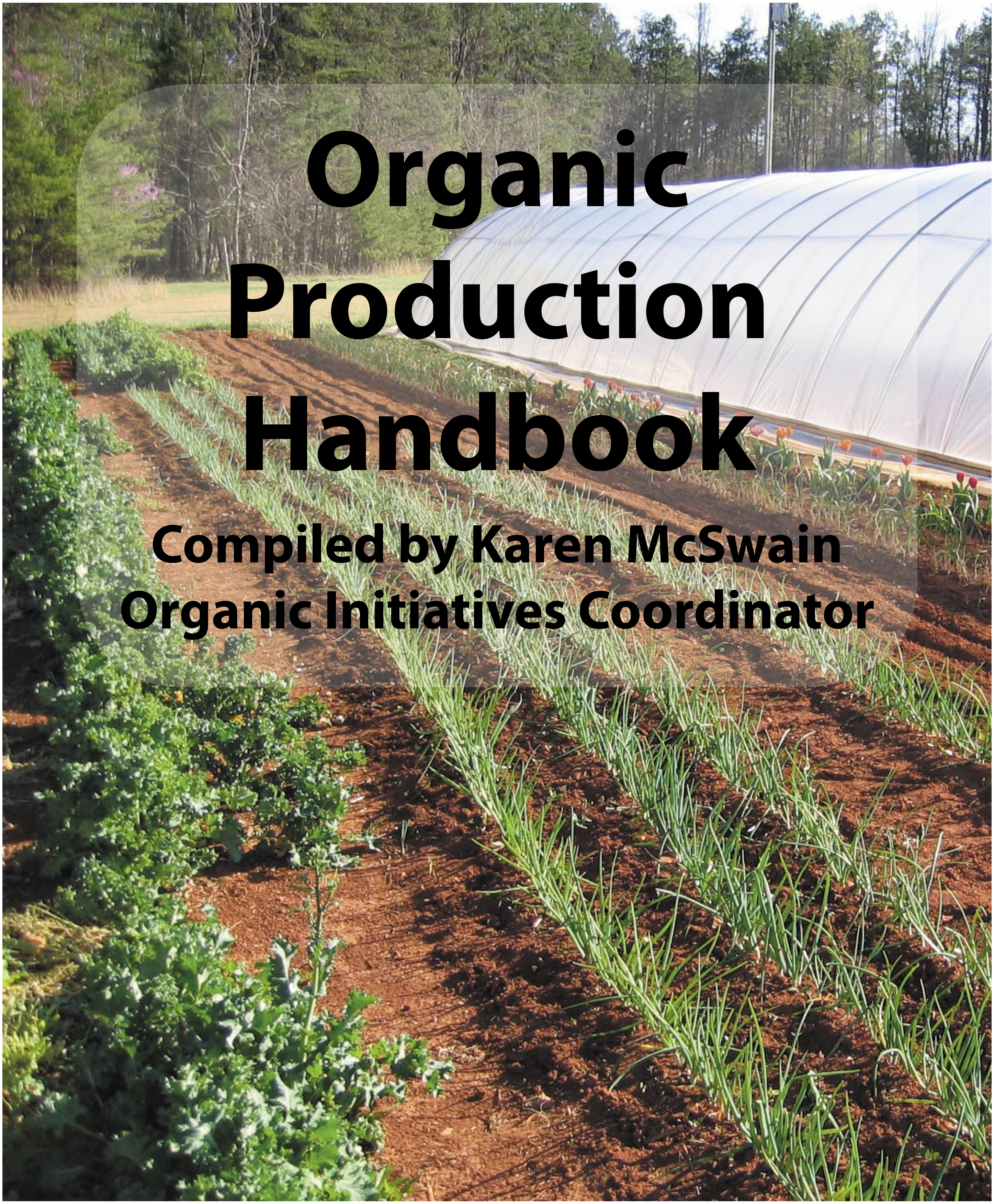


Organic Production Handbook

Compiled by Karen McSwain
Organic Initiatives Coordinator

carolina farm stewardship association

Table of Contents

Acknowledgements
This project received support from the South Carolina Department of Agriculture.
The author would like to thank Mark Schonbeck and Brian Baker, Ph.D. for contributing documents to this handbook.

A special thanks to those who provided photos, including Anna MacDonald Dobbs, Debbie Roos, Grace Kanoy, and Emma Hauser.

A Brief History and Philosophy of Organic Farming

by Mark Schonbeck

What is organic farming?

Organic farming is a method of food and fiber production that utilizes natural materials and biological processes to achieve production and conservation goals. While the organic approach is most widely known for excluding synthetic fertilizers and pesticides organic farmers also aim to:

- Design and manage the farm as a whole living system.
- Build and maintain a healthy, living soil.
- Use biological processes to sustain crop and livestock production.
- Maintain high biodiversity for ecological stability.
- Manage pests through preventive practices, biological and physical controls.
- Utilize on-farm and renewable resources whenever practical.
- Diversify enterprises for economic stability.
- Manage the farm for long-term sustainability - ecological, economic, and social.

As public demand for organically produced food grew during the late 20th Century, private and state agencies began to offer organic certification programs to assure customers that the food they are buying has indeed been grown by organic methods, and to assist organic farmers to access markets. Differences among the many programs led to confusion, and demand from growers, buyers, and consumers for a uniform nationwide organic standard. That standard became legal and practical reality in October 2002, when the USDA National Organic Program (NOP) was fully implemented. Now, any producer with gross sales exceeding $5,000 annually must become certified under the NOP in order to market her / his products as organic.

What is meant by "organic"?

The word "organic" has several definitions. Pioneers of ecologically based agriculture first used the term about 75 years ago, meaning:

- Based on living organisms and their life processes
- Simulating the life processes, organization and integration of natural ecosystems
- Composed of, or derived from the residues of living organisms (as in soil organic matter, or organic fertilizers)

Another definition of "organic," and one that science majors learn in college, is: "having a chemical structure based on carbon atoms linked together in chains or rings." Carbohydrates, fats, proteins, and humus all fit this definition – as do most synthetic pesticides, petroleum, and plastics, so this definition is not as useful to understanding organic agriculture.

The current definition of "organic" in the United States is codified in the NOP Final Rule:

A production system that is managed in accor-

dance with the Act and regulations in this part to respond to site-specific conditions by integrating cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.

How did organic farming start?

Some say that Organic was the "only way farming was done" in the days before fossil fuels, plantation monoculture and agrichemicals. However, simply returning to the old ways is not sufficient for achieving a sustainable organic agriculture. Pre-industrial farming methods ranged from utterly unsustainable (for example, the extreme desertification of the Tigris-Euphrates River Valley in what is now Iraq, and the widespread soil erosion that helped bring down the Roman Empire) to highly sustainable (for example, the "Farmers of Forty Centuries" in mountainous parts of China, who have kept terraced fields productive since 2000 BCE).

Agricultural pioneers such as Sir Albert Howard, Lady Eve Balfour, J.I. Rodale, and E.E. Pfeiffer first developed organic farming concepts in the early to mid 20th Century to address problems with declining soil productivity, seed quality, crop vigor, livestock and human health. Howard, a British soil scientist, documented the vital role of soil organisms in decomposing plant and animal residues into humus, recycling nutrients and thereby maintaining soil fertility:

> The leaf has to decay and fall, the twig is snapped by the wind, the very stem of the tree must break, lie and gradually be eaten away by minute vegetable or animal agents … The accumulated reserve – humus – is the very beginning of vegetable life and therefore of animal life and of our own being. Such … arrangements … are the basis of all Nature's farming and can be summed up in a phrase – the Law of Return.
>
> *Sir Albert Howard, 1947. The Soil and Health, p 31.*

Based on this understanding, Howard developed and promoted composting as a means to recycle manure and other agricultural "wastes" into a beneficial soil amendment rich in humus. Early leaders in the organic movement also viewed the farm as a whole ecosystem, and each farm as a unique individual:

> "Every agricultural enterprise is a self-contained biological unit … The whole is not merely the sum of all its parts but a harmonic unity of a higher order."
>
> *E.E. Pfeiffer, 1943. Bio-Dynamic Farming and Gardening, introduction.*

J. I. Rodale launched the organic farming movement in the United States in the 1940s, and Rodale Institute continues to conduct long term farming systems research comparing productivity, sustainability, soil quality, and carbon sequestration for several organic and non-organic farming systems.

Organic Farming and Conservation

Today's USDA Conservation Programs have origins that closely parallel those of organic farming. Soil conservation pioneer Hugh Hammond Bennett founded the USDA Soil Conservation Service in the 1930s to help farmers stop the devastating soil and crop losses of the Dust Bowl in the Great Plains. That agency is now the Natural Resources Conservation Service (NRCS), whose stated mission and goals are: productive soil, clean and abundant water, healthy plant and animal communities, clean air, and working farms and ranches. These goals are widely shared by organic farmers today as well as throughout the history of organic farming.

An updated Correlation Chart showing the relationship between NOP Organic Production Standards and the Conservation Practice Standards used for NRCS working lands programs is available online at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045638.pdf.

Organic Practice Guide

by Brian Baker, Ph.D., The Organic Center

LAND REQUIREMENTS

Soil management forms the foundation of an organic system. Organic farming can be summed up by the aphorism, "Feed the Soil to Feed the Plant." The NOP Rule requires that (a) the soil fertility, seeds and planting stock, crop rotations, and pest management practices all meet the organic standards requirements; (b) prohibited materials cannot be applied for a minimum of three years prior to the harvest of any crop sold as organic; and (c) that the organically managed area be clearly identified.[1]

Soil Fertility

Organic producers are required to maintain or improve the soil that they manage.[2] The soil is a living system that requires proper maintenance of balanced soil ecology to farm sustainably. Organic farmers regenerate the fertility of the soil through renewable resources. For most farms, operators build the soil through the increase of the partially decomposed biological fraction of the soil, known as organic matter. Increased organic matter makes nutrients more available, buffers and neutralizes soil pH, improves soil structure, raises biological activity, enhances water field capacity and drainage, and decreases erosion. While organic farmers may supplement soluble sources of various nutrients for crop deficiencies, such practice is in conjunction with a soil building program.

Tillage and Cultivation

Field preparation practices used by organic operators must conserve soil and water. While tillage and cultivation are an important part of organic farmers' weed management, it must be done in a way that maintains soil and water quality. Surveys show that most organic farmers use what is usually considered minimum tillage equipment, such as chisel plows, disks, spaders, and harrows. While organic farmers will use moldboard plows, ganged plows, and rippers, these are often reserved only for cases where a field has been fallow or has a compaction layer, and are not regularly used equipment. Some organic farmers have adopted various permanent bed systems that do not involve disturbing entire fields. Beds are tilled and cultivated individually by lighter equipment. A growing number of organic farmers are experimenting with no-till systems, at least with specific crops in their rotations. Cultural practices play an important role in producing favorable conditions for beneficial soil biota. Tillage systems that mix subsoil with surface soil, and cause compaction that leads to poor drainage and air circulation, create conditions favorable to disease causing organisms. Adequate organic matter in the rhizosphere provides a food source for organisms that cycle nutrients and suppress diseases.

Nutrient Management

Management by neglect is not sustainable and cannot be certified as organic. Organic farmers must replenish what is harvested primarily by relying on

renewable resources. Operators are required to have a soil building program that consists of plant or animal materials. Various crop residues, food processing wastes, blood meal, bone meal, and manure all are available options for organic farmers. The use of manure is tightly restricted.

Most synthetic fertilizers are prohibited by OFPA— in particular, synthetic nitrogen, phosphorous, potassium, and calcium sources.[3] The NOP Rule also explicitly prohibits sewage sludge.[4] Plant foods labeled 'organic' may contain materials prohibited in organic production because fertilizer-labeling laws in almost every state in the Western US are not consistent with the NOP Rule. Therefore, it is important to know that all of the ingredients in a blended fertilizer comply with the NOP Rule before recommending that it be applied to an organic farm.

For many farms that transition from conventional to organic production methods, nitrogen management is the greatest difference in nutrient management and perhaps the entire farm operation. Rather than rely on synthetic soluble nitrogen sources obtained from the combustion of natural gas, nitrogen is recycled primarily from two sources: nitrogen-fixing cover crops and animal manure usually applied as compost. Nitrogen applied in this way is stable and slowly released. While organic nitrogen is less likely to leach or volatilize, it is also not as readily available to the plant. As a result, organic crops have physiological differences related to slower growth rates, lower free nitrogen, and less lush green vegetation.

Compost and Manure Management

Manure is a valuable source of nutrients for organic farms. However, manure also contains relatively high levels of human and plant pathogens; soluble or volatile nutrients that may cause water or air pollution; and weed seeds. Manure from conventional farming sources also includes antibiotics, parasiticides, pesticides, hormones administered for growth promotion, and other prohibited substances. Organic farms are thus required to manage manure in a way that protects the crop from potential environmental, health, and food safety risks. The NOP Rule requires that manure either be composted or that the operator observes a minimum interval between the application of manure and harvest of crops for human consumption. The NOP Rule provides a strong incentive to use composted manure and places stringent restrictions on uncomposted manure.

Composting is the decomposition of organic matter through a controlled microbiological process. The use of compost has long been considered a defining feature of organic systems. Organic farmers are strongly encouraged to use compost because it reduces human, plant, and livestock pathogens; destroys weed seeds; decomposes organic matter; and makes nutrients more available to plants. Soluble or volatile nutrients are stabilized when microorganisms consume them. These organisms can also help make relatively insoluble nutrients more soluble by the production of humic acids and other means.

According to organic standards, manure and plant material used as a feedstock must have a carbon to nitrogen (C:N) ratio of between 25:1 and 40:1 prior to composting.[5] Feedstocks must meet a thermophilic temperature range of 131° and 170°F for a minimum time period that varies according to the method used.

In-vessel or aerated static pile systems have a minimum thermophilic period of three days. In-vessel systems hold the manure and other feedstocks in a building, reactor, or container with sufficient capacity for the feedstock to reach thermophilic temperatures. In aerated static pile systems, the feedstock is stacked and either passively aerated through tubes inserted into the pile and baffles underneath, or actively aerated through a ventilation system that blows air through perforated pipes. Windrow systems require five turnings over fifteen days. Windrow composting stacks feedstocks in long, relatively narrow, low rows with a large surface area.

If manure is applied without being composted, then it must be incorporated in the soil, and cannot be left on the soil surface.[6] Crops that have edible portions in contact with soil— usually considered root crops and edible greens— the minimum interval is 120 days.[7] Other crops intended for human consumption must be harvested at least 90 days following incorporation of manure into the soil.[8] Manure that is not composted according to these standards require a minimum interval between application and harvest of crops destined for human consumption. Crops that do not meet these standards cannot be sold as organic. Operators should still manage fields used to grow crops for livestock in a way that breaks the life cycle of parasites and reduces transmission of potential human pathogens.

Mined Minerals

Some non-renewable resources may be used as a supplement to nutrient cycling. Another nutrient source used by organic farmers is the application of mined minerals. The mined minerals that are most commonly applied on organic farms are rock phosphate, gypsum, limestone, potassium sulfate, and magnesium sulfate. After compost, the most widely applied source of phosphate in organic farming is rock phosphate from apatite ore that has not been acidulated or otherwise chemically treated. Hard rock phosphate is the most common in the Western US, and is a dense, nonporous mineral that contains between 59% to 75% tricalcium phosphate. The main apatite deposits in the Western US are found in Idaho of which some may be high in arsenic, lead, and cadmium. When washed, the dried slurry from rock phosphate mining is a finely divided raw mineral phosphate or phosphatic clay that contains between 50% to 58% tri-calcium phosphate and is marketed as colloidal phosphate. Soft rock phosphate is a powdery clay source that contains between 40% to 60% tri-calcium phosphate.

The addition of rock phosphate to compost can improve the phosphorous content of the compost and make the phosphate more readily available by providing exchange sites for the calcium. Compost's biological activity appears to make the phosphate more readily available, particularly through the production of humic acids and the symbiotic activity of vesiculararbuscularmycorrhizae (VAM).

Gypsum and limestone are applied for their calcium content, and to help balance the pH of soil. In many alkaline or sodic soils, application of mined gypsum is a common practice to displace sodium from the soil. The sodium must be leached, usually by irrigation sufficient to wash the salts into the drainage system. In the Western US, natural potassium sulfate obtained from the Great Salt Lake in Utah offers one of the most commonly used sources of natural potash used by organic farmers in the Western US. A number of the less soluble natural potassium silicate sources are also applied, such as basalt and granite. These latter minerals have long been observed as providing a measurable crop response, particularly when combined with organic matter. However, they are generally out of favor with conventional farmers and are not recognized as having fertilizer value by fertilizer control officials.

Some mined minerals are restricted because of their high solubility, high salt index. Sodium nitrate and potassium chloride are on the National

List of prohibited natural substances with specific restrictions that allow limited use. Because they are prone to leach, can pollute water, and degrade soil quality when abused, organic operators are discouraged from using these fertilizers. The NOP Rule restricts their use by requiring documentation in the Farm Plan and evidence that the restrictions placed on their use are met. Sodium nitrate cannot provide more than 20% of the total nitrogen added to a crop.[9] Use is particularly discouraged on high sodium desert soils. The nitrogen contribution of compost, cover crops, and other sources of these nutrients either need to be documented by laboratory analyses or estimated conservatively to avoid certification problems. Potassium chloride must be applied in a manner that minimizes chloride accumulation in the soil.[10]

Ashes

Ashes from wood ash and other crop residues offer a readily available, economical source of nutrients, particularly for calcium and potash. Ashes can be blended with a compost to balance their nutrient levels. However, ashes are usually alkali and can have adverse effects on soil pH and structure when applied repeatedly. Also, some sources of ashes have been reported high in arsenic and lead, particularly when pressure treated lumber or demolition wastes have been incinerated. Manure ash is prohibited due to the environmental impact of its manufacture and its adverse impact on soil quality when compared with compost and raw manure.

