

Organic Gardening

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Learning Objectives:

- 1. To learn how many basic good gardening practices are based on organic gardening**
- 2. To understand organic gardening as a systems approach, not simply substituting an organic product for a synthetic chemical product**
- 3. To learn the basic principles of organic gardening and the basic principles of Integrated Pest Management (where they have commonality and where there are different perspectives)**
- 4. To learn how to build good soil, increase the organic matter component of the soil and use the many forms of organic matter effectively**
- 5. To identify and understand the use of organic gardening supplies and products, such as organic fertilizers and biological controls**
- 6. To recognize that most garden insects are beneficial or harmless, to understand that insects are part of a complex ecosystem, to identify many specific beneficial insects, and know how to attract and maintain these populations**
- 7. To sort the science from the myths about "companion plants," and to understand what plant combinations are beneficial for physical or practical reasons, pest deterrence, or establishing habitat for beneficial insects**

Organic Gardening (Provisional Chapter)

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Nature's Systems and the Organic Gardener ¹

Philosophy

Organic gardening involves building soil, not using synthetic chemical pesticides, and using natural fertilizers rather than synthetic ones. All of these are good choices. However, if we stop here we are boxed into an awkward hard-to-defend system of product substitution. The questions become, "What organic fertilizer or pesticide do I use instead of 10-10-10 or diazinon?" But it doesn't work like that. Organic methods are a lot more than environmentally sound ways to kill pests and supply fertility.

As Eliot Coleman puts it, in *The New Organic Grower* ², organics is an "overriding philosophy of living, (which assumes that) we are part of an integrated ecosystem, with a set of principles that are nature's not man's." The successful organic approach means working with and within those principles—and all the rest follows.

We begin by asking how we can work with and like nature at its best. It soon is apparent that applying nature's principles to one's own back yard results in a very changed garden. Indeed, nature's systems are very different from the traditional American or Anglo-Saxon farming/gardening tradition.

Biodiversity

Look at a rain forest for the definition of biodiversity. There are a variety of plants and animals living interdependently and in close proximity. There is water or soil moisture, shelter, continual bloom (providing pollen as a food source for insects), and the entire system works to supply all the needs of all the life forms within the system. There is no monocropping, no neat rows of plants with cultivated soil between them, and no need for pest control. In fact, nothing is a "pest" because everything has a role as predator and prey. In such a system there is no conceivable role for anything ending in "-cide," as removal of any element interrupts the balance, and the mini-ecosystem begins to falter.

What happens when we apply the biodiversity principle at home? We arrange companion planting and interplanting, (whether multi-cropping or succession crops, between-row cover crops or groundcovers). We arrange for habitat for beneficial insects, birds, snakes, toads and other predators (which leads to flowers among our vegetables, pools of water, hedgerows, and permanent groundcover or wildflower borders). And we certainly do not spray pesticides or otherwise wipe out any "pest" population, lest we kill parts of the whole. If we kill the aphids, what reason is there for a lady beetle or lacewing population to become established? Arranging for biodiversity has already changed garden layout, plant choices, and gardening habits, and we are on the way toward and organic—albeit different-looking—system.

The Soil is Alive

The second premise, that the soil is alive, also leads to gardens that are different from our "Weed-'n-Feed" shopping neighbors. (No particular product disrespect intended; for organic purposes, all the synthetic fertilizers and pesticides present the same conceptual and practical problems.) We accept that the soil is full of microscopic plants and animals,

as well as macro-organisms (insects and earthworms). In fact, a tablespoon of healthy soil may have 50 billion micro-organisms! If we accept that these life forms require air and water (good soil being 25% air and 25% water), we do a lot of things differently.

Above all, we feed the living soil. We constantly supply organic matter, through cover crops, compost, manure, or directly incorporating leaves, straw, grass clippings and kitchen scraps. Then we protect the living soil and its structure (that sought-after tilth). We avoid anything that destroys soil texture and the water-holding and air-holding ability that lets roots penetrate and absorb nutrients. Soil protection takes many forms: wide row gardening, making raised beds, using permanent paths, and between-row groundcovers or mulches. We arrange things for the least traffic and the least soil compaction. Whenever possible we aim for no-tilling systems, or for a minimum amount. Organic gardening involves a different set-up and some activities quite unlike that chemical-dependent neighbor. He feeds his plants; we feed our soil.

The Soil is Covered

The old saying, usually muttered with a grim expression while weeding, is that “nature abhors a vacuum.” Indeed, our rain forest eco-system shows us no bare spots. The organic gardener makes this a positive, however, not a negative: we fill the bare spots with our choices, applying Mother Nature’s principles—not just her sense of whimsy regarding our quarter acre. The organic garden’s soil is covered by wide-row plantings, intensive planting, and the cover crops, companions, or mulch that have been mentioned.

A Different Garden

Nature’s principles have given us a different garden from that organically unaware neighbor. Every principle leads to certain choices, and the steps that follow are organic gardening. Where we cooperate with nature’s systems, and enhance them to meet our goals of fine food, beauty, and a well-maintained earth. There are millions of organic gardeners—indigenous people of several continents and our own forebearers—who succeeded long before an organic gardening movement. Without books and articles, seminars and conferences, they did it. Their teacher, was Nature, and the principles some of the ones we have been considering. Perhaps we heed no more.

Basic Principles and Practices ³

In a time of ever increasing awareness of ecological problems, organic gardening has engaged the attention of home gardeners as well as consumers as a way of addressing both health and environmental concerns. Further, organic gardening practices are quite simply good gardening practices, and our efforts to re-build soil and handle insect and disease problems in the least toxic way are not only the “right thing to do” but also produce successful lawns, flower, and vegetable gardens. As to the larger environmental picture, the homeowner’s choices about lawn care and garden in techniques do have significant impact on soil, water, and wildlife. While non-organic commercial agriculture uses more chemicals in volume than home horticulture, the average homeowner uses 10 times more toxic chemicals per acre than farmers, so the organic direction is indeed appropriate to consider in our own backyards.

In addition to the systems approach discussed above, organic gardening involves some major differences from the practices of non-organic gardeners. There are three obvious primary areas:

- (1) **Re-build the Soil:** In commercial agriculture, former non-regenerative farming practices have led to disaster – in billions of dollars lost from soil erosion, polluted waters, and decreased costs; in millions of acres of abandoned farmlands, and in wetlands drained for agriculture use. Similarly, in our own gardens, the practice of using the soil without rebuilding it leads to poor soil structure, disappearing topsoil, fertilizers, or amendments. The organic gardener solves most soil problems by constantly adding organic matter. While it could be said that all good gardeners add organic matter and re-build the soil, the difference for organic gardeners is that they **MUST** rebuild soil with organic matter. That's because the soil is the source of nutrients, and there is no reliance on synthetic fertilizers.
- (2) **Use No Synthetic Pesticides:** Organic gardeners do not use herbicides or insecticides (with the possible exception of some botanical poisons, discussed later). Most also avoid fungicides, although some use sulfur or copper based fungicides selectively. Reasons for synthetic chemical pesticide avoidance include concerns for groundwater, the health of birds and other animals, food contamination and protection of beneficial insects which are an integral part of organic pest control.
- (3) **Use No Synthetic Fertilizers:** Most organic gardeners also avoid synthetic fertilizers out of concern for the residual chemicals (salts) left behind, their effect on plant growth (excessive amounts of quick-release high nitrogen fertilizers lead to lush foliage growth and poor root structures, also part of the cause of thatch build-up in lawns), and their negative effects on earthworms and other soil microbial life.

Integrated Pest Management ⁴

A good horticulturist strives to maintain a perfect plant; one that is healthy, vigorously growing and free of all pest problems. Integrated pest management (IPM) is a simple, practical and most importantly, a flexible way to manage pests when they attack plants. IPM involves the use of a blend of pest management tactics to protect plants against insects, mites, plant diseases, nematodes and weeds. People who practice IPM monitor their plants and integrate chemical, biological, cultural and mechanical techniques to suppress plant pests.

Organic gardening is closely related to IPM, an approach to pest management that seeks solutions with the least harmful impact on other living things. IPM starts with prevention, accurate identification of the pest, monitoring selection of treatment that is accurate in terms of timing, quantity, frequency, or targets, and least toxic. Part of Integrated Pest Management thinking is questioning: What weed or pest level is tolerable and need not be treated?

Basic IPM Principles ⁵

Prevention

It may seem obvious: The best way to handle a problem is not to have the problem at all! Yet many gardeners put little effort into prevention, choosing instead to react to pests or diseases after they occur. Prevention is an important part of both IPM and organic gardening systems. Prevention requires specific knowledge of the problem to be avoided, and several specific tools and techniques.

The following are some of the preventive steps and methods that stop a problem before it is a problem:

- 1 Careful Plant Selection: First, choose the correct plant for the site – an element that is essential to all good gardening. The right site includes the zone, soil, drainage, sun available, etc. (A healthy plant in the right site is not stressed by cultural problems, and it resists both disease and insect pests.) Second, choose plants that are known for specific resistance to the insects or diseases known for specific resistance to the insects or diseases known to be pests in your area. Cornell and other Land-grant colleges, as well as Rodale Institute and other organic gardening/farming institutions, perform trials and provide lists of plants with superior performance and pest resistance.
- 2 Good Cultural Practices: Even in the right site, careless gardening practices increase the risk of diseases or pest invasions. Good practices include:
 - Watering: Do so in the morning or daytime, rather than at night; avoid splashing plants and keep water in the root zone. (These steps decrease fungus growth).
 - Movement in the garden: Avoid brushing among plants when they are wet by morning dew or after watering, since this transmits disease. Walk on paths and don't compact soil near plant roots (which causes stress, leading to more problems.)
 - Maintain good air circulation by proper pruning or thinning of plants; don't overcrowd plants/ (Even with wide-row and intensive systems, plant distances must be observed.)
 - Garden clean-up and weeding can prevent overwintering or spread of insects or disease.
 - Proper cultivation (choices about depth, frequency, timing in relation to plantings) and crop rotation prevent many disease problems as well as weeds (which in turn harbor some pests).
- 3 Block pests: There are many tools and methods to block a pest from contacting the plant. These include row covers, netting, interplanting with other crops, chicken wire, and collars (such as cans or cups placed around seedlings.) For more on these, see pages...
- 4 Timing: Another method of preventing pests is timing the plantings so that the crop is not vulnerable when the problem disease or insect is not prevalent. For example,

carrots planted in May are often plagued by the larvae of the carrot rust fly (sometimes called carrot maggots). But sowing the carrots in June, after the larvae have emerged, prevents the problem.

Identification and diagnosis of the pest

Accurate identification is key to IPM. It is important to know the pests that are likely to show up, where to look for them, and how to identify them. With IPM it is necessary to understand the biology of a pest and its interactions with other organisms and its environment. Diagnosis is the process of recognizing a disorder from its symptoms and signs. Early, accurate identification and diagnosis are essential to a successful IPM program.

Monitoring

The purpose of monitoring is to check the status of the plan. Monitoring is simply sampling or making periodic observations to determine pest population trends. Ultimately, the population or damage estimates derived from these samples or observations are used as a basis for pest management decisions. Regular visitations will allow a horticulturist to follow plants through time and pinpoint what plants have a problem regardless of climatic variation and previous plant history.

Careful monitoring of plants provides information on the plant's "real needs." Acting as an early warning system, plant monitoring helps provide current information on the status of the plant and allows early detection of pest infestations. Problem plants can be "spot treated," using less material than blanket cover sprays. Such treatment decreases the potential of hazards from misapplication and helps preserve beneficial organisms.

Economic injury level is the lowest pest density that will cause economic damage. Economic damage is the amount of injury that will justify the cost of artificial control measures. This economic injury level may vary from area to area, season to season, or with our changing scale of economic and aesthetic values.

Economic threshold is the pest density at which controls should be used to prevent an increasing pest population from reaching the economic injury level. The economic threshold is lower than the economic injury level to permit sufficient time for the initiation of control measures and for these measures to take effect before the population reaches the economic injury level.

Pest Management Strategies

IPM uses a combination of compatible control techniques. These include biological, cultural, mechanical, and chemical techniques.

Biological control refers to the use of natural enemies to control pests. The actions of parasites, predators or pathogens on a host or prey population is common in nature. Enhancing and preserving biological control agents is an important component of IPM. In some cases it is advantageous to release commercially reared natural enemies to augment control.

Cultural controls are modifications of horticultural practices to disrupt or reduce pest populations. Correct fertilization and watering are major cultural practices that influence the health of plants and their susceptibility to pests.

Mechanical control refers to barriers or traps to exclude or catch pests. An integration of all the above control methods is the best way to get safe, long-term pest management with a s little adverse effect on the surrounding environment as possible.

Chemical control includes the use of pesticides. Pesticides are manufactured and formulated in many ways. According to the IPM philosophy, if they are applied at the correct rate and time, pesticides are usually sage and effective.

Record Keeping

Brief, concise and accurate information recorded on a data sheet is the best way to make a diagnosis of decision. IPM programs rely on records to make field recommendations. When program evaluations and future plans are developed, field records and data analysis are priceless. The time spent recording information on a ledger or data sheet is often hard to justify as productive. All production inputs must be recorded: date, time, type of application and results obtained. Pest managers trying to make a diagnosis of a problem without records are at a serious disadvantage and will overlook potential causes.

Why IPM?

For the last 40 years the dominant strategy for pest control has been the use of chemical pesticides. Such pesticides are inexpensive and often used as a quick fix to solve a pest problem. The chemical pesticide has replaced many of the pest management tactics used for centuries. The overuse and misuse of these chemicals has created many ecological and sociological problems. Today, more than ever, we must maintain the perspective that pesticides are just one choice of many that can be used to effectively manage pests. People who practice IPM use pesticides efficiently and at the most critical times.

Designs for Composting Systems⁶

In rebuilding the soil, organic gardeners construct compost systems to generate organic matter at home. There are many ways to compost wastes. The method of composting you choose will depend on whether you plan to compost yard wastes or kitchen wastes, how much money and time you wish to spend, how much room you have, and how soon you need the compost. To determine which composting system is for you, first decide whether you will be composting yard and garden or kitchen wastes. Then read the brief comparisons of the different systems on the chart that follows.

System Used	Cost	Time for Finished Compost (Rate of Composting)
Yard Waste		
Compost mound	None	Slow if not turned; fast if turned often
Holding unit	Low	Slow
Turning unit	High *	Fast, minimum 6 weeks
Mulch	Low	Can use immediately, but material should be shredded
Commercial bin	High	Fast, minimum 2 weeks
Kitchen Waste	None	Can use immediately
Compost pockets	Low	Slow; faster if turned or mixed
Garbage can composter	Medium	Fast, minimum 4 weeks
Worm composting bin	High	Fast, minimum 6 weeks
Turning unit		
* Lower if scrap and recycled materials are used for construction		
Note: Kitchen and yard wastes can be composted together, but the combination may attract rodents.		

Compost Mound

Yard wastes can be composted without a bin if you don't mind the appearance of an uncontained compost mound in your yard. The only costs are your time and work.

What You Need

Shovel or pitchfork and work gloves.

Building a Compost Mound

Find a good location and pile your yard waste in a mound about 3 feet x 3 feet x 3 feet (1 meter x 1 meter x 1 meter). If you cover the pile with a layer of soil, it will keep in moisture for the microorganisms and soil animals working to make compost.

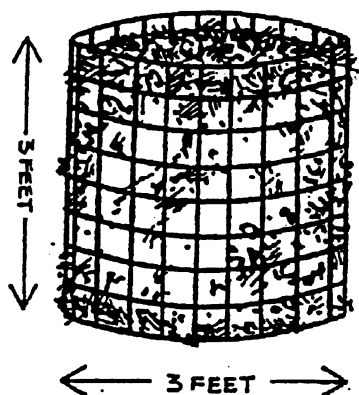
Adding Wastes

Add wastes as they become available. Nonwood materials such as grass clippings and garden wastes work best.

Maintaining Your Compost Pile

It is best to have two piles. After the first pile is large enough, stop adding organic material and let it work. In the meantime, add your wastes to the second pile. Make sure the pile is moist, especially if it is not covered with soil. You can turn the pile to speed up composting. Compost should be ready in three to four months if you turn the pile, or in about one year if you don't turn the pile.

Wire Mesh Bin



A wire mesh bin is inexpensive and easy to build out of either galvanized chicken wire or hardware cloth. (nongalvanized chicken wire can also be used but will not last very long.) Posts provide more stability for a chicken wire bin, but make the bin difficult to move. A wire mesh bin made without posts is easy to lift, allowing you to get at the compost that is already “done” at the bottom of the pile while the top of the pile is still cooking.

What You Need

Materials: 12 ½ feet of 36-inch wide 1-inch galvanized chicken wire or ½-inch hardware cloth, heavy wire for ties, 3 or 4 4-foot wooden or metal posts (for chicken wire bin).

Tools: Heavy-duty wire or tin snips, pliers, hammer (for chicken wire bin), metal file (for hardware cloth bin), work gloves.

