sweet corn) and at least 120 days before harvesting a crop where the edible portion does touch the soil (e.g., watermelons, potatoes). This practice, commonly referred to as the "90/120-day rule," is strongly recommended for home gardeners as well. Manure generally releases nutrients slowly and should be mixed into the soil before planting. Soil incorporation also reduces the potential for nutrient losses from runoff in heavy rains or volatilization of selected nutrients, such as N, if the manure is not incorporated into the soil.

Because P, copper (Cu), and Zn are frequently added to poultry feed, repeated applications of poultry litter on the same location should be avoided. This practice prevents accumulation of heavy metals at concentrations toxic to plants and reduces the chance of P contaminating surface water like lakes and rivers. A number of private labs offer manure analysis for a nominal fee. Gardeners who plan to use the same manure source for several years should consider having the source analyzed.

Manures vary greatly in their nutrient content according to the type, age, and condition of the animal; the kind of feed used; the manure's age and moisture content; and the kind and amount of litter or bedding mixed in the manure. Table 3 shows nutrient concentrations of N, P, and K (potassium) as well as recommended application rates of raw manures based on their wet weights. Animal manures also provide most of the micronutrients needed by plants. Keep in mind that manure is not always a complete, well-balanced fertilizer. Depending on soil test results and the type of manure used, it may be advantageous to apply a complete fertilizer or ground rock phosphate and potash in addition to the manures.

Before planting, broadcast the manure evenly over the plot and spade, till, or otherwise work it into the top 6 inches of topsoil. Use the "90/120-day rule" described above for human and plant safety. Clumps of partially decomposed organic matter not only interfere with planting, but may also result in nutrient deficiencies and possible soilborne disease problems, such as "damping-off" of young seedlings, so gardeners should be sure to break up the clumps and distribute manure evenly throughout the top 6 inches.

Some farmers and gardeners have reported damage to crops that has been associated with the class of herbicides known as pyridine carboxylic acids (PCA) (aminopyralid, clopyralid, fluroxypyr, picloram, and triclopyr). These herbicides are registered for use in pasture, row crops, roadsides, and some vegetables and fruits. In pastures, these herbicides are important to control toxic weeds that can sicken or kill grazing livestock. According to the Environmental Protection Agency, the compounds pass safely through the animal's digestive tract and are excreted as urine and manure. Typically, the compounds break down through natural processes (i.e., sunlight, heat, biological decomposition) within 30 days, but sometimes the compounds can be persistent in manure, compost, and baled hay, especially if stored in static piles. Persistent PCA herbicide activity has occasionally resulted in poor seed germination; twisted, cupped, or elongated leaves; and reduced fruit development. Keep in mind many factors can cause these symptoms (e.g., disease, insects, herbicide drift from a neighbor). Gardeners can ask for a history of herbicide use prior to purchasing manure, compost, or hay. If in doubt, a simple test can be conducted to observe plant development from seed to the three-leaf stage by comparing commercial potting mix to the soil amendment in question. This procedure is explained in detail in Washington State University's *Bioassay Test for Herbicide Residues in Compost* (http://www.puyallup.wsu.edu/soilmgmt/Pubs/CloBioassay.pdf).

Cover Crops and Green Manure

Cover crops are short-term plantings grown to provide a benefit to the garden but not grown for harvest. During their growing period, cover crops cover the soil and thus reduce soil loss during heavy rains. Cover crops are often used in Florida to discourage weeds from taking over the garden during summer and winter months. Cover crops provide habitat for beneficial insects and, when in bloom, they provide a source of pollen and nectar for pollinators. Cover crops in the grass family have large, fibrous root systems known to improve soil physical structure. Legume cover crops benefit the garden by providing a source of N for subsequent crops. Some cover crops also help to reduce nematode populations. For more information, see Additional Resources at the end of this publication. Green manure is typically defined as a cover crop that is plowed into the soil while still fresh and green. Growing cover crops during the off-season is a good way to give the garden a rest from tillage. Cowpea, velvet bean, soybean, and sunflower are recommended in summer (June through September), and cereal rye (cv. FL 401), crimson clover, and Austrian winter pea are recommended in winter (November through February). Buckwheat is easily grown during the cooler spring and fall seasons.

Compost

Compost is decomposed organic matter produced by alternating layers of "green" organic materials, such as yard trimmings and kitchen table wastes, with "brown" organic materials, such as fallen leaves, animal or plant manure, or even unbleached paper. Because of the risk of transferring pathogens such as *E. coli*, *Salmonella*, and *Listeria* from animals to humans, it is always preferable to compost animal manures. Composting removes most of the problems with raw manures and improves the quality of the organic matter being added to the garden. Mixing the green and brown materials with water and air encourages microbial decomposition. Some gardeners add organic fertilizers, topsoil, lime, or minerals to enhance the nutrient concentration of compost. There are many recipes and several methods of composting from which to choose. Table 5 provides a list of materials and what each might contribute to the compost. For more information regarding home composting methods, see *Compost Tips for the Home Gardener* (http://edis.ifas.ufl.edu/ep323) and visit the UF/IFAS Composting Center (http://sarasota.ifas.ufl.edu/compost-info/).

Compost for the garden should be ready in 2 months to 1 year, depending on the time of year, type of materials added, and how intensely the compost is managed. When the compost is broken down into a somewhat homogenous mixture, smells sweet, and is not hot, it is ready for use as a mulch or soil amendment. Broadcast over the entire garden and incorporate into the soil to a depth of 6 inches 2–3 weeks before planting. If you have only a small quantity of compost, it may be mixed into the soil along each planting furrow.

