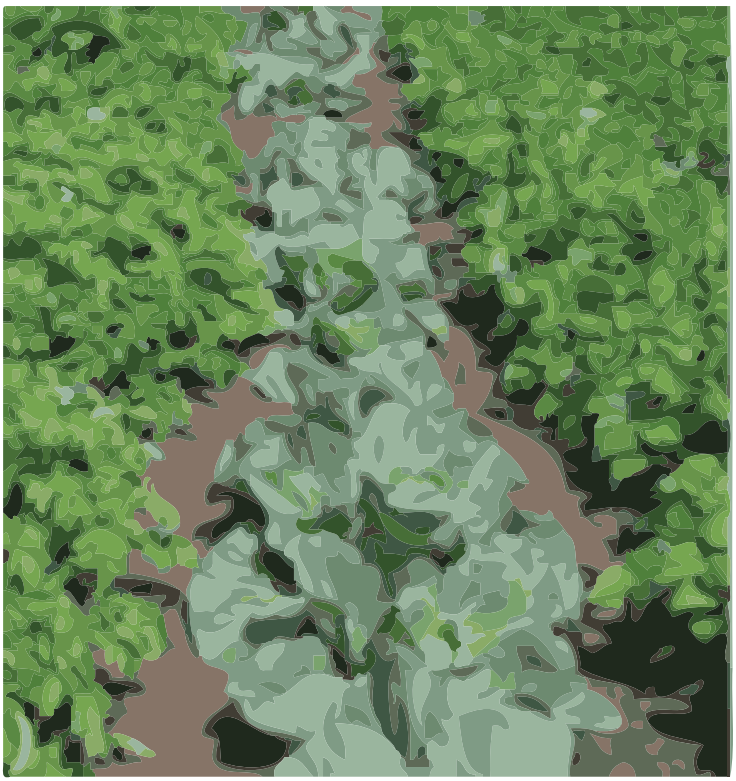
MOFGA's Technical Bulletin Series

Bulletin #1

Basics of Organic Vegetable Gardening



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Introduction

The science of gardening is complex, but the actual practice is simple. The central goal of organic gardening is to maintain or improve the ability of the soil to support plant life as it produces a crop of vegetables each year. That ability depends on a dynamic balance between minerals and the animal, microbial, fungal and plant members of the community. Concern for the long-term productivity of the soil contrasts with the conventional gardener's concern with short-term plant nutrition and is exemplified by the common slogan of organic gardeners, "Feed the soil and it will feed the plants."

A groundswell of interest in organic gardening has developed over the past few decades. Paralleling this interest, a large number of books have been published. However, too often they get carried away with the tenets of the practice and become long-winded. Our bulletin passes on the nitty-gritty facts and teaches you the basic methods of caring for your plants and soil and protecting your plants from the most common pests. Other MOFGA bulletins and fact sheets (see www.mofga.org) build on this basic bulletin.

I. Getting Started

Choosing a site. Most vegetables require "full sunlight," commonly defined as at least five or six hours of direct sun during the middle of the day. Excessive shading results in spindly, weak plants that are susceptible to disease and produce little fruit. If you have no sunny sites, do not put aside the idea of a garden. A few vegetables, although they often will grow quite slowly, will produce in partial shade. These include beets, carrots, kale, lettuce, peas and spinach. If possible, the garden should be close to the kitchen, not only for convenience, but because woodchucks, rabbits and deer are a little less likely to venture close to the house.

An important factor to consider when choosing the site is the soil. Gardening can work well in many types of soil, but common vegetables do best, with the least effort by the gardener, on friable (easily crumbled), porous soils. A deep sandy loam is ideal, as it will provide good aeration and allow root penetration. A soil that is too sandy will not hold water well and will allow the soluble nutrients to be leached away (carried out of the root zone by water). In contrast, a soil with too much clay will hold nutrients and water but will offer poor aeration and may become waterlogged at times.

Sites to avoid include: 1) areas composed of "fill dirt." Fill usually consists of bottom soil (soil that was beneath the richer topsoil), stones and debris. The fertility is usually very poor; 2) depressions that remain wet after brief rains. Such wet soil has very poor aeration, and the roots of vegetables need oxygen.

If you create your garden site in an old field or lawn, you are likely to have a few problems during the first season. First, nitrogen will be unavailable to the plants while the grass is decomposing because of the rapid growth of bacteria. As the number of bacteria increases in response to the sudden increase in food (the sod), these microorganisms use most of the available nitrogen to build their own cells. Only as the bacteria themselves decompose will the nitrogen be released from the bacterial bodies and become available to the vegetable crops. The second problem is weeds: Many of the perennial grasses that you turned under when preparing the garden spot will grow right back. Also, many species of insects that live in the sod, such as grubs and wireworms, may become serious pests of vegetable crops the first year. Ideally, you should prepare your garden site far enough in advance to avoid these problems. The following is an example of how you could prepare sod ground for a garden:

1. Take a soil test in order to determine fertilizer requirements. The soil test kit that you can obtain at your local Cooperative Extension Service office has directions for taking a soil test.
2. Turn over sod in late summer the year before you intend to plant the garden. Add lime, rock phosphate and manure as recommended by a soil test, and plant a winter cover crop such as winter rye (or oats if you do not have equipment that can turn under the rye the following spring. Oats are winter killed, so they are easy to turn under or pull aside when you're ready to plant.)
3. Turn the cover crop under early in the spring, once the soil is no longer muddy but at least a few weeks before planting the garden.
4. Plant vegetables that are fairly competitive—such as tomatoes, corn, squash, beans or cole crops—the first year, as many weeds may still be prevalent.
5. Keep the area well weeded all summer. The vegetables listed in step 4, above, can all be mulched, which will help control weeds.
6. Cut the grass short around the border of the garden to avoid a source of weed seeds.

A Simple, Beginner's Garden Plan

12′	2′	**12′**	
Corn Corn Corn Corn		Peas Peas Beans Beans	**4′**
			2′
Summer Squash Cucumbers Broccoli Cabbage		Tomatoes Eggplant Peppers	4′
			2′
Carrots Lettuce Spinach Onions		Potatoes Potatoes	4′

Garden Size. The size of a garden depends on the availability of space, water and your time—not only to plant, but to care for the garden. The variety and amount of vegetables you want, and whether or not you will preserve part of the harvest, are also major considerations. Consider starting small and expanding when you are sure you can maintain a larger garden. If space is limited, you probably should not plant corn, squash or melons, because they require large amounts of space. See the discussion of each vegetable for estimated yields per 50 feet of row.