Synthetic Crop Nutrients

Finally, growers may use synthetic substances that are on the National List if their use is planned and they comply with the NOP Rule annotations for those substances. These are described below.

Fish that has been hydrolyzed or emulsified can be an effective source of crop-available nitrogen. However, it must be stabilized to prevent putrefaction and potential food safety problems, with phosphoric acid as the preferred stabilizer and sulfuric acid an acceptable substitute.

Aquatic plant products such as Ascophyllum nodosum can be applied either to soil or foliage as a source of trace minerals. They also contain relatively concentrated amounts of plant auxins, growth regulators and stimulants – such as indole-3-acetic acid (IAA), gibberellic acid and cytokinins. Such natural plant hormones can help promote rooting in transplants and cutting, and also help to delay senescence and decay in mature crops. Aquatic plant products are often extracted using potassium hydroxide in order to increase their solubility.

Elemental sulfur offers a means by which alkali soils can be acidified. While gypsum will help to reduce sodium, it will not lower pH appreciably in most situations. Sulfur will have a more immediate effect on lowering pH. However, sulfur is not buffered and can damage soil structure. Also, in soils where available calcium is limited, application of soil sulfur instead of gypsum may cause calcium deficiencies by tying up the available calcium.

Magnesium sulfate from synthetic sources may also be used as a foliar feed or to deal with specific soil conditions. Also known as Epsom salts, magnesium

sulfate is available from some natural sources, such as keiserite and langbeinite. However, the synthetic form is more readily applied as a foliar feed.

Synthetic micronutrients— cobalt, copper, iron, manganese, molybdenum, selenium, and zinc— can be applied to correct a deficiency provided that they are from sulfate, carbonate, oxide, or silicate sources. Nitrate and chloride forms of these micronutrients are explicitly prohibited. Synthetic soluble sources of boron can also be applied. The micronutrients cations (copper, iron, manganese and zinc) are less available in soil than the primary and secondary cations, potassium, calcium and magnesium.

Available micronutrients depend on the pH of the soil; total nutrient levels alone will not provide enough information to document sufficiency. In many high pH soils, crop deficiencies are more likely to be diagnosed by leaf or petiole samples than by soil tests. Organic matter is another factor that influences micronutrients availability. Micronutrients attached to inorganic soil particles will not be able to readily contribute to plant nutrition. Use requires documentation of soil deficiency through testing. The NOP Rule does not specify sampling the soil matrix, and professionals
may use plant tissue testing to estimate soil deficiencies with models that correlate availability and plant tissue levels of the specific trace minerals intended to be applied. Over the long run, producers are expected to increase the amount of essential trace elements through the application of compost and natural mined minerals, and increase their availability by adjusting the pH and increasing the cation exchange capacity.

Chelating agents are compounds to which an element in its ionic form can be attached. Micronutrients can be made more available to plants by chelation with various compounds. Naturally occurring chelating agents such as citric acid may be used. Synthetic chelating agents on the National List such as lignosulfonic acid and its salts; and humic acids are more commonly used. Synthetic chelating agents not on the National List such as EDTA and DTPA are prohibited.

SEEDS AND PLANTING STOCK

The NOP Rule requires that organic farmers plant organic seed, but allows nonorganic seeds to be used, if the operator can document that organic seeds are not commercially available. 'Commercially available' is defined by the NOP Rule as "[t]he ability to obtain a production input in an appropriate form, quality, or quantity to fulfill an essential function in a system of organic production or handling, as determined by the certifying agent in the course of reviewing the organic plan."[11] A growing number of sources for organic seeds are now available. Annual planting stock must be organically produced in any case. Perennial stock from a nonorganic source may be transitioned to organic production after twelve months. The standards permit seeds and planting stock treated with prohibited substances as the result of Federal or State phytosanitary requirements.

CROP ROTATION

Crop rotation is the cultivation of different crops in temporal succession on the same land. Diversifying crops cultivated over time in the same field improves the efficiency of nutrient cycling, particularly if leguminous green manures that fix nitrogen are added to the rotation. Crop rotations can break host cycles for pests and diseases. Alternation of crops with different seasonal patterns and growth habits can also help to suppress weeds. Properly managed rotations can also increase microbiological diversity and activity; raise organic matter content; conserve soil; and enhance soil structure. Even simple rotations over a short time period significantly improved soil quality in controlled experiments.[12]

The Farm Plan should include details for which crops will be rotated in a given field. Simply including a fallow period could be a start, but a sustainable rotation will require more diversity over the long run. Assisting farmers to plan rotations will require knowledge of the complimentary nutrient requirements. Organic production systems will have difficulty meeting crop nutrition needs if crops that require high levels of fertility are grown frequently. Heavy feeders produce more when rotated with light feeders and nitrogen-fixing legumes. Transitions to organic production are often best begun with a nitrogen-fixing green manure. Hay crops such as alfalfa or clover can also be successful transition crops.

Rotation and diversification are important strategies to reduce pests and diseases, and improve a diverse balance of organisms in the field. Continuous cultivation of the same crop year after year allows the population of pest organisms that feed on that particular crop to steadily increase. By planting a non-host crop, one can reduce the amount of food available to specific pests and pathogens. Complicating the system by intercropping or planting buffer strips can also reduce soil-borne pest and disease pressure. Completely clearing a field of weeds may actually promote nematodes and soil-borne diseases by reducing the diversity of the habitats for competitive microorganisms and the natural enemies of pests.

Pest, disease, and weed management also depends heavily on rotations. Breaking host cycles requires more than avoiding the same crop planted back-to back in a given field. Crops that host common pests must also be avoided in succession. Economics ultimately determine the success of crop rotations. Planting a green manure or leaving land fallow carries both operating expenses and opportunity costs, and is particularly difficult to manage on leased land. Farms that produce high value heavy feeders without rotating other crops often face increased production costs and decreased yields over the long run. Operators faced with mounting infestations of pests, diseases, and weeds, and declining fertility may be faced with the choice of either withdrawing from organic production or farm failure.

PEST, DISEASE, AND WEED MANAGEMENT

Crop protection is based on a systems approach that is founded upon the premise that healthy plants are protected by natural defenses and immune systems. Experience backed by research indicates that crops that are nutritionally imbalanced can have a greater potential to be infested with opportunistic pests and diseases. Thus, proper, balanced nutrition is the cornerstone of organic pest management. Crop rotations, sanitation, planting of resistant varieties, and other preventive measures offer a planned, strategic approach that minimizes the use of interventions. Operators may resort to the use of a limited number of pesticides only if biological, cultural, and mechanical means prove ineffective, and only if they are included in the Farm Plan. It is important to know that the standards apply to formulations and not simply active ingredients. Inert ingredients must also be nonsynthetic or appear on the National List. The National List includes all inert ingredients that the EPA has determined as of August 2004 to be minimum risk (List 4) and was recently amended to allow specific inerts of unknown toxicity (List 3) to be used with passive pheromone dispensers.

Pests

Organic farmers need to protect crops from various pests without the use of most chemical insecticides. The few exceptions that are made to this rule are based on criteria that take into account considerations of human health and the environment. Classical biological control— the release of the natural enemies of pests— is another strategy that helps to control insect and arachnid pests. Various predators and parasites can help to reduce the population of

insects if their release is properly timed and they are released in sufficient quantities. Their effectiveness can be enhanced through the management of a community of plants that provide shelter and alternate food sources.

Various mechanical controls are also available. Finally, there are a number of non-toxic repellants that are exempt from registration as pesticides. These can also serve to discourage insects from feeding as well as form physical barriers that protect crops from pests.

A number of mechanical and physical devices are available to protect crops from insects, mites, and other pests. Some of these tools involve various baits. Ammonium carbonate can be used as bait in insect traps, provided there is no direct contact with crop or soil and is primarily used to bait traps used to control various flies (diptera). Lures, traps, and repellants are also allowed for pest control. For example, various adhesive bands may be wrapped around trees to repel ants in citrus. Copper bands are used to protect various crops from mollusk pests such as snails and slugs.

Mating disruption with pheromones is an important tool for many organic farmers to manage caterpillar (lepidoptera) pests found in the Western US, such as codling moth, oriental fruit moth, and pink bollworm. Various sticky traps and barriers can also help to prevent the movement of insects. Copper bands can prevent molluscs from moving up the trunks of citrus trees. Adhesive bands used on trees can form a barrier for ants in citrus. Boric acid is allowed as a structural pest control, provided there is no direct contact with organic food or crops and is primarily used to control ants and cockroaches.

Only a few synthetic insecticides are allowed for foliar application. One is soap— widely used for soft-bodied insects such as aphids. Elemental sulfur and

lime sulfur are also used on foliage. Both are used more for disease control, but are also labeled for other pesticide uses. Sulfur is used as an acaricide; lime sulfur can be used to control scale as well as mites. Oils that are within the narrow range— a 50% distillation point of between 415° and 440°— can be applied as a dormant spray. Petroleum distillates in the narrow range are also applied to foliage as suffocating oil. In some areas, petroleum distillates are only recently accepted for use in organic production. Historically, organic farmers have been discouraged from applying petroleum distillates to the edible parts crops.

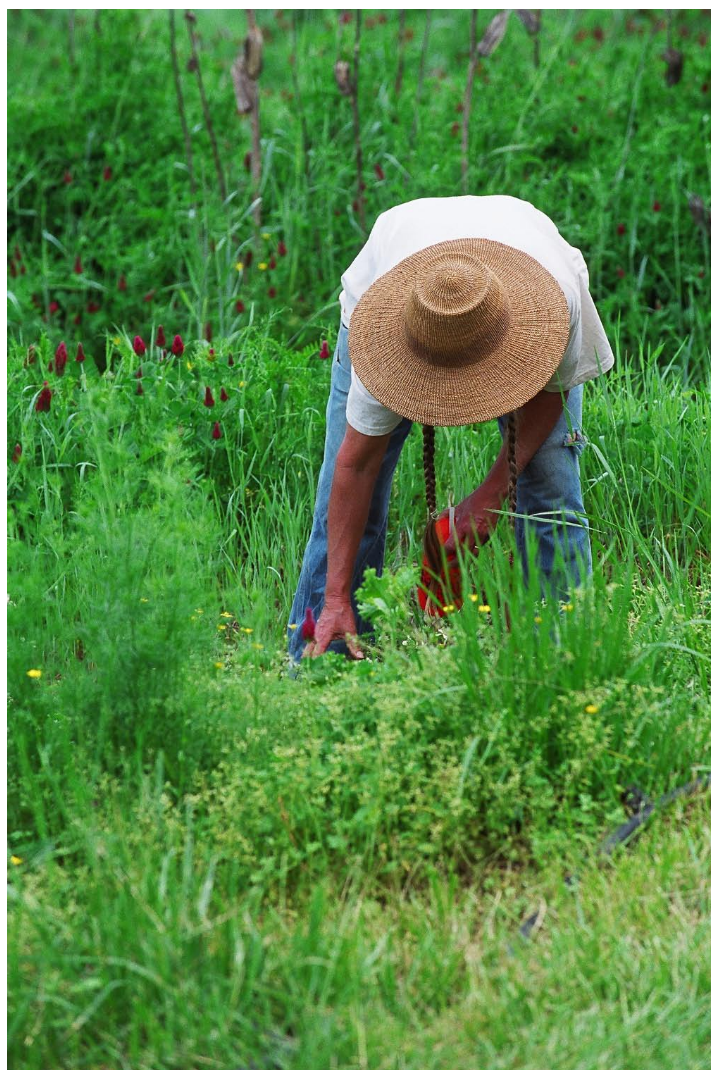
Two natural insecticides are on the list of prohibited nonsynthetic substances: sodium fluoaluminate from the mineral cryolite and nicotine from tobacco. The potential risks these insecticides posed to the environment and human health led to their prohibition.

Given their limited production and availability, reduction in their registered uses, and declining use based on the introduction and distribution of superior alternatives for the few remaining crop / pest complexes allowed on their labels, tobacco and cryolite were not widely used by organic farmers in the Western US prior to their prohibition. Organic farmers rely on traps, physical barriers, and cultural practices to reduce vertebrate pest pressure. In the Western US, the principle vertebrate pests of concern are gophers and ground squirrels. Deer can be repelled using ammonium soaps, provided they are applied without no contact with soil or edible portion of crop. Newly planted trees can be painted on the trunk. Sulfur smoke bombs can only be used underground to control rodents. The natural botanical strychnine from Nux vomica is banned as a rodenticide because of its high toxicity and potential risk to nontargetspecies. The only synthetic rodenticide allowed is vitamin D3, also known as cholcalciferol.

Diseases and Plant Pathogens

Organic farmers have a number of cultural and biological tools to protect the health of plants in addition to nutrition, rotation, and variety selection. Removal of diseased plant tissue, and roguing seriously or systemically infected plants offers another cultural means to reduce pressure from pathogenic organisms. Compost has been shown to have diseasesuppressivecapability, particularly for soil-borne pathogens. While there are fewer natural substances that are available for disease control than for pest management, there are still a few options. These include various clays, such as kaolinite and diatomaceous earth, certain EPA registered biological pesticides such as Trichoderma spp. and botanicals such as garlic and neem.

Fixed coppers exempted from the requirement of a pesticide residue tolerance by EPA can be applied as long as they are used in a way that minimizes copper accumulation in the soil. Among those that are allowed include copper sulfate, copper hydroxide, copper oxide, and copper oxychloride. Copper sulfate is often combined with hydrated lime to make Bordeaux mix. Sulfur and lime sulfur are two other fungicides allowed for use in organic production.



Narrow range oils used as dormant, suffocating, and summer oils can be used for disease control as well as for insects and other pests. Hydrogen peroxide and potassium bicarbonate are two familiar substances that are relatively new as fungicides. Finally, growers with fire blight can use streptomycin, (in apples and pears only) and tetracycline (oxytetracycline calcium complex). Antibiotic resistance is a concern, so growers with fireblight are advised to prune and rotate antibiotics with other tools, such as copper.

Weeds

In survey after survey, organic farmers have identified weed management as their single greatest production problem, and the highest priority for research. Most organic farmers build a weed management program around tillage and cultivation practices. Most operations rely on hand weeding for at least some measure of control. For many intensive vegetable operations, labor for hand weeding will be the single greatest expense that an organic farm incurs. Crop rotation and planting competitive varieties are strategic management measures used to reduce weed pressure. Mowing is practiced mainly in perennial systems. More extensive operations can use livestock. Other options include flame, heat, or electrical control but these methods generally require special equipment. Mulching with straw, leaves, or other fully biodegradable materials can smother weeds. Finally, the NOP Rule permits plastic or other synthetic mulches for weed control, with the provision that they are removed from the field at the end of the growing or harvest season. In general, synthetic substances are not permitted for weed control. The National List explicitly forbids a number of substances such as copper products and other micronutrients to be used as herbicides.

WILD HARVEST

Wild crafted herbs and wild-picked berries, and gathered mushrooms are the main crops that are wild harvested in the Western US. Plants gathered in the wild can be marketed as organic, provided that (1) the land from which they are gathered has not had a prohibited substance applied for three years prior to harvest, (2) the gathering of the crop is not destructive to the environment and (3) the growth and production of the wild crop is sustainable. Throughout much of the Western US, wild harvested crops are mostly harvested from public lands. Agricultural professionals can assist wild crafters by identifying and facilitating contact with the responsible public agency. Certification is a particular challenge given the vast areas covered and the lack of control that the operator has over the management of the land.

LIVESTOCK

Organic livestock production has four basic parameters: (1) organic livestock sources; (2) organically produced feed; (3) holistic health care; and (4) humane living conditions.

Stock Sources

The NOP Rule specifies the conditions under which dairy and breeding stock can be converted from conventional to organic production, and when an animal can be sold organically, depending on both its origin and the products produced.[13] In principle, organic animals are raised organically from birth. The NOP rule requires that non-poultry slaughter stock must come from organic breeding stock and be raised organically from the last third of gestation.14 In the case of poultry, stock may come from any source and are raised organically beginning day one.[15]

Animals that produce milk or dairy products sold as organic must be under continuous organic management for at least one year. The rule contains an exception for entire new herds to be converted to organic production.[16] Breeder stock may be brought into the organic operation at any time before the final trimester of gestation.[17] The N OP rule prohibits livestock, edible livestock products, breeder, or dairy stock from being represented as organic if the animals are not under continuous organic management for the specified time requirements.[18]

Feed

Organic animals are required to receive a complete, balanced ration composed of organically produced agricultural products, including forage and pasture.[19] Organic livestock production is best integrated into the whole organic farming system and requires a connection of livestock to the land and surrounding vegetation.

Range and Pasture

One possible strategy used by mixed crop-livestock operations is to rotate pasture with crops. Organic producers have found that pasturing animals improves nutrition and health care. Rotation that includes a well-managed pasture for grazing animals can also help to cycle nutrients and control weeds for subsequent crops. While the NOP Rule specifically requires access to fresh pasture only for ruminants, [20] producers have also found nutritional, health, and crop benefits to pasturing non-ruminant animals as well. Most of the research on pasture-based systems has taken place in temperate humid climates. More research in animal nutrition is needed to find which grass and clover mixes offer the best forages on irrigated pasture for various Western climates.