Special consideration should be given to compost and other inputs used in school gardens, gardens for the elderly, and other at-risk populations. To minimize risk of illness, look for the U.S. Composting Council's (USCC) Seal of Testing Assurance (STA). The USCC regulations have specific time/temperature requirements to ensure pathogen destruction. The seal assures that the compost was made according to EPA standards and is of the highest quality. STA compost is considered certified pathogen free for fecal coliform bacteria or *Salmonella*. The STA label is voluntary, so other compost suppliers may offer properly composted manures with minimum risk of fecal coliform bacteria. These companies keep composting records and most provide certificates of analysis, if requested. Most states require commercial facilities to obtain permits to sell compost. In Florida, permits can be obtained from the Department of Environmental Protection.

Most composts contain N, P, and K, but may supply too much of one and not enough of the other, a problem frequently overlooked with organic sources. N availability in compost is slower than P and K availability because N must be transformed by microbes before plants can use it. For that reason, compost application rates might be best calculated based on P in P-sensitive areas of Florida. For an accurate recommendation, submit a sample of your compost to the UF/IFAS ESTL (http://soilslab.ifas.ufl.edu/ESTL Home.asp) for nutrient analysis.

Compost Tea

Compost tea is made by soaking or steeping compost in water and extracting microorganisms in the process. In theory, the beneficial microbes in the compost tea provide some protection against disease pathogens when the tea is applied to the soil or foliage. Because results depend on complex environmental and biological conditions, scientific studies on the effectiveness of compost tea to suppress pathogens are not consistent. Generally, many other cultural practices can be used with a greater likelihood of success (e.g., rotation, selecting resistant cultivars, etc.). Compost tea does not provide a measureable amount of nutrition to plants.

There are several recipes and methods for making compost tea. Make the tea with potable water and mature compost that has reached high temperatures (i.e., measured with a compost thermometer). Some recipes call for a sugar source to boost microbial activity, but gardeners should be aware that compost tea made this way can also increase the number of pathogens in the tea, and therefore that practice is discouraged by the National Organic Standards. It is likely that commercial producers are not allowed to apply compost tea topically to plants or soil because of strict regulations outlined in the Food Safety Modernization Act. Do not make tea from raw manures. Tea from raw manures is prohibited in the organic program because this practice does not follow the "90/120-day rule." More information about compost tea can be found in the Additional Resources section at the end of this publication.

Nutrients from Natural and Organic Fertilizers

Vegetables need a number of nutrients. A *primary nutrient* refers to N, P, and K, which are used in considerable quantities by crops. *Secondary nutrients* refer to Ca, Mg, and sulfur (S), which are used in moderate quantities by crops and influence soil pH. Sometimes, primary and secondary nutrients are grouped together and called *macronutrients*. *Micronutrients, trace, or minor elements* refer to the essential plant nutrients used in relatively small quantities. These micronutrients include boron (B), Cu, iron (Fe), chloride (Cl), manganese (Mn), molybdenum (Mo), and Zn.

Nitrogen (N). Nitrogen is frequently the most limiting nutrient in vegetable production systems, and N management can be challenging in organic gardening because of the variability of N concentrations in organic amendments. Organic N must be converted by microorganisms into inorganic N (nitrate) before plant roots can absorb it. Furthermore, because the rate of N release depends on many environmental factors such as temperature, soil moisture, and microorganisms, even the best estimate may not always reflect the actual release rate. Nevertheless, N from organic sources is typically sufficient to support crop growth.

The application of N depends largely on the crop's requirements and the form being applied. Soluble forms of N (often present in synthetic fertilizers) are avoided in organic gardening because of the philosophical opposition of using synthetic products as well as the scientific observations that highly soluble nutrients contribute little to the soil biology. However, keep in mind that misapplication of N in *any* form poses a risk to ground and surface water quality.

Phosphorus (P). Phosphorus is plentiful in many Florida soils. Rock phosphates are natural deposits of phosphate in combination with Ca. The material is hard and yields P slowly (months to years). When finely ground and with impurities removed, the powdery material is only slightly soluble in water, but may be beneficial to plants in subsequent seasons following application. The reaction of phosphate rock with acids from decaying organic matter in the soil or compost makes the P available to garden plants. Colloidal phosphate is also available and widely used. A soil test will reveal whether additional P is needed. Since phosphate materials are so slowly decomposed, sidedressings are seldom beneficial. Only the minimum amount of P should be used because of its negative impact on water quality.

Potassium (K). Potassium is widely distributed in nature, occurring in rocks, soils, plant and animal tissues, and in sea and lake water. In gardening, materials such as wood ashes, seaweed, potash salts, greensand, and ground rock potash are used alone or in combination with other materials, such as manure or compost. Since potash-bearing materials vary so much in composition and rate of decomposition, application rates must be determined for each.

Secondary and Micronutrients. An advantage of using organic materials as fertilizers is that these organic sources often contain many other elements that plants need in addition to N, P, and K. Other nutrients are found in naturally occurring materials such as gypsum (Ca and S), marl (Ca), dolomite (Ca and Mg), and limestone (Ca). Micronutrients are needed by plants in very small quantities and are present in many organic sources. For example, Mn is typically present in manure. Avoid phytotoxicity problems by applying micronutrients only when indicated by a soil or plant tissue test. Boron (B) is commonly sold as Solubor®. However, approved products containing other micronutrients (such as Zn, Cu, and Fe) can be difficult to locate. Try to find formulations that are chelated (or coated) with natural agents. Never apply foliar nutrients during the hottest time of day.