Building a Wire Mesh Bin Using Chicken Wire

- 1 Fold back 3 to 4 inches of wire at each end of the cut piece to provide a strong, clean edge that won't poke or snag and which will be easy to latch.
- 2 Stand the wire in a circle and set in place for the compost pile.
- 3 Cut the heavy wire into lengths for ties. Attach the ends of the chicken wire together with the wire ties, using pliers.
- 4 Space wood or metal posts around the inside of the chicken wire circle. Holding the posts tightly against the wire, pound them firmly into the ground to provide support.

Building a Wire Mesh Bin Using Hardware Cloth

- 1 Trim the ends of the hardware cloth so the wires are flush with a cross wire to get rid of edges that could poke or scratch hands. Lightly file each wire along the cut edge to ensure safe handling when opening and closing the bin.
- 2 Bend the hardware cloth into a circle, and stand it in place for the compost pile.
- 3 Cut the heavy wire into lengths for ties. Attach the ends of the hardware cloth together with the wire ties, using pliers.

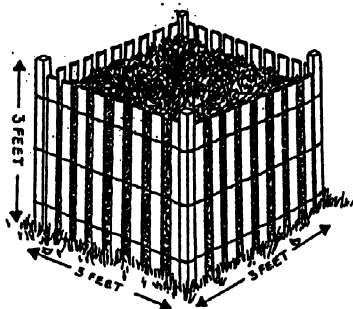
Adding Wastes

Add wastes as they become available. Nonwood materials such as grass clippings and garden weeds work best. You can speed up the process by chopping or shredding the wastes.

Maintaining Your Compost Pile

As you keep adding wastes to the wire mesh bin, the material at the bottom will become compost sooner than the material at the top. If you want to use the compost at the bottom of the pile, you can remove the wire holding unit and place it next to the pile. Then, use a pitchfork to move the compost back into the moved holding unit, adding the material from the top of the pile first. Continue until you have replaced all the compost. Now the compost at the top of the bin is ready to use. You also can scoop finished compost from the bottom of the pile by lifting one side of the unit. Although you do not need to turn this pile, make sure it is moist during dry spells. Compost should be finished in about one year.

Snow Fence Bin



A snow fence bin is simple to make. It works best with four posts pounded into the ground for support.

What You Need

Materials: 4 wooden or metal posts, at least as tall as the snow fence, heavy wire for ties.
12 ½ feet of snow fencing, at least 3 feet tall.

Tools: heavy-duty wire or tin snips, pliers, sledge hammer, work gloves.

Building a Snow Fence Bin

- 1 Choose a 3-foot square site for your compost bin and pound the four wooden or metal posts into the ground 3 feet apart, at the corners of the square.
- 2 Cut the heavy wire into lengths for ties. Attach the snow fence to the outside of the posts with the wire ties, using pliers.
- 3 Attach the ends of the snow fence together in the same way, forming a 3-foot square enclosure.

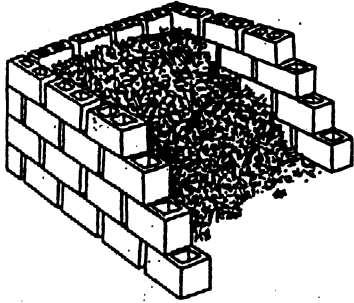
Adding Wastes

Add wastes as they become available. Nonwood materials such as grass clippings and garden weeds work best. You can speed up the process by chopping or shredding the wastes.

Maintaining Your Compost Pile

Although you do not need to turn this pile, make sure that it is moist during dry spells. Compost should be ready in about one year. Simply remove the fencing and the compost is ready to use.

Cinder Block Bin



A cinder block bin is a sturdy, durable, and easily accessible. If you have to buy the cinder blocks, it is slightly more expensive to build than the wire mesh or snow fence bins.

What You Need

About 26 cinder blocks for the first bin, optional: about 32 blocks for a second bin, and work gloves.

Building a Cinder Block Bin

- 1 Place 5 cinder blocks in a row along the ground at your composting site, leaving about ½ inch between each block to let in air.
- 2 Place 4 cinder blocks in another row along the ground perpendicular to and at one end of the first row, forming a square corner; leave about ½ inch between each block.
- 3 In the same way, place 4 cinder blocks at the opposite end of the first row to form a three-sided enclosure.
- 4 Add a second layer of blocks, staggering them to increase stability and leaving about ½ inch between each block. There should be a layer of 4 cinder blocks on each of the three wall of the enclosure.
- 5 Add a third layer of blocks, again staggering them to increase stability, with 5 blocks across the back of the enclosure and 3 on each side.
- 6 The last and top layer should have 4 blocks across the back and 3 on each side.
- 7 Optional: If you wish to decrease your composting time, build a second bin next to the first so the wastes in one can mature while you add wastes to the other. Use one side wall of the first bin so you only need to build two additional walls.

Adding Wastes

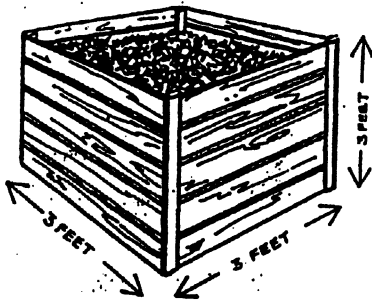
Add wastes as they become available. Nonwood materials such as grass clippings and garden weeds work best. You can speed up the process by chopping or shredding the

wastes. If you have two units, when the first unit is full let the compost mature and add wastes to the second unit.

Maintaining Your Compost Pile

Although you do not need to turn this pile, make sure that it is moist during dry spells. Compost should be ready in about one year or more.

Wooden Box Bin



A wooden box bin can be built inexpensively using wooden pallets. Or you can use lumber to make a nicer looking bin. The costs will vary, depending on whether you use pallets or new lumber. Used pallets are often available from manufacturers and landfills.

What You Need

Materials: 4 wooden pallets (5 pallets if you want a bottom in the container) sized to make a four-sided container at least 3 feet x 3 feet x 3 feet, nails, wire ties or 1 12-foot length of 2 x 4 lumber, 5 12-foot lengths of lumber 6 x 3/4, nails.

Tools: Saw, sledge hammer, and work gloves.

Building a Wooden Box Bin Using Wooden Pallets

- 1 Nail or wire four pallets together to make a four-sided container at least 3 feet x 3 feet x 3 feet. The container is ready to use.
- 2 A fifth pallet can be used as a base to allow more air to get into the pile and to increase the stability of the bin.

Building a Wooden Box Bin Using Lumber

- 1 Saw the 12-foot length of 2 x 4 lumber into four pieces, each 3 feet long, to be used as corner posts.
- 2 Choose a 3-foot square site for your compost bin, and pound the four posts into the ground 3 feet apart, at the corners of the square.
- 3 Saw each of the five 12-foot boards into four 3-foot pieces. Allow five boards to a side and starting at the bottom, nail the boards to the posts to make a four-sided container. Leave 1/2 inch between the boards to allow air to get into the pile.
- 4 If you wish to decrease your composting time, build a second holding unit so the wastes in one can mature while you add wastes to the other.

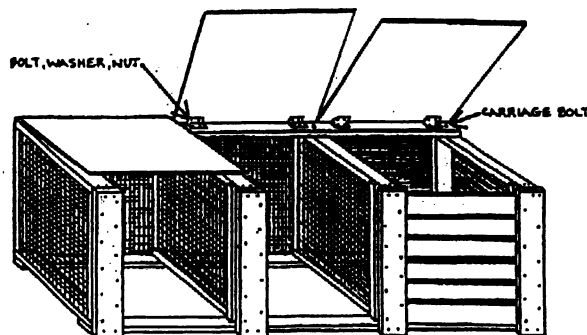
Adding Wastes

Add wastes as they become available. Nonwood materials such as grass clippings and garden weeds work best. You can speed up the process by chopping or shredding the wastes. If you have two units, when the first unit is full let the compost mature and add wastes to the second unit.

Maintaining Your Compost Pile

Although you do not need to turn this pile, make sure that it is moist during dry spells. Compost should be ready in about one year.

Wood and Wire Three-Bin Turning Unit



A wood and wire three-bin turning unit can be used to compost large amounts of yard, garden, and kitchen wastes in a short time. Although relatively expensive to build, it is sturdy, attractive, and should last a long time. Construction requires basic carpentry skills and tools.

What You Need

Materials: 4 12-foot (or 8 6-foot) lengths of pressure-treated 2 x 4 lumber, 2 10-foot lengths of pressure-treated 2 x 4 lumber, 1 10-foot length of construction grade 2 x 4 lumber, 1 16-foot length of 2 x 6 lumber, 6 8-foot lengths of 1 x 6 lumber, 1 4 x 8-foot sheet of ½-inch exterior plywood, 1 4 x 4-foot sheet of ½-inch exterior plywood, 22 feet of 36-inch wide ½-inch hardware cloth, 2 pounds of 16d galvanized nails, 250 poultry wire staples (or a power stapler with 1-inch galvanized staples), 12 ½-inch carriage bolts 4 inches long, 12 washers and 12 nuts for the bolts, 6 3-inch zinc-plated hinges, 24 washers and 24 nuts for the hinges, and 1 quart wood preservative or stain.

Tools: tape measure, hand saw or circular power saw, hammer, tin snips, carpenter's square, optional : power stapler with 1-inch galvanized staples, drill with ½-inch bit, screwdriver, ¾-inch socket or open-ended wrench, pencil, safety glasses, ear protection, dust mask, and work gloves.

Building a Wood and Wire Three-Bin System

- 1 Cut two 31 ½-inch and two 36-inch pieces from a 12-foot length of pressure-treated 2 x 4 lumber. Butt joint and nail the four pieces into a 35-inch x 36-inch "square." Repeat, building three more frames with the remaining 12-foot lengths of 2 x 4 lumber.

- 2 Cut four 37-inch lengths of hardware cloth. Fold back the edges of the wire 1 inch. Stretch the pieces of hardware cloth across each frame. Make sure the corners of each frame are square and then staple the screen tightly into place every 4 inches around the edge. The wood and wire frames will be dividers in your composter.
- 3 Set two dividers on end 9 feet apart and parallel to one another. Position the other two dividers so they are parallel to and evenly spaced between the end dividers. The 36-inch edges should be on the ground. Measure the position of the centers of the two inside dividers along each 9-foot edge.
- 4 Cut a 9-foot piece from each 10-foot length of pressure-treated 2 x 4 lumber. Place the two treated boards across the tops of the dividers so each is flush against the outer edges. Measure and mark on the 9-foot boards the center of each inside divider.
- 5 Line up the marks, and through each junction of board and divider. Drill a ½-inch hole centered 1 inch in from the edge. Secure the boards with carriage bolts, but do not tighten them yet. Turn the unit so the treated boards are on the bottom.
- 6 Cut one 9-foot piece from the 10-foot length of construction grade 2 x 4 lumber. Attach the board to the back of the top by repeating the process used to attach the base boards. Using the carpenter's square or measuring between opposing corners, make sure the bin is square. Tighten all the bolts securely.
- 7 Fasten a 9-foot length of hardware cloth to the back side of the bin with staples every 4 inches around the frame.
- 8 Cut four 36-inch long pieces from the 16-foot length of 2 x 6 lumber for front runners (Save the remaining 4-foot length.) Rip cut two of these boards to two 4 ¾-inch wide strips. (Save the two remaining strips.)
- 9 Nail the 4 ¾-inch wide strips to the front of the outside dividers and baseboard so they are flush on the top and the outside edges. Center the two remaining 6-inch wide boards on the front of the inside dividers flush with the top edge and nail securely.
- 10 Cut the remaining 4-foot length of 2 x 6 lumber into a 34-inch long piece and then rip cut this piece into four equal strips. Trim the two strips saved from step 8 to 34 inches. Nail each 34-inch strip to the insides of the dividers so they are parallel to and 1 inch away from the boards attached to the front. This creates a 1-inch vertical slot on the inside of each divider.
- 11 Cut the 6 8-foot lengths of 1 x 6 lumber into 18 slats, each 31 ¾ inches long. Insert the horizontal slats, 6 per bin, between the dividers into the vertical slots.
- 12 Cut the 4 x 8 foot sheet of exterior plywood into two 3 x 3-foot pieces. Cut the 4 x 4-foot sheet of exterior plywood into one 3 x 3-foot piece. Center each 3 x 3-foot piece on one of the three bins and attach each to the back top board with two hinges.
- 13 Stain all untreated wood.

Adding Wastes

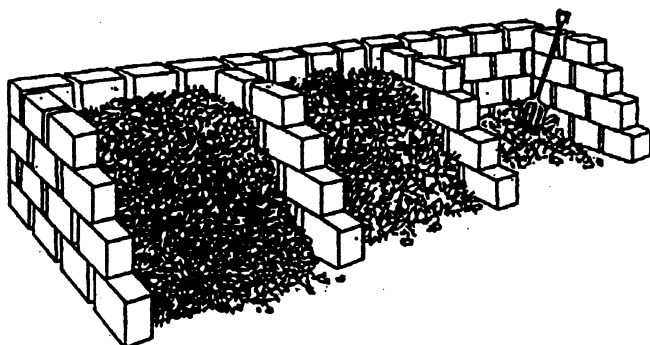
Do not add wastes as they become available with this system. Collect enough wastes to fill one of the three bins at one time. You can collect woody as well as nonwood wastes.

Add thin layers of different kinds of organic materials or mix the wastes together. Before adding new wastes to an empty bin, collect enough to fill the entire bin.

Maintaining Your Compost Pile

Take the temperature of your pile every day. After a few days, the temperature should reach between 130° and 140°F (54° to 60°C). If your pile gets very hot, turn it before the temperature gets above 155°F (68°C). In a few days, the temperature will start to drop. When the temperature starts going down, turn your compost pile into the next bin with a pitchfork. The temperature of your compost pile will increase again and then, in about four to seven days, start to drop. Turn your compost pile into the third bin. The total time for composting should be less than one month.

Cinder Block Turning Unit



A cinder block turning unit looks like three cinder block holding units in a row. It is sturdy, and if you can find used cinder blocks, it is inexpensive to build.

What You Need

About 98 cinder blocks and work gloves

Building a Cinder Block Turning Unit

- 1 Place 12 cinder blocks in a row along the ground at your composting site, leaving about ½ inch between each block to let in air.
- 2 Place 4 cinder blocks in another row along the ground perpendicular to and at one end of the first row, forming a square corner; leave about ½ inch between each block.
- 3 In the same way, place 4 cinder blocks at the opposite end of the first row to form a three-sided enclosure.
- 4 Place two more rows—4 cinder blocks each—along the ground, parallel to the ends and evenly spaced within the enclosure. This divides the enclosure into three separate bins.
- 5 Add a second layer of blocks, staggering them to increase stability and leaving about ½ inch between each block. There should be a layer of 13 cinder blocks across the back and 3 cinder blocks on the sides of each bin.
- 6 Add a third layer of blocks. Again staggering them to increase stability, with 12 blocks across the back of the enclosure and 3 on each side.
- 7 The last and top layer should have 13 blocks across the back and 2 on each side.

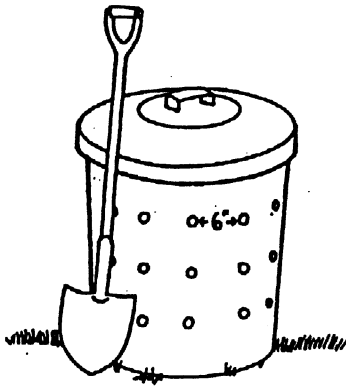
Adding Wastes

Do not add wastes as they become available with this system. Collect enough wastes to fill one of the three bins at one time. You can collect woody as well as nonwood wastes. Add thin layers of different kinds of organic materials or mix the wastes together. Before adding new wastes to an empty bin, collect enough to fill the entire bin.

Maintaining Your Compost Pile

Take the temperature of your pile every day. After a few days, the temperature should reach between 130° and 140°F (54° to 60°C). If your pile gets very hot, turn it before the temperature gets above 155°F (68°C). In a few days, the temperature will start to drop. When the temperature starts going down, turn your compost pile into the next bin with a pitchfork. The temperature of your compost pile will increase again and then, in about four to seven days, start to drop. Turn your compost pile into the third bin. Continue to take the temperature and turn the compost pile until the compost is ready. The compost should be ready in about one or two months.

Garbage Can Composter



A garbage can composter is inexpensive and easy to build. It can be used for food or garden wastes. You do, however, need to turn the wastes.

What You Need

Materials: garbage can with cover, coarse sawdust, straw, or wood chips

Tools: drill, pitch fork, shovel, or compost turner, and work gloves

Building a Garbage Can Composter

- 1 Drill three rows of holes 4 to 6 inches apart all around the sides of the garbage can. Then drill several holes in the base of the can. The holes allow air movement and the drainage of excess moisture.
- 2 Place 2 to 3 inches of dry sawdust, straw, or wood chips in the bottom of the can to absorb excess moisture and let the compost drain.

Adding Wastes

Add fruit, vegetable, and garden wastes. Make sure not to add too much of any one waste at a time.

Maintaining Your Compost Pile

Regularly mix or turn the compost with a pitch fork, shovel, or compost turner and keep it covered. This adds air and mixes up the different wastes, preventing the compost from getting smelly. A smelly compost pile may attract animals and cause neighbors to complain.