Feedstuffs

The common operating assumption in much of the Western US is that animals are maintained in drylots and fed concentrated rations and dry hay, rather than pastured. The opportunity to rotate organic feed and forage crops is a potential benefit for the Western environment, given the extensive production of animal feed and forage. Wheat, barley, triticale, and berseem clover may all be more appropriate concentrates and hays than corn, soybeans, and alfalfa in the arid and hot regions of the Western US.

Additives and Supplements

A balanced diet requires that all nutrient requirements be met. However, it is often difficult in arid regions and areas with short growing seasons to consistently meet vitamin and mineral requirements. In general, all feed, feed additives, and feed supplements must comply with FDA regulations. Natural feed additives and supplements are permitted.[21] For example, mined minerals, enzymes, and probiotic organisms may be used in animal feeds. Synthetic vitamins and minerals also appear on the National List as feed additives, provided FDA approves them.[22] Such feed additives must be included in the Farm Plan, and the amounts fed must be for adequate nutrition and health maintenance for the species.[23] A number of feeding practices are explicitly and categorically prohibited. Organic livestock producers must not use animal drugs, including hormones, to promote growth. Animals provided feed supplements or additives in amounts above those needed for adequate nutrition and health maintenance for the species at its specific stage of life are not eligible for organic certification. Plastic pellets cannot be fed as a source of roughage.[24] Feed formulas that contain urea or manure are also prohibited.[25] Given the concerns about BSE, organic mammals and poultry cannot be fed mammalian or poultry slaughter by-products.[26]

Health Care

The organic paradigm for health care relies on (1) the selection of appropriate breeds and types; (2) proper balanced nutrition; (3) appropriate housing, access to the outdoors, and sanitation; (4) stress reduction by the allowance of natural behavior and exercise; and (5) preventive measures such as vaccines and other inoculants. Prophylactic treatments, hormones, and antibiotics are categorically incompatible with

organic practices.

Animals are treated with medications only when they are sick— indeed the standards make it illegal to withhold treatment from an ill animal. However, animals treated with a prohibited substance cannot have their products sold as organic. The animal must be diverted from organic production and the products must be sold through conventional channels. Veterinarians and other professionals who work with organic producers need to be aware that the Food, Drug, and Cosmetic Act (FDCA) takes precedent over OFPA for medications and internal parasiticides, and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) takes precedent over the NOP for external parasiticides.

Vaccinations are helpful preventive measures against such endemic diseases as bovine diarrhea and vibriolepto. No matter how well a producer manages a herd, animals still get sick in spite of all the preventive measures taken. Holistic veterinarians specialize in alternatives that do not rely on synthetic chemicals for treatment of animal illnesses. Traditional herbal medicine, homeopathy, acupuncture, chiropractic, and probiotics all offer alternative modes to veterinary treatments administered in conventional livestock production to counter the effects of illness, also referred to as allopathic medicine. These modes of animal health care need not be mutually exclusive. Each deserves consideration, criticism, and further exploration. However, organic animal husbandry has far more questions than answers. Organic standards go beyond food safety concerns. They also include issues of consumer acceptance, animal welfare, and resource management. In general, organic consumers expect organic animals to be both treated humanely and not treated with drugs. Organic producers may need to resort to allopathic methods in order to save the life of an animal. However, an animal treated with a prohibited substance loses its organic status.[27]

Traditional herbal medicine is based on the use of botanical preparations to cure ailments. Many plants have healing powers that are documented and recognized by both practitioners and skeptics of modern Western medicine. Many farmers and their veterinarians have come to recognize the prophylactic and therapeutic benefits of many of the plants that

a well-established field of veterinary practice commonly accepted in the organic community. However, professionals should be aware that the FDA officially regards homeopathic medicine to be a 'nontraditional' form of veterinary practice, and the legal status of various remedies is not always clear.

Acupuncture is also a long-established practice, based on traditional Chinese health care. Needles are inserted into the patient in a way intended to stimulate the body's adaptive–homeostatic mechanism. Treatment is viewed as complimentary with other forms of treatment. The physiological responses to the insertion of needles in various sites of the surface of the body have long been documented in both animals and humans. However the specific action remains to be fully understood. The primary aim of veterinary acupuncture is to strengthen the body's immune system. Acupuncture is also used as a technique to relieve pain and to stimulate the body and improve the function of organ systems.
Chiropractic can be used to treat a broad spectrum of conditions in animals through the manipulation of their spine, bones, joints, and muscles. The practitioner makes specific adjustments to vertebra in order to restore homeostasis.

Organic producers may treat their animals with probiotics consisting of a number of naturally occurring live microorganisms. Many probiotic organisms help to boost immunity, while others produce substances that are closely related to antibiotics, but in much lower concentrations. Some also appear to act as antagonists to pathogenic organisms. The FDA has been receptive to probiotics, and a number are FDA registered. As long as the organisms contained in these products are not genetically engineered, there

commonly grow in pastures, on the edges of fields, and in rangeland. Animal husbandry throughout the world makes use of readily available local herbs to treat sick animals. Much of this lore has been lost with the development of Western medicine. Herb-based medicines have been used throughout recorded history, and show great healing potential. While organically produced herbs comply with the NOP rule when used as feed or feed supplements, it is important to recognize that commercial preparations that are marketed with health claims may not be sanctioned under the FDCA and thus their regulatory status may be questionable.

Homeopathy is the use of remedies that would produce the symptoms of the disease being treated in healthy animals. This is referred to as the principle of "Similia Similibus Curentur" or "like cures like." Homeopathic remedies are based on plants, minerals, drugs, viruses, bacteria, or animal substances that are diluted to the point where they are rendered harmless. When a large dose of a toxic substance is swallowed, it can produce death, but when a homeopathic, diluted, minute dose of the substance is given, it can save an animal's life. While the mode of action is not entirely understood, homeopathic remedies are thought by some to contain vibrational energy essences that match the patterns present in the diseased state within an ill animal. Homeopathy is is general agreement that prophylactic use is allowed without probiotics appearing on the National List.

A number of synthetic allopathic medications appear on the National List, but these are subject to restrictions. None may be used to treat an animal in the absence of illness.[28] Several require withdrawal times longer than the label instructs.[29] Where Federal law restricts use by or on the lawful written or oral order of a licensed veterinarian, the NOP also requires use by or on the lawful written order of a licensed veterinarian.[30] Excipients must Generally Recognized As Safe (GRAS) by the Food and Drug Administration (FDA), used in food, or are part of a New Animal Drug Application or NewAnimal Drug Application (NADA) that is approved by FDA.[31]

Parasite Management

Parasite management and health care pose the greatest barriers to organic livestock production in the Western US. Parasites are generally managed by cultural methods. Routine use of parasiticides is prohibited.[32]

Slaughter stock treated with parasiticides is not eligible to be sold as organic.[33] At present ivermectin is the only FDA registered internal parasiticides allowed for use in organic farming in the US, and that use carries with it a number of restrictions.[34] Like all other parasiticides, ivermectin is prohibited for use on slaughter stock. Ivermectin is only allowed as an emergency treatment for dairy and breeder stock when organic system plan-approved preventive management does not prevent infestation.[35] Milk or milk products from a treated animal cannot be labeled as organic if it is taken within 90 days following treatment with ivermectin.[36] Breeder stock must be treated with ivermectin prior to the last third of gestation for their progeny to be sold as organic and young stock may lose their certification if nursing on an animal treated with ivermectin during the lactation period.[37] As with diseases, heavily infested animals are required by the NOP Rule to be treated and if treated with a prohibited substance must be diverted to conventional channels.[38]

Given the limited access to conventional parasite management tools, cultural and biological means are essential for successful animal production. Because of growing resistance of parasites to anthelmintics, even conventional producers cannot necessarily rely entirely upon parasiticides. Local concerns for parasite management vary widely and need to be taken into account. Breeding stock and fiber-producing animals–in particular sheep for wool–appear to have the greatest need in the Western US. Cattle, goat, and sheep production in warmer and wetter climates, such as the coastal areas may prove to be more difficult to manage without the use of parasiticides than is the interior.

Understanding the ecology, phenology, morphology, and genetics of parasitism in a broader context is crucial to develop a classical biological control program for internal parasites. Livestock host a broad array of organisms: many, if not most, are beneficial, a great number innocuous or obscure in their biological function, and only a few clearly pathogenic or parasitic to domesticated animals and humans. A wide variety of micro-arthropods, protozoa, viruses, bacteria, and fungi are potential biocontrol agents for nematode parasites of farm animals. The evolution of hostparasite relationships are believed to be the result of immunological phenomena.

The most promising alternatives to internal parasiticides require methods that disrupt the life cycle of the target organism outside the host. Rotational grazing, fecal examination, culling heavily infected animals, selection of resistant breeds, biological control at susceptible (usually free-living) stages in the life-cycle are all components of an overall strategy to break parasite-host cycles and maintain parasite loads to tolerable levels.

Producers can break the life-cycle of parasites by providing a sufficient host-free period. Strategies to break the host cycle include rotational grazing, spelled pastures, alternating sheep and cattle on pasture, or alternation between irrigated and non-irrigated pastures. Three systems of systems grazing that are commonly used to break the host cycle are characterized as (1) deferred grazing; (2) alternate grazing; and (3) alternate use.

Deferred grazing is a form of pasture rotation in which the pasture is rested for 6 months during the cool season and 3 months in the warm part of the year. Pastures are then tilled and replanted with infective larvae succumbing to the effects of UV light and desiccation. Alternate grazing depends on the two or more species of grazing animals ingesting different parts of the forage and coincidentally ingesting each other's parasite larvae. To be effective, it is important for the animals to not serve as alternate hosts, and to have supplemental strategies when those species share common parasites.

Alternate use relies on intensive grazing of the pasture for a short period of time, leaving that pasture to the production of harvestable hay that when baled and removed takes away most of the parasite burden, and returning animals to the original pasture when new growth emerges after haying.

In conjunction with pasture management, there is evidence that organic farming practices such as green manuring and decreased emphasis on anthelmintic (dewormer) use increase the abundance and variety of coprophilic micro-organisms and arthropods in the dung of pasturing animals that, in turn, act to control fecal forms of intestinal parasites.

Cultural practices, such as fecal examinations of all incoming stock, routine fecal examinations of all animals, and culling heavily infested animals can help maintain levels of parasites within tolerable levels. Selection of livestock resistant to parasites is a long term strategy that is limited in the short run by the availability and suitability of eligible breeding stock.

Live organisms applied outside of the animal are not considered drugs. Hyperparasites of the infective stage of nematodes can reduce fecal counts of nematodes of animals grazed on treated pastures. New methods are being developed in which new antiparasitic agents such as certain Bacillus thuringiensis (Bt) isolates, Penicillium spp., Streptomyces species, among others are used. Such substances may not necessarily be considered nonsynthetic depending on how they are derived or if a synthetic analog of a natural compound is commercialized from the natural compounds that are the original subject of research.

While some claim that nonsynthetic herbal remedies, botanicals, and mined minerals have anthelmintic properties, most of these materials have not had their efficacy substantiated in controlled experimental trials. Pharmaceutical companies are in the process of screening a number of natural compounds derived both from plants and from micro-organisms. Whether traditional or novel, most of these alternatives are not FDA registered and may not be legal to prescribe or use for the purpose of controlling internal parasites.

Certain nonsynthetic and allowed synthetic materials are registered with EPA for parasite management. Botanical ectoparasiticides, such as pyrethrum, are nonsynthetic and are allowed for external application to livestock subject to the restrictions that they appear in the Farm Plan and not be used on a routine basis. Pyrethrum, copper sulfate, hydrated lime, and mineral oil also are used as synthetic external parasiticides. External parasiticides used on organic animals must be formulated with only natural or minimum risk (List 4) inert ingredients.

Hygiene and Sanitation

In general, teat dips and udder washes must be natural or on the National List. A number of commercial teat dips contain synthetic antimicrobials that are prohibited for use in organic production. Among those that are allowed are iodine, glycerin, and lanolin, as well as a number of vegetable oil bases. Chlorohexidine is allowed for use as a teat dip only when alternative germicidal agents and/or physical barriers have lost their effectiveness.

Pain and Stress Reduction

Physical alternations are performed as needed to promote the animal's welfare and in a manner that reduces pain and stress. Local anesthetics lidocaine and procaine are on the National List to help reduce pain. Chlorohexidine is also allowed for surgical procedures conducted by a veterinarian, as are a number of other topical disinfectants.

Living Conditions

Organic livestock producers are required to provide living conditions to accommodate the health and natural behavior of the animals that they raise.[39] The NOP Rule requires that all animals have access to the outdoors.[40] Ruminants are also required to have access to pasture.[41] Animals are also required to have access to shade and shelter, as well as exercise areas, fresh air, and direct sunlight.[42] The shelter must be designed to accommodate the natural maintenance, comfort behaviors, and opportunity to exercise.[43]

In general, animals are expected to have adequate space to be able to stand up, lie down, turn around, groom, and engage in other behavior that is natural. Tie stall are generally considered inappropriate. Shelters are required to maintain a temperature level, ventilation, and air circulation suitable to the species.

Equipment and facilities must reduce the potential for livestock to be injured. These must be suitable to the species, its stage of production, the climate, and the environment. Animals must have clean, dry bedding, and if the bedding can be eaten, then it is required to be organically produced.[44]

Animals may be confined only on a temporary basis and then only for the following reasons:[45]

(1) Inclement weather;
(2) The animal's stage of production;
(3) Conditions under which the health, safety, or well
being of the animal could be jeopardized; or
(4) Risk to soil or water quality.

Manure Management

Organic farms maintain stocking densities, rotate grazing lands, and manage manure to sustain the resource, nourish the animals, and maintain soil and water quality. As with crop producers, the NOP Rule also requires that organic livestock operations manage manure to prevent contamination of crops, soil, and water and optimize the recycling of nutrients from manure.[46]

Cleaning Compounds

The materials used to disinfect livestock facilities must either be nonsynthetic or appear on the National List and used consistently with any restrictions. At present, the chlorine products sodium hypochlorite, calcium hypochlorite, and chlorine dioxide; hydrogen peroxide, and phosphoric acid are the only synthetic equipment and facility cleaners allowed.

HANDLING, PROCESSING, AND LABELING

Once the crops are grown or the animals are raised, they are ready for the organic market. Growers, packers, shippers, handlers, and processors must meet the standards for handling, processing, and labeling organic food. Organic food processing is beyond the scope of this practice guide, but as a general rule, agricultural products that are labeled as 'organic' must meet organic standards. While it is not possible to make non-agricultural products organic, it is very possible to make organic products nonorganic. This can be done by commingling organic and nonorganic agricultural products, or by contaminating an organic product with a prohibited substance.

Handling Requirements

Operations that pack, ship, store, and sell crops other than their own are considered handlers.[47] Commingling[48] is generally a problem on split operations—ones that handle both conventional and organic products at the same facility. Split operations require a much greater degree of caution in handling commodities. Harvest equipment, packing lines, and storage facilities all need to be thoroughly cleaned before being used to handle organic products.

Materials such as floating aids used when post-harvest handling unprocessed agricultural commodities must be either nonsynthetic or appear on the National List. Packaging materials and storage containers are not permitted to contain synthetic fungicides, preservatives, or fumigants. Container, bins, and bags need to be made of food grade material that does not migrate into food. Reused bags and containers must be thoroughly cleaned. Organically produced products or ingredients cannot come into contact with prohibited substances remaining in the container from previous uses.

Post-harvest Pest Control

As with production in the field, handlers[49] are expected to rely first on management practices to prevent pest infestations that threaten stored crops. Exclusion or prevention of the pests from having access to the handling facility is one such practice. The pest habitat, food sources, and breeding areas all need to be removed. Environmental factors, such as temperature, light, humidity, atmosphere, and air circulation, all must be managed in a way that prevents pest reproduction. Any subsequent action taken to control pests is predicated on all of these positive management steps taking place.

Handlers may use lures, repellents and other materials with nonsynthetic active ingredients that are not prohibited or synthetic ingredients allowed for such purposes on the National List. Such products may be applied in direct contact with food provided they are labeled for such use and are not present as an ingredient in the final product. If allowed materials are not effective, a handling operation is then permitted to use any synthetic substance provided that the operator and certifying agent agree on the substance, the method of application and the measures taken to prevent contact with organic ingredients or products with the substance used.[50] Pesticide applicators and other professionals need to realize that synthetic pesticides that do not appear on the National List are prohibited, even if their use in a post-harvest handling facility does not automatically result in decertification. The operator is responsible to prevent pesticides from contacting the commodities. Products contaminated by prohibited substances may still lose their organic status if the levels exceed 5% of EPA tolerance.[51] Even residues that fall below that level may trigger an investigation and an operator who failed to take sufficient precautions to prevent contamination may also lose certification. Finally, any pest control materials required by Federal, State or local laws and regulations are permitted, provided that the handler take measures to prevent contact with organically produced products or ingredients.[52]

Labeling

Organic food ingredients that are labeled as 'organic,' or are used in products labeled '100% Organic' must be organic. Ingredients that comprise at least 95%[53] of a product that is labeled as 'Organic' must also be organically produced. All non-agricultural substances used in or on organic food, whether synthetic or nonsynthetic, must be included on the National List of Allowed Synthetic and Prohibited Nonsynthetic Substances. Otherwise, any non-agricultural substance is prohibited.[54] Products with a minimum organic content of 70% can make a claim that the product contains specific organic ingredients, provided that the label does not make the claim that it is an organic product.