Lime. Reducing the acidity of the soil is the primary purpose for using lime in the garden. Lime should be applied only when the need has been established by a reliable soil pH test. Soil pH test strips only provide a measure of the active acidity in the soil, and are not an accurate method to determine the amount of lime needed. The UF/IFAS ESTL uses a special extraction (the Adams-Evans buffer) to determine the amount of lime needed. Liming materials also provide nutrients for plant use. Gypsum is used where Ca is needed, but a pH adjustment is not. Natural deposits of lime that an organic gardener might use are limestone, dolomite, shell, and marl. All these forms must be finely ground to provide maximum benefit to the soil and plants. Apply lime well in advance of the planting date, preferably 2–3 months before the garden is planted. Mix well with the soil and keep moist for best results. Application closer to planting time is permissible, but benefits will be delayed.

Developing a Fertilizer Plan

A number of fertilizer products contain formulated balanced blends of nutrients and have been approved for use in organic production. These products are made of different combinations of granulated animal waste materials, organic materials derived from plants and animals, and natural deposits of rocks and minerals. In addition to the store-bought bags and boxes of fertilizers and amendments, gardeners may want to use animal manures, compost, and/or cover crops in the garden. Most gardeners use some combination of all of the above.

Gardeners who have a soil test-based recommendation can develop a plan to provide nutrients to crops with the following considerations: nutrient concentration, estimated percent of nutrient available during the season, and nutrient balance. Tables 2, 3, and 4 provide general estimates of the nutrient contents of common organic fertilizers and amendments for the garden. If manure or compost will be used, it is best to begin building your fertilizer plan by estimating the N, P, and K they will provide. Once the concentrations of these nutrients are known, consider the rate at which they will become available to plants. Approximately 20% (horse)–50% (poultry) of the total N from animal manures will likely be available during the year, but that number is significantly less for N from compost (10% for composted horse manure, 20% for composted poultry litter, and 10% for vegetable waste). Although most gardeners estimate compost and manure rates based on N, compost can contain a significant amount of P. Adding mature compost to garden soil slows the loss of P to the environment because the organic matter helps to hold the P in place. Gardeners should determine their application rates based on the nutrient that poses the greatest threat to water quality, N or P, depending on local recommendations.

The following example shows how to estimate the amount of compost and manure to apply. Applying 100 lb. of compost (containing 1.5% N) to 100 sq. ft. of garden area provides 1.5 lb. of potentially available total N per 100 sq. ft. Assuming 10% of that N will be available to plants after microbial transformations, only 0.15 lb. is useable by plants during the season. Using a similar calculation, but this time with broiler house poultry manure (containing 3.6% N), 100 lb. of manure applied to 100 sq. ft. of area provides 3.6 lb. of potentially available total N. However, poultry manure is much more readily transformed by microbes. In fact, 45% of the total potential N will likely be available, leaving 1.62 lb. N useable by plants during the season. Commercial vegetable producers add approximately 200 lb. N, 175 lb. of K_2O, and 0–150 lb. of P_2O_5 per acre to their crop during the season, depending on soil test results. This is equivalent to 0.46 lb. N, 0.40 lb. K_2O, and 0–0.34 lb. P_2O_5 on a 100-square-foot basis. Therefore, gardeners should aim for similar rates.

If the P and K concentration is low in your manure or compost, you can obtain them from other sources. Slowly available P sources limit risk to the environment while providing valuable nutrients. Rock or colloidal phosphates can be applied at the rate of 2–5 lb. per 100 sq. ft. of garden soil. Or, when applying compost, mix at the rate of 2½ lb. phosphate per 25 lb. compost. Broadcast the material over the soil surface and work into the top 6 inches of soil before planting. Potassium is generally available quickly as it is readily soluble in the soil. Ground rock potash at 5 lb. per 100 sq. ft. may be broadcast over the soil surface 3 weeks before planting and incorporated into the soil. Langbeinite (Brand name: Sul-Po-Mag®) is used at 1 lb./100 sq. ft. (equivalent to 96 lb. per acre of K_2O). There are numerous off-the-shelf fertilizers to choose from. Finally, to ensure the nutrients in the garden are available, manage the soil pH when needed by adding lime. In most Florida soil conditions, applications of 2–5 lb. of finely ground dolomitic limestone per 100 sq. ft. increases the soil pH by one unit.

Water Management

When irrigating the garden, apply enough water to thoroughly moisten the root zone. A section of bed that is 1 foot wide by 1 foot deep and 100 ft. long requires 24 gallons of water. On average, about ¾ of an inch of water can be stored in every foot of soil. Light sprinklings every day merely tend to wet the surface and encourage shallow root growth. Excess irrigation pushes valuable nutrients below the root zone and out of reach of plants. Drip or trickle irrigation is encouraged as a method for conserving water. Drip irrigation uses water up to 35% more efficiently than overhead sprinklers because the water is placed directly on the soil. Established plants need water at least weekly, either by rainfall or irrigation. Most water from wells in Florida is high in Ca and Mg and increases the pH of the soil. If you plan to irrigate from well water, be careful not to add too much lime to the soil.