Use the following chart to identify and fix problems in your compost pile.

Symptom	Problem	How to Fix It
Pile is wet and smells like a mixture of rancid butter, vinegar, and rotten eggs	Not enough air	Turn pile
	Or too much nitrogen	Add straw, sawdust, or wood chips
	Or too wet	Turn pile and add straw, sawdust, or wood chips; provide drainage
Pile doesn't heat up	Pile is too small	Make pile larger
	Or pile is too dry	Add water
Pile is damp and sweet smelling but will not heat up	Not enough nitrogen	Add grass clippings or other sources of nitrogen
Center is dry and contains tough materials	Not enough water	Add water and turn
Pile is attracting animals	Meat and other animal products have been added	Keep meat and other animal products out of the pile; enclose pile in ¼ inch hardware cloth

Using Organic Matter in the Garden ⁷

Health of the garden depends on organic matter. What happens below the soil line may not be as romantic as roses, but it does make the garden more healthy and those roses more beautiful. In gardening, many products are called organic matter. Animal manures, peat moss from bogs, leaves, straw, newspaper, sludge, yard and garden waste, kitchen scraps, and green manures or cover crops - all are forms of organic matter that can be incorporated directly into the soil. Often such products are composted, rather than used directly, and the compost is used in the garden. Compost can be made at home from kitchen, garden, and yard wastes, or it can be produced by an industry or local municipality.

Organic matter is used in the garden and landscape for many reasons, beginning with its effect on soil structure. Organic matter helps soil particles bind together into aggregates, or clumps, which makes it easy to dig or penetrate. We often call this quality tilth. In this way, adding organic matter helps all poor soils, whether they are too sandy or made of too much clay. A soil with good tilth also has good nutrient-holding and water-holding ability. In addition, organic matter improves soil by stimulating or feeding the life of the soil. It provides nutrients to bacteria, fungi, earthworms, and other organisms in the soil, which in turn recycle the nutrients into forms that are readily available for plants to absorb through their roots. Organic matter also helps to prevent soil and wind erosion by binding sandy soil particles together. Organic matter also prevents caking, cracking, and water run-off that occurs when clay soil dries out. This publication describes some of the

more familiar organic materials available to home gardeners, their effect on soil, plants, and soil life, and how they are commonly used.

When to Use Organic Matter

The short answer is "as often as you can." Amending the soil of planting areas for landscaping -- trees, shrubs, lawns and herbaceous plants -- is an important gardening practice for new homeowners or those who are revamping their property. Adding organic matter to a vegetable garden, a fruit orchard, or to an existing lawn is equally important for success. Experienced gardeners often consider soil building or soil replacement, i.e. bringing in and incorporating organic matter, nearly half the work of gardening.

Community projects often begin with substandard soil that needs amendment. In the rush to set out plants, gardeners sometimes do not add any or add insufficient amounts of organic matter. In reality, the soil preparation for planting beds is more important than the act of planting.

There is some disagreement about using any organic matter amendments in *backfilling planting holes* for trees, shrubs, or woody perennials. There is little data about long-term benefits. Some professionals have demonstrated that amending the original soil hole with a backfill mix encourages a *teacup effect*. That is, the artificial well or teacup of improved soil is so different from the surrounding soil that the roots never leave their comfort zone, becoming entrapped in the teacup over time. Other professionals have shown that there is early root growth and possibly reduced soil-borne pathogens in soil that has been amended with organic matter. Currently, backfilling planting holes with organic matter, when planting new trees or shrubs, is not recommended for homeowners unless the soil quality is exceptionally poor. Incorporating organic matter over an entire site or planting bed, however, is recommended

In most situations, gardeners should add organic matter to "poor" soils, whether they are too clayey, too sandy, compacted or poor in nutrients.

Compost

Compost is often called *black gold* and many consider it the most important form of organic matter. It is universally recognized for improving soil structure and water-holding capacity. Compost helps the soil stay loose and easy to cultivate. Compost is, in fact, the end-product of the decomposition of organic matter. Making and using compost is also a way to *recycle* organic matter, especially products which might otherwise have been treated as home or industrial wastes.

In addition to soil improvement and the economic and social benefits of recycling organic matter, composting can provide other benefits. Composts help fight soilborne plant pathogens. However, not all composts are suppressive to all diseases. Compost, along with other organic matter, improves the capacity of soil to hold nutrients through a complex process called *cation exchange capacity*. In addition, compost indirectly provides nutrients for plant use when earthworms and other organisms digest the organic matter, producing nutrient- rich castings, or excrement. These products are significantly

richer in nutrients than the surrounding soil, and in a form, which is readily available to plant roots. While compost provides some nutrients and makes other nutrients more available, it is not considered fertilizer. However, in many organic gardening or farming systems, compost is the major amendment to enrich soil.

Not all composts are alike. Composts vary greatly, depending upon what goes into them and how they are processed. Quality also varies depending on maturity, pH, presence of weed seeds, concentration of toxic substances, and the population of soil-dwelling organisms, such as earthworms, insects and microorganisms. Higher quality compost has good water holding capacity and nutrient availability.

Maturity makes a difference. Use of immature composts can cause problems. Maturity means that the compost has decomposed extensively and has become fairly stable. Immature compost may still contain some plant inhibitors. When immature compost is added to the garden, its bacteria compete with plants for nitrogen in the soil. The result is unhealthy plants with symptoms such as yellow leaves or stunted growth. If compost is still hot, smells like ammonia, or you can still recognize the original form of organic matter, then it is not ready to use. When in doubt, let compost mature longer.

Maturity is not the same as quality. Maturity means the energy and nutrient containing materials have merged into a stable organic mass. Mature compost (also called “finished compost”) is dark-colored and has an earthy odor. Quality is the chemical composition of that mass. For example, a compost could be mature, but of poor quality, if nutrients had leached away or it contained contaminants.

Source materials affect quality. Soluble salts, nutrients and contaminants vary, depending on what the source material of the compost is. Soluble salts are actually chemically charged particles (ions) usually from dissolved fertilizer and irrigation water but may come from the composted material itself. While not a human health concern, concentrated soluble salts can cause problems in plant growth. Compost made from food (fruits and vegetable scraps, fish residues, coffee grounds, brewery and bakery wastes) is typically richer in nutrients, but may have high soluble salt content. The concentration of soluble salts, as well as the concentration of contaminants like lead and other heavy metals, in composted sewage sludge varies greatly, depending upon which industrial waste products are discharged to the sewage treatment plant. Yard waste compost is typically low in nutrients, contaminants and soluble salts. Composted manure is generally high in nutrients and soluble salts, while low in contaminants.

Hot is different from cold. Composts may or may not heat up during decomposition. Particularly in small-scale home composting systems, compost may not get hot. Some tests have shown that finished cold compost may actually have a higher nutrient content than products from a hotter compost. However, weed seed and disease organisms are more likely to be destroyed in hot compost.

Uses of Compost. Gardeners and landscapers use compost in many ways. It is used in establishing a planting bed; improving soils; mulching gardens or landscape plantings;

backfilling during the planting of trees, shrubs, or perennials; establishing or topdressing lawns; side-dressing vegetables; or controlling erosion.

The **amount** of compost to use varies, depending upon soil and site characteristics, plant selection, compost quality, and availability. Most mature composts can be used in most planting situations without serious concern for precise amounts. In estimating how much compost is needed, measure the overall planting area, and calculate how much compost you will need to cover the area with 1 inch (or your preferred amount) of compost in a season. For instance, to apply 1 inch of compost over a 10 x10-foot area, you'll need about 8 cubic feet , or about 300 pounds, of compost. For a home garden, two 4 x 4 x 4-foot piles of compost can provide enough compost to accomplish this. Experienced compost users rarely have enough compost for its many functions and are concerned with dispersing the *black gold* equitably among the garden and landscape plants.

There are easy ways to **apply compost** for different horticultural uses. Compost in **planting beds** for perennials is often applied at a rate of 1 to 2 inches. This could be about 8 to 16 cubic feet of compost per 100 square feet of the planting beds. Incorporate the compost evenly about 6 to 8 inches into the soil. The prepared bed for trees and shrubs, however, should be 30-50% by volume to change structure, as well as to improve drainage, and root penetration into the site. To achieve this, add 4 inches of compost and incorporate it into the top 12 inches of the planting bed. This is about 32 cubic feet of compost per 100 square feet of planting bed. To use it as a **landscape mulch**, apply compost 1-3 inches deep over the soil surface. This could be 8-24 cubic feet of compost per hundred square feet of mulched area. A few inches of compost may also be layered under other landscape mulches, such as wood chips, to provide improve the soil without working the compost into the soil. In using sludge composts, apply no more than 2 inches. Limit sludge compost to one inch if you are mulching around salt sensitive plants. In **establishing a lawn**, mix compost with the planting soil, in order to improve drainage, especially in a heavy clay soil. Compost may also suppress specific soil-borne diseases and plant pathogens in lawns. Before seeding a new lawn, evenly apply 1-2 inches of compost over the entire area. This could be 8-16 cubic feet of compost per hundred square feet of lawn. Incorporate into the top 5-7 inches of soil, resulting in a final volume of 30% compost content. **Established lawns** may be top-dressed, that is, sprinkled with compost over the top of the grass and watered into the top layer of soil. However, it is important not to apply more than a quarter of an inch at a time, as the compost could smother established lawns, if it is applied more thickly.

Compost may be added in many ways to **vegetable gardens**. Prior to planting, compost may be spread 3 inches over the surface and worked into the top 3-6 inches of soil. Other guidelines suggest 2-3 bushels of compost per hundred square feet should suffice. Side-dressing, or digging in compost next to growing plants, is often done a month or two after planting. Compost is also an excellent vegetable garden mulch, which breaks down slowly, encourages soil life and maintains an even soil temperature in the heat of summer.

For **erosion control**, compost may be added to a sloped area to increase the soil's ability to retain water and discourage run-off. To do this, spread a 3-4 inch layer of compost over the entire area and work into the top 6-8 inches of soil.

Biosolids or Sludge

What does sludge have to do with gardening? Biosolids or sewage sludges are the semi-solid residue from wastewater plants that treat residential, commercial and pre-treated industrial wastewater. Sludge is typically about half organic matter and is half inorganic and may be available to homeowners.

The goal of wastewater treatment is to clean up the water, and most pathogens and contaminants are deposited in the sludge. Before distribution for use, sludges must be treated to essentially **eliminate pathogens**. Sludges are also treated to regulate the level of 9 **metal contaminants** often found in municipal and industrial sludge. Standards for legally acceptable levels of these metals is regulated by NYS Department of Environmental Conservation (DEC) and by the U.S. Environmental Protection Agency (EPA). Testing for those contaminants is required with a frequency determined by the size of the treatment plant. There are no requirements for providing such quality information to users.

Biosolids are fairly rich in plant nutrients (similar to manure) and the pH level is generally 6.0-7.5. Some biosolids used to produce composts have been treated with liming agents, which can affect pH, buffering capacity and soluble salts level, thus limiting their horticultural use with certain plants.

NYS regulations prohibit the use of sludge products made in NYS on crops for human consumption, such as in the home vegetable garden. There is a concern that crops can potentially be affected by pathogens in the sludge. In addition, there is concern that crops may take up heavy metals (such as cadmium, lead, zinc, mercury, etc.) from sludge. Cadmium could be taken up in all parts of the plant; it is very soluble at lower pH's. Keeping the pH at 6.8-7.0 or higher is useful in decreasing solubility of cadmium and other heavy metals. However, higher pH alone is not enough to reduce uptake of lead. Increasing the organic matter or phosphorus is also necessary to tie up lead in the soil, making it less likely to be absorbed by the crop.

Use of sludge products presents a special risk to children, who might unknowingly eat particles of soil. The exposure of children to lead, cadmium and other potential metal contaminants in soil enriched with sludge is the chief concern. When sludge is used, it should only be incorporated as an amendment to soil growing ornamental plantings. Using sludge in ornamental plantings in limited amounts where young children aren't in contact with the sludge in the soil is a relatively low risk. If sludge has already been applied, a concerned resident can dilute it with additional topsoil or cover it with mulch.

Milorganite as a Fertilizer and Deer Repellent. Milorganite is a commercially available dried sludge aerobically digested sewage. It has been available from Milwaukee since the 1930's as an organic-slow release fertilizer for lawns, gardens and citrus

production in Florida. Because brewery waste contributes to the production of Milorganite, it has a higher nitrogen content than most other sewage sludges. The processing of Milorganite kills pathogens and adds iron as a clumping agent.

Milorganite has also achieved some popularity as a possible deer repellent for landscape plantings. In a demonstration project in Dutchess County, New York in the mid-nineties, Milorganite, used as a deer repellent, provided some protection for perennials and woody plants during the summer and early fall. These are times when deer have much alternative forage available. It provided almost no protection during winter and early spring, when either snow covered the ground or deer were short of food.

Sludge products like Milorganite are not legally registered as deer repellents by federal EPA and therefore cannot be recommended.

Manures

Animal manures have long been a popular form of organic matter as well as fertilizer for farms and gardens. Farm manure is still the most readily available manure, purchased directly or sometimes free from the farm. It is sometimes bagged and sold in garden centers - with a wide range in its quality, nutritional content, age, and weed seeds present. It is not recommended that homeowners use any manure from dogs, cats, or other meat-eating animals, since there is risk of parasites or disease organisms that can be transmitted to humans.

Characteristics of animal manures: Farm animal manures provide NPK - nitrogen (N), phosphorus (P), and potassium (K). Generally, cow and horse manures are more readily available than other kinds of animal manures. For nutrient analysis of manure from eight kinds of farm animals, as well as other kinds of organic matter, refer to Cornell's Eco-Gardening Factsheet #8, "A Guide to the Nutrient Value of Organic Materials."

Using manure: Manures differ from each other because of their source, their age, how they were stored (piled, spread, turned over or not), and the animal bedding material, which may be mixed in. For that reason it is difficult to provide precise guidance about how long manure should be aged before use, or how much to use. Composting is the safest way to make the most of manure's nutritional potential - if the logistics of making and hauling compost are viable. For direct use in the garden, first aging manure for 6 months is a good rule of thumb. Many farmers and gardeners spread fresh manure in the fall or winter, and till or turn it in at spring planting time. When manure is spread in the spring, even if aged, it is safest to wait for at least one month before planting crops, since the microbial activity it stimulates may interfere with seed germination or plant growth before that time.

When composted manure is spread directly over the soil, it is helpful to add about 40 lbs. per 100 square feet, turned into the top 6 to 9 inches. Aged manure is often used in home vegetable gardens as a side-dressing, or placed directly in holes under the soil where vine crops such as pumpkins are planted.

Manure tea, made by soaking bags of manure in tubs of water, is a nutrient- rich liquid that is full of microbial life. It is another way to use manure as a fertilizer, whether it is poured on the leaves of plants (called *foliar feed*) or into the soil.

Problems with manure: While it is one of the most readily available forms of organic matter and fertilization for many gardeners, manure can present some problems.

- The relatively high nitrogen content makes manure extremely valuable in composting, where it activates soil bacteria and contributes to rapid decomposition of organic matter. But, as a direct soil amendment, that same high nitrogen content can be a deficit. Fresh, raw, or hot manure activates and builds up soil microbial activity to the extent that the nutrients *volatilize*, or burn up, before plants can use them.
- Fresh manure also can damage plant tissue and kill seedlings. An excessive amount of soil nitrogen can produce plants with a high nitrate content. These high nitrate levels are not only potentially harmful to humans; they also are more attractive to pests than crops grown with less nitrogen, and do not store as well either.
- Manure also is notorious for adding undigested weed seeds to the garden, particularly from horses and other animals that eat hay. Composting in a hot system (when the pile reaches over 155 degrees) destroys most weed seeds, but most composting systems are inexact and seeds can come through. For that reason, those who use manure usually plan on weed-control techniques such as mulching, interplanting (growing cover crops between rows), mechanical or hand-weeding, or herbicides in some situations.
- Particularly in agriculture, manure use can pose pollution problems when rain or irrigation systems carry nitrogen from the fields before it is used by plants. Nitrogen from manure or synthetic fertilizers has been identified in New York State as a pollutant found in groundwater.
- Fresh manure must be used with caution in the garden because it may contain pathogenic bacteria such as *E. coli*, *Listeria*, and *Salmonella*. Although the chance of contamination is slim, severe sickness and even death may occur if contaminated produce is eaten. To be safe, either compost your manure or apply it in the fall after harvest. Try to leave at least 120 days between application of fresh manure and harvest of a crop.

Green Manures or Cover Crops

Several grasses, grains, and legumes are used in gardening and farming and referred to as cover crops or green manures. The term *cover crops* describes an important function of these crops: to cover the soil, block weeds, prevent erosion, and maintain soil moisture, among other benefits. *Green manure* refers to the other primary function of using these crops: to add organic matter to the soil. Green manure crops are grown during fallow seasons (when a garden or field is not in use), during part of the growing season, or over winter, to add biomass to the soil. *Biomass* is the quantity of organic matter that living crops provide. Some green manure crops are also used between crop rows or plants while

they are growing, called *intercropping* or *interplanting*. Cover crops are sometimes broadcast over existing crops a few weeks before harvest, so that the cover crop is already growing before the area is left bare. There are as many systems for green manuring or covercropping as there are garden layouts, and many ways to add organic matter with these plants.