The NOP Rule applies not only to ingredients that are required to appear on the label, but also to any substance used in or on organic food. Processed products labeled as '100% Organic' must be processed only using processing aids that are organicallyproduced.[55] Solvents, filtering aids, and other substances that have a technical functional effect are required to appear on the National List. All ingredients in products that bear an organic label—including the nonorganic ingredients in a 70%+ 'Made with Organic [specified ingredients]' claim—must not be produced or handled using Genetically Modified Organisms (known as 'excluded methods' under the rule),sewage sludge, and ionizing radiation.[56]

This guide was developed with funding from the Western Region USDA SARE program.

---

1 7 CFR 205.202.
2 7 CFR 205.203(a).
3 7 USC 6508(b)(2); see also 7 CFR 205.105(a) and 7 CFR 205.203(e)(1).
4 7 CFR 205.105(g).
5 7 CFR 205.203(c)(2)(i).
6 7 CFR 205.203(c)(1)(ii) and 7 CFR 205.203(c)(1)(iii).
7 7 CFR 205.203(c)(1)(ii).
8 7 CFR 205.203(c)(1)(iii).
9 7 CFR 205.602(h).
10 7 CFR 205.602(g).
11 7 CFR 205.2.
12 For example, see the literature review by M. Liebman and E. Dyck. 1993. Crop rotation and intercropping strategies for weed management. Ecological Applications 3(1):92-122.
13 7 CFR 205.236(a).
14 7 CFR 205.236(a).
15 7 CFR 205.236(a)(1).
16 7 CFR 205.236(a)(2).
17 7 CFR 205.236(a)(3).
18 7 CFR 205.236(b).
19 7 CFR 205.237(a).
20 7 CFR 205.239(a)(2).
21 7 CFR 205.237(a).
22 7 CFR 205.603(d).
23 7 CFR 205.237(b)(2).
24 7 CFR 205.237(b)(3).
25 7 CFR 205.237(b)(4).
26 7 CFR 205.237(b)(5).
27 7 CFR 205.238(c)(7).
28 7 CFR 205.238(c)(2).
29 7 CFR 205.603(a), Entries for Atropine, Butorphanol, Tolazine, and Xylazine.
30 7 CFR 205.603(a). Entries for Atropine, Butorphanol, Magnesium hydroxide, Tolazine, and Xylazine.
31 7 CFR 205.603(f).
32 7 CFR 205.238(c)(4).
33 7 CFR 205.238(c)(5).
34 7 CFR 205.603(a)(12).
35 7 CFR 205.603(a)(12).
36 7 CFR 205.603(a)(12).
37 7 CFR 205.603(a)(12).
38 7 CFR 205.238(c)(7).
39 7 CFR 205.239(a).
40 7 CFR 205.239(a)(1).
41 7 CFR 205.239(a)(2).
42 7 CFR 205.239(a)(1).
43 7 CFR 205.239(a)(4).
44 7 CFR 205.239(a)(3).
45 7 CFR 205.239(b).
46 7 CFR 205.239(c)
47 The NOP Rule defines to handle as "[t]o sell, process, or package agricultural products, except such term shall not include the sale, transportation, or de livery of crops or livestock by the producer thereof to a handler." 7 CFR 205.2.
48 Commingling is defined as "[p]hysical contact between unpackaged organically produced and nonorganically produced agricultural products during production, processing, transportation, storage or handling, other than during the manufacture of a multiingredient product containing both types of ingredients."7 CFR 205.2.
49 A handler is defined as "[a]ny person engaged in the business of handling agricultural products, including producers who handle crops or livestock of their own production, except such term shall not include final retailers of agricultural products that do not process agricultural products." 7 CFR 205.2.
50 7 CFR 205.271(d).
51 7 CFR 205.671(a).
52 7 CFR 205.271(f).
53 The 95% figure is calculated based on the net weight of the nonorganic ingredients excluding water and salt. 7 CFR 205.302(a).
54 7 CFR 205.105(c).
55 7 CFR 205.301(f)(4)
56 7 CFR 205.301(c), 7 CFR 205.301(f)(1), 7 CFR 205.301(f)(2), and 7 CFR 205.301(f)(3)

National Organic Program Regulations

Adapted from Title 7- Agriculture Part 205

by Karen RM McSwain

The information provided here pertains solely to regulations associated with crop and livestock production. It does not include regulatory information for processing or handling of certified organic products. It is intended to be a summary of National Organic Program (NOP) regulations in order to provide NRCS district conservationists with a better understanding of the guiding principles of certified organic production. This document is NOT intended to be a guide for certification, producers wishing to transition to certified production should contact a certifying agent for more detailed information regarding NOP regulations.

§ 205.100 Who has to be certified.

Any production or handling operation that produces or handles crops, livestock, livestock products, or other agricultural products that are intended to be sold, labeled, or represented as "100 percent organic," "organic," or "made with organic ingredients" must be certified.

§ 205.101 Exemptions and exclusions from certification.

A production or handling operation that sells agricultural products as "organic" but whose gross agricultural income from organic sales totals $5,000 or less annually is exempt from certification but must comply with the applicable organic production and handling requirements. The products from such operations shall not be used as ingredients identified as organic in processed products produced by another handling operation.

§ 205.105 Allowed and prohibited substances, methods, and ingredients in organic production and handling.

To be sold or labeled as "100 percent organic," "organic," or "made with organic ingredients" the product must be produced and handled without the use of synthetic substances and ingredients, prohibited nonsynthetic substances, ionizing radiation, sewage sludge, and genetically modified organisms (GMO's)

§ 205.202 Land requirements.

Any field or farm parcel from which harvested crops are intended to be sold, labeled, or represented as "organic," must have been managed in accordance with the standards set by the National Organic Program (NOP). Land must have had no prohibited substances applied to it for a period of 3 years immediately preceding harvest of the crop. Land must have distinct, defined boundaries and buffer zones to prevent the unintended application of a prohibited substance to the crop or contact with a prohibited substance applied to adjoining land that is not under organic management.

§ 205.203 Soil fertility and crop nutrient management practice standard.

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

Raw animal manure, which must be composted unless it is applied to land used for a crop not intended for human consumption; incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles.

Composted plant and animal materials must be produced through a process that establishes an initial C:N ratio of between 25:1 and 40:1 and maintains a temperature between 131 °F and 170 °F for 3 days using an in-vessel or static aerated pile system; or between 131 °F and 170 °F for 15 days using a windrow composting system, during which period, the materials must be turned a minimum of five times.

A producer may manage crop nutrients and soil fertility to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. A producer must not use any fertilizer or composted plant and animal material that contains a synthetic substance not included on the National List of synthetic substances allowed for use in organic crop production. The use of sewage sludge is not permitted in certified organic production.

§ 205.204   Seeds and planting stock practice standard.

A producer must use organically grown seeds, annual seedlings, and planting stock except under the following circumstances.

- Nonorganically produced, untreated seeds and planting stock may be used to produce an organic crop when an equivalent organically produced variety is not commercially available.
- Nonorganically produced seeds and planting stock that have been treated with a substance included on the National List of synthetic substances allowed for use in organic crop production may be used to produce an organic crop when an equivalent organically produced or untreated variety is not commercially available.
- Nonorganically produced annual seedlings may be used to produce an organic crop when a temporary variance has been granted. However it can only be labeled, or represented as organically produced only after the planting stock has been maintained under a system of organic management for a period of no less than 1 year.

§ 205.205   Crop rotation practice standard.

The producer must implement a crop rotation

including but not limited to sod, cover crops, green manure crops, and catch crops that provide the following functions: a) maintain or improve soil organic matter content; b) provide for pest management in annual and perennial crops; c) manage deficient or excess plant nutrients; and d) provide erosion control.

§ 205.206   Crop pest, weed, and disease management practice standard.

The producer must use management practices to prevent crop pests, weeds, and diseases including but not limited to crop rotation, soil and crop nutrient management, sanitation, and cultural practices that enhance crop health.

Insect pest problems may be controlled through mechanical or physical methods including but not limited to augmentation or introduction of predators or parasites of the pest species, development of habitat for natural enemies of pests, and the use of nonsynthetic controls such as lures, traps, and repellents.

Weed problems may be controlled through mechanical or physical methods including but not limited to mulching with fully biodegradable materials, mowing, livestock grazing, hand weeding and mechanical cultivation, flame, heat, or electrical means, or plastic or other synthetic mulches provided that they are

removed from the field at the end of the growing or harvest season.

Disease problems may be controlled through management practices which suppress the spread of disease organisms or the application of nonsynthetic biological, botanical, or mineral inputs.

When mechanical and physical control methods are ineffective in preventing or controlling crop pests, a biological or botanical substance or a substance included on the National List of synthetic substances allowed for use in organic crop production may be applied to prevent, suppress, or control insect pests, weeds, or diseases. However, the conditions for using the substance must be documented in the organic system plan.

§ 205.236 Origin of livestock.

Livestock products that are to be sold, labeled, or represented as organic must be from livestock under continuous organic management from the last third of gestation or hatching except in the following circumstances.

- Poultry or edible poultry products must be from poultry that has been under continuous organic management beginning no later than the second day of life.
- Milk or milk products must be from animals that have been under continuous organic management beginning no later than 1 year prior to the production of the milk or milk products that are to be sold, labeled, or represented as organic.
- Livestock used as breeder stock may be brought from a nonorganic operation onto an organic operation at any time provided that if said livestock are gestating and the offspring are to be raised as organic livestock, the breeder stock must be brought onto the facility no later than the last third of gestation.

§ 205.237 Livestock feed.

The producer of an organic livestock operation must provide livestock with a total feed ration composed of agricultural products, including pasture and forage that are organically produced and handled by operations certified to the NOP. The producer of an organic operation must not use animal drugs, including hormones, to promote growth, provide feed supplements or additives in amounts above those needed for adequate nutrition and health, feed plastic pellets for roughage, feed formulas containing urea or manure, feed mammalian or poultry slaughter by-products to mammals or poultry; use feed, feed additives, and feed supplements in violation of the Federal Food, Drug, and Cosmetic Act, provide feed or forage to which any antibiotic has been added, or prevent, withhold, restrain, or otherwise restrict ruminant animals from actively obtaining feed grazed from pasture during the grazing season

During the grazing season, producers shall provide not more than an average of 70 percent of a ruminant's dry matter demand from dry matter fed. This shall be calculated as an average over the entire grazing season for each type and class of animal. Ruminant animals must be grazed throughout the entire grazing season for the geographical region, which shall be not less than 120 days per calendar year. Due to weather, season, and/or climate, the grazing season may or may not be continuous. Producers must provide pasture of a sufficient quality and quantity to graze throughout the grazing season and to provide all ruminants under the organic system plan with an average of not less than 30 percent of their dry matter intake from grazing throughout the grazing season.

§ 205.238 Livestock health care practice standard.

A producer must establish and maintain preventive livestock health care practices including the following.

- Selection of species and types of livestock with regard to suitability for site-specific conditions and resistance to prevalent diseases and parasites;
- Provision of a feed ration sufficient to meet nutritional requirements, including vitamins, minerals, protein and/or amino acids, fatty acids, energy sources, and fiber (ruminants);
- Establishment of appropriate housing, pasture conditions, and sanitation practices to minimize the occurrence and spread of diseases and parasites;
- Provision of conditions which allow for exercise, freedom of movement, and reduction of stress appropriate to the species;
- Performance of physical alterations as needed to promote the animal's welfare and in a manner that minimizes pain and stress; and
- Administration of vaccines and other veterinary biologics.

When preventive practices and veterinary biologics are inadequate to prevent sickness, a producer may administer NOP allowable synthetic medications on breeder stock, when used prior to the last third of gestation but not during lactation if progeny are to be sold, labeled, or represented as organically produced and on dairy stock, when used a minimum of 90 days prior to the production of milk or milk products that are to be sold, labeled, or represented as organic.

The producer of an organic livestock operation must not sell, label, or represent as organic any animal or edible product derived from any animal treated with antibiotics, any substance that contains a synthetic or nonsynthetic substance not allowed under NOP regulations. Producers must not administer any animal drug, other than vaccinations, in the absence of illness, use hormones for growth promotion, or withhold medical treatment from a sick animal in an effort to preserve its organic status.

§ 205.239 Livestock living conditions.

The producer of an organic livestock operation must establish and maintain year-round livestock living conditions which accommodate the health and natural behavior of animals. The producer must provide year-round access for all animals to the outdoors, shade, shelter, exercise areas, fresh air, clean water for drinking, and direct sunlight, suitable to the species, its stage of life, the climate, and the environment. For all ruminants, the producer must manage pasture and daily grazing throughout the grazing season. Appropriate clean, dry bedding must be used, when roughages are used as bedding, they shall have been organically produced in accordance with NOP regulations. Shelter must be designed to allow for natural maintenance, comfort behaviors, and opportunity to exercise and temperature levels, ventilation, and air circulation must be suitable to the species.

The use of yards, feeding pads, feedlots and laneways shall be well-drained, kept in good condition, and managed to prevent runoff of wastes and contaminated waters to adjoining or nearby surface water and across property boundaries.

The producer of an organic livestock operation may provide temporary confinement or shelter for an animal because of inclement weather, certain animal life stages, when conditions may jeopardize their health, safety, or well-being, there is a risk to soil or water quality, or during healthcare procedures, breeding, sorting and shipping, or during 4-H, Future Farmers of America, or other youth projects.

§ 205.240 Pasture practice standard.

The producer of an organic livestock operation must, for all ruminant livestock on the operation, demonstrate through auditable records in the organic system plan, a functioning management plan for pasture. Pasture must be managed as a crop in full compliance with NOP regulations as does all land used for the production of annual crops for ruminant grazing. Pastures must be managed in order to comply with livestock feed and living requirements as required by the NOP. A pasture plan must be included in the producer's organic system plan, and be updated annually in accordance with NOP regulations.

The National List of Allowed and Prohibited Substances

§ 205.601 Synthetic substances allowed for use in organic crop production.

In accordance with restrictions not specified in this section, the following synthetic substances may be used in organic crop production provided that the use of such substances does not contribute to contamination of crops, soil, or water. Substances allowed in this section, except disinfectants and sanitizers, may only be used when the provisions set forth in the crop pest, weed, and disease management practice standard (§ 205.206) have been met.

Algicides, disinfectants, and sanitizers.

- Alcohols
- Ethanol
- Isopropanol
- Chlorine materials
- Calcium hypochlorite
- Chlorine dioxide
- Sodium hypochlorite
- Copper sulfate
- Hydrogen peroxide
- Ozone gas
- Peracetic acid
- Soap-based algicide/demossers
- Sodium carbonate peroxyhydrate (CAS #–15630–89–4

Herbicides and Mulches

- Soap based herbicides
- Mulches
- Newspaper or other recycled paper, without glossy or colored inks.
- Plastic mulch and covers

Insecticides

- Ammonium carbonate
- Aqueous potassium silicate
- Boric acid
- Copper sulfate
- Elemental sulfur.
- Lime sulfur
- Horticultural oils
- Insecticidal soaps
- Sticky traps/barriers
- Sucrose octanoate esters
- Pheromones

Plant Disease Control

- Aqueous potassium silicate
- Fixed coppers (copper hydroxide, copper oxide, copper oxychloride)
- Copper sulfate
- Hydrated lime
- Hydrogen peroxide
- Lime sulfur
- Horticultural Oils
- Peracetic acid
- Potassium bicarbonate
- Elemental sulfur
- Streptomycin
- Tetracycline

Plant or soil amendments

- Aquatic plant extracts
- Elemental sulfur.
- Humic acids
- Lignin sulfonate
- Magnesium sulfate
- Soluble boron products.
- Sulfates, carbonates, oxides, or silicates of zinc, copper, iron, manganese, molybdenum, selenium, and cobalt.
- Liquid fish products
- Sulfurous acid

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

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

- Ash from manure burning.
- Arsenic.
- Calcium chloride, brine process is natural and prohibited for use except as a foliar spray to treat a physiological disorder associated with calcium uptake.
- Lead salts.
- Potassium chloride
- Sodium fluoaluminate (mined)
- Sodium nitrate
- Strychnine
- Tobacco dust (nicotine sulfate)

Guidance for Selection of Conservation Practices to Support Organic Operations

Adapted from the 2012 EQIP Organic Initiative Practice List and National Organic Program Rules Correlation Matrix

by Karen RM McSwain

The Natural Resource Conservation Service's (NRCS) mission and vision is to "improve the health of our Nation's natural resources while sustaining and enhancing the productivity of American agriculture" in order to maintain "productive working lands in harmony with a healthy environment." The National Organic Program (NOP) defines organic production as a "production system that is managed…. by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity." While the NRCS and the NOP may differ in their approach to conserving natural resources there are a number of conservation practices offered through the Environmental Quality Incentives Program – Organic Initiatives that compliment organic production practices. Below are examples of EQIP-OI practices that support NOP production requirements on cropland.

§ 205.202 LAND REQUIREMENTS:

c) Have distinct, defined boundaries and buffer zones such as runoff diversions to prevent the unintended application of a prohibited substance to the crop or contact with a prohibited substance applied to adjoining land that is not under organic management.