Soil Amendments. Almost all soil can support some kind of plant life, but for a good yield of garden vegetables the soil must provide ample basic requirements. Those requirements include water, air and minerals. Soil structure refers to physical features that determine the ability of the soil to hold water and air, while soil fertility refers to the ability of the soil to provide the nutrients required by plants. Both structure and fertility can be adjusted to suit the needs of vegetables by adding soil amendments and carrying out certain practices. As briefly mentioned in the introduction, organic gardening infers an interest in maintaining well-structured and fertile soil that will provide plants with nutrients, air and water. In contrast, many "modern" agricultural practices revolve around feeding the plant directly with soluble nutrients in synthetic chemical forms that are immediately available to plants. Such highly soluble chemicals are easily lost in water moving through the soil. Organic soil amendments and rock powders release nutrients slowly and maintain a high reserve of nutrients.

Many organic gardeners believe that amendments from off-farm sources should be minimized. This is often difficult for gardeners in non-farm communities. Consequently, the following description of soil amendments includes purchased as well as home-produced products.

Organic matter is important in all soils because it improves both soil structure and fertility and feeds the soil life. It must be added regularly, as it continually decomposes. Organic matter plays a major role in improving soil structure. As it decomposes it releases "glues" that hold soil particles together, forming a crumb-like structure that allows for good drainage and aeration. In addition, the organic matter itself improves the nutrient and water-holding capacity of the soil. Consequently, organic matter should be added to excessively sandy soils to increase water- and nutrient-holding capacity, and to clay soils to make them more friable and to improve drainage and aeration by building structure.

Organic matter releases many plant nutrients as it decomposes, so it essentially is a fertilizer. Furthermore, it has a property that often is a very important advantage over purchased, synthetic fertilizers: It releases minerals slowly over a long period of time. This reduces leaching, decreases the risk of throwing the soil system out of balance and decreases the risk of "burning" the plant. (Some synthetic chemical fertilizers are so concentrated that they can kill, or "burn," plant tissues. Some manures, applied to excess or when too fresh, can do the same.)

Here are some common sources of organic matter:

1. **Farm manure** is one of the best sources of organic matter and can supply the bulk of the fertilizer elements that vegetable gardens need. The general rate of application for cattle, hog or horse manure is 300 to 500 pounds per 1,000 square feet of garden. A simple way to estimate this is to apply a layer 2 to 4 inches thick on top of the soil and work it in to a 6-inch depth. Poultry, sheep, goat and rabbit manures should be applied at half this rate because of their higher nutrient content. If organic matter increases to more than 7 percent, avoid adding manure for a year or two.

If you are using cattle, hog or horse manure, work in rock phosphate as well at a rate of 4 to 5 pounds per 100 square feet (if your soil test indicates a need for phosphorus). Unless manure is well rotted, it should be applied before plowing, tilling or spading and then be turned under. Concentrated manure should not be piled around a plant as it may burn the plant.

Compost can be made in piles, in simple, inexpensive bins or in fancy bins. The choice is simply a matter of esthetics.

2. **Green manure:** Organic matter levels can be maintained or increased in a soil by planting a green manure. Green manure is a crop grown with the intent of turning it under while it is still green. In addition to adding organic matter, green manure also returns nutrients accumulated in the plants to the soil. Legumes make particularly good green manure because they possess deep roots that draw up minerals from the subsoil. Also, they live symbiotically with bacteria that can incorporate atmospheric nitrogen that will also be released in the soil when the plant is turned under. Sow a green manure either as a winter cover crop or in a different portion of the garden each season. Some common green manures are: oats (planted in early fall for a winter cover or grown in the summer) and buckwheat or red clover (grown in summer). [See the MOFGA Fact Sheet, "Using Green Manures."]

3. **Compost** is an excellent source of organic matter and nutrients. In its finished form it contains the major plant nutrients, nitrogen, phosphorus and potassium, as well as all the minor nutrients that plants need. Furthermore, it releases these nutrients slowly, thus minimizing runoff and leaching. A compost pile may be made of leaves, weeds, hay, manure, waste vegetable matter, coffee grounds—essentially any vegetable matter. Items to avoid because they decompose slowly and attract unwanted animals include meat, bones and fat.

Pile the vegetable matter in layers if possible: first an 8-inch layer of vegetable matter, then a 4-inch layer of manure, then a thin layer of soil, then repeat the layers. The pile needs to be quite large and built all at once before it will begin composting; 5 feet in diameter and 3 to 5 feet in height will be very good. Smaller piles and piles built bit by bit decompose and produce a fine soil amendment, but they do not heat enough to kill pathogens and weed seeds.

As you make the layers, water them. The pile should be kept moist but not wet. Turn the pile with a fork 10 days after you start it and again two or three weeks later. The compost is finished when it looks dark and decomposed and smells earthy. Good compost can be made in 6 months, but under less than ideal conditions, it may take a year.

For a good fertilizing program, add a layer of compost 1/2 to 1 inch thick to the top of the soil and work it in each spring. If your organic matter increases to over 7 percent, or if your phosphorus increases to more than 40 lb/A, avoid compost for a year or two. Soil tests will tell you if you need any other nutrients—you may not. (For details on fertility, see the MOFGA Fact Sheet, "An organic Farmers Guide to the Interpretation of a Standard Soil Test from The University of Maine.") Some people grow good gardens using just compost for fertility, and research shows that this is possible. (For more details on Composting see the MOFGA Fact Sheet, "Composting in the Backyard or on a Small Farm.")

Soil Amendments (rock powder and ashes): Lime is commonly used to adjust the pH of the soil. The symbol pH indicates the soil acidity or alkalinity, 7.0 being neutral, while above 7.0 is alkaline and below 7.0 is acid. Most vegetables grow best on a slightly acid soil—one with a pH between 6.5 and 7.0. Lime should be used on a garden only when a soil test shows that it is necessary. In Maine, most soils are acid unless lime has been added previously.

Soil test recommendations for liming are based not only on the pH, but also on the quantity of organic matter and clay. If no recommendations are available, you can follow these rough guidelines: If the pH is 5.5 to 6.0, use 3 pounds of ground limestone for each 100 square feet of garden on sandy soils and 5 pounds on heavy clay soils. Many soils in the Northeast are deficient in magnesium, especially after lime and potassium fertilizer have been added, so dolomite (high magnesium) limestone is recommended.