Crops used for green manure: There are many choices of green manure crops, with a variety of benefits for using them. The crops are divided into legumes (beans, peas, alfalfa, clovers, hairy vetch, and soybeans) and non-legumes. The latter includes annual ryegrass, buckwheat, oats, winter rye, sudan grass, and winter wheat. The legumes provide the benefit of fixing nitrogen, actually taking nitrogen from the air and holding it as nodules on plant roots. As plants are turned under or cut off at the stem this nitrogen becomes available in the soil for future plant use. Other cover crops are biological *subsoilers*, such as alfalfa, with roots that reach down into the subsoil up to 8 feet, bringing valuable hard-to-reach nutrients up to the soil surface as the crops are harvested.

Which green manure to choose In choosing a green manure crop, many factors have to be considered: the amount of biomass, the nitrogen-fixing factor, time required to grow, and most of all how the crop coordinates with the other plants in the particular garden's system. Even the equipment available, or your individual strength, are factors in choosing. For instance, taller crops, such as oats or winter wheat offer the most biomass, but they require serious equipment or massive effort to cut them down or turn them under.

Crops that over-winter, such as winter rye, protect the soil during the winter and provide spring growth, which is later cut down and turned under. However, to incorporate these into the soil in late spring requires powerful equipment. Tilling earlier in the spring is possible, but getting into the garden or onto the field during a wet spring can be a problem. Other crops, such as buckwheat, do an excellent job of blocking weeds and attracting beneficial insects, but offer less biomass. The governing factor in most cases is the timing. Once the summer crops are harvested there are only a few choices that can be established in September (annual ryegrass or oats) or as late as October (winter rye or winter wheat). For additional information on seeding rates and selection of cover crops, please refer to: Cornell's Eco-Gardening Fact Sheet #9, "Improve your soil with cover crops".

Peat Moss

For many years, bales of peat moss have been on our list of garden supplies and we've never given it a thought. Now, gardeners around the world wonder if peat companies are destroying these fragile and unique bog ecosystems by removing the peat. They ask whether these companies are harvesting this abundant resource in a responsible, sustainable manner. Canada, where we get most of our peat moss in the United States, has 25% of the world's peatlands and only .02% of them is being harvested. The industry is regulated and practices restoration and reclamation to attempt to keep peat a sustainable resource. Environmental assessments are conducted before opening a virgin bog to harvest. Horticulturally, peat is used in a variety of ways. It is a soil amendment,

an ingredient in potting soils and planting mixes, and used as a bulking agent and carbon source in composting.

Can you use North American peat without feeling guilty? Perhaps the answer to this question can be found by using peat conservatively. Use peat in your growing mixes for starting seeds and cuttings. Since peat is sterile, it minimizes disease problems. However, focus on composting to supply the larger quantities of organic matter needed to improve your garden soil. By substituting compost for some of your garden needs, you can help to cut down on the rate of peat moss mining.

If you choose to use peat moss in the landscape, plan to add 33% (by volume) of peat moss before tilling it into garden beds. This could be 1-6 inches laid over the top of the planting bed before tilling. The actual amount will depend on how deeply you incorporate it into the soil. A shallow incorporation may only require a one inch layer, while deep digging will require more in order to achieve the 33% volume of peat moss to the entire soil mass.

A highly decomposed form of peat, dark brown to black in color, is peat *humus*. It has a much lower water-holding capacity and is more expensive than peat moss. It is, however, an excellent soil conditioner.

Because of its tight, fibrous structure, peat moss should not be used as a soil surface mulch. As it dries, it has the tendency to absorb water to itself, robbing the soil underneath from valuable water from rain or irrigation. Peat should only be mixed into the soil, not laid on top of it.

Since compost is often considered a substitute for peat moss, the following chart may help to delineate the **differences and similarities between peat moss and compost.**

<u>Peat Moss</u>	<u>Compost</u>
Expensive	Often Free
Poor in Nutrients	Relatively rich in nutrients (but not a fertilizer)
Low pH	pH usually neutral or slightly alkaline
Doesn't compact	May compact
Excellent at holding water	Good at holding water
Hard to re-wet	Re-wetting capacity varies
Uniform in composition	Variable in composition and contaminants
Might contain pathogens	Full of microorganisms (mostly beneficial)
Contains no weed seeds	May have weed seeds if not composted properly*
Little or no disease suppressing qualities	Capable of suppressing some plant disease-pathogens
Uses a natural resource, obtained by mining	Recycles organic waste matter
Not a mulch	Excellent as a mulch

* "Not composted properly" refers to situations where the compost has not gotten hot enough for a long enough period of time or where the compost goes anaerobic or where it has not been turned adequately to assure that all particles have been exposed to hot temperatures.

Other kinds of Organic Matter

In various regions of the state and across the country, plant and animal products from lakes, orchards, vineyards and fields are available. Such products as fruit pomace (seeds, pulp, skins), seaweed, brewery waste, buckwheat hulls, mushroom waste, fish industry, zoo, fair and circus waste are only a few kinds of organic mater that may only be available in specific regions.

Paper

Several paper products - especially newspaper and cardboard - are useful in the garden and landscape. While it provides no nutrients, paper is organic material, made primarily of wood fibers. It decomposes slowly but provides structure when used in a compost pile. Shredded newspaper or telephone book paper are good paper choices for composting or digging into soil directly; they decompose well when mixed with high nitrogen products such as a manure. Shredded newspaper may also be used under other mulches in the landscape, where it is broken down by earthworms. Shredded computer or other office paper may be used although it breaks down slowly. Glossy magazine-style paper decomposes even more slowly and contains dioxin. There are enough concerns about the dioxin in glossy paper that it would be wise not to use it in the garden. Waxed paper almost never breaks down.

There has been concern about using colored paper or ink, which contains heavy metals. Evidence shows such low concentration of heavy metals - if any at all - that colored paper may be used without danger. Many inks currently used are soy-based.

Cardboard and newspaper (several sheets thick) are effective mulches around vegetables or flowers, used to block weeds and retain soil moisture. For similar reasons, in landscape plantings, cardboard or paper may be used under other mulches such as wood chips. This method has several other benefits: the paper products may block the light and prevent weeds longer than less solid mulches, and may decrease the amount of wood chips or other surface mulches needed. In addition, there is the benefit of reusing paper products, which reduces costs and the need for their disposal in overcrowded landfills.

Direct Incorporation of Organic Matter

Composting is not always a viable option for the home gardener. However, there are many other ways to add organic matter to the soil and still reap the benefits. Some of the methods of *direct incorporation* include:

- **Sheet method:** spreading organic matter such as leaves and grass clippings, straw, rotted hay or raw manure directly over the soil. Some users turn it under whenever it is applied and others let it cover the soil in winter and turn it under in spring. When opaque (black or red) plastic is used, a variation on sheet composting is to spread the organic matter under the plastic, where it decomposes more quickly using the heat created by the plastic.
- **Trench method:** one of the oldest and simplest ways to add organic matter is simply digging a trench or one hole at a time and burying organic matter as it becomes available. The trench can even be made between plants or rows during the growing season. The organic matter is typically kitchen waste, such as food scraps or coffee grounds, but any organic matter can be added this way.
- **Hugel method:** often called **in-place composting**, the gardener creates a mound or hill (*Hugel*, in German) of organic matter in the garden. While there are several variations, all include piling up organic materials in layers, usually with the coarsest on the bottom and letting the materials decompose in place. In most systems, crops are planted in the top layers while the lower layers are still in the original undecomposed form. Possible materials from bottom to top are: twigs, leaves, manure, straw, grass clippings and compost or soil.

Mulch

Another way that organic matter is used in the garden is to cover the soil. Mulches can be applied in winter or summer. Winter mulches protect young perennials, while summer mulches retain soil moisture and limit weed seed germination. Tree bark, branches and trunks can be chipped and spread as a mulch. Plant residues from locally grown crops such as buckwheat, peanut, cocoa, wheat, corn, and salt marsh grasses can serve the same purpose. Even newspaper is used. Almost any composted material can be used as a mulch, while peat moss cannot. Mounding compost mulch (or any mulch) against tree trunks poses serious dangers of disease, rodent or insect damage to the tree.

Fertilizing Organically ⁸

A healthy soil contains all the minerals, organic matter, and micro-organisms required to provide nutrients in a form that plants can use. Plants need nitrogen, phosphorus, potassium, calcium, magnesium, sulfur and some minor nutrients, all of which are provided naturally as minerals in the soil or through the decomposition of organic matter. This decomposition is carried out by micro-organisms, insects, and earthworms. Our work as organic gardeners is to provide a healthful environment for this life in the soil, so that corrective measures additional fertilization – is rarely needed.

When a nutrient deficiency is suspected, as in the case of poor root growth or yellowish leaves, synthetic fertilizers are not the solution, however. A primary reason is the negative effect on earthworms: Studies have shown up to 66% fewer worms in soil that was over fertilized with synthetic N-P-K standard fertilizer. If encouraged in the soil, by a high organic content, worms actually produce 1/3 lb. of fertilizer (N-P-K and other nutrients) per worm per year – in a form plants can use. Furthermore, worms delve far below the topsoil, bringing up valuable mineral rich subsoil while simultaneously aerating the soil. The organic gardener chooses to encourage, not drive away, these precious helpers. Furthermore, plants tend to have shallow root systems and weaker, leggier stems (sometimes all foliage and poor roots or fruits) if quick release synthetic nitrogen fertilizers are provided. In the case of lawns, such fertilization practices – especially with frequent shallow watering – lead to tangled surface roots and ultimately thatch build up. This happens because roots remain on top of the soil not having to reach down for food and water, and grass clippings do not decompose as readily. The latter occurs because earthworms and micro-organisms, who normally eat through the debris and surface roots and aerate the soil for good root penetration, are driven away by the chemical fertilizers.

Organic fertilizers or nutrient sources, if required to enhance soil fertility, include the following (numbers in parenthesis indicate equivalent N-P-K fertilizer):

Nitrogen-rich fertilizers:

Bloodmeal (10-0-0): Good slow release of nitrogen; rather expensive, best used as side-dressing or for special shrubs or beds with high nitrogen need

Cottonseed meal (7-2-1): the same as above

Compost

Manure

Milorganite (6-2-0), processed sewage sludge, often used on lawns

Phosphorus fertilizers: When a general feeding is necessary, rock phosphate is a slow acting fertilizer, used at the rate of 2.5 lbs. per 100 sq. ft. For fast-release solutions for immediate deficiencies, use liquid fish emulsion.

Potassium fertilizers: For a slow feeding general fertilization, use greensand or granite dust, 2.5 lbs. per 100 sq. ft., in fall. In the case of short term deficiency of specific plants, diluted fish emulsion or wood ashes are effective. Caution: wood ashes may raise soil pH.

Other nutrient sources for specific deficiencies:

Rock phosphate, gypsum (sulfur)

Copper sulfate, iron sulfate, zinc sulfate, magnesium sulfate (each of these may also lower pH)

Two balanced mixtures one can prepare at home: (each approximating a 10-10-10 fertilizer)

(1) 2 cups dried blood / 4 cups wood ashes / 1 cup rock phosphate

(2) 4 cups coffee grounds / 1 cup bonemeal / 1 cup wood ashes

Preventing Problems⁹

As with human health, it is easier to prevent problems than cure them; similarly, insects are more easily handled by anticipation and preparation rather than handled as a large infestation. More than other gardeners, organic gardeners need knowledge of potential pests, their life cycles, and natural predators in order to work with nature for the goal of a healthy garden. The optimum condition is a yard or garden teeming with life: Animals, birds, snakes, toads, insects, flowers and produce, all interdependent and complementary of each other. In fact, a minimum number of garden “pests” – potato bugs, aphids, caterpillars, etc. – is actually desired in such a scheme, as they provide enough food to lure and maintain a population of their natural predators. When a pesticide is used, insect predators are usually killed, along with the target insect, so that future infestations have no natural predator and the cycle of spraying must be perpetuated.

The organic gardener’s preventive measures include the following (with many more to be found in organic gardening literature, lore and personal experience):

Insect Traps

- Mechanical Traps
- Visual Lures
- Chemical Lures or Bait Traps

Barriers

- Cutworm Collars and Paper Shields
- Row Covers

Insect Traps and Barriers¹⁰

Insect traps and barriers are in widespread use, and have been on the market for many years. However, many misconceptions exist among home gardeners as to what, and what they will not do. This fact sheet categorizes traps as to type, and will help you decide whether the trap or barrier will be appropriate for use in your garden.

Mechanical Traps

Sticky traps for home gardens are one option. They may be purchased commercially, or they may be handmade. These traps have a sticky surface so that an insect or small animal encountering them will adhere to the surface. Sticky cards are available for monitoring such pests as whiteflies; when traps are properly placed, they may help reduce the population. Placement of the trap is important, as is renewing the sticky surface or discarding traps when they are full.

Pitfall traps are sometimes used to help detect and monitor crawling pests. A well-known trap of this type is the pie-tin-beer trap for slugs. (Home remedies *) A small pan or tin is placed in the soil with its top flush with the soil surface. The pan is filled halfway with beer. Beer attracts slugs, which fall in and drown. A similar pit-fall trap has been used to monitor black vine weevil populations in nurseries and home landscapes.

Other traps employ such tactics as placing boards or grapefruit skins in gardens to provide hiding places for slugs and insects. Rolled up newspapers can serve as a similar device for catching earwigs. Pans with soapy water can be used for aphid monitoring and as an aid in control. These are often used with visual color lures.

Visual Lures

Visual lures are generally effective for a limited number of species. Light traps have been used for many years to monitor insects, helping us determine which are present and in what numbers. Unfortunately, light traps catch many types of insects, including both beneficial and damaging species.

Some day-flying insects are attracted to specific colors. Colored traps can be coated with a sticky substance to capture these insects.

Proper construction and placement of the traps are critical since they must present the proper appearance (visual image and/or color) to the targeted pest to be effective. Some visual traps that can provide partial control of insects when properly used include red sticky balls for apple maggot, yellow sticky cards for aphids and whiteflies, and white cards for plant bugs. In addition, some visual traps are enhanced with chemical lures.

Chemical Lures or Bait Traps

Pheromones are a well-known type of chemical lure. Pheromone traps utilize a sex attractant for the pest species.

They are excellent monitoring devices, and several have been shown to provide control of certain species such as codling moth.

Aggregation pheromones are used in traps to collect elm bark beetles.

Feeding attractants are also used to trap insects. Japanese beetle traps, which have been on the market for a number of years, often contain a feeding attractant; some also contain a sex pheromone. The effectiveness of the Japanese beetle trap as a control method

continues to be investigated, and it is likely that they can protect small garden areas from too much damage if properly placed. Improper placement, however, can attract more hungry beetles to the garden area. Situate traps of this type well away from the garden, so beetles fly away from garden plants.

Synthetic apple volatile lures are available for use with apple maggot traps; they greatly increase the efficiency of the traps.

Barriers

Barriers are useful for preventing damage from certain pests. Unlike traps, they are used for blocking the feeding activity of the pests. Cutworm collars are valuable for reducing losses to transplanted tomatoes, peppers, broccoli, and related plants. They can be constructed of cardboard, metal, plastic or similar materials. They should be 4 inches tall, and placed firmly in the soil as soon as the crop is transplanted. The collars must be pushed down into the soil approximately one inch to be effective.

Partial control of cabbage root maggot on transplanted crops can be achieved with tar paper shields. To make a shield, cut a round or square piece that is at least 6 inches across. Make a small hole in the center, cut a slit from the edge to the center, and fit the paper around the base of the stem; it should lie flush with the ground. This shield will serve as an egg laying barrier to the adult flies if it is placed promptly after transplanting and fitted snugly around the stem.

Row Covers ¹¹

Late frosts, low yields, a short growing season and insect damage are four common problems that home gardeners would rather do without. Fortunately, the development of rowcovers has added a new dimension to the eco-gardener's management strategy. Rowcovers are available in a variety of materials, including both plastics and fabrics. They can enhance yields of some crops, while producing an early harvest on others. They may offer a few degrees of frost protection, and when properly used, they can effectively block the feeding activity of some insects.

The use of protective coverings to produce a miniature greenhouse effect is certainly not a new idea. A popular practice among some European growers in the early 1900's was to place glass bell jars over individual plants. It was reported in 1910 that there were over 2 million of these jars being used in the Paris vicinity alone.

Less expensive paper materials were eventually developed which replaced the bell jars, and by the mid 1950's "hot caps" or "hot tents" were being used in several areas of the United States. Although these are still in use in home gardens today, many gardeners are enthusiastic about the advantages that rowcovers have to offer.

The ideal rowcover would be one which is inexpensive, prevents air temperatures from falling below freezing at night, increases growing degree-days, and avoids excessively high temperatures and humidity that can have a negative impact on growth and flower development. If you have already done some experimenting with rowcovers on your own,

you probably have already found that no such ideal material exists at this time. In fact, there are no rowcovers that can offer more than a few degrees of frost protection. Their major benefit is associated with more rapid growth by increasing daytime temperatures, not with frost protection.