Mulch

Mulch is any material placed on the soil *surface* around plants. Mulch provides the following benefits: (a) conserves soil moisture, (b) conserves nutrients, (c) reduces soil erosion, (d) reduces crop loss from nematodes, (e) reduces weed growth, (f) provides a barrier between fruit and soil, thus reducing rotting of fruit, and (g) moderates soil temperature. Organic mulch can attract many insects, including beneficial spiders and ground beetles, but may also attract organisms like slugs or snails that can damage crops. Organic materials most commonly used for mulching are oak leaves, grass clippings, Bahia hay, pine straw, and mature cover crops, which have been cut and returned to the garden as mulch. Apply mulch before or after seeding or transplanting. Generally, 3–4 inches of moderately packed mulch is recommended to prevent weeds. Hardwood or pine mulch chips are best used in walkways and border areas around the garden. These mulches are slow to break down, provide a surface to walk on when the garden soil is wet, and can reduce weeds. Adding a weed barrier or even several layers of newspaper under the chips reduces weed growth even further. The most affordable way to purchase mulch is in volume. Mulch is typically sold by the cubic yard. One cubic yard (yd^3) covers 100 sq. ft. spread 2–3 inches deep.

At the end of the garden season, organic mulch may be removed and composted or incorporated into the garden soil. If the mulch consists mainly of dry and woody plant stems (which have a high concentration of carbon), add manure or other N-rich organic fertilizer to promote their decomposition.

Synthetic mulch materials, including plastic, are allowed and used frequently in commercial organic systems in combination with drip irrigation. These mulches can be reused for several seasons before needing replacement. Black mulch and Infra-Red Transmitting (IRT) mulch increase soil temperature—an advantage in the winter season. White mulch reflects the sun's rays and keeps the soil cooler than other types of mulches. White mulch is best used when daytime temperatures are high enough to slow plant growth. Clear plastic mulch has the disadvantage of allowing weeds to grow underneath it because of light penetration. Gardeners relying on compost and other solid materials to fertilize their crops need to apply those materials before laying down synthetic mulch.

Pest Management

The main objective of many organic gardeners is to produce food that has not been exposed to synthetic pesticides. Pests include weeds, insects, diseases, nematodes, and even animals like raccoons and birds. The first step to effective pest management is good cultural practices such as observing planting dates, using fertilizer and water appropriately, rotating crops, and controlling weeds that harbor certain pests. Selecting vegetable varieties that are resistant or tolerant of pests is another approach that should be integrated into a home gardener's pest management plan. Seed catalogs, seed packets, and transplant labels often indicate if pest resistance is a varietal characteristic through statements or letter designations. For example, a tomato variety name may be followed with *VFNTA* indicating that it is resistant (in this case) to *Verticillium* (V) and *Fusarium* (F) wilt diseases, Nematodes (N), Tobacco Mosaic Virus (T), and *Alternaria* fungus (A). The *Florida Vegetable Gardening Guide* (http://edis.ifas.ufl.edu/vh021) provides an extensive list of "no-pesticide" approaches to pests. Table 6 provides a list of pesticides with formulations that are approved for use in organic vegetable production.

Crop Rotation. Changing the location of crops within your garden area with time is called rotation. Rotation is an essential component to pest management because it interferes with the life cycles of pests in the soil (such as nematodes and soilborne diseases). Many crop pests are frequently attracted to plants in the same plant family. For example, bell pepper, tomato, and eggplant are in the family Solanaceae. Avoid planting crops from the same family in the same section of the garden in consecutive seasons. Some pests can persist in the soil for years, so it may be necessary to allow several planting seasons or years to pass before repeating a crop in a problematic section of the garden. Moving the garden plot from one part of the yard to another is also helpful.

Many gardeners find it helpful to draw a sketch of the garden and the succession of crops to be planted. Try to plan at least 2 years in advance; 3–5 years is even better. Refer to the *Florida Vegetable Gardening Guide* (http://edis.ifas.ufl.edu/vh021) for planting dates and plant families to help plan crop succession.

Weed Management. A few herbicides are labeled for use in organic systems, but they are expensive and not very effective. When it comes to controlling weeds, prevention is best. As previously discussed, mulches are effective at preventing weeds from becoming the dominant crop in your garden. Select a garden site that is as free of weeds as possible. But fair warning, just because weeds are not currently present as plants, weed seeds are definitely below the soil surface. Some weed seeds can survive in the soil for hundreds of years, so you most likely have a weed seed "bank" in your soil just waiting to germinate. Weed seeds are naturally managed to some extent by diseases that kill them and microbes and small rodents that consume them. Weed seeds may be introduced into the garden in transplants, improperly prepared compost, plant mulches, and animal manures.

After the initial soil preparation for the garden is complete, it is beneficial to avoid disturbing the soil surface as much as possible so as not to expose new weed seeds to the surface. Weeds are best controlled when they are small and have not begun to consume soil nutrients. Hand pull weeds or use one of the many excellent hand tools available for weed control. Only shallow cultivation and hoeing are advised so as not to damage the crop root system. If weeds are too large to cultivate with hand tools, cut them off at the soil with pruning shears. Never allow weeds to flower and produce seeds, or they will reseed themselves and reappear in the future.

Nematode Management. Nematodes are microscopic worms that can seriously reduce growth and yield of most vegetables by feeding in or on their roots. Some vegetables, such as okra, are more frequently attacked by nematodes than others. Other vegetable varieties, such as 'California Blackeye 5' pea, are tolerant of nematode damage and continue to produce fruit when nematodes are present. Many kinds of nematodes can damage plants. Sting nematodes cause roots to appear stunted or "stung." Root knot nematodes infect roots and form galls—swollen areas in the root that contain female nematodes and their young. Do not confuse these galls with another type of swollen growth called nodules. Nodules are formed by *Rhizobium*, a beneficial bacterium that inhabits root systems and provides N to leguminous plants. Nodules are easily distinguished from galls because they turn pink when sliced open and are easily removed from the root (Fig. 3).