Purpose Specific to Organic Operations: Establish physical barriers and increase distances between organic and nonorganic crops to protect against airborne or surface contaminants by prohibited substances or other nonorganic operations.

Resource Concern Addressed: Degraded Plant Condition
Sub Resource Concerns: Plant Productivity, Health and Vigor
EQIP Conservation Practices to Consider
327 Conservation cover
380 Windbreak and Shelterbelt Establishment
386 Field Borders
390 Riparian Herbaceous Buffer
391 Riparian Forest Buffer
393 Filter Strips
422 Hedgerow Planting
650 Windbreak and Shelterbelt Renovation

§ 205.203 SOIL FERTILITY AND CROP NUTRIENT MANAGEMENT

a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical chemical and biological condition of soil and minimize soil erosion.
Purpose Specific to Organic Operations: Develop a system of conservation practices that address all forms of erosion to meet the minimum treatment level as described in the FOTG. Utilize NRCS assessment tools to evaluate current and proposed alternatives.

Resource Concerns Addressed: Soil Erosion
Sub Resource Concerns: Sheet and Rill Erosion, Wind Erosion, Gully Erosion
EQIP Conservation Practices to Consider
311 Alley Cropping
327 Conservation Cover
328 Conservation Crop Rotation
329 Residue and Tillage Mgmt.- No Till
330 Contour Farming
331 Contour Orchards and other Fruit Areas
332 Contour Buffer Strip
340 Cover Crop
342 Critical Area Planting
344 Residue and Tillage Mgmt. – Seasonal
345 Residue and Tillage Mgmt. - Mulch Till
346 Residue and Tillage Mgmt. - Ridge Till
362 Diversion
380 Windbreak and Shelterbelt Establishment
386 Field Border
393 Filter Strip
410 Grade Stabilization Structure
412 Grassed Waterway
423 Hillside Ditch
449 Irrigation Water Management
484 Mulching
557 Row Arrangement
585 Strip Cropping
588 Cross Wind Ridges
589 Cross Wind Trap Strips
600 Terrace
601 Vegetation Barriers
603 Herbaceous wind Barriers
638 Water and Sediment Control Basin
650 Windbreak and Shelterbelt Renovation

§ 205.203 SOIL FERTILITY AND CROP NUTRIENT MANAGEMENT

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

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

Purpose Specific to Organic Operations: Implement a nutrient management system that considers realistic yield goals, nutrient budgets, mineralization rates and soil biological activity when developing conservation alternatives to reduce impacts on water quality.

Resource Concerns Addressed: Soil Erosion and Water Contamination
Sub Resource Concerns: Contaminants from animal waste and commercial fertilizer, excessive nutrients and salinity in ground and surface water, harmful levels of pathogens in ground and surface water.
EQIP Conservation Practices to Consider
311 Alley Cropping
317 Composting Facility
328 Conservation Crop Rotation
329 Residue and Tillage Mgmt., No Till/Strip Till/Direct Seed
340 Cover Crops
345 Residue and Tillage Mgmt. (Mulch Till)
346 Residue and Tillage Mgmt. (Ridge Till)
393 Filter Strip
554 Drainage Water Management
590 Nutrient Management

CROP ROTATION- § 205.205.

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

a) Maintain or improve soil organic matter content

b) Provide for pest management in annual perennial crops

c) Manage deficient or excess plant nutrients

d) Provide erosion control

Purpose Specific to Organic Operations: Crops grown in a planned reoccurring sequence minimize pest problems, enhance nutrient availability and cycling, reduce soil erosion, and increase soil organic matter.

Resource Concerns Addressed: Soil Erosion, Soil Condition, and Water Quality
Sub Resource Concerns: Ephemeral Gully, Sheet, Till and Wind Erosion, Organic Matter Depletion, Soil Compaction, Excessive Nutrients, Salinity, and Organics in Ground and Surface Water, and Excessive Suspended Sediment and Turbidity in Surface Water
EQIP Conservation Practices to Consider
311 Alley Cropping
327 Conservation Cover
328 Conservation Crop Rotation
329 Residue and Tillage Mgmt. - No Till,
330 Contour Farming
332 Contour Buffer Strips
340 Cover Crops,
345 Residue and Tillage Mgmt. - Mulch Till
346 Residue and Tillage Mgmt. - Ridge Till
590 Nutrient Management
595 Integrated Pest Management

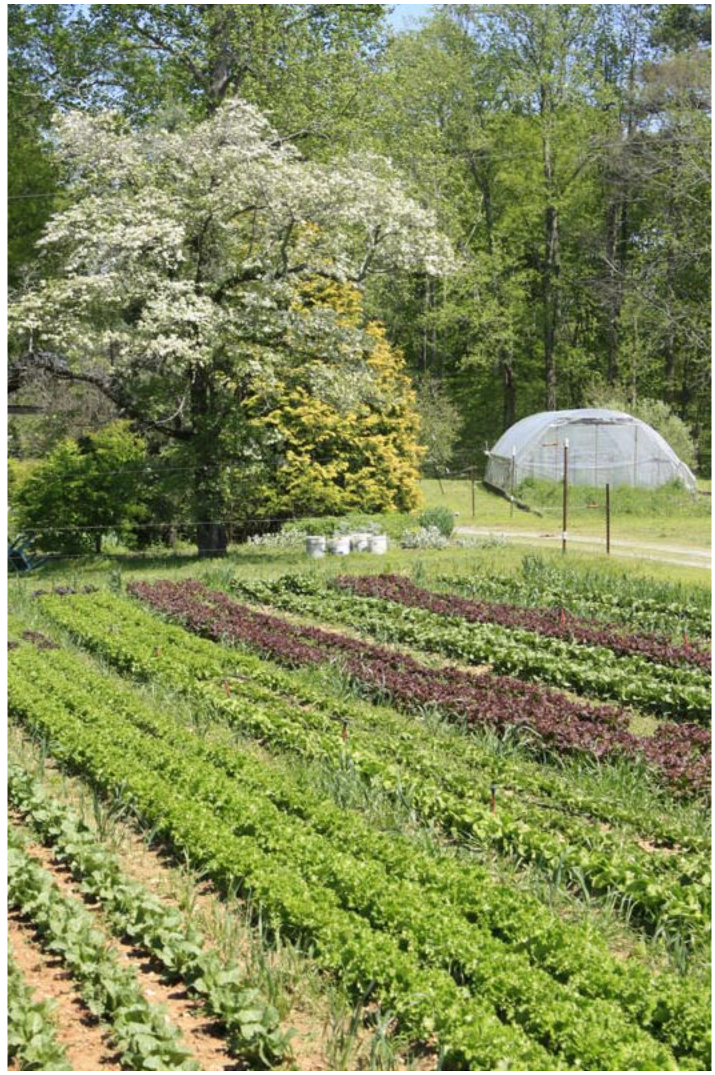
CROP PEST, WEED, AND DISEASE MANAGEMENT - § 205.206.

a) The producer must use management practices to prevent crop pests weeds and diseases

b) Pest problems may be controlled through mechanical or physical methods per NOP rules.

Purpose Specific to Organic Operations: Implement a system of practices to mitigate pest pressures that focuses on prevention, avoidance and monitoring.

Resource Concerns Addressed: Plant Condition
Sub Resource Concerns: Plants not adapted or suited and Productivity, Health, and Vigor
EQIP Conservation Practices to Consider
327 Conservation Cover
328 Conservation Crop Rotation
340 Cover Crops
386 Field Boarder
390 Riparian Herbaceous Cover
391 Riparian Forest Buffer
422 Hedgerow Planting
484 Mulching
595 Integrated Pest Management



The Organic Certification Process

by Karen RM McSwain

There are many reasons why a producer may decide to become certified. The most common reason is because of market demands. Certification is used as a tool when the customer does not have direct contract with producers. Therefore, it is more common for producers selling wholesale to become certified as opposed to those selling retail through farmers markets, community supported agriculture (CSA's) or farm stands. Many wholesale markets require producers to be certified because they themselves and their customers are unable to have direct contact with the producers in order to provide assurance that products are produced in an organic manner. However, because of the increase in competition, many producers who sell retail are finding that becoming certified gives them a competitive advantage. One reason for this is that it is getting more and more difficult to get into many farmers markets. In some markets, priority is given to certified organic farmers; therefore farmers may choose to certify in order to get into those markets. Another reason for certification is that being certified is an additional marketing tool that defines a production operation and many customers prefer that reassurance over trusting the producer's word. Finally, many producers become certified because they share in the philosophy of organic production and want to support the movement.

There are many steps to the certification process and it typically takes three years to transition land from conventional to certified organic. However, in some cases, if a producer can prove that the land they are wanting to certify has not had any prohibited substances applied to it, and has either been unmanaged or managed according to NOP regulations, some certifiers will allow shorter transition periods. However, the steps to certify are still the same.

Step 1. Identify a Certifier

There are a few factors to consider when choosing a certifier including cost, services provided, and whether or not the agency is recognized internationally. Producers must choose a USDA-accredited certification agency in order to ensure that the USDA NOP regulations are being followed. A list of accredited agencies can be found on the NOP website. In South Carolina, most producers are certified through the Department of Plant Industry at Clemson University; however, some producers use Quality Certification Services, International Certification Services, or Oregon Tilth.

Costs vary depending on operation, size, and certifier. The NOP estimates certification costs to be around $750 per farm operation per year. The 2008 Farm Bill allocated money to cost share the certification fee up to 75% with a $750 pay out maximum. The contact person for this program in SC is Larry Boyleston with the SC Dept of Agriculture (lboylest@scda.sc.gov).

Common Certification Agencies in the Carolinas

- Clemson University - Department of Plant Industry
  www.clemson.edu/public/regulatory/plant_industry/organic_certification/index.html
- Quality Certification Services
  www.qcsinfo.org
- International Certification Services
  www.ics-intl.com
- Oregon Tilth
  http://tilth.org/

Step. 2. Submit an application, including an Organic System Plan

The Organic System Plan (OSP) is a legally binding document between the certifier and the certified operation that describes practices and procedures used in production. It is a management tool that helps producers anticipate production conditions and make decisions on how they will address soil fertility and potential pest problems. The plan can also help producers identify resources in order to use them more efficiently. Finally, it is a useful economic tool and can help producers budget their production expenses and determine future income, which can also aid in the planning and decision making process. The plan must list all substances to be used in production, describe monitoring practices and procedures, record keeping systems, management practices, and any physical barriers established to prevent commingling of organic and nonorganic products. You can download a copy of the plan from NCAT Sustainable Agriculture (ATTRA) at https://attra.ncat.org/organic.html.

Step 3. Application and Organic System Plan Review

The certifier reviews the OSP and any other documentation required for certification. If the application is complete and the operation is in compliance with NOP regulations an inspector will be assigned to the operation and will schedule an on-site inspection. It is important to note that there is a difference between a certifier and an inspector. A certifier is the accredited agency that issues certification, the inspector is an individual who works for that agency who gathers information from the producers in order to report back to the agency regarding whether or not regulations are being followed. The inspector can provide information to producers about the certification process, answer questions about NOP standards and regulations, and explain management practices and record keeping. They cannot act as an advisor or crop consultant, recommend specific products, practices, animal and plant varieties, or give advice on how to meet NOP regulations.

Step 4. On-Site Inspection

Once the application has been reviewed, an inspector will perform an on-site inspection. These are arranged ahead of time and are done on an annual basis when certification is up for renewal. The inspector is there to review production records, verify that the OSP reflects actual operations, and ensure that prohibited inputs are not being used and that the risk of contamination from surrounding land is being addressed. The inspector may take soil, tissue or product samples to verify NOP regulations are being followed. USDA accredited certification agencies are required to perform a specific number of unannounced inspections of certified organic operations a year. Operations for surprise visits are chosen randomly and can happen anytime during the year.

Step 5. Review of Application and Inspection Report

After the on-site inspection is completed the inspector submits their inspection report to the certifier who then reviews the report and application in order to determine whether or not the operation is in compliance with the regulation. The final decision is communicated in writing to the producer along with any additional requirements necessary for certification. Significant noncompliance issues may result in a denial or revocation of certification until issues are addressed. Certification and/or renewal may be granted even if there are minor noncompliance issues; however, the certifier will determine a date in which those issues must be addressed.

Step. 6. Organic Certification

If certification is granted, the producer is then considered in compliance with the NOP standards and is issued a certificate. Once the certificate has been received, the producer is able to identify their operation as certified organic and may use the USDA seal of certification. Operations are then inspected on an annual basis at the time of renewal. If the operation is still in compliance, recertification is granted. If the certifier finds the operation is no longer in compliance, certification may be denied, or postponed until issues are addressed.

Practical Nutrient Management for Organic Vegetable Crops

by Mark Schonbeck

One of the biggest challenges facing new or transitioning organic farmers, and agricultural professionals working with them, is determining appropriate organic fertilizer and other inputs based on a standard soil test. Fertilizer recommendations provided with soil test reports are based on research into yield responses to nutrient applications on conventionally managed soils. Thus, one of the most frequently asked questions is: "How do I translate this into 'organic'?"

Nutrient management for organic or sustainable systems requires a different approach from that used in conventional crop production of the late 20th century, for a couple reasons. First, conventional fertilizers become available immediately (e.g., ammonium nitrate, potassium chloride), or over a short and predictable time span (e.g. superphosphates, urea). In contrast, most organic sources of fertility release nutrients more slowly, and the rate of release depends on soil temperature, moisture, and biological activity. Second, crop nutrients (whether from soluble or slow-release fertilizers, or from soil organic matter) behave differently in biologically active soils under long term sustainable organic management, compared to soils fertilized mainly with soluble inorganic materials, and soils early in the process of transitioning to organic.

Organic nutrient management aims to build a healthy, living soil, in which the action of soil organisms on active (decomposable) soil organic matter releases most of the nutrients required by the crop. A diversity of organic materials, including cover crops, compost, organic mulches, and crop residues, is returned to the soil to feed soil life, replenish organic matter, and replace nutrients removed in harvest. Whereas the vital role of soil life in soil fertility and crop nutrition has gained widespread recognition over the past 15 years, Extension and other agricultural professionals still seek practical tools for making organic fertilizer recommendations that will give reliable results. The truth of the matter is that there is no definitive formula for translating standard soil test recommendations into "organic." Yet, experienced organic producers manage nutrients effectively, obtaining yields comparable to conventional agriculture while reducing water pollution with nitrogen (N) and phosphorus (P) (Liebhardt, 2001).

Organic gardeners often say, "feed the soil, and the soil will feed the crop." However, economic reality in a farm enterprise may require a "feed the soil and the crop" approach. Certain "supplements" are often needed to obtain economically satisfactory yields, especially in fields recently converted to organic production. Cover crops, compost, and organic residues are added to restore depleted soils, and NOP-allowed fertilizers and mineral amendments are applied to:

- Address deficiencies in specific crop nutrients.
- Adjust soil pH as needed.
- Replenish depleted soil nutrient reserves.

Once soil quality is restored, and nutrient and pH levels are near optimum, organic fertilizer inputs can be reduced. The farmer then adjusts annual inputs to:

- Replenish nutrients removed in harvest.
- Meet nutrient demands of heavy-feeders (some vegetable crops just have to be "fed").
- Maintain soil life, active organic matter, humus (stable organic matter) and soil quality.
- Avoid building up nutrient excesses.

Nutrient Dynamics

Plants take up most nutrients, especially nitrogen (N), phosphorus (P), and potassium (K), in soluble mineral forms, including nitrate (NO_3^-), ammonium (NH_4^+), phosphates (e.g., $H_2PO_4^-$), and potassium ion (K^+). Soil testing protocols are designed to measure these plant-available forms of NPK.

The bulk of soil N is present in organic form, as an integral part of the soil organic matter (SOM). Soil life mediates N availability to the plant, and is essential for releasing N from the soil organic matter so crop roots can take it up. Because of the environmental,

Plant-available soil K is held on the cation exchange capacity (CEC - negatively charged clays and humus, which hold positively charged K, calcium (Ca), and magnesium (Mg) in plant-available form). Most soils also have a lot of insoluble K bound up in their mineral fraction. Some soils tend to "fix" K when large amounts of soluble K are applied at once, which can make it difficult to raise available soil test K to optimum levels. However, grasses and trees can unlock some of the mineral-fixed K, and subsequently return it to the soil in more available forms. Building soil organic matter contributes to CEC and helps keep plant-available K on hand.

Secondary and micro-nutrients essential to plants include calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), molybdenum (Mo), and nickel (Ni). Of these, B is often deficient in southeastern US soils, and deficiencies of Mg, Ca, S, Mn, Cu, and Zn occasionally occur.

Most vegetable crops are heavy nitrogen feeders, requiring 100–200 lb N/ac. Warm-season crops like tomato, sweet corn, or pumpkin absorb N over a fairly long period while the soil is warm. Thus, a fertile, biologically active soil may release sufficient N through mineralization to meet crop needs. However, an early-maturing, cool-season heavy feeder like broccoli or spinach requires a lot of N in a short period of time in spring, while the soil is cool. In this case, the soil life may not mineralize enough N to keep up with crop N demand. An application of a faster-releasing organic N source, such as feather meal, blood meal, or soybean meal, may be needed.

climate, water quality, and human health impacts of nitrate-N leaching and denitrification from fertilized soils, managing N to meet crop needs while avoiding these adverse impacts is a major challenge for both conventional and organic farmers.