Cooler rowcover materials can be selected so that the risk of damaging high temperatures is minimized, but keep in mind that cooler materials will not increase growth and yield as quickly. You may want to use a cooler tunnel or hot caps on most of your plants, and a warmer but riskier product for earliest yields on a few plants. An approximate ranking of row cover types from warmest to coolest would be:

Most plastic rowcovers are supported by wire hoops. After the crop is planted, 10 gauge hardened galvanized wire pieces (36 in. long for 4 ft. plastic, 48 in. for 5 ft. plastic) are bent in the shape of an arch and placed in the soil at 3-4 ft. intervals. Do not place hoops directly over the plants so that you can create slits for ventilation or irrigation if necessary. The height of the tunnel is determined by the height of the crop to be grown.

Floating rowcovers made of lightweight spunbonded or woven fabrics can be placed loosely over the plants without wire supports. The edges can be held down with soil or stones. These are easier to apply, and are the choice for small gardens. Fabric materials can be used again unless they have been damaged or ripped.

Proper ventilation is essential, particularly with the hottest materials. Growers drill holes in the rolls of plastic prior to application; home gardeners may do this or slit plastic after it has been rolled out. Allowing excessive heat buildup is the most costly and most common error with first-time rowcover users. As a general rule, if outside air temperatures approach 80 degrees F., additional ventilation should be considered. In years with unseasonably warm temperatures, covers do more harm than good.

Normally, rowcovers are removed from vegetable crops 3-4 weeks after transplanting, and from Junebearing strawberries at the beginning of bloom to allow bees to pollinate. You may want to allow plants to acclimate gradually by increasing the size of slits over a 3-7 day period prior to complete removal.

For insect control, rowcovers must go on before the insects are present. Also, rotate the location of crops that attract insect pests that overwinter in the soil. If you don't you may increase insect problems by trapping the insects with their food source. For row covers to be effective barriers to insects, they must be sealed at the sides and ends of the rows, (i.e., edges covered with soil) so that insects cannot crawl under them.

Heritage Red Raspberry: Rowcovers are applied after pruning plants to the ground in March, and are removed 2 months later. The response to rowcover may vary between years, but in general, the use of rowcover can help to enhance the early production of the crop. This is beneficial since the harvest of 'Heritage', a late season raspberry, is often prematurely terminated by frost.

Junebearing Strawberries: Rowcovers can enhance both early production and yield of strawberries. In gardens experiencing high winds, cold temperatures and inconsistent snowfalls, mulch the strawberries with straw in the late fall. Remove the straw after March 1, and cover the plants immediately with the rowcovers. Place rowcovers over the plants in the late winter. Remove the covers as soon as the plants begin to blossom in the spring, or the rowcovers may interfere with pollination. Use spunbonded materials; plastics may enhance earliness to the point of creating problems with late spring frost.

Rowcovers can also reduce injury by tarnished plant bug. Due to accelerated flowering, the insects are present after the susceptible stage of development.

Muskmelon: The most success using tunnels on vegetable crops has occurred with muskmelon. Ventilated clear plastic is often used. A 7-10 day jump on the season with an increase in yields can be attained. Melons are not particularly sensitive to the high temperatures which sometimes develop with the clear plastic tunnel. Remove tunnels when the plant begins to flower.(Also see vine crops)

Summer Squash: Similar to melons, it is one of the easiest and most responsive crops to grow under tunnels.(Also see vine crops)

Cucumber: More sensitive to high temperatures than melons, the cucumber can still show a very positive response to tunnels. When temperatures are cool, a clear tunnel with holes may be best, but ventilated white plastic or fabric tunnels, however, are safest.(Also see vine crops)

Pepper: Flower abortion and loss of early yields can occur under high temperatures, so adequate ventilation is critical. Early growth and early yield can be successfully obtained with ventilated white plastic.

Tomato: In general, rowcovers are not recommended for this crop. Loss of early yields due to high temperature is the major problem; although vegetative growth and total yield may be enhanced, early fruit are frequently small or absent.

Cole Crops, Lettuce, Spinach, Celery: Rowcovers increase early production with these crops. Most are well-suited to floating rowcovers.

Spinach, Beets, and Chard: Rowcovers can help provide protection from leafminers. Place over the newly seeded crop and remove at harvest (spinach) or when plants outgrow them.

Vine Crops: Rowcovers can exclude striped cucumber beetle which can vector bacterial wilt. Rowcovers need to be removed at flowering time for pollination to occur.

Good Gardening Practices ¹²

If the gardener builds wonderful soil, plants correctly, feeds, waters, and prevents insect pests, there is much likelihood of garden success. However, the entire production can be undermined by careless or incorrect gardening practices, from poor sanitation to improper tilling or garden layout. Fortunately, these choices are entirely within the gardener's control, and the organic gardener in particular is wise to make the effort ... Work now, toward the goals of disease prevention and weed control especially, means much less work later – as well as avoiding some serious trouble.

Sanitation

- (1) **FALL CLEAN-UP:** This is the most important time for clean-up work, as many diseases and insects overwinter in crop or weed debris, and weeds seed themselves prolifically. There is some confusion at times, upon deciding which crops to till under, what to leave as mulch (in a no-till system particularly), and what to remove for compost or waste. Basically, crop debris and weeds should be removed from the vegetable garden, and composted if disease free and without weed seeds. One exception is legumes such as peas and beans, which decompose quickly and are nitrogen-fixing (make nitrogen from the air available in the soil), and may be turned under the soil directly. Similarly, in the yard or flower garden, all leaf and blossom debris should be removed to minimize overwintering diseases, especially in such cases as hollyhocks or phlox (rust) or roses (blackspot or other fungus disease). If mulch is used as winter protection it should be disease-free and applied after the ground freezes.
- (2) **SPRING AND SUMMER HABITS:** Good habits of weed removal before seeding, complete removal of diseased specimens, and regular inspection of the garden (including early hand-picking of pests, many of which spread disease) minimize potential trouble. Thorough mulching also eliminates weeds. Many gardeners cover all exposed soil with either mulch or a cover crop, which can be planted at any time to benefit soil fertility, structure, and block weeds.

Tilling

First, many organic gardeners achieve – or aspire to – a no-till system, in which the garden is kept permanently mulched, with permanent beds and paths. And the soil becomes fluffy and laden with earthworms. Certainly tilling, by whatever method, interferes with soil structure and chops up earthworms, so the gardener is advised to till the least possible for the maximum effectiveness. Fall tilling should be at 7-inches depth, followed by another tilling two weeks later at 2-inches. In spring, when the soil is dry, tilling should be done at 2-inch depths and then two weeks later (immediately before planting), also at 2 inches. Ideally, those who plan to till regularly should arrange for permanent paths and a walk-beside tiller, in order to minimize soil compaction.

Rotation

A basic practice in correct commercial agriculture, crop rotation is often associated with field rotation of heavy feeders (large nutrient users) like corn or vine crops, light feeders like leafy vegetables, and soil improving cover crops like alfalfa or clover. However, in

the basic home vegetable bed, rotation is just as essential. One approach is the same as above, to rotate heavy and light “feeders” with cover crops, for soil building and nutrient replacing purposes. Another approach, particularly when there has been a problem, is to rotate plant groups according to susceptibility to various insects or diseases.

For example, corn should not be planted for three years where there has been corn smut, and carrots should be moved from the area of the plot where root maggots have been present. A typical rotation involves the nightshade family. Tomatoes, potatoes, and eggplants – which share a number of insects and diseases and should best be moved every year, not to return to the same spot for three years. Especially when diseases have been present, tilling should not be done in a way that spreads soil from one section to another, or the effect of rotation is defeated. Other rotational plans involve soil pH and various plant needs. For example, acid -loving potatoes are grown the year before a soil is “limed” to raise the pH in preparation for another crop.

Layout

Closely related to the rotation plan, tilling practices, and one’s plan for soil building and protection, garden layout can cause problems or solve them, depending upon the choices made. Considerations include: (a) Moisture and drainage, which crops can survive dry or damp conditions?; (b) Sunlight and shade, what plants require full sun/some shade/protection from hot summer sun?; (c) Soil quality and depth of topsoil, which beds or locations have sufficient fluffy topsoil for root crops like carrots,? What crops can grow in clay soil which has not yet been improved with organic matter? What likes a high or low pH?; (d) Wildlife.

Plant Selection ¹³

“The Right Plant in the Right Place” might well be the motto of every good gardener, as proper plant selection makes all the difference in the likelihood of plant survival, the ease and success of gardening, and in our own satisfaction with our work. Choosing plants that are not winter hardy for our area, ones that will quickly outgrow their site, or ones that are very susceptible to disease or insect problems are typical causes for landscape disappointments.

Site Matters

In the case of flower gardening, we must be realistic about the amount of sun available, as well as soil type and pH, drainage, wind and the amount of care we are willing to provide...before choosing the perennials or annuals that are so enticing in the garden center. Likewise, the vegetable gardener should plan ahead – before purchasing or planting – to factor in the plant’s need, including soil, light, water, companions, and pest protection. Particularly with our ever changing climate, it is ecologically and environmentally sound to think about potential drought or very wet seasons as well, and make landscape plans accordingly. In *xeriscaping* (landscaping for dry conditions), one chooses plants for low moisture requirements, mulches heavily, and plants less grass and more ground covers, for example. For wet seasons, we should consider improved

drainage, raised beds, and plants tolerant of wet conditions and resistant to fungus diseases and slug damage.

Native species or not?

In general, it makes sense to use plants that you already see growing successfully in the area. Most of the time, choosing native species is intelligent and correct, from an ecological or gardening viewpoint, and decreases the odds that your landscape maintenance will be an uphill - or losing - battle. However, "native" is no guarantee of success, as a native plant in the wrong site will fare as poorly as any other. Further, some native plants have severe problems, even in a proper site, that an improved cultivar or resistant non-native plant could avoid. One possible reason could be new diseases or insects, that have been imported or have developed because of agricultural practices or environmental change, that the native plant cannot overcome.

Invasive plants

Most flower gardeners learn to avoid plants that "take over" - crowding and replacing less aggressive neighbors. Or, the gardener might place such aggressive plants where they can spread freely, compete with equally aggressive choices, or function as groundcovers. However, a more important problem occurs when the invasive plant escapes to the wild, and displaces native plant species, disrupting habitat and food sources for wildlife, or clogging streams. One familiar example is the invasive purple loosestrife, which has caused significant ecological and economic losses. Non-native invasive plant species (sometimes called N.I.S.) are being studied and watched by naturalists, scientists, including the Natural Resources Department at Cornell University. There is a top-ten or twenty "N.I.S." list that responsible gardeners and landscapers should learn to recognize, remove, and avoid planting. They include: Japanese honeysuckle, garlic mustard, multiflora rose, phragmites (common reed grass), Russian and autumn olive, barberry - and several other familiar plants. Their control or management are extremely difficult or impossible, so plant selection - i.e. avoidance - is the key.

Disease and Insect Resistance

Almost every plant group has species and cultivars that are disease and insect resistant. There are also those that are highly susceptible to common pest problems that should be avoided. Here are sample listings of disease and insect resistant vegetable, apple and a few ornamental cultivars.

Disease Resistant Vegetable Cultivars¹⁴

Here is a partial list of vegetable varieties - and a few suggestions for home garden care.

Beans

Green beans are very easy to grow, provided you use good seed and have quick emergence. Although susceptible to several diseases, rotation and raised beds will reduce soil-borne problems such as root rots and white mold. Varieties listed here are resistant to common bean mosaic, but they are susceptible to two prevalent virus diseases in New York (bean yellow mosaic and clover yellow vein). Rogue out plants that show mild green or prominent yellow mosaic before aphids spread the virus further.

Snap Beans (Green): Atlantic, Blush Blue Lake 274, Provider, Strike, and Tenderette.
Bush Wax Beans (Yellow): Honey Gold, Slenderwax, and Sungold.

Cucumbers

Of all cucurbits, cucumbers have the most disease resistance as a result of breeding. The concern is bacterial wilt, which is spread by cucumber beetles. Beetles can be reduced by constructing tents of fine cheesecloth or using floating row covers over young transplants and seedlings. Covers do need to be removed early to mid-season to allow for pollination. If the resistant variety listed is grown, angular leaf spot (ALS), cucumber mosaic virus, powdery mildew, and downy mildew are of no concern.

Slicers: Dasher II (tolerant to ALS), Marketmore 76, Marketmore 80, monarch, Salad Bush (not ALS resistant), Supersett, and Trailblazer (not ALS resistant).
Pickles: Calypso, Regal, and Score.

Summer Squash

Summer squash are currently susceptible to powdery mildew and several virus diseases, but resistant varieties will shortly be released. In the meantime, tolerate mildew, plant an extra plant, and rogue if you get mosaic. The yellow varieties listed here have a gene that keeps them yellow when other yellow squash will turn speckled green from a common, though harmless, virus.

Zucchini: Senator, Zucchini Elite
Yellow: Multipik–Straightneck, Supersett–Semi-Crook.

Eggplant

Verticillium wilt (VW) is the major disease of eggplant. This is a soil-borne disease which can survive for years, so rotation is required to achieve a good crop

Dusky, Black Magic, Black Pride(tolerant to VW).

Pepper

The main disease of pepper grown in home gardens is cucumber mosaic. Rogue diseased plants to prevent aphid spread of this virus. Maintain adequate moisture to prevent blossom end rot.

Early Bells: Ace, New Ace, and Stokes Early Hybrid.
Main Season Bells: Lady Bell and Bell Tower.
Novelty Bell: Klondike Bell (yellow) and Sweet Chocolate.
Sweet Types: Cubanelle, Italian Sweet, and Cherry Sweet.
Hot Types: Hungarian Wax, Cayenne, and Anaheim Chili.

Tomato

Most varieties offer resistance to Fusarium wilt (F1 & F2), Verticillium wilt (VW), and rootknot nematodes (RN). Early blight is very common, especially if gardeners can't rotate over a large area. Early maturing varieties are very susceptible and serve as a source of infection for later maturing types. Therefore, early varieties should be

separated from later varieties by a good distance. If this is not possible, rogue out (uproot and destroy) any plant when blight becomes excessive. And select seedlings free of target-shaped lesions to avoid introducing early blight into the tomato patch. Home gardeners who fail to rotate can also expect to find Septoria leaf spot. This disease prefers cool, moist (rain and dew) conditions. Gardeners can reduce its spread by removing lower, infected leaves early in the season. Look for beige lesions with black specks in the middle (the source of spores that is spread by splashing rain or careless watering), surrounded by a narrow yellow halo. Be sure to remove and destroy all tomato debris at the end of the season to reduce carryover of disease from year to year.

Early Maturing: Springset (F1, VW), Jet Star (F1, VW), Pik-Red (F1, F2, VW, RN), Pilgrim (F1, F2, VW).

Mid Season: Jackpot (F1, F2, VW, RN), Celebrity (F1, F2, VW, RN), Burpee's Supersteak (F1, VW, RN), Better Boy (F1, VW, RN), Sunny (F1, F2, VW).

Late Season: Mountain Pride (F1, F2, VW), Market Pride (F1, F2, VW), Mountain Delight (F1, F2, VW).

Cherry: Supersweet 100 (F1, VW), Sweet 100, Sweet Million (F1, RN), Presto.

Disease Resistant Apple Varieties¹⁵

Apples are plagued with an enormous pest complex. The demands of proper timing of sprays, the lack of suitable equipment, and concerns about food safety and the environment have made routine pesticide applications a questionable practice for the individual with a few trees.

The development of disease resistant cultivars has greatly diminished the number of sprays required to grow a successful crop. In fact, it is no longer recommended that home gardeners attempt to grow disease susceptible apple cultivars, unless they are capable of meeting the requirements of a rigorous spray schedule. Despite the tremendous reduction of fungicide sprays, however, insect control is still required with disease resistant material.

Disease resistance is a major factor to consider when growing apple trees in the home garden because of the "major" apple diseases of scab, powdery mildew, fireblight, and cedar-apple rust. New and traditional varieties resistant to these diseases include 'Pristine,' 'Redfree,' 'Freedom,' 'Liberty,' 'Priscilla,' 'Jonafree,' 'Golden Russet,' 'Enterprise,' and 'Goldrush' – listed in order of their harvest time, from August to early November. These varieties will produce usable fruit without fungicide sprays, although they may be blemished by other "minor" fruit diseases prevalent in the warmer and more humid regions of the Northeast.