Wood ashes have two-thirds the effect on soil acidity as does lime and should not be applied in large quantities unless the soil is known to be acidic. If lime is needed, wood ashes are good because they also add potassium. Store the ashes in a covered container through the winter to keep them dry, because the potassium in them is very soluble.

Table I lists some other sources of nitrogen, phosphorus and potassium along with the percent analysis. Remember that nutrients in these materials are not immediately available. Furthermore, their release depends heavily on soil conditions in many cases. Consequently, deficiencies identified in soil tests are more difficult to remedy with organic and rock powder amendments than with synthetic fertilizers. Synthetic fertilizers allow a gardener to accurately match the quantity of available nutrients with the needs of a particular crop. In

Table I. Nutrient Content of Common Organic Fertilizers

(Note: Percentage composition is misleading when referring to organic residue and rock powder, because most is not available immediately.)

Organic Soil Amendment	Nitrogen (%N)	Phosphorus ($\%P_2O_5$)	Potassium ($\%K_2O$)	Typical First Application, lbs./1000 sq. ft.
Legume Hay	2.0	0.5	2.0	50
Grass Hay	1.2	0.2	1.5	75
Seaweed (kelp)	0.6	0.09	1.3	50
Cattle Manure (fresh)	0.55	0.15	0.45	300 to 500
Rabbit Manure (fresh)	2.4	1.4	0.6	75 to 125
Bone Meal	4.0	23.0	0	2
Wood Ash	0	2.0	6.0	by result of soil test for pH
Blood Meal	13.0	1.5	0.8	5 to 10
Rock Powder				
Rock Phosphate	0	30	0	20 to 40
Greensand	0	0	7 (plus 3% Mg and 20% Fe)	10 to 20
Sul Po Mag	0	0	22 (plus 11% Mg)	5

contrast, the organic gardener has a goal of maintaining a balanced reservoir of nutrients in the soil that slowly becomes available to the plant. Building this reservoir takes time. Soil tests are important in order to quantify its development. They should be done each year for the first few years. Once good levels of nutrients are achieved, a test once every three years is fine. (See the MOFGA Fact Sheets, "An Organic Farmer's Guide to Interpretation of Soil Tests" and "Natural Sources of Plant Nutrients" for more detailed information.)

II. Preparing the Soil and Planting

Adding Amendments and Turning the Soil. Slow release fertilizers such as lime or rock phosphate should be added in the fall as the soil is turned. However, lime and rock phosphate should not be applied together, because the calcium from the lime will slow or prevent the release of phosphorus from the rock powder. Ideally, you should get the pH up to at least 6.0, then have a soil test done to determine the phosphorus need. Sometimes, raising the pH will free enough phosphorus from its unavailable forms in the soil to satisfy crop needs. If you need phosphorus the following spring, bone meal may be a better source, because its phosphorus is more available than that in rock phosphate. Garden soils and the plants growing on top of them are turned over to incorporate the plant material into the soil and to loosen the soil so that vegetable crops will grow well in it. We do not recommend turning the soil in the fall unless a winter cover crop is planted after turning to prevent nutrient leaching and soil erosion, or unless the garden is mulched for the winter. Soils with good nutrient reservoirs are often better worked in the spring. If some nutrients are deficient, the soil may still be worked in the spring, but a quicker release is demanded from the fertilizer.

Do not work with soils that are too wet. A good test is to mold a handful of soil into a ball. If the ball is not sticky and crumbles readily when pressed with the thumb, the soil is ready to be worked. Working wet soil, especially with power equipment, destroys its structure and compacts it.

Table II. Common Vegetable Families

Tomato	Cucurbits	Crucifer (Brassica)
Tomato	Cucumber	Cabbage
Potato	Melon	Broccoli
Eggplant	Squash	Cauliflower
Pepper	Pumpkins	Turnip
Numerous weeds, such as ground cherry and nightshade		Brussels Sprouts
		Wild Mustard
		Radish

Some gardeners turn the soil only when they are first gardening on a particular spot. After that, if weeds are not a problem, they just push a garden fork into the soil and wiggle it back and forth a few inches to loosen the soil, rather than turning the soil over completely. This is easier on the gardener and may be easier on the soil life (although turning a green manure under can stimulate a great increase in soil life).

Planting. Draw a garden plan before planting. Include the locations of crops, length of rows, and spacing between rows. Locate tall vegetables at the north side of the garden so that they do not shade the short ones. Avoid planting crops that are susceptible to the same insects or diseases (crops from the same families; see Table II) near each other.

Crop rotation is important even in a small garden. Many plant pests overwinter in the soil and will build up from year to year if provided with a host each spring. Furthermore, crops repeatedly planted in the same place deplete the soil of particular nutrients. Generally, crops in the same family should not be replanted in a garden space for two or three years. Ideally, gardeners should have two or more garden plots far apart from each other.

Most gardeners plant in rows in a flat garden, but some prepare raised beds. Such beds are either free-standing mounds of soil, 6 to 12 inches above ground level and 3 to 5 feet wide; or they are sup-

Table III. Planting Periods According to the Frost-Free Date

In each column, the top group is hardy and can be planted outdoors early. The lower group will live but may be set back by colder than usual weather; plant these toward the end of the period.

4 to 6 Weeks Before Mean Frost-Free Date	2 to 4 Weeks Before Mean Frost-Free Date	On Frost-Free Date	Summer
Peas Radish Spinach Turnip Parsley	Beets Cauliflower (6)* Celery (10-12)*	Chard Beans Sweet Corn	**Mid-June** Beans Sweet Corn Cabbage Carrots Radish
Broccoli (3 to 4)* Cabbage (3 to 4)* Carrots Brussels Sprouts Early Potatoes Lettuce Leeks** Onions**	Early Sweet Corn Dill Fall Potatoes Parsnips	Winter Squash Summer Squash Cucumber (3 to 4)* Tomatoes (6)* Eggplant (8)* Pepper (8 to 9)*	**Early to Mid-July** Broccoli Cauliflower Beets Kale **Late July** Lettuce Beets Peas Spinach Radish

* Age of transplants in weeks ** Transplant seedlings that were started in February or March

ported on the sides by wood, stone, concrete blocks or other materials. Supported beds can be much deeper than 6 to 12 inches. Beds offer excellent drainage and aeration, quick warming in the spring, and long-lasting soil structure, because the soil is never trampled. Furthermore, the soil can be amended much more efficiently, because it is in a confined space and amendments are not wasted on permanent walkways between the beds. Compost, loamy soil, rotted manure and other amendments can be turned in each year, building up the bed. Weeds are also easier to control in this design, but quackgrass may creep under wooden sides. Because conditions are kept so close to ideal in the bed, one can garden much more intensively, i.e., place plants much closer together. On the other hand, close planting increases the chance of disease or insect spread.