Most of the soil P is present as insoluble mineral and organic forms. When readily available fertilizer P is added, a significant fraction of it rapidly becomes "fixed" or immobilized into insoluble mineral or organic forms. Thus, flooding the soil with a large amount of available P at one time (via manure or soluble fertilizers) is not an efficient way to provide for crop P nutrition. On the other hand, soil life, especially the root-symbiotic mycorrhizal fungi, can solubilize organic P and even some of the mineral-fixed P. Good soil biological activity is essential to efficient utilization of P, and to adequate crop P nutrition in sustainable production.

Vegetable crops utilize only about 20 lb P/ac, or 1 lb P (2.3 lb P2O5) for every 6–10 lb N. Because readily available fertilizer P tends to become immobilized ("fixed") in insoluble soil minerals, P recommendations often considerably exceed the amounts crops are expected to consume, in order to ensure adequate P nutrition for the crop. With continued heavy annual P applications, the soil's P fixation capacity becomes saturated, and surpluses begin to build up. Excessive soil P levels pose a threat to water quality and aquatic ecosystems, and also inhibit the growth and activity of the highly beneficial mycorrhizal fungi in the soil and crop roots.

Excess P in runoff has become a major water quality resource concern in the Chesapeake Bay, the Gulf of Mexico, and elsewhere. At the same time, P fertilizer is a limited resource worldwide, and "peak phosphorus" is considered a major threat to global food security. This paradox presents a double imperative to utilize P as frugally as practical in crop production.

Vegetable crops use a lot of potassium (K), perhaps 100–300 lb/ac. Some soils, especially those rich in mica clays, can tie up K in insoluble or "mineral-fixed" forms, making it harder for vegetable crops to access the nutrient. Including cereal grains (for harvest or cover crop), perennial grasses, and woody perennials in the cropping system can help unlock the fixed K. Sandy soils with low SOM have little capacity to hold on to K, and K may be lost to leaching. Efforts to build stable SOM are especially important for K nutrition on these soils. Generally, crop rotation and good soil organic matter management can help maintain crop K nutrition, and reduce the need for expensive NOP-allowed K fertilizers.

Unlike N and P, excess soil K does not pose serious water pollution or other environmental hazards. However, K management merits attention, since K excesses can adversely affect crop nutrition, livestock health, and physical properties (tilth) of soils rich in certain clays.

Causes of Crop Nutrient Deficiencies

Crops can be nutrient deficient for any of several reasons:

- The nutrient is truly lacking or limiting in the soil.
- The soil life is depleted or out of balance, so that nutrients remain locked-up.
- The soil is dry or cold, rendering the soil life dormant.
- The soil is compacted, or a subsurface hardpan exists, thereby restricting root growth.
- A highly acid subsoil with little SOM contains toxic amounts of aluminum (Al), which inhibit root growth beyond a certain depth.

Two or more of these conditions often occur together, and need to be addressed in an integrated approach. The first is remedied through the addition of appropriate organic fertilizers or amendments. Soil life is restored by introducing a diversity of beneficial soil biota (sources include good compost, worm castings, compost teas, biodynamic preparations, and mycorrhizal and other soil inoculants), and providing sufficient "food" (cover crops, crop residues, and other organic inputs). Appropriate irrigation, optimum planting dates, and season extension help maintain favorable conditions for soil life as well as the crop. Subsoiling or chisel plowing, followed by deep rooted cover crops can relieve compaction or hardpan. Calcium amendments, especially gypsum (calcium sulfate) reduce solubility and phytotoxicity of subsoil Al.

Goals and Pitfalls in Organic Nutrient Management

Organic farmers use a combination of "feed the soil" and "feed the crop" practices to secure satisfactory economic returns while building and maintaining a high quality soil. Research-based guidelines for nutrient management in sustainable production (Magdoff & van Es, 2009; Peet, 1996) can help in achieving this balance.

Short term organic nutrient management goals include:

- Correct acute soil nutrient deficiencies, and nutrient or pH imbalances.
- Tailor nutrient availability to each crop to maintain profitable yields.
- Restore soil organic matter and soil life. Longer term goals include:
- Maintain high levels of active organic matter and humus, and a diverse soil biota that provides for most crop nutrient needs.
- Maintain optimum soil nutrient and pH levels.
- Balance nutrient exports (harvest) with nutrient inputs.

Pitfalls in organic nutrient management include insufficient nutrient inputs resulting in low yields or long-term depletion of soil reserves ("soil mining"); and excessive nutrient inputs resulting in potential N and P pollution of nearby water resources, increased pest or weed problems, and unnecessary costs to the farmer. New farmers who interpret organic philosophy as "avoid purchased inputs and let nature take its course," and organic farmers managing larger acreages, tend to underapply nutrients. Farmers and market gardeners with small, intensively managed acreages of high-value crops sometimes overapply nutrients in the belief that "the more compost, aged manure, and organic mulch, the better." In addition, farmers in transition from conventional to organic production of heavy feeding vegetable crops sometimes overcompensate for the slower release of organic nutrient sources to make sure crops are not nutrient limited.

One common pitfall is the use of composted or aged manure to provide most of a crop's N requirements, year after year. Crops consume N and P in a 6:1 ratio or higher, while manure and compost often contain N and P in a 2:1 or 3:1 ratio, with only 25-50% of the N immediately available to the current crop. As a result, using these materials as the primary N source will add several times as much P as the crop will use. If soil P reserves are low, this is a good way to build them up; however once soil P levels reach optimum ranges, manure and compost inputs need to be cut back. Otherwise, P excesses will build up, which can tie up micronutrients, inhibit the growth of the valuable crop-symbiotic mycorrhizal fungi, and pollute nearby waters.

Poultry litter and compost or fertilizers based thereon (such as Harmony™ 5-4-3 N-P2O5-K2O) are especially rich in P. Because crops often respond dramatically to these materials, many conventional and organic farmers use them regularly. In addition to P, poultry manure-based amendments also contain large amounts of Ca (9% in Harmony 5-4-3), substantial liming (pH-raising) capacity, and significant amounts of the micronutrients Zn and Cu. They can be valuable on soils that are low in these nutrients, but should be avoided or used sparingly if soil pH is near 7 (neutral), or soil test P, Ca, Zn, or Cu is already high.

Because much of the "unavailable" N in compost or manure is added to the soil's mineralizable organic N pool, surpluses of N as well as P may build up if heavy annual inputs are continued. Studies on New York farms have shown that, once soil organic matter, N and P levels are adequate, annual total N and P inputs from organic sources can be budgeted to equal annual N and P removal through harvest, with no loss in yields (Drinkwater, 2003).

Similarly, the heavy use of grass hay mulches year after year can build soil K levels up high enough to upset nutritional balance. One result may be increased incidence of blossom end rot (tomato, pepper, and cucumber), tip burn (lettuce and other leafy crops) and other physiological disorders related to localized Ca deficiency. Excess K can also increase problems with certain weeds. In addition, livestock feeding on forage or crop residues that are very rich in K relative to Mg can suffer from grass tetany, a potentially life-threatening condition. Because vegetables are heavy K consumers, K surpluses are easier to avoid or to draw down through harvest, than P surpluses. In addition, whereas some K may leach from sandy soils low in organic matter, K leaching is not considered a

significant threat to water quality or aquatic ecosystems.

Cover crops add organic matter by converting carbon dioxide in situ into organic carbon (C), and legumes fix atmospheric N. However cover crops do not add more P or K. Thus, legume cover crops become an important nutrient management tool in organic crop production on soils that already have optimal or excessive P or K levels. At the same time, on soils with lower levels of these nutrients, cover crops can enhance the availability of soil P (especially legumes and buckwheat) and K (especially cereal grains) to following cash crops.

Some organic farmers and consultants seek to "balance" cation nutrients (K, Ca, and Mg) to adjust base saturation [percentages of soil CEC occupied by each element] to levels considered optimum for soil and crop health: 3–5% K, 65–70% Ca, and 10–15% Mg. Some may also aim to raise sulfur (S) and other micronutrients to high levels to promote crop pest resistance and "nutrient density." Numerous studies have shown that most crops grow well in a fairly wide range of soil Ca and Mg levels (~50–80% Ca and 10–25% Mg). Most soils in our region have significant S reserves in the subsoil, although crop S deficiency can occur on sandy soils with S test values below 10 ppm. Although using lime, gypsum, and other amendments to achieve "ideal" base saturation percentages and S levels is not harmful to crop, soil, or water quality, it can entail unnecessary costs to the farmer and to the environment (through impacts of mining).

Boron (B) is one essential crop micronutrient that is often deficient in southern US soils. Brassica vegetables, beets, and alfalfa are most susceptible to B deficiency; tomato, spinach, carrot, and other root crops are moderately so. Boron should be applied as needed, broadcast evenly at no more than 1–2 lb elemental B per acre at any one time, to avoid harmful excesses.

Nitrogen Budgeting for Organic Farmers: Slow-release N and C:N ratio

Unlike conventional nutrient management, in which soluble N is applied on a schedule designed to match crop needs, organic N management requires careful consideration of the role of soil life and of carbon to nitrogen (C:N) ratios. When raw organic materials with a C:N ratio of less than 20:1 (such as fresh manure with little or no bedding, or a succulent all-legume green manure like hairy vetch or alfalfa) are added to the soil, soluble N is released fairly rapidly into the soil, from which it can be taken up by growing crops – or lost through leaching, denitrification, or volatilization, similar to conventional N fertilizers. Organic materials with a C:N ratio of about 25:1 release N slowly while decomposing, whereas materials with C:N ratios above 35:1 (such as a mature rye cover crop, tree leaves, or straw) can immobilize (tie up) soil N for several weeks or months. The soil food web generates the most active organic matter and stable humus from organic residues with C:N ratios of 25-35:1. A grass-legume cover crop biculture, grown to early flowering, usually has a C:N ratio in this optimum range.

Because biological processes regulate N release from organic materials, organic farmers need a different approach to N budgeting from the formulaic "X pounds of N per acre for Y bushels-per-acre crop" of conventional production. Any farmer who uses manure or cover crops can and should calculate "N credits" from these sources to save on N fertilizer bills and protect water resources. Furthermore, in biologically active soils, the SOM itself is a significant N source for the current crop. Cornell University estimates 20 lb/ac N released per 1% SOM content per year, while some private soil testing labs such as A&L Eastern Labs in Richmond, VA calculate an "estimated nitrogen release" (ENR) based on %OM, CEC and soil texture. In our warmer climates, a sandy soil with 2.5% OM or a clay-loam with 4% OM may release about 100 lb N/ac annually, which is over half the N requirement of most vegetable crops. Replenishing this OM-derived N through legume cover crops and organic inputs is vital for long term sustainability.

The percent of total N that is available to the current year's crop can be estimated at 50% for manure and most cover crops, and just 10-25% for compost. Most of the rest of the compost N, as well as N in a grass-legume green manure, becomes incorporated into the soil organic N pool, thus helping to replenish this vital long-term source of N. Some manure N may leach or volatilize, and some may enter the organic N pool, depending on the C:N ratio of the manure-bedding mix. While the "available" portion of compost, manure, and cover crop N helps provide for the needs of the current crop, the "unavailable" portion of compost and cover crop N, and at least part of unavailable manure N go toward replenishing soil organic N.

How to Read a Soil Test Report

Standard soil test reports obtained through land grant university Extension services, state departments of agriculture, and private labs display elemental P, K, Ca, Mg, and micronutrients in lb/ac (e.g., Virginia Tech), in parts per million (e.g., A&L Eastern Labs in Richmond, VA; 1 ppm = 2 lb/ac), or as an "index" value (e.g., North Carolina State Department of Agriculture.). Values are rated as:

VL (very low – critically deficient; NCDA index <10)

L (low – likely yield limiting; expect yield response to nutrient application; index 10-25)

M (medium – possible crop yield response to adding nutrient; index 26-50)

H (high – optimum, crop not likely to show response to added nutrient; index 51-100)

VH (very high – ample and possibly excessive; index >100)

Some labs (e.g., Virginia Tech) simply rate micronutrients as "sufficient" or "deficient."

Soil tests also shows soil pH, buffer index (pH measured in a buffer solution, used to determine lime rates), cation exchange capacity (CEC), and percentages of the CEC occupied by acidity (hydrogen + aluminum), Ca, Mg, and K.

Soil organic matter content (%OM) may be part of the standard test (A&L) or offered for an additional fee (VA Tech). NCDA measures "humic matter" (fulvic + humic acids), giving figures considerably lower than total OM.

Recommendations for lime, P and K applications are based on the soil test report and on research data on crop responses to nutrient applications on a wide variety of soils with different soil test values. At lower nutrient levels, more P and K are recommended than the crop is expected to remove in harvest, in order to ensure adequate crop response and restore soil levels. Recommended applications are closer to crop removal rate at high soil test nutrient levels. Liming rates are geared to adjusting soil pH to 6.5-7.0, based on pH and CEC, or on buffer pH.

NOTE: fertilizer recommendations are given in terms of phosphate or P2O5 (1 lb P2O5 = 0.44 lb elemental P) and K2O (1 lb K2O = 0.83 lb elemental K).

How to Use Standard Soil Tests in Organic Vegetable Production

Because research-based formulas do not exist for determining organic amendment rates based on soil test results, organic producers use the soil test somewhat differently from their conventional counterparts. An initial soil test can identify nutrient deficiencies and excesses, and pH imbalances that need to be addressed, and can help guide efforts to improve soil quality. For example suppose a farmer is bringing a new field into organic production, and the soil looks "farmed-out," with little organic matter and hardly any earthworms. The soil test might show an acid pH of 5.0 and low levels of P, K, Ca, and micronutrients. In this case, some lime, plus a generous application of composted poultry litter, followed by a heavy N-feeding cover crop like sorghum-sudangrass may be ideal. However, the test may reveal acid pH and very high P and K, because of a history of intensive use of conventional fertilizers. Legume cover crops, not poultry litter or other manures, are the best organic inputs for restoring this soil.

Organic farmers repeat soil tests every 2–5 years to monitor trends in nutrients, SOM, and pH. Soil samples should be collected at the same time of year, ideally at the same point in a crop rotation, and either consistently prior to, or consistently after tillage. Successive samples should be sent to the same lab to allow direct comparison. Repeat soil tests help the grower determine whether enough organic matter is being returned to the soil, whether more lime is needed, and whether P, K or other nutrient inputs need to be adjusted up or down to maintain optimal levels.

A note on liming: organic systems often require less lime, because good SOM and biological activity tend to buffer soil pH and widen crop pH tolerance ranges. In addition, many soils in the humid parts of the southern US should be limed only to about pH 6.0, to avoid lime-induced micronutrient deficiencies (Brady and Weil, 2008).

Ask the Crop: Foliar Nutrient Analysis

Organic farmers are well advised to conduct a foliar nutrient analysis on one or more major crops. This reveals what the crop actually "sees" in terms of nutrients, which may or may not match the soil test report. When crop deficiencies or imbalances are suspected, the farmer can take samples from an apparently healthy crop, and another that shows poor growth or deficiency symptoms (the same crop in two different fields, or different crops in the same or different fields), and compare results to identify limiting nutrients. A foliar nutrient analysis can also provide documentation to justify application of micronutrient amendments under the NOP.

On a deep, biologically active soil without hardpan, crops may show optimum levels of nutrients that test only "low" or "medium" in the soil, because roots can spread wide and deep, and soil organisms such as mycorrhizal fungi help plants access nutrients that are not detected in the soil lab. On the other hand, crops growing in a compacted, biologically-depleted soil may show deficiencies in nutrients that are "high" in the soil test, owing to restricted root growth or lack of beneficial organisms to help the crop take up nutrients.

Direct field observations can also be revealing. For example, healthy, high-yielding peas, beans, or edamame in a field in which other crops do not thrive, and spring greens and brassicas do especially poorly, are a "smoking gun" for N deficiency, especially that caused by organic inputs with excessively high C:N ratios. A bad aphid problem in brassicas, plus lodging in a neighboring oat cover crop, may indicate too much N and insufficient K. If broccoli gives disappointing yields of poor quality heads and beet roots fail to grow to marketable size, while peas, onions, beans, sweet corn, and cucurbits are doing OK, check for a boron (B) deficiency.

USDA National Organic Program (NOP) Allowed Fertilizers and Amendments

Adjusting pH: Dolomitic or calcitic (high calcium) limestone to raise pH; elemental sulfur (S) to lower pH. (Hydrated lime, quicklime, and aluminum sulfate are prohibited under the NOP).

Nitrogen: Feather meal, blood meal, fish meal, and non-GMO seed meals are NOP allowed N fertilizers. Chilean sodium nitrate is allowed but restricted to 20% of a crop's N requirement. Legume cover crops can provide N much more inexpensively than purchased organic N fertilizers. (Urea, ammonium nitrate, potassium nitrate, and anhydrous ammonia are prohibited).

Phosphorus: Rock phosphate, calphos, colloidal phosphate, and bone meal are allowed P fertilizers. The first three are fairly insoluble, and only about 10% of the total is considered plant available. However, on a biologically active soil, most or all of the P becomes available over a 5-10 year period; thus, natural mineral phosphate fertilizers do not need to be applied every year. (Single and triple superphosphate, and ammonium phosphates are prohibited under the NOP.)