Disease Resistant Hawthorn and Crabapple Ornamental Trees ¹⁶

Hawthorn	Insect/Disease Factors
<i>Crataegus crus-galli inermis</i>	Resistant to cedar-hawthorn rust, leaf blight, lacebug
<i>Crataegus phaenopyrum</i>	Resistant to cedar-hawthorn rest, less susceptible than other hawthorns to disease.
<i>Crataegus viridis</i>	Resistant to cedar-hawthorn rest, less susceptible than other hawthorn to disease
Crabapple	Insect/Disease Factors
<i>Malus</i> 'Adams'	Excellent resistance to cedar-apple rust and fireblight, good resistance to scab and mildew, moderately resistant to gypsy moth, cankerworm, eastern tent caterpillar
<i>Malus</i> 'Adirondack'	Excellent resistance to cedar-apple rust, fireblight, scab and mildew
<i>Malus baccata</i> 'Jackii'	Excellent resistance to cedar-apple rust, scab and mildew, fair resistance to fireblight
<i>Malus</i> 'Baskatong'	Disease resistant except for minor susceptibility to scab, good resistance to Japanese beetles
<i>Malus</i> 'Centurion'	Excellent resistance to cedar-apple rust, fireblight and mildew, good resistance to scab
<i>Malus</i> 'Dolgo'	Excellent resistance to cedar-apple rust and mildew, good resistance to scab and fireblight, resistant to frog eye leaf spot
<i>Malus</i> 'Donald Wyman'	Excellent resistance to cedar-apple rust and mildew, good resistance to scab, fireblight and frog eye leaf spot
<i>Malus</i> 'Doubloons'	Excellent resistance to cedar-apple rust and mildew, good resistance to scab and fireblight
<i>Malus floribunda</i>	Excellent resistance to cedar-apple rust, good resistance to scab and mildew, fair resistance to fireblight, highly resistant to Japanese beetles
<i>Malus</i> 'Harvest Gold'	Resistant to scab, fireblight, rust, powdery mildew, good resistance to Japanese beetles
<i>Malus</i> 'Henry Kohankie'	Reportedly disease free
<i>Malus</i> 'Indian Summer'	Excellent resistance to cedar-apple rust, mildew and fireblight, good resistance to scab

<i>Malus</i> 'Liset'	Excellent resistance to cedar-apple rust, good resistance to scab and fireblight, fair resistance to mildew, resistant to frog eye leaf spot
<i>Malus</i> 'Madonna'	Resistant to gypsy moth, fall cankerworm, eastern tent caterpillar, apple skeletonizer, apple aphid, rose chafer, disease resistant foliage
<i>Malus</i> 'Ormiston Roy'	Excellent disease resistance to cedar-apple rust, scab, and mildew, good resistance to fireblight, resistant to frog eye leaf spot, good resistance to Japanese beetle
<i>Malus</i> 'Prairifire'	Excellent resistance to cedar-apple rust, fireblight, scab and mildew, resistant to frog eye leaf spot
<i>Malus</i> 'Professor Sprenger'	Excellent resistance to cedar-apple rust, fireblight, scab and mildew
<i>Malus</i> 'Purple Prince'	Excellent resistance to cedar-apple rust, fireblight, mildew and scab
<i>Malus</i> 'Red Jewel'	Excellent resistance to cedar-apple rust, good resistance to scab and mildew, fair resistance to fireblight, resistant to frog eye leaf spot, gypsy moth, fall cankerworm, eastern tent caterpillar, apple skeletonizer, apple aphid, rose chafer

<i>Malus</i> 'Robinson'	Excellent resistance to cedar-apple rust, fireblight and mildew, good resistance to scab
<i>Malus</i> 'Sentinel'	Excellent resistance to cedar-apple rust and mildew, good resistance to scab and fireblight, resistant to frog eye leaf spot, very susceptible to Japanese beetle
<i>Malus</i> 'Silver Moon'	Resistant to scab, fireblight, rust, mildew, frog eye leaf spot, good resistance to Japanese beetle
<i>Malus</i> 'Strawberry Parfait'	Excellent resistance to cedar-apple rust, scab and mildew, resistant to fireblight, frog eye leaf spot, highly resistant to Japanese beetle
<i>Malus</i> 'Sugartyme'	Excellent resistance to cedar-apple rust and mildew, good resistance to scab, fair resistance to fireblight, resistant to frog eye leaf spot, gypsy moth, fall cankerworm, eastern tent caterpillar, apple skeletonizer, apple aphid, rose chafer

<i>Malus</i> 'White Angel'	Resistant to scab, fireblight, rust, frog eye leaf spot
<i>Malus x zumi</i> 'Calocarpa'	Excellent resistance to cedar-apple rust and scab, good resistance to mildew, fair resistance to fireblight

Companion Plants ¹⁷

Perhaps no other practice in organic gardening is more controversial than the concept of companion plants. Plants are very active in ways that are not so obvious to the casual observer. For example, plants change the chemistry of the soil, and influence the types of microorganisms that grow there. They actively compete with other plants for space. Groups of plants which grow well together are called "companions."

Perhaps the best historical example of companion planting is the "Three Sisters" in which corn, beans, and squash are planted together in a hill. Native Americans developed this system to provide food for a balanced diet from a single plot of land. Each of the crops is compatible with the others in some way and use garden space with maximum efficiency. The tall corn stalks provide a support structure for the climbing beans. The beans contribute nutrients as nitrogen "fixers." Squash provides a dense ground cover that shades out many weeds and blocks animal invaders.

Home gardeners have rediscovered some of the beneficial interrelationships among plants. This knowledge, coupled with a long tradition of folklore, is being used to improve home garden production. While the subject is full of folklore, tradition, myth, and whimsy, there are scientifically valid reasons for the success stories and sensible principles worth considering as you select plants and plan garden layout.

When companion planting works, it is for one or more of the following reasons:

- (1) **Physical Structure or Plant Needs:** Some plants just grow well next to each other because one is tall and offers shade and another is short and likes some shade, i.e. pole beans, flowers, shrubs, or even broccoli used to shade lettuce or spinach. Some plants have deep roots, while others have surface roots, and there is room for close co-habitation. Some plants offer physical support for another to climb on (pole beans climbing on corn, with no adverse effect and even the benefit of beans "fixing" nitrogen and replacing some of what the heavy-feeding corn uses). Some plants produce early and finish in time to make room for later plants while occupying the same bed. For instance, peas and broccoli or spinach and cole crops, which are early combinations, may be followed by later beans and tomatoes. This is called *succession planting*. As the gardener works at *intensive gardening* – making the most of planting bed space and keeping the soil covered to prevent weeds—more possible and practical combinations become apparent. Companion choices are also made according to size and plant needs, such as bulbs, carrots and beets planted at varying depths according to their needs, or bulbs planted behind taller and later blooming perennials or annuals, to allow the less attractive but necessary bulb foliage to mature undisturbed.

- (2) **Repelling Insect or Wild Pests:** Some plants are known to repel insects or animals that are threatening landscape or garden plants. There is much evidence that the alliums – garlic, onions, chives, and shallots, for example – repel many pests. They are often used around roses or other precious flowers. Similarly, they may discourage Japanese beetles throughout the garden. Other strong-smelling plants often used to deter insect pests are marigolds, basil, artemesias, mints or other herbs. Interplantings of garlic, onions or soybeans are also reported to discourage rabbits or other animals, but homemade sprays from these plants are even more likely to be successful as the odor is more intense. In the case of most plants that repel pests by odor, there is some question whether they are actually repelling pests or simply confusing potential pests by mixing up the odor or attractive “signals” issued by a monocrop. (For example, green bean rows alternated with potato rows has been shown to decrease the numbers of both Mexican bean beetles and Colorado potato beetles – for whichever of the above reasons.)
- (3) **Trap Crops or Lures:** Some plants lure a potential pest away from the desired planting, like alfalfa to attract groundhogs away from the vegetables, or borage, zinnias, or white geraniums to trap Japanese beetles. Some vegetable gardeners plant a few sacrificial plants, such as eggplants, to attract and trap Colorado potato beetles or other pests, thus minimizing the damage to neighboring crops. The effectiveness of this method is increased if the trap crop is timed so that the pest starts on the sacrificial plants and is present in time to lure natural predators, which then control the population before it moves on to threaten the main crop. In the landscape, mulberry trees will lure birds from cherry orchard, so the smart homeowner might locate mulberries in the vicinity of the cherry orchard.
- (4) **Habitat and Food for Beneficial Insects:** Some plants are good choices for interplanting or as garden neighbors because they attract, feed, or shelter beneficial insects. The effort to attract and keep these insects around is important for organic gardening success, as their presence determines whether a pest infestation is controlled by nature or whether the gardener must take over. Further, if the infestation gets out of control, the gardener's workload increases significantly from handpicking to trapping or spraying - and he or she may resort to pesticides. Remember: Even the "organic" or botanical pesticides are poisons, and can kill the developing beneficial insect population, and some also have other adverse environmental effects (harming fish, birds, earthworms, or groundwater). Prevention of the problem - by having hungry predators standing by - is a much better choice.
- (5) **Chemical Interaction:** Like allelopathy, in which some plants release substances into the soil that discourage other plant growth (black walnut being the most familiar example), there is an opposite reaction in which plants release substances that help other plants. One well-proven example is the way that French marigolds (*Tagetes Patula*) are used to repel or “cure” a nematode infestation: The nematode-infested area is planted with a solid block of the marigolds, which are then turned into the soil after a season ; marigolds release a substance that suppresses nematode populations and prevents their reproduction. (Roots of some mustards, wild chicory, *Chrysanthemum pyrethrum*, and *Chrysanthemum coccineum* are also known to kill or reduce soil nematodes). The nitrogen-fixing property of legumes is also an example of a chemical interaction.

How Can Home Gardeners Utilize Companion Planting?

Here Are Several Practical Steps:

- **Avoid monoculture** in terms of space and time. A one-hundred foot long row of broccoli presents a large target for a cabbage moth that is flying by, but the same number of cabbage plants scattered over several thousand square feet, and interplanted with other crops, is less obvious and attractive to the insect. Pests which routinely plague large, commercial plantings of crops may never be a problem in the diversified home garden.
- **Know thy friends**, attract them and avoid killing them inadvertently.
- **Make diverse plantings**, including herbs and flowers. Plant dill, marigolds, chives, onions, parsley, basil and other flowers throughout the garden. Allow parsley, carrot and celery to remain in the ground over the winter. They will produce flowers the second season and attract beneficial insects. Also, plant strong smelling herbs among vegetable crops.
- **Try specific combinations** that science or folklore says are effective companions. Chives could be planted at the base of roses to repel aphids, garlic could be planted at the base of peach trees to repel borers; basil planted among tomatoes may repel tomato hornworms; nasturtiums grown near squash may repel squash bugs; tomatoes planted among asparagus may repel asparagus beetles; and marigolds, mint, thyme, or chamomile may repel cabbage moths. Radishes make excellent trap crops for cucumber beetles among squash and cucumbers. Radishes also attract flea beetles when planted near cole crops. Garden borders planted with low growing thyme or lavender may deter slugs. Tansy and pennyroyal repel ants.
- **Observe your plantings carefully**, and write down combinations that seem to work for pest control and growth enhancement. Communicate your observations with others. Try to replicate your observations or have others try the same combinations. Testimonials that are shared by many observers often turn out to be valid. Scientists have spend relatively little time looking at these relationships among plants and their communities, especially for home garden application; furthermore, the number of possible combinations is enormous. You can be the first one to discover a new set of compatible plants!

Plants to Attract, Feed, or Shelter Beneficial Insects ¹⁸

Many insects are helpful because they eat or parasitize harmful insects. Most species of wasps and spiders are beneficial as are ground beetles, praying mantids, lady bugs, pirate bugs, and several species of flies. It is possible to attract beneficial insects by planting flowers near the garden. Dill, parsley, carrot, coriander, angelica, and parsnip feature flat topped clusters of small flowers that have strong fragrances. They also seem to attract large numbers of beneficial insects, particularly predatory wasps and flies. This characteristic makes them good candidates for companion planting.

Certain plants are particularly suitable for beneficial insects because the pollen or nectar is readily accessible. (Most beneficial insects have small mouth parts.) These insects also

need a high protein and sugar diet all season, so planning for early bloom (calendulas or gazania, for example) and continual bloom is helpful.

- (A) **Compositae** – the daisy family – are most popular with ladybird beetles (“ladybugs”), green lacewings, spiders, hover flies, and small wasps. Choices include Coreopsis, Cosmos, Black-eyed Susans, Anthemis, Yarrows, and Tansy (perhaps the most popular plant for many beneficials). One study indicated significantly larger populations attracted by the Cosmos variety ‘White Sensation’.
- (B) **Umbels** – the parsley family – are particularly important for attracting the tiny parasitic wasps (*Trichogramma*, for example), which benefit from the shallow flowers that allow access to nectar. Many are herbs, such as dill, fennel, caraway, parsley, angelica, lovage, and coriander, which can be interplanted among vegetables or flowers. Queen Anne’s Lace, considered a wildflower or weed, is also valuable for this purpose, and might be allowed to bloom in borders or fields near the garden.
- (C) **Cover crops, grasses, grains, and hedgerows** function as insect attractants and homes too, and can be used in the home garden plan as well as on larger organic plots. Well tested choices include:
 - Buckwheat:** As well as a great soil builder and weed blocker, buckwheat attracts bees, wasps, flies, and ladybugs. A permanent patch or strip of it near the garden or bordering the yard is an attractive way to help the insects.
 - Hairy vetch, alfalfa, red clover, and sweet clover:** These cover crops may be interplanted or maintained in separate strips to attract predatory wasps, big-eyed bugs, minute pirate bugs, and lady beetles.
 - Hedgerows:** In the appropriate setting, hedgerows, or property borders made of grasses, shrubs, trees, and flowers, will provide shelter, nectar and pollen for beneficial insects. Possibilities include dogwoods, shasta daisies, goldenrod, lilacs, curly willow, and black locust.
- (D) Other favorites with beneficial insects include the following:
 - Borage:** A major source of nectar for bees and others
 - Mints:** While caution is advised because of the aggressive behavior of most mints, they attract spiders and many desired flies, while repelling some insect pests as well.
 - Nasturtiums:** An excellent ground cover for hiding such helpers as spiders, ground beetles, and damsel bugs. Also helpful for trapping aphids and/or repelling vine crops pests.
 - Any groundcover or straw mulch**

Beneficial Insects

Attracting Them to Your Yard or Garden ¹⁸

All insects need food (nectar or other insects), water, shelter, and places to breed, and the wise gardener can ensure a broad predatory insect population by providing these elements. The plants listed above represent both habitat and food sources for a broad range of beneficial insects. If the habitat plants are not fully established in the garden, additional food should be provided to keep beneficials around during any lags in the pest

population. Commercial products are available, but a sugar/water mixture of one-part sugar to four-parts water is very attractive if sprayed lightly on lower plant leaves. Lady beetles and lacewings especially like this, and it is one of the most effective techniques for attracting them or for keeping and establishing recently purchased beneficials.

Water is essential and should be available in nearby ponds or streams, ideally, as well as within the immediate garden. Two types of locations are needed: first, an elevated dish or shallow bird bath (lined with stones, perhaps) helps flying insects; second, crawling insects need ground-level water dishes. (The latter are popular with toads as well.) For maximum benefit, these water sources should be placed every 400 square feet within the protected area. It may seem that maintaining standing water could encourage mosquito buildup, but an organic garden full of insects is likely to have a healthy population of birds, toads, lizards, snakes, or bats, which generally cure the problem. Stirring up the water

To Buy or Not to Buy

The decision to purchase beneficial insects is an individual choice based on cost factors and willingness to experiment, but it should be done only with full knowledge of the timing, care, and conditions required for success with the particular beneficial insect population. Many organic gardeners find it more sensible to attract beneficial insects naturally, so that they arrive and stay because the pest is present and conditions are right. However, there are some well-tested predators that can be purchased with great success if all directions are followed and the habitat is prepared.

Among the most effective purchases are the following **INSECTS TO BUY**:

(1) Lacewings, usually shipped as eggs, which are placed throughout the garden, up to 3 per plant; (2) Lady beetles, especially effective in a greenhouse as they tend to fly away. However, reputable supply companies will recommend procedures (such as cooling the insects upon arrival, placing them under screens or moist straw, providing food and water) that may keep them; (3) Braconid wasps, which need parsley family plants for food; (4) Minute pirate bugs and spined soldier bugs; (5) Predatory mites (not insects). Although available commercially, the praying mantis is not recommended for purchase, as they do not survive and/or are cannibalistic and may destroy local specimens.

Taking a Bug's Eye View¹⁹ ©

Introducing the Good Guys

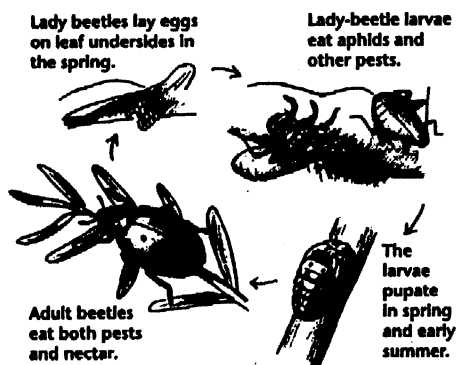
So who are all the "good guys?" Lady beetles probably top most people's lists, followed by praying mantids and honeybees. Of course, spiders are helpful, and so are pest-eating lightning bugs, and then there are earthworms—certainly worth their weight in gold, even if they're not insects. But they're just the beginning. Believe it or not, 95 to 99 percent of all insects are beneficial or harmless to human life and endeavors.