Raised beds can dry out faster than level planting areas. If you have a very light, sandy soil, level gardens may be a better choice for you.

Raised beds are a great way to simplify gardening. Each bed can be treated as a distinct field and receive different amendments or cover crops.

When to Plant. The garden can be planted over a period of three to four months. Some crops go in early because they tolerate cool, early spring weather, or they need cool weather, or they need long daylengths or a long growing season. Other plants cannot tolerate cool weather or late frosts and are planted later. Some long-season crops cannot tolerate frosts and need to be started indoors or purchased as seedlings and transplanted to the garden. Frost-sensitive plants should not be put out unprotected before the frost-free date. Table III lists planting dates according to the number of days before or after the frost-free date. To give you an idea of dates, in Greene, Maine, the mean last frost date in spring is around May 15, and the mean first frost date in fall is around September 15. If you are not sure when the frost dates are in your area, call your local Cooperative Extension.

Simple, inexpensive covers can protect plants from spring frosts.

Extending the Season. Two common methods of getting a little more out of the short growing season in Maine are: 1) starting plants indoors and 2) growing plants under protective cover outdoors during the early months. Certain vegetables suffer little from transplanting and can be started indoors in large flats, while others are quite sensitive and should be planted in individual containers in order to reduce root disturbance when they are transplanted. Many kinds of plants cannot withstand the stress of transplanting and should only be started directly from seed in the garden. (See Table IV.)

Extending the growing season with plant covers is very common in Maine. Hotcaps, empty plastic milk containers with their bottoms cut off and top left off, plastic row covers on wire hoops and polyester cloth row covers laid loosely over plants give a few degrees of frost protection and provide warmer conditions in the spring (especially the plastic). In addition, polyester cloth excludes harmful insects and is especially useful on the cole crops, onions and cucurbits (see below for details). For additional warmth, these season extenders can be used over black plastic mulch. All of these materials should allow air exchange to avoid overheating, so leave the caps off the milk containers and use slitted plastic row covers.

Transplants. Home gardeners are often advised to buy transplants from local supply stores. The most common problem with home-raised transplants is that they require at least four hours (and preferably six to eight hours) of direct sunlight or sufficient artificial light each day, otherwise they will be tall, spindly and susceptible to disease.

The advantages of home-raised transplants are that you get to choose from a great selection of varieties, and you can raise them free of fungicides, insecticides and synthetic fertilizers.

The key to raising satisfactory transplants, besides providing enough light, is fertile, disease-free soil mixtures. Artificial soil mixes are highly recommended, because they are less likely to harbor disease than mixes that contain soil, are lightweight and aerated, and hold water well. Such mixtures are available in garden stores. Artificial mixes need to have all nutrients added. Most store-bought mixes come with synthetic fertilizer added, but fertilizer-free mixes are available. Watering with manure or compost tea, or liquid fish or seaweed products once a week is a good substitute for synthetic fertilizers. Rock powders and most other organic fertilizers release nutrients too slowly for transplants. A mixture of equal parts

Table IV. Plant Response to Transplanting

Tolerant of Transplanting from Flats		Need Individual Containers	Generally Not Transplanted
Beets	Lettuce	Corn	Beans
Broccoli	Onions	Cucumbers	Carrots
Cabbage	Parsley	Melons	Peas
Cauliflower	Peppers	Squash	Parsnips
Eggplant	Spinach		
Leeks	Tomatoes		

soil, compost, vermiculite and peat will provide the nutrients, without supplements, for finished transplants raised up to eight weeks. (See the MOFGA Fact Sheet "Soil-less Mixes for Vegetable Seedling Production" for information on making your own mix.) This mixture could be "sterilized" by baking the soil and compost in an oven at 350° F for 45 minutes. All parts of the soil should reach 180° F and should stay at that temperature for 30 minutes. Overcooking or overheating releases toxic materials and kills helpful microorganisms.

Wet the mixture in a bucket. The peat in the mix may require a few hours to become wet; using hot water can hasten the wetting. After the mix is uniformly moist, put it into growing containers (flats, cells or individual containers). Plant extra seeds and thin out smaller or weakest looking seedlings, leaving one per cell or container. Warmth is very important for germination of many vegetables. (See Table V for recommended and minimum germination temperatures.) If your house is near the minimum temperature, provide supplemental heat (using a heating mat made for germinating seeds, for example).

Excess watering may promote fungal diseases. However, once seedlings have a few true leaves, daily watering may be needed.

Plants grown indoors are sensitive to the outdoor conditions of wide fluctuations in temperatures, direct sunlight and wind. Thus, seedlings should be hardened off (acclimated) before they are set in the garden. Hardening off is best accomplished in a cold frame. A week or two before the date when the transplants can be safely set in the garden, slowly introduce them to direct sun and evening temperatures by putting them in a cold frame (or just outside, in a protected spot) first for an hour or two a day and then gradually extending the time until they are out all day. Watch their water needs and keep an eye on the cold frame to ensure that the plants don't "bake" on sunny days.

Black plastic, although loaded with negative environmental impact, warms the soil, conserves water and suppresses weeds.

Table V. Optimum and Minimum Temperatures (F) for Germination

Crop	Optimum	Minimum
Cabbage	85	40
Cauliflower	80	40
Cucumber	95	60
Eggplant	85	60
Lettuce	75	35
Melon	90	60
Onion and Leek	75	35
Pepper	85	60
Tomato	85	50

III. Controlling Weeds and Preserving Soil Moisture Using Mulch

Weeds can be the gardener's worst enemy. They compete for moisture and nutrients, offer a home for insects, harbor diseases and block the sun. Weeds can be controlled by hand weeding, cultivation and mulches. Most gardeners use a combination of all three. Shallow cultivation is less injurious to crop roots than deep cultivation and is just as effective. Hoe 1/2 to 1 inch deep; that's all.