Potassium: Natural, mined potassium sulfate and sul-po-mag without synthetic additives are allowed K fertilizers. Greensand (7%K) is sometimes used, but the K is mostly mineral-fixed and released very slowly; thus it is not economically effective as a K fertilizer. Grass hay mulches contain about 2% K on a dry weight basis, and a 4-inch mulch may deliver 200 lb K per acre or more. (Potassium chloride, or muriate of potash, is prohibited under the NOP.)

Boron: Borax, solubor, and the natural mineral sodium calcium borate are allowed under NOP when soil or foliar tests verify a need for B supplementation.

Calcium: lime (also raises pH); gypsum (does not raise pH).

Magnesium: dolomitic lime (raises pH), Epsom salts, sul-po-mag (these do not raise pH).
Sulfur: elemental sulfur (lowers pH); gypsum, potassium sulfate, sul-po-mag, Epsom salts (none of these significantly change pH).

Zinc, copper, manganese, iron: sulfate salts and chelated forms of these micronutrients are allowed under NOP when justified by soil or foliar test results.

Some Examples from Actual Soil Tests

Following are some examples of soil test reports from Virginia Cooperative Extension, and possible recommendations for selected organic vegetable crops.

Sample 1. Field in Carroll Co., Virginia.

Nutrient	lb/ac	Rating	% of CEC
P	39	H-	
K	213	H	4.3
Mg	297	VH	19.4
Ca	1446	H-	57.4

Soil pH: 6.0
Estimated CEC: 6.3
Crop: Cucumber
Micronutrients: all "sufficient".
Conventional recommendations :
870 lb/ac 10-10-10
2,500 lb/ac agricultural limestone.

Suggested organic approach:
Lime may not be needed, especially if soil organic matter and biological activity are high. If lime is applied, calcitic or high calcium lime is preferred, as Mg is already quite high.

For a cucumber crop, recommendations include 100–125 N/ac, 50 lb phosphate (P2O5) for a "high" soil test P; and 100 lb potash (K2O) for "high" soil test K (Peet, 1996).

If a rye + vetch cover crop containing 120 lb/ac total N is incorporated prior to planting, and compost with a N-P2O5-K2O analysis of 1-1-1 is applied in crop rows at 2 tons/acre, the cover crop will make about 60 lb N available to the vegetable, and the compost about 4-10 lb N (at 10-25% available), plus about 40 lb each phosphate and potash.
That leaves about 35 lb N, 10 lb P2O5 and 60 lb K2O needed to meet recommendations. About 350 lb/ac fish meal (10-2-2) and 100 lb/ac potassium sulfate (0-0-51) will approximately provide these amounts.

NOTES:

a. Whereas a pH of 6.0 is sufficient for many vegetables, a few, including brassicas, beet, and asparagus, may prefer a somewhat higher pH. If these vegetables are next in the planned rotation, liming now will yield the desired pH increase by next season.

b. Applying Harmony (5-4-3) at 2,000 lb/ac, or increasing the compost application to 5 tons/ac would meet the N and K needs, but would apply considerably more P than will be needed by the crop, leading to a buildup of soil P. Whereas this is probably acceptable on this soil for a year or two, these practices may, over the long run, lead to a P excess in the soil.

c. The soil test did not include organic matter, and showed fairly low boron (B) at 0.3 ppm. A test by a different lab showed 3.6% organic matter with estimated nitrogen release (ENR) at 108 lb/ac, which suggests that the crop may derive sufficient N from soil organic matter, and the compost + cover crop are sufficient to replenish this organic N. The second test also confirmed low B; thus, 1 lb/ac elemental B would be recommended for brassica or beet family crops.

c. Because soil P and K tested in the "high" range, the current crop may show little yield response to additional nutrient; however, total P and K inputs should approximately replace the nutrients removed in harvest. A 10 ton per acre cucumber harvest would remove about 30 lb phosphate (P2O5), and as much as 170 lb potash (K2O) per acre.

Sample 2*. Field in Carroll Co., Virginia.

Nutrient	lb/ac	Rating	% of CEC
P	821	VH	
K	447	VH	3.4
Mg	522	VH	12.8
Ca	5634	VH	83.8

Soil pH: 7.2

Estimated CEC: 16.8

Crop: Potato

Micronutrients: all “sufficient”.

Zn unusually high

Conventional recommendations:

225 lb/ac am. nitrate (33-0-0), or 75 lb/ac N.

*Same farm as Sample 1, different field history.

Suggested organic approach:
P is in extreme excess; this combined with high Zn and Ca suggests a history of heavy poultry litter applications. K is ample. A second soil test confirmed the P excess and showed ample organic matter (5.7%, with ENR of 143 lb/ac/year).

The challenge here is to maintain organic matter, soil life, and mineralizable N levels for crop production without adding any more P. This is accomplished by stopping all applications of manure, poultry litter, and fertilizers or compost based on these materials, and relying on high biomass grass + legume cover crops to maintain organic matter and N levels. Limit compost to 1 ton/ac/year of a low-P compost rich in biological activity, to maintain soil microbial diversity. Use a fish-seaweed based foliar fertilizer if crops seem to need a boost.

NOTES:

a. Most vegetables should be able to obtain plenty of nutrients from this soil from organic matter breakdown by the soil life, without the need for organic fertilizer supplements. The extremely high P level may inhibit the activity of mycorrhizae, which could adversely affect some crops during drought, or leave crops more vulnerable to soilborne disease organisms. Crop harvests will gradually draw down P levels over time, especially heavy P feeders like potato.

b. Because potato actually prefers moderately acid soils (pH 5.5-6.0) and may suffer scab disease at high soil pH, the farmer may consider swapping the potato and cucumber crops with field 1 above, and postponing lime application in field 1 until after potato harvest.

Sample 3. Field in Giles Co., Virginia.

Nutrient	lb/ac	Rating	% of CEC
P	4	L	
K	329	VH	6.9
Mg	134	M+	9
Ca	1076	M	43.7

Soil pH: 5.3

Estimated CEC: 6.2

Crop: Snap Bean

B low, other micronutrients “sufficient”.

Conventional recommendations:

4,960 lb/ac agricultural limestone

Suggested organic approach: Lime to achieve a soil pH of 6.0-6.5. Start with 1.5 ton/ac of Dolomitic Lime to provide both Mg and Ca, as Mg is quite low relative to K. Higher lime rates could tie up micronutrients or hinder release of P from rock phosphate (recommended below). If practical, start the crop rotation with acid-tolerant cover crops (buckwheat, oat, rye, vetch), or vegetables (potato, tomato, sweet potato), as the lime will take effect gradually over a two-year period. Retest soil at the end of that period; if pH remains below 6.0, apply another ton/ac of lime (calcitic is OK for second application).

Provide P as a combination of readily available (manure or compost based) and slow-release (rock phosphate or colloidal phosphate) materials. Grow high biomass legume-grass cover crops to build OM and the organic N pool.

For snap bean, recommendations include 40-80 lb N (assumes this legume crop will fix some but not all of its N requirement); 80 lb/ac phosphate for low soil test P, and just 20 lb/ac potash for very high soil test K (Peet, 1996).

Assume that the soil is limed and rye + vetch is planted the previous fall, and the cover crop produces a moderate biomass and 80 lb N/ac (40 lb/a available N). Prior to planting beans, spread 1,000 lb/ac rock phosphate or colloidal phosphate, which will slow-release phosphate over a 5-10 year period, with about 30 lb/ac P2O5 available the first season. If a good compost with a 1-1-1 analysis is available, ap-

ply at 2.5 tons/ac banded in the crop row to provide another 50 lb P2O5. This will also provide perhaps 10 lb available N (+ 40 lb available N from the cover crop = 50 lb total, which is enough), and somewhat more K2O (50 lb/ac) than needed. Other vegetable crops in the rotation may utilize the extra K.
If compost is not available, use 5-4-3 fertilizer at 1,200 lb/ac, or poultry litter (1 ton/ac – at least 120 days before harvest to meet NOP requirements), to provide plant-available phosphate.

NOTES:

a. If the desired crop is blueberry, no lime is needed, as the pH is ideal for this crop.

b. Snap bean probably does not need boron, and can be damaged by too much. Boron should be applied at 1 lb/ac elemental B before growing brassicas, beet family, and possibly tomato.

Sample 4*. Field in Craig Co., Virginia.

Nutrient	lb/ac	Rating	% of CEC
P	68	H	
K	400	VH	6.4
Mg	184	H	9.5
Ca	2589	VH	81.1

Soil pH: 6.5

Estimated CEC: 8.0

Crop: Sweet Corn

Micronutrients: all “sufficient”.

Conventional recommendations:

870 lb/ac 10-10-10 (87 lb each N, P_2O_5 and K_2O).

*On a limestone formation.

Organic Nutrient Management: K is ample, and high relative to Mg, so K inputs should be kept low to promote good nutrient balance. Sweet corn requires about 150 lb N/ac, 80 lb P2O5 for high soil P, and 40 lb/ac K2O for very high soil K (Peet, 1996). If the corn is preceded by a high biomass winter cover crop (legume + winter cereal grain) containing about 150 lb/ac N (of which 75 lb is available to the corn crop), an application of 1500 lb/ac Harmony 5-4-3 would provide another 75 lb N, 60 lb phosphate and 45 lb potash. Because the current soil P levels are not yield limiting, and the sweet corn harvest is not likely to remove more than 60 lb P2O5, this application may be sufficient. However, if an on-farm or local source of aged manure or manure compost is available that can provide N, P and K in approximately the right proportions, it may be more economical than the purchased fertilizer. Because its edible portion is tightly covered by husk, the interval between manure application and harvest under NOP rules is 90 days for corn.

References and Resources on Soil and Nutrient Management for Organic Systems

NOTE: Much of the above discussion is based on information in the following publications.

A&L Laboratories. Undated. A&L Soil and Plant Analysis Agronomy Handbook. 132 pp. Contact A&L Eastern Laboratories, Inc, Richmond, VA; 1-804-743-9401.

Brady, Nyle C., and Ray R. Weil. 2008. The Nature and Properties of Soils, 14th ed. Pearson Education, Inc., Upper Saddle River, NJ. 965 pp.

This soil science classic covers everything from soil taxonomy and mineralogy to nutrient cycles and nutrient management. The 14th edition, revised and updated primarily by co-author Ray Weil, fully incorporates recent research findings about the vital roles of soil life and soil organic matter in nutrient cycles and crop nutrition. This is a superb reference volume for anyone who seeks to develop science-based, site-specific recommendations for organic growers based on soil test reports and direct field observations.

Drinkwater, Laurie. 2003. Nutrient Management in Organic Grain and Vegetable Systems. Research report to Organic Farming Research Foundation. 17 pp.

Drinkwater documents N and P balance on organic vegetable and grain farms in New York, and presents a nutrient budgeting tool for balancing inputs and exports while maintaining high yields. http://ofrf.org/funded/summaries/drinkwater-03s1-nutrient%20budgets.pdf

eXtension, the Extension Service Website, Organic Resource Area. 2009. Managing soils in organic production, including: nutrient cycling, nutrient and organic matter management, soil life and soil food

web, nematodes, mycorrhizae, effects of tillage, and best tillage management.
Listing of 18 articles and 7 video clips at: http://www.extension.org/article/18602.

Gugino, B.K., O.J. Idowu, R.R. Schindelbeck, H.M. van Es, D.W. Wolfe, B.N. Moebium, J.E. Thies and G.S. Abawi. 2007. Cornell Soil Health Assessment Training Manual, edition 1.2.2. Practical field and lab techniques for soil health assessment. Cornell University, Geneva, NY. 52 pp. Order at https://www.nysaes.cornell.edu/store/catalog/, or download at http://soilhealth.cals.cornell.edu.

Liebhardt, B. 2001. Get the facts straight: organic agriculture yields are good. Organic Farming Research Foundation Information Bulletin 10: 1, 4-5. www.ofrf.org.

Magdoff, Fred, and Harold van Es. 2009. Building Soils for Better Crops, 3rd Edition. Sustainable Agriculture Network (national outreach arm of SARE). Handbook Series Book 10, 294 pp. www.sare.org.

This volume covers all key aspects of ecological soil management: organic matter, soil life, soil conservation, crop rotation and cover crops, nutrient dynamics, and soil tests and recommendations, with specific examples. The new edition is beautifully illustrated with photos and diagrams, and includes several farmer stories. The authors take a "conservative" approach to fertilizer inputs to reduce input costs and protect environmental resources while sustaining good yields.

Peet, Mary. 1996. Sustainable Practices for Vegetable Production in the South. Focus Publishing, R. Pullins Company, Newberry, MA. 174 pp.

Includes nutrient recommendations based on soil test values for 12 major vegetable crops.

Seaman, Abby. 2009. 2009 Production Guide for Organic Cucumber and Butternut Squash for Processing. Cornell University Cooperative Extension and New York State Department of Agriculture and Markets. 47 pp.

This publication includes a thorough discussion of nutrient management (pp 8-12), including step by step calculation of N, P2O5 and K2O needs based on soil test results and credits from cover crop, manure and other organic inputs. This and three other guides by the same author on organic carrot, snap bean and pea are available at http://nysipm.cornell.edu/organic_guide/.

USDA Natural Resources Conservation Service. 1999. Soil Biology Primer. 50 pp.

Beautifully color-illustrated description of the web of life in soils under different vegetation types and management regimes, the role of the soil food web in soil health, and six major groups of soil organisms: bacteria, fungi, protozoa, nematodes, micro-arthropods, and earthworms.

Wander, Michelle. 2009. Soil Fertility in Organic Systems: Much More than Plant Nutrition. http://www.extension.org/article/18636;

Wander, Michelle. 2009. Nutrient Budget Basics for Organic Systems. http://www.extension.org/article/18794.

Ecological Weed Management for Organic Farms

by Mark Schonbeck

Introduction: an Ecological Understanding of Weeds

Weeds are Nature's way of protecting and restoring soil that has become exposed by fire, flood, landslide, clear-cutting, clean tillage, herbicide application, or other disturbance. Pioneer plants – what we call weeds – are those species that can rapidly occupy the open niche of bare soil, covering the surface, halting erosion, beginning to rebuild organic matter and soil life, and launching the process of ecological succession. Agricultural weeds are those pioneer plants that are especially well adapted to the periodic mechanical disturbance (tillage) and high nutrient levels of cultivated fields and gardens, and that can reproduce prolifically in such environments.

Humans "make" weeds by:

- Creating open niches for pioneer plant species to exploit.
- Introducing exotic plant species into a region without their natural enemies.

Production of annual crops disturbs the soil and creates open niches (bare soil) in time (between one harvest and establishment of the next crop) and in space (between rows or beds until the crop has closed canopy). Weeds emerge and grow in these open niches – until they are stopped by cultivation, pulling, mowing, or herbicides.

Weeds are the most costly pest problem in terms of crop losses and control costs, and organic producers consider weed management a top research priority. In addition to competing for light, nutrients, and moisture, weeds can hurt crop by releasing plant growth inhibitors (allelopathy), hosting crop pests or pathogens, promoting crop disease by restricting air circulation, physically hindering crop development (bindweeds), and interfering with or contaminating harvest.

The Organic Grower's Dilemma

Organic farmers consider healthy, living soil rich in organic matter as the foundation of organic production. Because organic farmers do not use herbicides, they rely on tillage and cultivation for weed control, especially in annual crops. Tillage accelerates the breakdown of soil organic matter, and can compromise soil quality. Thus the organic grower's dilemma is: How can I control weeds without tilling the soil to death?

Controlling weeds in annual cropping systems without herbicides means some tillage and cultivation. However, organic weed control does not simply substitute steel for herbicides. Cultivation is just one of a multitude of vital components in the organic farmer's weed management strategy. Effective weed management begins with careful observation and planning, followed by preventive (cultural) practices, and (inevitably) control tactics.

Planning for Effective Weed Control

Know the Weeds

Obtain correct identification of the major weeds present on the farm. Use a good taxonomic key or field guide that covers all of a region's important agricultural weeds. Monitor fields regularly throughout the season. Keep records on what weeds emerge in each field at different seasons, and on efficacy of any preventive and control measures taken.

Learn each weed's life cycle, growth habit, seasonal pattern of development and flowering, modes of reproduction and dispersal, seed dormancy and germination, and how the weed affects crop production. Find the weed's weak points that can be exploited in the management strategy, including the stages in its life cycle that are most vulnerable to cultivation or other control practices, and other stresses to which the weed is sensitive.

Knowing a weed's life cycle is especially important for selecting best management strategies. Summer annuals emerge after the spring frost date, reproduce prolifically by seed, and complete their life cycle by fall frost. They are usually most troublesome in warm season annual vegetable and row crops. Examples include pigweeds, common lambsquarters, and crabgrasses. Winter annuals emerge in late summer, fall, or early spring, and flower, set seed, and die by the onset of the following summer. They are usually most troublesome in cool season vegetables and winter grains. Examples include shepherd's purse, henbit, and annual sowthistle. Simple perennials persist year to year as a hardy rootstock, such as a heavy taproot. They are most troublesome in perennial crops and pasture, and are fairly intolerant of tillage. Examples include common dandelion, curly dock, and tall fescue. Invasive perennials proliferate vegetatively through stolons, rhizomes, tubers, bulbs, and other underground structures. These are the most difficult weeds to control, and are troublesome, both in tilled fields and perennial plantings. Examples include purple and yellow nutsedges, Bermuda grass, and field bindweed.

Design the Cropping System to Minimize Niches for Weed Growth

Keep the soil covered with desired vegetation or organic mulch as much of the season as possible. Schedule plantings of each cash or cover crop as soon as practical after the preceding crop is finished. Use narrow crop row spacings when practical to promote early canopy closure.