There are four main job descriptions for beneficial insects" *predator*, *parasitoid*, *pollinator* and *soil builder/garbage collector*. Whether you see them at work or not, you

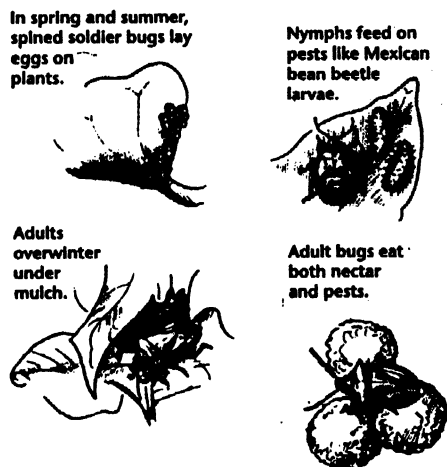
can bet your companion garden employs thousands of beneficial insects carrying out these four important jobs.

Like all insects, beneficials have distinct stages in their life cycles. Some types of insects undergo a process called complete metamorphosis. These insects emerge from eggs as larvae, such as caterpillars, which look completely unlike the adults. A larva feeds and grows, then forms a pupa (a resting stage in which the insect covers itself with a hard shell). After resting awhile in the pupa, the adult emerges.

Other types of insects have a type of lifestyle known as incomplete metamorphosis. These insects emerge from eggs as nymphs, resembling tiny adults. The nymphs feed and molt several times before reaching adult size and form. All stages in the life cycle of a beneficial insect can be helpful to gardeners.



Insect life cycles. Insects have complicated life cycles, sometimes going through dramatic changes in size and shape. You'll see all stages of beneficial insects, such as lady beetles (above) and spined soldier bugs (below), in your companion garden.



Insect Predators

The most familiar beneficial insects—lady beetles and praying mantids—are predators. They hunt down and eat their prey just as the lion hunts the antelope. Predatory insects are usually larger than their prey, and often they hunt in the larval (caterpillar or grub) stage as well as in the adult stage.

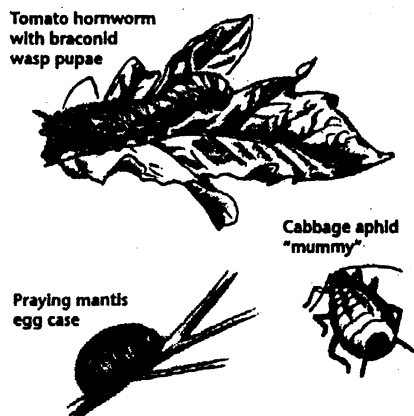
Predatory insects usually prey on several kinds of insects. The praying mantis, for example, captures and eats just about anything it can wrestle to the ground—including another praying mantis! Many predators have names that are clues to their behavior: assassin bugs, ambush bugs. Soldier beetles, and tiger beetles. Other colorful names describe the insect's appearance, like big-eyed bugs, dragonflies, and lacewings. Delicate lacewings can actually be fierce hunters. Certainly the larvae are voracious eaters—that's why they're nicknamed aphid wolves!

Paper wasps are also fine insect hunters. People are often afraid of these wasps, but they are rarely aggressive toward humans unless their lives are threatened. What paper wasps seek are full-size caterpillars, such as gypsy moth larvae and imported cabbageworms, which the wasps feed to their young.

Insect Parasitoids

Parasites are organisms that live their entire lives directly on the bodies of their hosts. Mistletoe is a well-known plant parasite that develops special rootlike structures that puncture tree bark and absorb water and nutrients from the trees. Fleas and lice are insect parasites.

Parasitoids, a special kind of parasite, live on the body of their hosts for only a part of their lives. Parasitoid insects lay eggs on or inside the body of a host insect, larva, or egg. When the parasitoid larvae hatch, they feed on the host. The most common parasitoids are wasps and tachinid flies. Braconid wasps lay eggs in the bodies of tomato hornworms, and the larvae feed on the caterpillar. If you grow tomatoes in your companion garden, you will probably see tomato hornworms with little white bumps or growths attached, which are the wasp's pupae. The pupae develop when the hornworm is near death. More adult wasps will emerge from the pupae, ready to hunt down still more tomato hornworms.



Beneficials at work. Some of the distinctive signs of beneficial insects at work are white pupae of braconid wasps sticking out of tomato hornworms, the dead shells of aphids left after aphidid wasp larvae feed on them, and the papery egg cases of praying mantids.

Insect Pollinators

Bees pollinate about 75 percent of the world's food-crop plants. Most gardeners have no idea of the wonderful variety of bees—over 4,000 species of bees in North America alone. Bumblebees and a large group called “solitary bees,” which includes mason bees, leafcutter bees, and squash bees, actually do much more pollinating than honeybees.

Flies are the second most important pollinators include butterflies, beetles, moths, wasps, and even thrips. For the sake of pollination alone, never kill a bee, fly, or wasp in the garden—unless you're allergic to the stings, or unless it's a deerfly or horsefly that's about to bite you!

Soil Builders and Garbage Collectors

There is so much to praise about the insects and other creatures that build soil and break down decaying matter in nature and in our gardens. Anyone who has a compost pile has met some of these creatures, including millipedes, centipedes, beetles, sow bugs, and earwigs. They turn yard waste into “black gold.”

There are thousands of beneficial insects which help the gardener, while only a few are significant pests. Some of the most effective beneficials are listed in the chart that follows.

PREDATORS	PESTS	DESCRIPTION, HABITAT, AND NOTES
BEETLES		
LADY BEETLES (Coleoptera: Coccinellidae)	Aphids, spider mites, soft scales, whiteflies, mealybugs, rootworms, eggs of moths and beetles (including Colorado potato beetle)	Adults are orange, red, or pink, ¼-inch long, with up to 13 black spots. Eggs are orange-yellow; larvae black with orange, white, or reddish spots. Larvae and adults are serious predators. Convergent Lady Beetle larvae (<i>Hippodamia Convergens</i>) eat their weight in aphids daily, and adults consume 50 aphids daily; available commercially. The valuable <i>Coleomegilla maculata</i> (“pink-spotted”) and <i>Coccinella septempunctata</i> (“seven-spotted”) are also common in the Northeast. Attract with yarrow, tansy, and other compositae, and buckwheat or other cover crops.
FLOWER BEETLES (Coleoptera: Melyridae)	Aphids, small insects, eggs, and larvae	Adults are often brightly colored (black heads with greenish-yellow, red or yellow forewings), 3/8-inch, and often found as predators on potatoes and onions. May be attracted to alfalfa and permanent flowering plants
GROUND BEETLES	Soil-dwelling beetle and fly eggs, larvae, and pupae; some soft-bodied insects and caterpillars	Many species of dark, shiney, metallic, (some brightly-colored) beetles, ground-dwelling, often with thread-like antennae; found under stones and debris, fast-moving; predaceous as larvae or adults. Encourage with golden rod, clover, hedgerows, stones, and other shelters such as perennials

ROVE BEETLES	Cabbage maggots, aphids, mites, small worms, beetle larvae	Adults are brown or black, 1/16 to 3/4-inch, with a rear that curls up like a scorpion. They are scavengers with sharp mandibles (may bite if handled). Eggs overwinter in soil or dead plant matter. Attract with cover crops or permanent plantings
SOLDIER BEETLES	Soil-dwelling insects, larvae, aphids, and flea beetles	Also called "leatherwings," elongated beetles (1/2-inch) have tan leathery wings with dark spots on the head and wing tips. Found on many flowers, especially hydrangeas, golden rod, and milkweed.

PREDATORS	PESTS	DESCRIPTION, HABITAT, AND NOTES
TRUE BUGS		
ASSASSIN BUGS	Aphids, larvae or eggs of many insects, beetles including Colorado potato beetle, Mexican bean beetle, and Japanese beetle	Slender, long-legged, brown or black, with narrow head and long curved beak, 1/2 to over 1 inch long. Their bite is painful and itchy. They grasp prey with front legs and suck the body fluids. The "wheel bug" (<i>Arilus cristatus</i>) is especially effective with Japanese beetle larvae and caterpillars.
BIG-EYED BUGS (Hemiptera lygaeidae)	Mites, insect eggs, small insects and larvae; effectiveness known with corn earworm, tarnished plant bug, and leafhoppers.	Also called "seed bugs," most members of this family are valuable (with the exception of the cinch bug.) the 1/8-inch adults are tan or black and white, with very large eyes. They hide in weeds or mixed plantings that provide nectar and pollen, especially clover, potatoes, and alfalfa.
DAMSEL BUGS (Hemiptera: Nabidae)	Small insect eggs, larvae, and adults; mites and aphids	Slender yellowish or tan, with flat wings crossed at the tips and long bent antennae. May bite if handled. They seek shelter in alfalfa, low grasses and ground covers.
LACEWINGS		
(Neuroptera: Chrysopidae)	Aphids, thrips, whiteflies, corn earworms, mealybugs, and other soft-bodied insects.	Also called "aphid lions, aphid wolves," or "stink flies". The adults are delicate, green or brown flying insects with transparent lacey wings which fold like a tent over the back. There are several species including Green lacewings (about 1/2-inch) and Brown lacewings (about 1/4-inch.) The distinctive, delicate eggs hang from leaves on individual fine threads. Lacewings are considered the most effective of the commercially available predators. The ferocious larvae (pinkish-brown with fierce pincers) are very effective with pests, eating up to 60 aphids an hour.

PREDATORS	PESTS	DESCRIPTION, HABITAT, AND NOTES
PREDATORY FLIES		
APHID MIDGES (Cecidomyiid flies)	Over 60 species of aphids	Tiny mosquito-like flies, found on ornamentals and weeds all summer; prefer high humidity and require a source of honeydew. Aphidoletes aphidmyza is available commercially and is used in many IPM greenhouse programs.
HOVER FLIES (Diptera: Syrphidae)	Aphids and small caterpillars	Bee-like flies, known for the manner of hovering near flowers and their quick darting movements. Important as pollinators and the larvae consume many aphids. Preferred plants: yarrow, Queen Anne's lace, many herbs.
ROBBER FLIES (Diptera: Asilidae)	Adults eat a wide variety of small insects; larvae consume soil dwellers	These aggressive generalist predators are distinctive flies of varying sizes, mostly long and gray with prominent eyes, a bearded mouth, and a tapered, slender abdomen. Their practice of perching and pouncing upon victims and the buzzing sound when airborne are clues to identification.
PRAYING MANTIDS (Orthoptera: Mantidae)	Indiscriminate hunters of both beneficial and pest insects	The familiar praying mantis is green, 2 to 4 inches long, and consumes many insects as well as other mantids. While available commercially, they are not very effective as a pest control method, as they are territorial and frequently consume each other when released.
PARASITOID WASPS	Many insect hosts are parasitized by this large family of wasps, which lay eggs in or on the host in the egg, larval, or adult stage. The immature parasitoid develops in the host, feeding on its body fluids	Parasitic wasps are often brown or black, and small, from nearly invisible without a microscope to 1/3-inch. Many look like small flying ants or tiny flies. Females may have distinctive ovipositors. Symptoms of their presence may be the weakened or bloated host or a change in color; some cocoons on host bodies are common signs. Important members of the family follow.
BRACONID WASPS (Hymenoptera: Braconidae)	Over 1800 species in North America, parasitizing many pests, including caterpillars, leafminers, root maggots, tarnished plant bugs, striped cucumber beetles, imported cabbageworm, etc.	The braconid wasp is small (under 3/8-inch), dark and stout-bodied, with long curving antennae and sometimes obvious ovipositors. Her eggs are laid in the host body, and one or more larvae will emerge from each egg. One often sees white cocoons of this wasp on a dead or dying caterpillar, and they should not be destroyed.

PREDATORS	PESTS	DESCRIPTION, HABITAT, AND NOTES
ICHNEUMONID (Hymenoptera: Ichneumonidae)	Larvae and pupae of moths, butterflies, beetles, and flies	Medium-sized, slender wasps, with typical thin "waists"; females have very long ovipositors. Eggs are usually laid in or on the larvae or pupae of hosts. A silken cocoon is often an indicator of Ichneumonid wasps. (8000 North American species.)
TRICHOGRAMMA WASPS (Hymenoptera: Trichogrammatidae)	Eggs of many vegetable pests, including corn earworm, cabbage looper, and tomato hornworm.	Tiny wasps, up to 1/50-inch long. Which lay eggs in the egg of the host insect. The host eggs often turn black.
Other Beneficial Wasps:	Whiteflies, aphids, root maggots, egg or larvae of beetles or bugs	Many other beneficial wasp families exist, including Encyrtidae, Eucilidae, Eulophidae, and the better-known Encarsia formosa, often used in greenhouses for whitefly management. Most wasps can be encouraged and maintained by providing clover, buckwheat, alfalfa, and other ground covers and flowering weeds, as well as water.
PARASITOID FLIES	Caterpillars and leaf- eating beetle larvae; wide range of other hosts	Many flies function as beneficial scavengers, predators, or parasitoids. They are able to fly great distances, and are identified by on pair of wings, and sucking or piercing mouthparts.
TACHINID FLIES (Diptera: Tachinidae)	Caterpillars, beetle and fly larvae, some true bugs and beetles (including Mexican bean beetle, Colorado potato beetle, stink bugs, and squash bugs.)	Tachinid flies are often reddish, tan or gray, and many are fuzzy or bristly, about 3/8 to 1/2-inch long. They can be distinguished from houseflies sometimes by the bristles and often by their quick darting movements. This is a large and valuable group of insects, and the gardener is advised never to swat a fly in the garden.

Other Natural Predators

Toads: Eat many insects; will remain in the garden if there is water (a dish at ground level) and hiding places. Preferred places are rock groupings, under boards or brush piles, or toad "houses" made from inverted clay pots with a chipped lip for entry.

Bats: The common brown bat can eat 3000 insects (mosquitoes and flies) in a night, and bat houses, breeding houses, and a water source are good investments.

Birds: Will be attracted to a healthy organic garden and provide significant pest control; provide water and do not spray pesticides which sicken or kill many birds. Feeding birds in summer as well as winter will help to keep the population near the garden.

Snakes: Eat large numbers of insects and many eat rodents. Dangerous ones are rare. Protect snakes near the garden and offer hiding places such as brush piles or boards.

Lizards and salamanders: Eat vast numbers of insects and are never harmful. Salamanders especially will remain in cool, damp places.

Cats and dogs: While potentially pests themselves if allowed to trample, dig, or roll in the garden beds, both these domestic creatures repel wildlife pests either by their very presence or as hunters and deserve mention as generally friends of the gardener.

Moles: Although they make tunnels and disrupt lawn or plant roots, moles actually eat many grubs (i.e. Japanese beetle) and other larvae and may not warrant control in all settings.

Pest Management

Threshold Tolerance ²⁰

A serious factor in IPM and organic gardening is the threshold, or level of tolerance of a problem or imperfection. The threshold is the point at which the gardener or farmer decides he/she must treat the problem. In a “natural” landscape or organic farm there is undoubtedly a broader threshold for “imperfect” or damaged leaves, flowers, or produce. There are many who seek to change the tolerance threshold of our society in general, since produce can be “imperfect” yet tasty and healthful, and there is no need for most homes to have a weed-free turf. Certainly, there are powerful arguments for tolerating a great number of insects in the garden: Not only are most of them neutral or beneficial; it is also true that even the “pests” are part of the overall balance. The pests are food that maintain the population of beneficial predators.

In the home garden, a conscious decision should be made prior to initiating any pest management program – or in fact, before starting a garden or landscape. Some questions include: How important is a certain crop or plant? Is it worth erecting barriers, winter protection, or the extra measure of patrolling and perhaps pest management? What amount of damage (such as apple scab, insect-chewed leaves, or wildlife invasion) am I willing to live with? Threshold, standards, the definition of beauty, the purpose of the garden – all are highly individual matters. But if such questions as these are asked and answered in advance, many of the remaining pest management choices fall easily into place.

Growing Degree Days ²¹

Insects, like plants, are dependent on temperature to develop. Depending on air temperatures, insect development may vary from year to year by a few weeks. Using any pest insect management application, including horticultural oils, biorationals, botanicals (or other chemicals, when they are chosen by non-organic gardeners) are only effective if they are applied at the proper time in the pest's life cycle. That is, some insects are vulnerable to treatment in the adult, larval, or pupal stage. In organic systems or IPM, it is essential to know at what stage the management method is effective and time it accordingly. Knowing the GDD's and when that stage occurs, make it possible.

Timing for insect pest management should not be based on a calendar date. A Japanese beetle doesn't wake up one morning, look at the calendar, and say "Oops - June 15th already - I'd better get out there!" Rather, the insect's complex sensory system is prepared by the accumulated heat over a period of time so that it "knows" when the season is appropriate for moving through its life cycle. It is environmentally responsible to base timing on Growing Degree Days (GDD), a calculated number of air temperature heat units. GDD varies from region to region, depending on accumulated daily temperature for the year. Regional weather stations monitor and calculate GDD. Charts and pest management references indicate maximum and minimum GDD for specific pests. For instance, bagworms are managed between 600 and 900 GDD, while oystershell scale is managed between 363 and 707 GDD. In Long Island, the minimum GDD will be reached much earlier in the year than in the Adirondacks. Growing degree days have been calculated for most woody plant(tree and shrub)insect pests.