Mulch is material laid on the ground in order to shade out weeds and conserve moisture. Mulches may be either organic or plastic. Organic mulches are especially desirable, because they can be turned under in the fall or following spring and will add organic matter to the soil. Organic mulches are best applied after the soil has become warm and shortly after a heavy rain. Straw, old hay (watch for weed seeds), grass clippings, leaves, wood chips, newspaper and sawdust are common organic mulches. Cultivate before piling on the mulch, and pile it on thick enough (3 to 6 inches for hay, for example; or six sheets of newspaper covered with a few inches of hay to hold it down) to prevent the weeds from growing through.

Black plastic is very good at controlling weeds, conserving moisture and warming the soil. However, it does not decompose and needs to be picked up every fall. Because it warms the soil, black plastic frequently increases the yield of warm-season crops such as melons, peppers, eggplants and tomatoes. It is easier to lay the plastic before planting and plant through it than to lay it around plants. Lay the plastic and secure the edges with soil. Plastic is a nonrenewable resource and is a source of environmental pollution. It should not be an organic gardener's first choice of mulch. (Biodegradable plastic mulches made from cornstarch are available but are not approved for use in commercial organic production.)

Mulching helps to manage weeds, conserve water and add organic matter to the soil.

IV. Individual Crops

BULBS: A bulb is a short stem with numerous fleshy leaves crowded together. Bulbs commonly grown in gardens include onions, leeks, garlic and shallots.

Onions

Soil Preparation. Onions do best on sandy loam that is rich in organic matter, but they can be grown on most soils. The recommended pH is 6.0 to 6.5. Onions are heavy feeders. A fertile soil should be prepared before planting by working in an inch-thick layer of a mixture of 8 parts compost or manure, 1 part wood ashes (if the pH is low) and 2 parts phosphate rock (if the soil needs phosphorus) to the top 6 inches of soil.

Propagation. The initiation of the onion bulb depends on day length. The varieties grown in Maine require 15 hours of daylight, so onions must be planted in early spring here so that they have grown enough leaves to bulb well once we reach 15-hour days. However, very early spring plantings are more susceptible to the onion root maggot. (See below.)

Most varieties require a long season, so seeds should be started indoors in mid-February to early March. While onion seedlings are growing indoors, keep them trimmed to 2 to 4 inches tall by giving them a "haircut" with scissors.

Onions can be grown from sets (small bulbs grown the previous year and available at farm supply stores), seedlings or seeds. Sow two to four seeds per inch, 1/4-inch deep. Plant transplants 1 inch apart. Sets larger than 1/2-inch in diameter are likely to go to seed before developing good bulbs. Plant sets 1 inch apart with the top sticking just above the soil surface.

Culture. Keep onions well watered; they grow best with an inch of water per week. They are poor competitors and need frequent weeding—and they are shallow-rooted, so don't hoe deeply and don't let weeds get too big before you pull them. For large bulbs, thin throughout the season to allow 4 inches on all sides of each onion. You can eat the thinned onions as scallions.

Common Problems. The onion root maggot fly lays her eggs in early spring and the maggots crawl down to cut the roots. A heavy infestation can destroy the whole crop. Infected onions will not store well, because fungi invade through holes on the bottom of the onion made by the maggot. The best protection is to cover the whole planting with a polyester row cover (such as Reemay). A mixture of ashes and rock phosphate laid at the soil line around the onion plants may prevent some infection. Beneficial nematodes are good for controlling root maggots; they are available through garden supply companies.

Harvest. For fall and winter storage, allow onion tops to fall over and turn brown. Knock down any that do not fall over with the mass. After the necks and tops look dry (about 10 days after knockdown), the onions can be harvested and stored in a cool, dry place. Do not store them in plastic bags; do allow for air movement.

Yield: 50 pounds per 50-foot row.

Leeks

Soil Preparation. Fertilization requirements are similar to those for onions. Leeks should be planted in a trench about 6 inches deep. Gradually fill the trench during the growing season.

Irrigating a garden is often important. Drip tape, shown here, is one way to get water to the plants without wetting the leaves (which can spread diseases) or wasting water.

Propagation. Leeks are generally grown from transplants that are started indoors in February. Keep the seedlings trimmed to 4 to 6 inches tall until they are set in the garden in early spring.

Harvest and Storage. Leeks can be used throughout the season or harvested in the fall. Pack them in baskets and store them in the root cellar.

Garlic

Soil Preparation. Garlic grows best in well-aerated, deep, fertile soil with a pH of 6.5 to 6.7. Prepare the soil a few weeks in advance of the fall planting. Work in an inch-thick layer of rich compost or a well-rotted manure.

Propagation. Garlic is planted around the first week of October in central Maine. Break the head of garlic into individual cloves and plant each clove 2 to 4 inches deep, about 6 inches apart in rows that are about 12 inches apart. To protect the bulbs through the winter, cover the area with a 3- to 6-inch layer of mulch, such as straw or leaves.

Culture. In the spring, the garlic shoots will come up right through the mulch. Keep them evenly watered but be sure not to over-water. The ground should not be so wet or the drainage so poor that the roots are sitting in water. When the plants send up flower shoots, cut them off.

Harvest and Storage. Garlic is harvested in the summer. When the leaves start turning brown, it is almost harvest time. Garlic will store best if harvested when about half the leaves are brown, the cloves are softly bulging and the outer papery wrapper is starting to dry. Do not let the bulbs sit in the ground after they are ready to harvest or the cloves will start to break through their wrappers and they won't store well. Pull up the bulbs when they are ready and let them cure for a few weeks in a dry, shady spot. Don't wash them. When they are dry you can gently brush off the dirt. After curing, put the garlic in a cold, relatively dry place that never drops below freezing. Garlic stores very well through the whole winter.

COLE CROPS: Interestingly, many of the common cole crops in your garden are the same species (Brassica oleracea). The variation in form that you see is the result of selection by agriculturists over hundreds of years. Some of the cole crops are grown for their leaves or buds (cabbage, Brussels sprouts, kale), others for immature flowers (broccoli and cauliflower) and some for their roots (rutabaga, turnip).

The cole crops are relatively resistant to cold and do well in cool climates. Broccoli and cauliflower produce much better heads in cool weather, and they should be planted to time their flowering with early summer (plant in early spring from transplants) or early fall (plant seed in the garden in late June or early July). You can have a supply of cabbage all summer by spring planting varieties with different maturing dates. Soil preparation, propagation and culture for all the cole crops are generally the same.