Figure 3. Nodule cut in half showing pink color from the presence of living nitrifying bacteria (*Rhizobium* spp.). This nodule was on the root of the legume sunn hemp (*Crotalaria juncea* L.).
Credits: Danielle Treadwell

Nematode damage is less likely in soils with high levels of organic matter and where crops are rotated so that members of the same crop family are not planted repeatedly in the same soil. Excessive nematode populations may be reduced temporarily by "soil solarization" (Table 1) and other techniques described in *Nematode Management in Organic Agriculture* (http://edis.ifas.ufl.edu/ng047). See Additional Resources for more information.

Insect/Mite Management. Florida is home to many insect and mite pests, including a host of beneficial organisms that naturally suppress them. Certain cover crops attract beneficial insects that reduce pest populations. Another approach is to plant a strip or border of flowering plants known to attract natural enemies. Examples of such plants include sunflower (*Helianthus* spp.), mustards (*Brassica* spp.), alfafa (*Medicago sativa*), and Queen Ann's lace (*Daucus carota*). Buying and introducing beneficial insects into the home garden is expensive and seldom necessary.

A number of research studies have shown that excess N increases insect and mite populations. This finding creates a balancing act for gardeners who must provide enough N to grow a good crop without attracting pests. Weather patterns can also influence insects and mites. For example, hot, dry conditions tend to be associated with spider mites. It is a good idea to scout the garden weekly. Many insects are small even as adults and prefer to remain out of direct sunlight. Check the undersides of leaves, inside whorls of new growth (including flower buds), and at the soil surface near the base of plants. See Additional Resources for more information.

Disease Management. Diseases must be prevented as there are few curative controls available. Sanitation, resistant varieties, crop rotation, biological controls, and other cultural practices are common approaches to disease prevention. Sanitation practices include avoiding introducing diseased transplants into the garden and disinfecting tools following use. A number of materials, including hydrogen peroxide, chlorine, and sodium hypochlorite (plain bleach), are generally allowed for use in organic production systems for sanitation purposes. Prevent crop-to-soil contact by staking or mulching. Avoid keeping the plants and soil too wet by using raised beds and drip irrigation. Water only during daylight hours and allow vegetable foliage to dry before moving through the garden.

In organic gardens, pest management relies primarily on cultural practices, and pesticides should be used only as a last resort. For more information about pest management in the home garden, refer to http://edis.ifas.ufl.edu/topic_vegetable_garden_pests and the *Florida Vegetable Gardening Guide* (http://edis.ifas.ufl.edu/vh021).

When problems persist, it may be wise to submit a plant and/or soil sample for diagnosis to your local county Extension office. Contact information for county offices is located at http://solutionsforyourlife.ufl.edu/map/. Your county Extension agent may refer you to one of the UF/IFAS diagnostic labs listed in Additional Resources.

Additional Resources

Websites

ATTRA (National Sustainable Agriculture Information Service)
https://attra.ncat.org
Search here for publications on compost tea, seed and fertilizer sources, alternative soil testing labs, and more.

FOG (Florida Organic Growers and Consumers, Inc.)
http://www.foginfo.org

OMRI (Organic Materials Review Institute)
http://www.omri.org/
Search here for a list of allowed materials and organic seed sources.

Purdue University Extension
Organic Vegetable Production
http://www.ces.purdue.edu/extmedia/ID/ID_316.pdf

SARE (Sustainable Agriculture Research and Education)
http://www.sare.org
Publications: http://www.sare.org/publications/index.htm

NOP (USDA National Organic Program)
http://www.ams.usda.gov/AMSv1.0/nop

Compost Task Force Report
http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5058471

UF/IFAS EDIS Publications of Interest to Organic Gardeners

Florida Vegetable Gardening

Florida Vegetable Gardening Guide: http://edis.ifas.ufl.edu/VH021

Seed Production and Seed Sources of Organic Vegetables: http://edis.ifas.ufl.edu/HS227

Minigardening (Growing Vegetables in Containers): http://edis.ifas.ufl.edu/VH032

Growing Potatoes in the Florida Home Garden: http://edis.ifas.ufl.edu/HS183

Index for specific vegetable guidelines: http://edis.ifas.ufl.edu/TOPIC_Vegetables_A_thru_Z

Growing Heirloom Tomato Varieties in Southwest Florida: http://edis.ifas.ufl.edu/HS174

Manual of Minor Vegetables: http://edis.ifas.ufl.edu/topic_hs_minor_vegetables

Compost and Soil Amendments

Compost Tips for the Home Gardener: http://edis.ifas.ufl.edu/ep323

Producing Garden Vegetables with Organic Soil Amendments: http://edis.ifas.ufl.edu/mg323

Cover Crops

Cover Crop Benefits for South Florida Commercial Vegetable Producers: http://edis.ifas.ufl.edu/SS461

Cover Crops: Management of Nematodes with Cowpea Cover Crops: http://edis.ifas.ufl.edu/IN516

Pest Management

Beneficial Insects and Mites: http://edis.ifas.ufl.edu/in078

Biological Control for Insect Management in Strawberries: http://edis.ifas.ufl.edu/hs180

Coping with Deer Damage in Florida: http://edis.ifas.ufl.edu/uw128

A Series on Diseases in the Florida Vegetable Garden: Pepper: http://edis.ifas.ufl.edu/pp122