Some growers interseed clover, southern peas, or other cover crops between rows of established vegetables, so that the cover crop occupies the soil after vegetable harvest, thereby closing the niche for post-harvest weed growth. Others roll or mow mature cover crops and plant a following vegetable without tillage. This system works best when weed pressure is moderate and composed mostly of annual species, as invasive perennials readily penetrate the killed cover crop mulch. Intercropping (companion planting), relay cropping, alley cropping, agroferstry systems, strip tillage, and living mulches are some other strategies to reduce weed niches in space. All require skillful management, and additional research to refine techniques.

Organic mulches such as straw, old hay (seed-free) or chipped brush, and synthetic mulches like black plastic and landscape fabric restrict weed niches by blocking germination stimuli (light) and hindering seedling emergence. Established perennial weeds arising from rootstocks, rhizomes, or tubers can penetrate organic mulch, and a few can puncture plastic mulches.

With the exception of the synthetic mulches, all of these strategies to reduce niches for weed growth also add organic matter, build soil quality, and enhance farm biodiversity.

Design the Cropping System and Select Tools for Effective Weed Control

Develop control strategies to address anticipated weed pressures in each of the farm's major crops. Choose the best cultivation implements and other tools for cost-effective preplant, between-row, and within-row weeding. Match bed width and row spacing to match tractor and cultivation tool dimensions. Row spacings for different crops that are exact multiples of each other can facilitate precision tractor cultivation. Choose irrigation methods and other cultural practices that are compatible with planned weed control operations.

Keep the Weeds Guessing with Crop Rotations

Plan and implement diversified crop rotations that vary timing, depth, frequency, and methods of tillage; timing and methods of planting, cultivation, and harvest; as well as crop plant family. Alternate warm- and cool-season vegetables. Rotate vegetable fields into perennial sod crops for two or three years to interrupt life cycles of annual weeds adapted to frequent tillage.

If the soil is tilled on a regular, predictable schedule

year after year (e.g., continuous corn), those weeds most adapted to the pattern will proliferate and cause problems. A four-year vegetable rotation of sweet corn – snap beans – squash – tomato family with winter cover crops, though more diverse, can still allow certain weed populations to build up, because this rotation often entails tillage and seedbed preparation every May. Adding some early spring or fall vegetables and summer cover crops to the rotation will shift tillage and cropping dates, and make it harder for certain weed species to proliferate. Research has shown that rotating intensively-cropped fields to perennial cover for one or more years reduced annual weed populations.

Preventive (Cultural) Weed Management

Grow Vigorous, Weed-competitive Crops

Optimizing crop growth and vigor is one of the most important weed management practices. Vigorous crops can get ahead of the weeds, suffer less yield loss, and suppress weeds to some extent. Following are some tips for maximizing crop competitiveness against weeds:

- Maintain healthy, living soil.
- Choose locally-adapted crop varieties.
- Choose varieties that grow tall or form lots of foliage.
- Use only high quality seed.
- Use optimum plant spacings and planting dates.
- Provide optimum growing conditions – soil drainage and moisture, pH, and nutrients.
- Use in-row drip irrigation or other means to feed and water the crop and not the weeds.

Either insufficient or excessive levels of major nutrients (nitrogen, phosphorus, and potassium) can give certain weeds a competitive advantage over the crops. Trying to stretch the season for a given crop by planting earlier or later than usual can make the crop less vigorous and thus more prone to weed pressure. Utilize good season extension techniques, and plan on a little extra labor for diligent weed management during crop establishment.

Put the Weeds Out of Work—Grow Cover Crops!

Cover crops perform the same ecosystem services as weeds, only better! They rapidly occupy open niches, protect and restore the soil, provide beneficial habitat, add organic matter, and hold and recycle soil nutrients. They suppress weeds by shading, direct competition for water and nutrients, and sometimes allelopathy (the release of plant growth inhibitors into the soil).

Whenever a bed or field becomes vacant, plant a cover crop immeditely. Timely cover cropping minimizes open niches and puts the weeds out of a job. Be sure to use high quality seed, good planting technique, and adequate seeding rates to obtain rapid establishment and canopy closure. Where weed pressure is heavy, double the seeding rate if economically feasible.

Manage the Weed Seed Bank—Minimize "Deposits" and Maximize "Withdrawals"

The reason so many weeds come up soon after tillage is that most soils have a large weed seed bank – millions of viable, dormant weed seeds per acre, waiting for the right stimulus (often a light flash associated with tillage) to germinate and emerge. Manage the weed seed bank by encouraging "withdrawals" and minimizing "deposits."

Cultivate, pull, mow, or chop out weeds before they can form seeds. Remove topgrowth of invasive weeds with sweep cultivators, sharp hoes, or close mowing, before the weeds propagate underground. Mow fields promptly after crop harvest to interdict weed seed maturation. Avoid bringing seeds of new weeds into the field in seedy mulch hay, uncomposted manure, or soil clinging to boots, tools, or implements. Use crop seed that is free of noxious weed seeds.

Draw down the seed bank by preparing a stale seedbed. Till the soil several inches deep several weeks before crop planting, watch closely, and till again when more weeds appear. Immediately before crop planting or crop emergence, flame weed, or cultivate very shallowly (0.5–1 inch) to removing existing weeds without stimulating additional weed seed germination.

Encourage weed seed predation by providing habitat for ground beetles, field crickets, and other organisms that consume weed seeds. Maintain habitat (living vegetative cover or organic mulch) in part of the field at all times if practical. After a vegetable harvest, mow the field promptly, but consider delaying tillage for a few weeks to let nature's "cleanup crew" reduce weed seed numbers (balance this against the need to make a seedbed for cover crop planting).

Weed Control Tactics

Knock Out Weeds at Critical Times

Start with a clean seedbed, prepared just before planting. Even a few days' delay between seedbed prep and planting can give unseen germinating weeds a jump on the crop. A "blind" (full field) cultivation during emergence of large seeded crops, or flaming just before emergence of small seeded crops like carrot, parsnip, and spinach, can give the crop an additional head start.

Early in the season, get the weeds while they are small, from the "white thread" stage up to one inch. Very shallow cultivation can suffice at this stage; larger weeds are harder to control, requiring more fuel and deeper, more soil-damaging cultivation. Keep the crop clean through its "minimum weed-free period," about 4–6 weeks for vigorous crops like corn, squash, or transplanted tomato; and 8–12 weeks for slower growing crops like pepper, carrot, or onion.

Later-emerging weeds will not affect crop yield through direct competition. However, additional control measures are warranted if late season weeds host or promote crop disease, complicate harvest, or begin to propagate. Invasive perennial weeds can be weakened by cultivating every time regenerating shoots have 3–4 leaves (when underground reserves reach their minimum). At the minimum, remove perennial weed top growth every 3–4 weeks, or before weeds are a foot tall, to interrupt underground propagation.

Consider integrating other tactics – flame weeding, mowing, mulching, etc – with cultivation to reduce adverse impacts on soil quality. Market gardeners often apply straw or other organic mulch after one or two early season cultivations, thereby obtaining a long weed free period while reducing soil disturbance and adding organic matter.

Utilize Biological Control Processes to Further Reduce Weed Pressure

Rotate livestock, poultry, or weeder geese through fields to graze weeds and interrupt seed set. To ensure food safety and comply with USDA Organic Standards, time such grazing so that fresh droppings are not deposited any less than 120 days prior to harvest of the next crop. Encourage weed seed predation by maintaining high soil biological activity and providing habitat (mulch, cover crops, hedgerows) for weed seed consumers (conservation biological control).

Bring Existing Weeds Under Control Before Planting Weed-sensitive Crops

Weed control in perennial horticultural crops like asparagus, small fruit, and some cut flowers can be quite difficult, especially when perennial weeds dominate the weed flora. Bring existing weed populations under good control through repeated tillage and intensive cover cropping before planting perennial vegetable, fruit, or ornamental crops.

Choose fields with the fewest weeds for weed-sensitive annual vegetables, such as carrot, onion, and parsnip. Be sure weeds, especially perennial weeds, are under good control before attempting no-till management of cover crops prior to cash crop planting.

Fine-tuning the Organic Weed Management System

Keep Observing the Weeds and Adapt Practices Accordingly

Note and record any changes in weed species composition, emergence and growth pattern, or weed pressure. Watch out for the arrival of new weed species that could pose problems.
Modify practices as needed. For example, an increase in certain annual "weeds of cultivation" may indicate a need to reduce tillage, change method or timing of tillage, or diversify the crop rotation. An increase in invasive perennials may require more aggressive tillage for a time.

Expect weed populations and flora to shift over time. Every farm decision and field operation can elicit changes in the weed community, as can weather variations, to say nothing of long term climate changes. "Reading" the weeds each year becomes an information feedback loop, guiding weed management practices for the following season.

Experiment

Try out new tactics and strategies to deal with weeds, and keep your eyes and ears open for new developments in organic weed management. Farmers continually develop innovative strategies based on new tools that they fashion themselves or that researchers develop, new uses for old tools, and new combinations of preventive and control tactics. New methods or products may also come from the research community. When trying something new, do it on a small scale, and compare it with an adjacent "control" plot in which you use your normal practices, so you can see whether the new practice improves weed control.

For a longer (20 pp) version of this document, including farm stories, contact Mark Schonbeck at mark@abundantdawn.org. For more in-depth exploration of some of the planning, preventive, and control practices outlined above, visit the eXtension Organic Agriculture Resource Area; articles on organic weed management can be found at http://www.extension.org/article/19642.

Resources for Organic Weed Management

Weed Identification – Books, CD's and Web Sites

Charles. T. Bryson and Michael S. DeFelice. 2009. Weeds of the South. Very thorough field guide to many hundreds of weed species, with excellent photo illustrations by Arlyn W. Evans. University of Georgia Press, Athens, GA. 468 pp.

Georgia Cooperative Extension Service, Bulletin 761, 1995. Weeds of the Southern United States. 45 pp. Field guide to 120 major weeds of the South. Available for $3; to order, call Georgia Cooperative Extension at 706-542-8999 or -8575.

R. Old. 2008. 1,200 Weeds of the 48 States and Adjacent Canada: An interactive identification guide [DVD]. XID Services, Inc., Pullman, WA. Available at: http://xidservices.com/.

Jon M. Stuckey, Thomas J. Monaco and A.D. Worsham, 1994. Identifying Seedling and Mature Weeds Common in the Southeastern United States. North Carolina Agricultural Research Service & NC Cooperative Extension Service.

USDA, Agricultural Research Service, 1971. Common Weeds of the United States. Dover Publishing, Inc., New York, NY.

Richard H. Uva, Joseph C. Neal and Joseph M. DiTomaso, 1997. Weeds of the Northeast. Cornell Univ. Press, Ithaca, NY. 297 pp. Covers 299 weeds, most of which occur in the South.

Virginia Tech Weed Identification Guide, www.ppws.vt.edu/weedindex.htm, covers 324 weeds.

Weed Science Society of America – Weed Photo Gallery, can aid in identification. No verbal descriptions. http://www.wssa.net/Weeds/ID/PhotoGallery.htm.

Tools for Cultivation and Weed Control

Greg Bowman, ed., 1997. Steel in the Field: a Farmer's Guide to Weed Management Tools. 128 pp. Order at www.sare.org/publications/.

Earth Tools, Inc., Joel Dufour, manager, 1525 Kays Branch Road, Owenton, KY 40359, 502-484-3988, www.earthtoolsbcs.com. Hand tools and walking (2-wheel) tractor implements.

Vendors of tractor-drawn cultivation implements: Bezzerides Brothers (559-528-3011, www.bezzerides.com), Buddingh Weeder Co. (616-698-8613). Bigham Brothers (806-745-0384, www.bighambrothers.com/lilliston.htm). Brillion Farm Equipment (800-409-9749, www.brillionfarmeq.com).

Ecological Weed Management Principles and Practices

Vern Grubinger, 1997. 10 Steps Toward Organic Weed Control. American Vegetable Grower, Feb. 1997, pp 22-24.

National Sustainable Agriculture Information Service (aka ATTRA), Principles of Sustainable Weed Management for Croplands, available at www.attra.org/pest.html#weed.

Anne and Eric Nordell, A Whole-Farm Approach to Weed Control. Approximately 50 pp. Available for $10 by mail order, Eric and Anne Nordell, 3410 Rt. 184, Trout Run, PA 17771.

Key Resources for Organic Production

by Karen McSwain

This is by no means an exhaustive list of all the many great resources for organic production but a fairly good start.

THE CAROLINAS

Carolina Farm Stewardship Association
www.carolinafarmstewards.org

- NRCS EQIP-OI Program Assistance for district conservationists and producers.
- Annual Sustainable Agriculture Conference, Greenville, SC. 2012
- Organic Commodities and Livestock Conference, Rocky Mount, NC. 2012
- Regional Farm Tours

Clemson University

- Sustainable Agriculture Program at Clemson University www.clemson.edu/sustainableag/about.html
- Ask-an-Expert program lists extension agents in SC who specialize in organic production.
- Offers many classes throughout the year on various organic production topics.
- Department of Plant Industry – Organic Certification – www.clemson.edu/public/regulatory/plant_industry/organic_certification/index.html
- Certifying agency for most organic producers in South Carolina. Website contains information about the certification process, fees, and applications.

Coastal Conservation League
http://coastalconservationleague.org/
Works with farmers, government agencies/officials, businesses, nonprofit organizations, and communities to support sustainable agriculture by addressing statewide policy and local planning and regulation issues, offering education and outreach to farmers, and supporting local food distribution and marketing through their Grow Carolina project.

Low Country First
http://lowcountrylocalfirst.org
Provides education and relationship building in order to promote the benefits of supporting local, independent businesses and farmers. Support local food systems by connecting local farms, producers, and apprentices to local restaurants and institutions.

North Carolina State University

- NC Extension Service Web Site – Organic Production - http://www.extension.org/organic_production

Website contains hundreds of publications, webinars, and videos on a wide variety of topics related to organic production. This WONDERFUL resource ontains everything you need to know about organic production.

- Organic Field Crop Production and Marketing in North Carolina - http://www.organicgrains.ncsu.edu/

Contains a wealth of information about organic field crop production specific to the Carolinas, including the North Carolina Grain production Guide. Also has link to projects online newsletter and calendar of workshops related to organic grain production.

- NC Organic - http://www.ces.ncsu.edu/fletcher/programs/ncorganic/

Provides links to a number of resources about organic production, certification, and marketing.

Center for Environmental Farming Systems
http://www.cefs.ncsu.edu/
Contains numerous publications on organic production, links to resources, information on production research, and an events calendar.

Organic Production guide includes chapters on composting, cover crops, crop rotation, insect management, weed management and soil fertility.

Growing Small Farms
http://chatham.ces.ncsu.edu/growingsmallfarms/orgcertguide.html
Contains a wealth of information and links to helpful resources, including many regarding organic certification.

Organic Growers School
http://www.organicgrowersschool.org/
- Spring Conference, Asheville, NC.
- CRAFT Farmer Training Program
- Apprentice Link

Appalachian Sustainable Agriculture Project
http://www.asapconnections.org/
- Business of Farming Conference, Asheville, NC.
- Certified Appalachian Grown
- Resources for Beginning Farmers
- Information on farm to institutions/school programs

SOUTHEAST

Florida Organic Growers (FOG)
http://www.foginfo.org
Supports and promotes organic and sustainable agriculture by educating consumers, farmers, future farmers (children & youth), businesses, policy makers and the general public.

Georgia Organics
http://www.georgiaorganics.org
- Annual conference
- Farmer to Farmer mentoring, workshops and field days, farmer services consulting.

Southern Sustainable Agriculture Working Group (SSAWG)
http://www.ssawg.org
- Annual conference
- Many educational CD's available for order from website on various topics including organic horticulture and marketing and organic vegetable production.

Virginia Association for Biological Farming
http://www.vabf.org
- Annual conferences.
- Website includes an events list, news articles and a resource section with information sheets about sustainable and organic agriculture.

NATIONAL

National Organic Program (NOP)
http://www.ams.usda.gov/AMSv1.0/nop
Information about organic standards, certification, and compliance and enforcement.

National Sustainable Agriculture Information Service (ATTRA)
https://attra.ncat.org
ATTRA publishes bulletins on a wide range of topics including organic vegetable, fruit, and agronomic crops; greenhouse production; sustainable soil, pest, weed, and crop disease management; composting, cover crops and conservation tillage in organic systems; and marketing and business management.

Organic Farming Research Foundation (OFRF)
http://www.ofrf.org
Funds and provides report summaries for research projects on a wide range of organic production topics including fertility management, weed, pest and disease management, and organic farming systems.

Maintains up-to-date information on USDA programs related to organic.

Sustainable Agriculture Research and Education (SARE)
http://www.sare.org
Learning Center - http://www.sare.org/Learning-Center
Complete downloadable books and bulletins on sustainable and organic production including:
1. Building Soils for Better Crops, 3rd ed., F. Magdoff & H. Van Es, 2009.
2. Managing Cover Crops Profitably, 3rd ed., A. Clark, ed., 2007.
3. Crop Rotation on Organic Farms: a Planning Manual, C. L. Mohler & S. E. Johnson, 2009.
4. Manage Insects on Your Farm: a Guide to Ecological Strategies.
5. Transitioning to Organic Production. (bulletin).

Offers online course in Integrated Pest Management for Organic Crops.