Soil Preparation. Cole crops do best on rich loams with good water-holding capacity. Crops can be grown on most soil types if water can be made available when needed. The recommended pH is 6.0 to 6.8. The cole crops are quite sensitive to low pH, and at pH above 7.2, a boron deficiency may develop, especially on cauliflower. Work manure, greensand and phosphate rock (if needed) into the soil before planting. If a soil test suggests a deficiency of boron, a dilute solution of household borax (0.1 pound/100 gallons of water) can be used as a foliar spray.

Propagation. For early spring transplants, sow cole crop seeds indoors about four weeks (six weeks for cauliflower) before you expect to set the plants out. Set out plants 12 to 18 inches apart in rows that are 2 to 5 feet apart. Cole crops are often set out without being hardened off in order to avoid a check in growth. (See "Problems.") Plants are somewhat hardy and will take a slight frost, but a heavier frost may kill them. Cauliflower is the most sensitive. For a later crop, sow seeds in a seedbed in the garden in late spring or early summer. (See Table III.) After seedlings develop two true leaves, transplant them to rows and space them as above. Transplant on a cloudy day or in the evening, and water the transplants in.

Culture. Keep the soil evenly moist, avoiding long dry spells. Weed carefully, as the roots are shallow. A side-dressing of well-rotted manure or compost after plants have grown three or so weeks in the field is useful.

Broccoli. Cut out large central heads when they are ready and before they start to grow loose. This will promote the growth of smaller side heads. Cabbage. Mature heads do not last long in the field: They will split as they become over-mature, especially after a rain. A slice with a spade that cuts off part of the root system may prevent splitting.

Cauliflower does not form good heads in warm weather; fall ripening is best. Cauliflower heads are kept white by blanching—tying the outside leaves together around the developing head when it is 2 to 3 inches in diameter. (Some newer varieties are self-blanching; their leaves grow around their heads naturally and do not have to be tied.) Harvest the heads when they are still compact and fairly smooth.

Brussels sprouts require a relatively long growing season. Sow seeds outdoors in a bed in mid-May and transplant plants 2 to 3 feet apart in rows 4 to 5 feet apart. They can be harvested over a long period. Pick as soon as they become firm, and the plant will continue to produce. The flavor is best after a hard frost or two.

Kale. Sow seeds about 10 weeks before the first expected fall frost for a late crop. Kale must be well watered. Its best flavor occurs when leaves are firm, crisp and bright green. The leaves become tough and bitter as they turn dark green. The flavor is also best after frost, and kale can be harvested into the winter. If mulched or grown in a hoophouse or coldframe, it may resume growth for an early spring crop.

Yields per 50-foot row: broccoli—27 pounds; cabbage—75 pounds; cauliflower—30 pounds; Brussels sprouts—80 pounds.

Common Problems. Cabbage maggots (the larvae of a fly) will attack cole crops that are set out early. Symptoms are yellowing of the lower leaves, slow growth or wilting. Injury results from maggots feeding on root surfaces and tunneling through them. The adult fly looks a bit like a small housefly and lays eggs in April or early May on the base of the plant. The eggs hatch in a few days, and the maggots crawl into the soil. Cabbage, broccoli, cauliflower and radishes are favorites. The most effective control is covering plant rows with polyester cloth (floating row cover). Dusting the base of the plant with a mixture of rock phosphate and wood ash may prevent the maggots from crawling. Beneficial nematodes, available from certain garden supply companies, may work very well.

Imported cabbage worm and the cabbage looper are caterpillars that feed on cabbage and broccoli as well as some other garden plants. They are easily controlled by the microbial pesticide Bacillus thuringiensis (Bt).

Cutworms, the larvae of a night-flying moth, are a major problem, especially for transplants. Cutworms crawl along the surface of the soil at night and sever the plant right at the soil line. Some species climb up the plant and sever leaves. The best protection is to cut the bottom from a paper cup and slip the cup over the small plant, pressing it into the soil slightly, to form a barrier that cutworms can't pass.

LEGUMES: Peas, dry beans and snap beans are popular garden vegetables that belong to the family of plants called legumes. Legumes produce their seeds inside a fruit called a pod. In some species the seed is the only edible portion, while in others the pod is edible as well. Peas are a cool weather crop, while beans need warm weather, especially for germination.

Soil preparation. Legumes possess the unusual ability to harbor symbiotic bacteria that fix atmospheric nitrogen into a form available to plants. Consequently, legumes require less soil nitrogen than other garden vegetables and may actually improve soil fertility as they grow and when the crop residue is turned under by adding nitrogen. (Most legumes grown in the garden will not add much nitrogen to the soil, since most of the "fixed" nitrogen is removed when the peas or beans are harvested.)

Legumes require a well-drained soil, rich in organic matter, with a pH between 6.0 and 7.5. Work in rock phosphate (if needed) and wood ashes (but if the pH is high, use Sul Po Mag instead of wood ashes). In sandy soils that are low in organic matter, a small amount of nitrogen fertilizer will be necessary to get the plants started.

Propagation. Peas can be sown directly early in the spring after the soil temperature has reached 40 degrees F, although seeds that are not treated with a fungicide may show spotty germination. Better germination of untreated seeds will occur when the soil is 50 to 55 F. Inoculation with nitrogen fixing bacteria is beneficial, at least the first time the particular legume is grown in your garden. Innoculants come as a dry powder (available in most garden stores and seed catalogs). Wet the seeds and shake them around in the powder just before planting.

Peas can be planted in rows, but other methods have advantages. Tall varieties can be planted on both sides of a wire fence. Dwarf varieties can be planted in wide rows, since they do not suffer from some crowding. Leave about 2 inches on all sides of each seed. Midsummer plantings for a later crop of peas are possible but often give disappointing results because of the heat of summer.

Beans are sensitive to frost, and the seed will not germinate in cool soil. Soil temperatures should be at least 60 degrees F. Successive plantings every 10 days to two weeks until mid-July will ensure a steady supply. Sow seeds 1 to 1 1/2 inches apart in rows 2 to 2 1/2 feet apart; 3/4 inch deep in loam soils and 1 inch deep in sandy soils.

Harvest. Peas are available as 1) edible pod varieties called snow peas in which the pod is harvested before the pea (the seed) develops; 2) snap peas, which offer both edible pods and peas; and 3) plain fresh peas in which only the pea is edible. The sweet flavor of peas is short-lived, so they should be harvested as soon as they become ripe.