A Series on Diseases in the Florida Vegetable Garden: Tomato: http://edis.ifas.ufl.edu/pp121

Insect Management in the Home Garden: http://edis.ifas.ufl.edu/vh036

Management of Nematodes with Cowpea Cover Crops: http://edis.ifas.ufl.edu/in516

Natural Enemies and Biological Control: http://edis.ifas.ufl.edu/in120

Nematode Management Using Sorghum and Its Relatives: http://edis.ifas.ufl.edu/in531

Nematode Management in Organic Agriculture: http://edis.ifas.ufl.edu/ng047

UF/IFAS DIAGNOSTIC LABS AND CLINICS

Plant Disease Clinic: http://plantpath.ifas.ufl.edu/clinic/

Insect Identification Service: http://edis.ifas.ufl.edu/sr010

Florida Nematode Sampling Instructions: http://edis.ifas.ufl.edu/sr011

The Florida Plant Diagnostic Network: http://edis.ifas.ufl.edu/PP151

Soil Testing Laboratory: http://soilslab.ifas.ufl.edu/

Landscape and Vegetable Garden Test Information Sheet: http://edis.ifas.ufl.edu/SS187

Books

Altieri, M. A., C. I. Nicholls, and M. A. Fritz. 2005. *Manage Insects on Your Farm: A Guide to Ecological Strategies.* Beltsville, MD: Sustainable Agriculture Network.
To purchase: 301-374-9696 or http://www.sare.org/WebStore
Free online version: http://www.sare.org/publications/insect/insect.pdf

Caldwell, B., E. B. Rosen, E. Sideman, A. Shelton, and C. Smart. 2005. *Resource Guide for Organic Insect and Disease Management.* Geneva, NY: Cornell University.
To purchase: 315-787-2248 or http://calsbookstore-lamp.cit.cornell.edu/catalog/
Free online version: http://web.pppmb.cals.cornell.edu/resourceguide/

Coleman, E. 1995. *The New Organic Grower*. White River Junction, VT: Chelsea Green.
To purchase: 800-639-4099 or www.chelseagreen.com

Ellis, B., and F. M. Bradley (eds.) 1996. *The Organic Gardener's Handbook of Natural Insect and Disease Control.* Emmaus, PA: Rodale Press.

Stephens, J. M. 1988. *Manual of Minor Vegetables.* Gainesville: University of Florida Institute of Food and Agricultural Sciences.

Stephens, J. M. 1999. *Vegetable Gardening in Florida.* Gainesville: University Press of Florida.

More for-sale resources about Florida vegetable gardening and pest management are available through the UF/IFAS Extension Bookstore (800-226-1764 or http://ifasbooks.ifas.ufl.edu/).

Table 1. Soil sterilization methods for the home gardener

For transplant media Place moistened soil in heat-proof container and bake at 180°F–200°F for 30–60 minutes. Cool thoroughly before use. If soil is high in clay content, mix with an equal portion of vermiculite or peat moss to avoid hardening (turning the soil into a brick!). A meat thermometer can be used to verify the temperature. This procedure can be very smelly and is probably best done on an outdoor grill rather than a home oven.
For garden beds In Florida, summer (July–August) is the best time to "solarize" soil in the garden. Clear plastic (low-density polyethylene mulch) does the best job of transferring heat to the greatest soil depths. Black plastic becomes hot on the surface, but does not transfer heat as well as clear plastic. Using thick plastic (> 4 mil) or doubling thinner plastic helps retain moisture in the bed, which then increases and retains soil at high temperatures. Moisten soil, cover with plastic, pull the plastic tight, and seal the edges with surrounding garden soil. Keep the plastic in place for at least 6 weeks. Soil temperature should reach 100°F–120°F to a depth of 6–8 inches below the soil surface to provide the best results. Results will vary by soil type. Sandy soils that are low in organic matter and water-holding capacity may not achieve target temperatures at sufficient levels. In this instance, it may be necessary to add organic matter to the soil before solarizing, or keep the plastic on longer than 6 weeks. This technique can suppress densities of plant disease causal organisms, including root knot nematodes, *Pythium* spp., and *Rhizoctonia solani*.

Table 2. Common ingredients for a soilless organic potting media[1]

Ingredient	Function/advantages	Disadvantages	Comments
Sphagnum peat moss or other peat (reeds, sedges, grasses)	Excellent substrate for root growth because of water- and air-holding capacity. Stable material.	Acidic (pH 3.5–4.0)	May be treated with a wetting agent. Different peats give different results.
Perlite	A sterile, pH-neutral material to improve aeration, drainage, and water-holding capacity.		Volcanic rock that is heated to expansion.
Vermiculite	Similar to perlite. Available in different grades (particle sizes). Medium is best for seeds; coarse for larger plants.	Compacts more easily than perlite. Contains asbestos; mix in well-ventilated areas and wet immediately.	Mica-like mineral that is heated to expansion. Most is from Montana.
Sand	Adds air to the media. Inexpensive with a near-neutral pH.	Heavy and dense if the particle size is small.	Coarse (builders) sand is best.
Limestone	Used to increase the pH and provide Ca and sometimes Mg. Ask for unprocessed or mined lime.	Lime products that are prohibited in organic gardening include burned lime (CaO), slaked lime (CaOH), and hydrated lime because of synthetic compounds used in manufacturing.	Calcium carbonate ($CaCO_3$). When Mg is present, it is called dolomitic limestone. Use a fine particle size for transplant media.
Compost	Source of slow-release nutrients. Improved water-holding capacity. If pine bark is used, has potential to suppress disease.	Must make compost at least 6 months in advance. For small transplants, use a maximum of 30% compost in a mix.	See Compost section of this publication.
Coir	Similar to peat, but easier to wet. pH of 5.5–6.8.	Expensive (shipping). Low-salt products reduce salt injury.	By-product of coconut industry. Most is imported.
Alfalfa	Similar to peat, but can be a good locally available alternative.	Must be processed before use: dry, grind to pieces < 1", wet, and decompose for 20 days, then dry 20 days before use.	Alfalfa has 2%–4% N by weight on a dry-weight basis.
Newspaper	Similar to peat when ground.		Limit to 25% of mix and omit glossy paper.