Organic Products ²⁰

An important component to organic gardening is not using synthetic, chemical pesticides. However, trying to substitute organic products for synthetic, chemical ones is awkward and hard to defend. Organic methods involve a wholistic systems approach to gardening, which is far more than finding environmentally sound ways to kill pests and supply fertility. The question of using an organic pesticide instead of diazanon is too simplistic. It misses the opportunity to adopt a whole range of practice in the garden.

However, it is helpful to be aware of the "organic" products for pest management that are available and how they work. They are still considered pesticides even if they are not synthetic chemical ones. In the language of Integrated Pest Management, *many* are considered less toxic options.

Insecticidal Soaps ²²

These specially formulated soaps contain potassium or sodium salts of certain fatty acids. They have become popular because of their low toxicity to humans, pets, and many beneficial insects.

Insecticidal soaps are one of the safest choices available for controlling pests in the garden or on ornamental plants. They control adelgids, aphids, mealybugs, whiteflies, mites, and other pests.

Insecticidal soaps work only on contact, so the spray solution must coat the pest. Once the spray has dried, an insect will not be harmed by walking over the residue. For example, spraying only the upper leaf surface will leave whiteflies alive and healthy because they usually feed on the undersurfaces of the leaves. Whitefly immature stages move little or not at all and will not be killed by contact with the wet material.

Spray only when and where an infestation appears, not as a preventive measure. Symptoms such as leaf or shoot distortion, sooty mold, and holes in leaves require further investigation to determine the cause and the extent of an infestation. Once you find the pest, treat only affected plants or spots.

Watch for phytotoxicity, an adverse plant reaction, or injury from the soap treatment. Symptoms on foliage include yellow or brown spotting, "burned" tips, and yellow or brown scorching on leaf edges. Soap spray may also cause marking on certain pome (e.g., apple, pear) and stone fruit varieties. Phytotoxicity is perhaps most people's greatest concern when using insecticidal soap.

Avoidance of Plant Injury

1. Do not treat plants that are under stress. Drought is a major stress factor. Newly planted ornamentals, transplants, and unrooted or newly rooted cuttings are under stress and should not be sprayed until they are well established. Conifers are particularly susceptible when under drought stress. Make sure plants are well watered before treatment.
2. Avoid treating sensitive plants. The following plants may show phytotoxic reactions after treatment:

Horsechestnut	<i>Aesculus hippocastanum</i>
Mountain ash	<i>Sorbus americana</i>
Japanese maple	<i>Acer palmatum</i>
Gardenia	<i>Gardenia</i> spp.
Bleeding heart	<i>Dicentra formosa</i>
Sweet pea	<i>Lathyrus odoratus</i>
Maidenhair fern	<i>Adiantum pedatum</i>
Crown of thorns	<i>Euphorbia milii</i>
Lantana	<i>Lantana</i> spp.
Nasturtium	<i>Nasturtium</i> spp.
Easter lily	<i>Lilium longiflorum</i> (during bud formation)

Certain varieties of azalea, begonia, camellia, fuchsia, geranium, and impatiens may be sensitive. Rinse these plants with a clean water spray if they show signs of wilting within a few hours after treatment. Test a small portion of palms, delicate ferns, ornamental ivies, and succulents before treating an entire plant or area.

3. Wait for new growth to harden off before treating. Tender, young foliage of evergreen trees or shrubs is especially sensitive. Fruit and nut trees in bloom should

not be sprayed. if in doubt, test a small part of the plant first. If the plant is sensitive, phytotoxic symptoms will appear within 48 hours.

4. Do not apply if the temperature is above 90°F or the plant is in full sun. High temperatures and high relative humidity may increase plant stress and therefore sensitivity. The best time to apply insecticidal soap is early morning.

Compatibility with Other Pesticides and Fertilizers

Insecticidal soap is compatible with many pesticides but should not be mixed with rotenone-based insecticides, Manzate, Dithane, lime sulfur, copper sulfate, or copper fungicides such as Bordeaux mixture. it should also not be combined with concentrated mineral fertilizers for spraying on foliage.

Compatibility with Water

Use soft water to dilute the soap. Hard water is unsatisfactory because soap combines with and is precipitated by certain minerals, especially calcium, iron, and magnesium, found in hard water. Test water by allowing a quart of the prepared spray solution to stand for 15 minutes. A scum or "curd" of soap scale on the surface indicates hard water and the need for a water conditioner. The solution should be a light, milky color.

Horticultural Oils ²³

These highly refined petroleum oils are manufactured specifically to control plant pests. They are paraffinic, degrade rapidly through evaporation, and have very low toxicity to humans and wildlife when used properly.

Horticultural oils, applied both in the summer and when plants are dormant, have gained wide acceptance in pest management programs. They are relatively safe for plants and the environment and control many insect and mite pests. They are also relatively nontoxic to the applicator and leave no toxic residue.

Horticultural oils interfere with respiration and membrane function, causing suffocation, and disrupt feeding activities of certain insects and mites. Complete coverage of the infested parts of the plant is essential. Horticultural oils are most effective against eggs, immature forms, and softbodied adults. Aphids, scales, mealybugs, leaffioppers, whiteflies, mites, and eggs of almost all species are readily killed.

Several grades of horticultural oil are available. Some are strictly limited to dormant use; others can be applied to actively growing plants in spring and summer. Most trees can be treated in the summer, but check the label to be sure. Under adverse spraying conditions such as high heat and relative humidity, sensitive species may suffer from phytotoxicity. The following plants appear to be sensitive: maples, hickories, and black walnut (dormant sprays); smoke tree and certain varieties of azalea (summer sprays); and cryptomeria (both). The following plants show a tendency toward sensitivity: beech, redbud, spruce, and Douglas fir (dormant sprays); savin junipers and photina (summer sprays); and

Japanese holly (both). Glaucus evergreens (those with a bluish cast) may temporarily lose their blue color if oil is applied, and the natural bloom may not return for one to two years. Never spray when trees are under stress or temperatures are expected to be 90°F or above.

A preventive application in late winter and early spring when trees are dormant can save valuable time later in the season. The oil is applied to aboveground plant parts and is effective against scales, adelgids, and mites in their overwintering stages. Oil should not be applied to plants for 48 hours before or after freezing temperatures occur or are predicted.

Spring and summer applications are safe on a wide variety of plants when used properly. Phytotoxicity may result if plants are under moisture stress. The biological stage of the pest will determine whether a dormant or summer application is needed. Pests that can be controlled by horticultural oil include:

Aphids	Juniper scale
Balsam twig aphid	Magnolia scale
Cooley spruce gall adelgid	Maple bladdergall mite
Cottony maple scale	Oystershell scale
Cottony taxus scale	Pine bark adelgid
Eastern spruce gall adelgid	Pine eriophyid mites
Elongate hemlock scale	Pine needle scale
Euonymus scale	Pine tortoise scale
European red mite	Rust mites
Fletcher scale	Spruce spider mite
Golden oak scale	Two-spotted spider mite
Hemlock scale	White prunicola scale
Hemlock woolly adelgid	

Biorational Pesticides²⁴

These include microbials and biochemical products. All biorational pesticides, unless exempt, are subject to the same legislation and use practices as chemical pesticides and are regulated by the U.S. Environmental Protection Agency (EPA). All pesticides should be used only as specified on the product label. Nematodes and biological insect parasites and predators are not regulated as pesticides by the EPA.

Microbial insecticides are made of microscopic organisms (bacteria, viruses, fungi, protozoa, or nematodes) or the toxins they produce. Microbials are either indigenous products, whose active ingredients occur in nature, or nonindigenous products, whose active ingredients are genetically engineered. They cause diseases in insects but are relatively nontoxic to animals and humans and leave no harmful residues. Microbials are often specific to a small group or even species of insect. Some pathogenic microbials may become established in a pest population and provide long-term control for generations or seasons.

Although the specificity of microbials is an advantage in some situations, they do not provide broadspectrum control. They may control only one of several species that are attacking a crop. Their effectiveness may be reduced if they are exposed to ultraviolet light or heat; proper timing and application procedures are thus essential. A few microbials may require special storage procedures that may limit their usefulness.

Microbial insecticides are applied as sprays, dusts, or granules just as conventional pesticides are.

Common examples include milky spore disease, caused by a bacterium that infects certain white grubs such as those of Japanese beetles; *Bacillus thuringiensis* var. *kurstaki* (Bt), another bacterial disease that affects various caterpillar pests including cabbageworms and cankerworms; Bt var. *san diego*, which affects Colorado potato beetle larvae; Bt var. *israelensis*, which kills the larvae of blackflies, mosquitoes, and fungus gnats; and entomopathogenic nematodes, *Steinernema* sp. and *Heterorhabditis* sp.

Microbials may kill insects a little more slowly than do conventional insecticides. For example, when a caterpillar ingests Bt, it will continue to feed until the Bt toxin is activated in its gut and will remain alive on the plant for a few days. Unfortunately, Bt does not reproduce and persist in the environment, so it must be applied at regular intervals, much like synthetic insecticides.

Some microorganisms can protect a plant from other, more harmful microorganisms. For example, dipping tree roots in a mixture that contains the "friendly" bacterium *Agrobacterium radiobacter* prevents attack by the pathogenic bacterium *Agrobacterium tumefaciens*. The harmless fungi *Streptomyces griseoviridis* and *Gliocladium virens* protect seeds, roots, and stems of plants from attack by *Pythium* and other fungi that cause root and stem rots. Commercial products containing these friendly bacteria and fungi are available in New York State.

Chitin protein, the active ingredient in Clandosan, is derived from crustaceans and is used to control plant pathogens. When incorporated into the soil, the protein complex stimulates soil organisms to produce enzymes (e.g., chitinase) that destroy pest nematodes.

Biochemical products include hormones such as growth regulators, pheromones and attractants, and enzymes. Insect growth regulators (IGRS) are relatively new biorational pesticides. Like naturally occurring biochemicals, IGRs are nontoxic. They disrupt the balance in the insect between juvenile hormone, which regulates development, and the hormone that regulates emergence into adulthood, causing abnormal pupation or adult development, resulting in the insect's death. IGRs kill isolated populations of insects over a period of months or even years but may fail if new individuals join a population.

Botanical and Mineral Pesticides²⁵

Botanical pesticides are derived from plants; some, such as nicotine, are as toxic as many synthetic chemical pesticides or more so. Remember, all pesticides are poisonous to some forms of life.

Organic gardeners like botanicals because they are relatively short-lived in the environment and act quickly on insects. If residual action is needed, botanicals do not provide adequate protection. The following botanicals are readily available.

Pyrethrum products are made from the ground-up flowers of a certain type of chrysanthemum. Pyrethrins are the toxins extracted from the chrysanthemum flowers. They decompose rapidly when exposed to light, air, and moisture. Pests are stimulated to move from hiding places when hit with the spray, but they may be only temporarily paralyzed and recover quickly. Synergists combined with pyrethrins may block an insect's ability to recover, but some synergists are toxic. The correct dose is important—be sure to follow instructions exactly when using these products.

Ryania, extracted from a tropical shrub, is a contact and stomach poison. It does not harm beneficial mites, lacewings, lady beetles, or parasitic wasps. *Ryania* is usually applied as a dust and is most effective in hot, dry weather. Rain washes it off plants. Its manufacture is dwindling, however, and *Ryania* may not be available in the future.

Sabadilla, extracted from the seeds of a plant in the lily family, is also a contact and stomach poison. It has little effect on common beneficials and is relatively nontoxic to humans and other mammals. *Sabadilla* is most effective against leafhoppers and true bugs. It breaks down rapidly in sunlight and air, lasting only about one day.

Rotenone is made from the ground roots of tropical plants. Cubé is the only commercial brand currently being sold, available as a dust or spray. Rotenone acts as a contact or stomach poison to insects. It is highly toxic to fish—do not use in areas where it may get into waterways—and moderately toxic to humans and most animals. It is not toxic to honey bees but will kill some beneficial insects. Formulations lose effectiveness within approximately one week of application.

Mineral pesticides include copper dust and sulfur. Sulfur controls plant disease organisms that cause black spot, scab, rust, powdery mildew, brown rot, and others. Bordeaux mixture is the product of a reaction between copper sulfate and lime. The mixture is sprayed to form a protective membranous coating over plant parts. It controls pathogens that cause anthracnose, downy mildew, cankers, and other diseases.

Diatomaceous earth is a dust made from fossilized shells of tiny aquatic organisms. The particles pierce the exoskeletons of soft-bodied insects, causing them to desiccate. The dust is nonselective, killing both harmful and beneficial insects. It loses its effectiveness if it gets wet, and another application is necessary.

Home Remedies²⁶

Although gardeners claim that certain herbs, onions, garlic and other plants will repel insects, evidence for such claims is scarce. Numerous commonly available products such as vegetable cooking oils, soap, and baking soda have pesticidal properties as do concoctions made from plant extracts such as mint, citrus peel, and marigolds. Both state and federal regulatory agencies prohibit their use on a commercial basis (even though

they are environmentally safe and inexpensive); to comply with these regulations we are obliged to refrain from recommending them in most cases. Where home remedies are listed in a Cornell publication, they are not endorsements by Cornell University of any product or procedure, nor are they recommendations for use either express or implied. Neither Cornell University nor its employees or agents is responsible for any injury or damage to person or property arising from the use of this information.

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Review Questions:

1. How does organic gardening differ from non-organic gardening, in terms of what the organic gardener does and does not do?
2. What is Integrated Pest Management?
3. Name at least three methods of composting?
3. What are the different kinds of organic matter used to add to soil?
4. What two flower types attract beneficial insects best?
5. What are row covers?
6. Why is selecting disease or insect resistant varieties of plants for our garden considered both an organic technique and a principle of IPM?
7. Describe the pest management behavior of a predator and a parasitoid?
8. Define biorational?
9. Do marigolds repel all harmful insects in the garden? Explain.
10. What is Cornell's position on recommending home remedies for pest control?
11. What is one big advantage of cleaning up debris in the garden during the fall?
12. Are organic sludge products made in NYS allowed to be used in a vegetable garden?
13. Do composts increase or reduce disease potential when added to the garden?
14. What is the concept of Monitoring?
15. Name three types of lures or traps and how they work.
16. Explain Threshold Tolerance.
17. What is a green manure?
18. What are horticultural oils?
19. What are pesticides? Name at least four categories of pesticides?
20. How would you answer the question: "What is the organic substitute for 'such-and-such' pesticide?"

Related Resources

Organic Gardening

<u>Title</u>	<u>Item Code</u>
Natural Enemies of Vegetable Insect Pests	139NVP
Pest Management Around the Home - Part I: Cultural Methods	139S74I
Home Composting (brochures)	123HCB
Composting to Reduce the Waste Stream: A Guide to Small Scale Food and Yard Waste Composting	123NRAES43
The Three Sisters: Exploring an Iroquois Garden	142LM15
Compost: Truth or Consequences	174VCTC
Master Composter Manual	174MCIG
Composting: Wastes to Resources	147CWRF

These titles are available for review and sale at The Resource Center's online bookstore:

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These titles are also usually available through your local Cooperative Extension association office.

Cornell Website information on **Organic Gardening**

All Cornell website information on gardening is accessible through the Cornell Gardening Resources Website www.gardening.cornell.edu


The following are specific sections of the Cornell Gardening Resources Website as of Dec.15, 2004. New web pages are added regularly. Please check www.gardening.cornell.edu periodically for updates and new information.

<http://www.gardening.cornell.edu/factsheets/orgmatter/index.html>


<http://www.organic.cornell.edu/> (commercially oriented)


<http://www.cce.cornell.edu/hortdl/og.htm>

Cornell Visual Presentation Resources in Organic Gardening


Master Gardeners may borrow resources from the Department of Horticulture's Home Grounds and Community Horticulture Resource Library in Ithaca, NY. MG's should discuss it with their county MG Coordinator and reserve a resource through that staff person. Resources in this library are slides, powerpoint CD-ROM's and videos. They are generally used by Master Gardeners to make presentations to community groups as part of the county CCE's educational mission. The  symbol means that it is appropriate for the Core Qualifying Course for Master Gardeners. The number preceding each resource is its library code number in Ithaca.

GARDENING, general principles and practices

157.  **Organic Gardening** Slide Set (80 slides & script) K. Hennigan, C. Mazza, S.Cunningham, Cornell University, 2001.


CD-5  **Organic Gardening** CD-powerpoint -- 80 frames (images and/or text) & script -- K. Hennigan, C. Mazza, S. Cunningham, Cornell University, 2001

COMPOSTING

113.  **Home Composting** Slide Set (48 slides & script) T. Richard & R. Kozlowski, Cornell University

V-10. **Zoo Doo & You Can Too. Composting in Seattle, WA** Video, (59 min.) Seattle Tilth Assoc.

V-29. **It's Gotten Rotten** Video & Teacher's Guide, (20 min.) Waste Management Institute, Cornell University

V-30.  **Compost: Truth or Consequences** Video, (15 min.) Waste Management Institute, Cornell University

Z-6.  **Master Composter Program Implementation Guide** (114 pages) Waste Management Institute, Cornell University