Snap beans should be harvested when they reach full length and before the seeds begin to develop. Frequent harvest induces the plant to continue to produce new pods.

Dry beans (soy, kidney) are harvested after the pods are brown and dry or nearly so. Once the beans are air dried, they will store for years if kept cool and dry.

Yields per 50-foot row: peas- 25 pounds; snap beans- 30 pounds.

TOMATO FAMILY (Solanaceae):

Tomatoes, peppers and eggplants are grown for their fruit and have similar cultural requirements. Potatoes are grown for their tubers, swollen portions of the underground stem, and will be treated separately.

Soil Preparation. A sandy loam that is well drained and contains a lot of organic matter is ideal. The pH should be 6 to 6.5. Well-rotted manure or compost and a handful each of rock phosphate (if needed) and greensand should be worked into the hole into which the transplants will go. Tomatoes are the heaviest feeders of the group. Too much nitrogen for any of these often leads to big, lush plants and delayed fruiting.

Propagation. These crops are sensitive to frost and require a long growing season. Normally tomatoes, peppers and eggplants are started indoors and are transplanted after the frost-free date. An early and midseason variety of tomato should be grown to have a supply from midsummer to fall. Tomatoes should be planted 2 to 3 feet apart in rows 4 to 5 feet apart. Peppers and eggplants can go 18 inches apart in rows 3 feet apart. If the transplants are tall and leggy, plant them 2 to 6 inches deeper in the soil than they were in the pot.

Culture. Peppers and eggplants need no staking, and tomatoes can grow with or without stakes. Staking keeps the fruit cleaner and helps avoid diseases. Plants can also be grown in wire cages. The crops benefit from mulch, but wait for the soil to warm or use black plastic. You can get a jump on the season by using black plastic mulch and row covers. Mulch can also help reduce diseases that otherwise splash onto plants from the soil during rains (see early blight below).

Yields per 50-foot row: eggplant—50 pounds; tomato—100 pounds; pepper—23 pounds

Staking vegetables increases yields and helps avoid diseases.

Common Problems. Fruit may not set or blossoms may drop if prolonged spells of cool nights occurred early in the season. Cold days and hot days (>90) prevent pollination, which, of course, prevents fruit development. The Colorado potato beetle will attack the whole family and is especially damaging to young eggplants. The best control in the garden is hand picking both adults and larvae and crushing the bright yellow egg masses. A natural-based insecticide called Monterey Garden Insect Spray helps control potato beetles. Row covers may also be used.

Early blight is a fungus infection of the leaves that may spread to the fruit. It is characterized by small, brown-yellow spots with concentric rings. The whole leaf will eventually turn brown and fall off the plant. Cool, humid conditions and shaded plantings promote the spread of the disease. The fungus overwinters on plant debris, so compost plants at the end of the season and rotate the location of the tomatoes every few seasons. Do not plant tomatoes where other family members have just grown.

Cutworms can also be a problem in tomato plots. (See cole crop section.)

POTATOES:

The edible part of the potato is a swollen food storage portion of the underground stem called a tuber. Short days, cool temperatures, low moisture and moderate fertility promote tuber development.

Soil Preparation. Potatoes are best grown in a moderately fertile soil that is high in phosphorus and potassium with at least moderate amounts of nitrogen available. Excess nitrogen will encourage too much foliage at the expense of tuber formation. Work in about an inch of compost along with phosphate rock (4 lbs per 100 square feet, if needed) and Sul Po Mag (1 lb per 100 square feet). Although potatoes grow best at a pH around 6.0, a pH higher than 5.7 promotes the fungal disease called scab. Manure applications should be made the fall before planting; otherwise they promote scab.

Propagation. Potatoes are grown from seed pieces, which are pieces of the potato tuber with buds (commonly called "eyes") on them. Although you can use old potatoes for seed pieces, this is not recommended, because they commonly carry diseases. Do not plant grocery store potatoes, because, unless they are organic, they

are commonly treated with anti-sprouting chemicals. Instead buy certified disease-free potato "seed" (actually tubers).

Cut the seed tubers into pieces about the size of a hen's egg and be sure to have at least one to two eyes on each piece. Let the cut surfaces dry for a day or two, and then plant the seed 4 to 6 inches deep, about 10 inches apart, in rows that are 2 to 3 feet apart. For larger potatoes, space seed pieces 15 inches apart in rows.

Culture. When the plants are 4 to 6 inches high, soil should be hoed up around the plants to cover the stems. This prevents the tubers from being exposed to light and turning green and promotes more underground stem development. Plants should be watered during long dry spells to maintain even moisture during the season. Alternate dry and wet spells produce cavities in the tubers and knobby potatoes.

Yields per 50-foot row: 60 pounds.

Common Problems. Colorado potato beetle is the most prevalent insect. (See tomato family.) Flea beetles will attack young plants and, in large numbers, may destroy them, but are usually not severe. Excluding the insects with floating row covers is the best control. The potato leafhopper is a major problem some years. This is a tiny, flighty insect that sucks nutrition out of the plant. The leaves brown from the edges and often die from what looks like a disease. Scout early and through the season for the pest. Some varieties are much more resistant than others. For example, Norland is very attractive to them and Keuka is much less so.

Early and late blight are common fungal diseases that destroy potato foliage and infect the tubers. Late blight appears as brown-black areas on leaves and brown to purple discoloration on the skin of the tuber. Late blight was one of the causes of the Irish famine in the 19th century. The disease is carried through the winter on infected tubers. During the growing season, the spread of the disease depends on weather conditions. Spores are produced only in cool weather, below 60 degrees F, then invade new leaves when higher temperatures occur. A cool, wet July is often followed by blight in August and September. Some varieties (Kennebec, Essex, Cherokee, Sebago) are resistant to the common strain of blight, but not to some new strains. Copper may offer some control. If leaves become infected, delay digging tubers until a week after the first frost has killed the vines; otherwise the tubers will be infected by spores on the soil surface. Destroy infected tubers and, the following year, watch for and destroy any volunteer potatoes growing from the year before.

Harvest. Dig potatoes with a spade after the tops have turned brown. Cure them for about 10 days by storing them at room temperature in the dark, then store them in a cool (40° F), dark cellar.

CUCURBITS:

Cucumbers, melons, squashes and pumpkins, all vine crops, are grown for their fruit. They are warm-season crops that do poorly during cool summers and in the shade. They respond well to fertile soil, and under good conditions a few plants will supply a household.