[1]Adapted from: G. Kuepper. 2004. *Potting Mixes for Certified Organic Production.* IP112. Butte, MT: National Sustainable Agriculture Information Service (ATTRA). https://attra.ncat.org/attra-pub/viewhtml.php?id=47.

Table 3. Raw manure nutrient concentration and recommended application rates on vegetable gardens 90–120 days in advance of harvest[1, 2]

Manure source	%N[3]	%P[4]	%K[4]	Estimated available %N	Example application (*Does not replace soil test recommendations*)
Cow (beef, no bedding)	0.65	0.40	0.60	35%	Mix 25 lb. manure (this rate is roughly equivalent to 5 tons manure per acre). The addition of 2–3 lb. of rock phosphate per 100 sq. ft. may be beneficial. Sidedress with up to 5 lb. manure per 100 sq. ft.
Horse (fresh)	0.65	0.25	0.60	20%	
Swine (with bedding)	0.60	0.30	0.50	25%	
Sheep (with bedding)	1.00	0.50	1.00	20%	Apply 20 lb. per 100 sq. ft. (about 4.5 tons manure per acre). Sidedress up to 4 lb. per 100 sq. ft.
Poultry (under cage)	1.30	1.60	1.00	50%	
Poultry (broiler house)	3.60	3.90	2.30	45%	Apply 12 lb. per 100 sq. ft. (about 3 tons manure per acre). Sidedress up to 2.5 lb. per 100 sq. ft.

[1]Adapted from Ozores-Hampton, M. 2013. "Developing a Vegetable Fertility Program Using Organic Amendments and Inorganic Fertilizers." *HortTechnology* 23(2):743–750.
[2]Apply manure 90 days in advance of harvest of a crop that does not touch the soil (e.g., sweet corn) and 120 days in advance of harvest of a crop that does touch the soil (e.g., melons).
[3]N = nitrogen, P = phosphorus, K = potassium.
[4]P x 2.2910 = P_2O_5; K x 1.2047 = K_2O

Table 4. Average nutrient content of plant and animal materials suitable as organic fertilizer (percentage based on dry weight)[1]

Meals and compost materials	%N	%P_2O_5	%K_2O	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 because of 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	Contains Ca.
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, but may be contaminated with unwanted trash.
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	Depletes N.
Sawdust	0.2	0	0.2	Depletes N.
Seaweed, dried	0.7	0.8	5.0	Contains micronutrients.
Shrimp heads	7.8	4.2	0	Contains chitin, used to manage nematodes.
Shrimp waste	2.9	10.0	0	Contains chitin, used to manage nematodes.
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	

[1]Adapted from: Zublena, J. P., J. V. Baird, and J. P. Lilly. 1997. *Soil Facts: Nutrient Content of Fertilizer and Organic Materials*. AG-439-18. Raleigh: North Carolina Cooperative Extension; and Sullivan, P. 2001. *Alternative Soil Amendments*. IP054. Butte, MT: National Sustainable Agriculture Information Service (ATTRA).

Table 5. Average nutrient content of mined or natural amendments used in organic production (percentage based on dry weight)[1]

MINERALS	%N	$\%P_2O_5$	$\%K_2O$	Comments
Nitrogen materials				
Sodium nitrate ($NaNO_3$)	16	0	0	Recommended use is 20% of total crop N requirements. Sodium accumulation and plant toxicity may occur with increased application rate.
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 Fe, Mg, 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) ($K_2SO_4{\cdot}2MgSO_4/MgSO_4$ $K_2SO_4{\cdot}6H_2O$)	0	0	22	11% Mg, 23% S
Potassium sulfate (K_2SO_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 ($CaSO_4{\cdot}H_2O$)	0	0	0.5	22% Ca, 17% S
Magnesium materials				
Magnesium sulfate (epsom salt) ($MgSO_4{\cdot}7H_2O$)	0	0	0	10% Ca, 14% S
Magnesium sulfate (kieserite) ($MgSO_4{\cdot}H_20$)	0	0	0	17% Ca, 23% S
Boron materials				
Solubor® ($Na_2B_8O_{13}{\cdot}4H_20$)	0	0	0	20.5% B

[1]Adapted from: Maynard, D. N., and G. J. Hochmuth. 1997. *Knott's Handbook for Vegetable Growers* (4th ed.). Hoboken, NJ: John Wiley and Sons; and Zublena, J. P., J. V. Baird, and J. P. Lilly. 1997. *Soil Facts: Nutrient Content of Fertilizer and Organic Materials*. AG-439-18. Raleigh: North Carolina Cooperative Extension.

Table 6. Pest management products for organically managed home gardens [1]

Insects			
Active ingredient	**Function/advantages**	**Disadvantages**	**Comments**
Beauveria bassiana	A soil fungus that is a parasite to many foliar-feeding pests, including thrips, whiteflies, aphids, and beetles.	Harmful to pollinators.	Must get the correct formulation for the pest you have.
Bacillus thuringenesis (Bt)	Targeted for caterpillars (immature stage of moths and butterflies). May also control soft-bodied larvae of flies and beetles. Larvae must ingest product. Can apply same day as harvest.	Degrades quickly in sun; washes away with rain.	Liquid and dust formulations. Must get the correct formulation for the pest you have. Bt for beetles is not available in Florida. Safe for beneficials.
Spinosad	This fermentation product from a soil fungus kills insects after ingestion.	Degrades quickly in sun; washes away with rain.	Safe for many beneficials, but not safe for foraging bees or parasitic wasps. Formulations for garden vegetables and fire ants.
Pyrethrum	Made from extracts of chrysanthemum flowers.	Broad-spectrum insecticide; harmful to beneficials.	Liquid and dust formulations.
Oil, horticultural	Kills some insect eggs and soft-bodied adults. Works on mites, aphids, and scale insects.	Degrades quickly. Coverage under leaves is critical. Harmful to beneficials.	May injure sensitive plants.
Soap, insecticidal	Most effective against soft-bodied pests, such as aphids, mites, whiteflies, thrips, caterpillars, and mealybugs.	Degrades quickly; harmful to beneficials. Less effective on beetles and grasshoppers.	Must come in contact with pest. Only active when wet and may burn sensitive plants.
Neem Neem oil Neem oil soap Azadirachtin	Kills aphids, whiteflies, thrips, leafminers, caterpillars, scales, beetles, mealybugs, and adelgids. Some effectiveness on mites and snails has been reported.	Broad-spectrum insecticide; harmful to beneficials. For best results, apply frequently on immature insects when population density is low to moderate. Neem is more effective in warm temperatures.	Azadirachtin is a compound made from seeds of the neem tree (Latin name for this tree is *Azadirachta indica*). Formulations are approved for use in organic production. Frequently sold as the active ingredient in horticultural soaps.
Diatomaceous earth (silicon dioxide)	Made from fossils of diatoms. Deters slugs, beetles, and many structural pests. This material cuts and tears epidermis or exoskeleton.	Possible effects on beneficials. Fine particle size may generate dusty conditions during application and does not adhere well to the foliage.	To minimize destroying beneficials, should be applied late evening or at night.
Boric acid	Similar to diatomaceous earth. Acts as a stomach poison and causes insects to die from starvation.	Has to be consumed by the insect and sometimes mixed with a sweetener. May not be effective if wet.	Available in paste, powder, aerosol, tablet, and liquid forms.
Diseases			
Active ingredient	**Function/advantages**	**Disadvantages**	**Comments**
Copper (Cu)	Copper is very effective on plant diseases, particularly diseases caused by bacteria. It is not used to manage insects.	As a metal, copper can accumulate in the soil and reach toxic levels with overuse. Some diseases are resistant because of poor copper management.	
Baking soda (potassium bicarbonate)	Non-toxic, effective, readily available and very inexpensive. Controls powdery mildew on various plants and early blight on tomato. Also effective on mites.	Must be applied weekly to control powdery mildew, and a surfactant or liquid detergent must be used to spread it evenly on the leaf.	Timing and application rates are important because high levels of sodium bicarbonate will burn plants.
Bacillus subtilus	*B. subtilus* is a soil bacteria used to manage plant diseases caused by *Sclerotinia fruticola*, *Verticillium*, *Rhizoctonia*, and *Fusarium*. It is sometimes mixed with another beneficial, *Streptomyces gramicifaciens*.	Degrades quickly in sun; washes away with rain.	Several strains are listed below, so be sure to get the proper strain for the application: Foliage – QST713 Soil – GB03, MBI 600, FZB 24 Seeds – GB03, MBI 600. For foliar diseases, it is often used in rotation with copper products.

Diseases			
Active ingredient	**Function/advantages**	**Disadvantages**	**Comments**
Sulfur (S)	Effective on preventing various blights, spots, certain rots, downy and powdery mildew, leaf blister, anthracnose, scab, stem canker, *Septoria* spp. and *Stemphylium* spp. leaf molds. Also effective on mites.	Sulfur is toxic to mammals, so follow all recommended precautions on the label when applying. Do not apply when air temperatures exceed 80°F or when oil has been recently applied.	It has no insecticidal qualities and will not burn plants. Safest on the good bugs. Sold as sulfur, line-sulfur, and Bordeaux mixture.
Streptomyces	Contains active cultures of streptomyces that grow around plant roots and prevent infection from other diseases, including Fusarium.	May cause sensitization by inhalation and skin contact. Wear all protective equipment, including a dust mask.	Do not allow re-entry for 4 hours after application.
Weeds			
Active ingredient	**Function/advantages**	**Disadvantages**	**Comments**
Corn gluten meal	A by-product of corn processing, this herbicide also has N. Some formulations have added K and P.	Not effective on emerged or established weeds. Expensive.	Effective on some broadleaf annual weeds when applied prior to weed emergence in the spring.

[1]Compiled from Caldwell, B., E. B. Rosen, E. Sideman, A. M. Shelton, and C. D. Smart. 2006. *The Resource Guide for Organic Insect and Disease Management*. Ithaca: New York State Agricultural Extension Service, Cornell University. http://www.nysaes.cornell.edu/pp/resourceguide/index.php; and Ellis, B. W., and F. M. Bradley (eds.). 1996. *The Organic Gardener's Handbook of Natural Insect and Disease Control.* Emmaus, PA: Rodale Press.