Soil Preparation. A well-drained soil that is high in humus is best. Cucumbers, winter squash, melons and pumpkins do well when planted in hills. (A hill is not a mound of soil but a group of three to five plants.) Prepare the hill by digging a hole 10 to 12 inches deep and putting 1/2 to 1 cup of rock phosphate (if needed) and 4 or 5 cups of well-rotted manure in the bottom. Mix a cup of wood ashes with the soil from the hole and stir some of that mixture into the manure and phosphate. Then fill in the hole.

Propagation. Early cucumbers, muskmelons and watermelons are best grown from transplants started indoors four weeks before the last spring frost. Main season cucumbers, squash and pumpkins are generally direct-seeded outdoors. Some gardeners transplant their vine crop seedlings and direct seed cucumbers, squash and pumpkins on the same day to ensure a longer harvest season. Space hills 3 to 5 feet apart. Seed will not germinate in cool soil, so wait until it reaches 60 to 65 ° F. This group benefits from warm soil and even moisture and does well planted through black plastic. Put the plastic on the soil a week or two before planting to help warm the soil.

Culture. If you did not use plastic mulch, apply a heavy organic mulch around the plants after the soil has warmed. Even moisture is essential. Sidedressing with well-rotted manure about 4 weeks after transplanting is beneficial. Cucurbits are not self-pollinating and require bees for pollination.

Yields per 50-foot row: cucumbers—45 pounds; muskmelons—40 pounds; summer squash—60 pounds; winter squash—80 pounds.

Common Problems. The striped cucumber beetle is the worst enemy. Not only does it destroy leaves and sometimes fruit, but it also carries an incurable disease called bacterial wilt. Large transplants are much more tolerant than tiny seedlings germinating in the garden. Covering a plant with a polyester row cover such as Reemay is a good solution, but be sure to remove the row cover once the plants flower so that bees can pollinate the flowers. Pyrethrum applied once a week is harsh but offers some control in serious infestations. Growing robust plants in healthy soil seems to help minimize cucumber beetle damage.

Harvest. Cucumbers and summer squash should be harvested when small because they lose flavor and texture when large. Keep them harvested, since ripening fruit draws energy from the plant at the expense of other, developing fruit. Winter squash should be allowed to mature to the point where the skin resists puncture by your fingernail. Store winter squash at room temperature in a dry place.

ROOT CROPS:

A diverse group, these plants are all grown for their enlarged, fleshy roots, thrive in cool weather and can be planted early in the spring. Many of these crops can be mulched and harvested well into the winter. Most are biennials and will produce flowers early in their second year. They include beets, carrots, radishes and parsnips.

Row covers help keep out pests and keep plants warmer.

Soil Preparation. Light, moderately fertile soil with good water holding capacity is best. Never add fresh manure, since excess soil nitrogen will promote hairy roots. The pH should be 6.5, and the soil should have plenty of potassium, so wood ashes are often appropriate. Dig the soil deeply and remove small rocks, since they will impede growth and lead to misshapen roots.

Propagation. Radishes germinate very quickly and mature in three to six weeks. Carrots and parsnips germinate slowly, and the soil must be kept moist during germination. Some gardeners sow quickly-germinating radishes in with carrots and parsnips in order to mark the rows before the carrots and parsnips germinate. All of these root crops are difficult to space correctly at planting and need to be thinned to allow large root development.

Culture. Weeding is essential. Carrots, parsnips and beets are slow to get started and are easily out-competed by weeds. Water during dry spells.

Harvest. Harvest when the roots are large enough to eat, since old roots lose their flavor and crack. Parsnip flavor is enhanced by frost, and some say the best crop is harvested the spring following the planting year. A thick mulch of hay will protect the roots, and they can be pulled through the snow until the ground freezes. Carrots can also be kept and harvested throughout the winter under a thick mulch of hay, but when Jean tried to do this, rodents ate her carrots.

Yields per 50-foot row: beets—35 pounds; carrots—45 pounds; parsnips—50 pounds; radishes—40 dozen.

SWEET CORN: Although sweet corn takes a great deal of space, it should be grown in any garden that has room, because peak quality occurs right after picking. Some gardeners say to get the water boiling before you walk out to the garden to harvest the corn. Many newer varieties of sweet corn hold their sweetness longer than older varieties.

Soil Preparation. Corn is a very heavy feeder and requires full sunlight. Fertilize the soil before planting, because once stunted, corn rarely recovers. Work a 2-inch-deep layer of well-rotted manure, 5 pounds per 100 square feet of phosphate rock phosphate (and 5 pounds per 100 square feet of greensand into the soil. Soil tests will indicate if less rock powder is needed in future years. A pH of 6.0 to 6.8 is recommended.

Propagation. Corn is planted directly in the garden, 6 inches apart in rows that are 3 feet apart. Thin plants to 12 to 15 inches apart. A supply of fresh corn can be obtained by following this schedule: Plant an early variety and midseason variety about two weeks before the last frost. When the early variety has produced four leaves, sow another planting of the midseason variety plus a late season variety. One week later plant some more late-season corn. For an extra-early harvest, some people also start corn seedlings indoors about two weeks ahead of time and transplant those seedlings at the same time that they direct seed their first crop.

Corn is wind pollinated, and pollen released from the tassel must land on every strand of silk in order to pollinate every kernel in the ear and avoid "skips." So corn is best planted in blocks of at least four rows to ensure good pollination.

Culture. Corn is a heavy feeder, so prepare a fertile soil as noted under "Soil Preparation." Sidedress with some manure when plants are 5 to 6 inches tall. Early weeding is essential. Hilling soil around the base of plants will keep down weeds and offer additional support. After the tassels are produced, corn needs 1 inch of water per week. Do not remove suckers (side stalks growing out from the base of plants), as this may injure the plants.

Note the different kinds of hoes. For a discussion of hoe types and their uses, see the Johnny's Selected Seeds catalog.

Yields per 50-foot row: 5 dozen ears.

Common Problems. Corn earworms and the European corn borer are the most common pests during the midsummer. The earworm does not overwinter in Maine, but adults migrate from the South by midsummer. The female moth lays eggs on the silk, and the larvae work their way to the tip of the ear and devour the kernels. Corn varieties with tight husks are more resistant. A few drops of mineral oil squirted into the ear through the silk channel may suffocate the worm. Bt squirted in the channel may work, especially with the oil. Johnny's sells a tool called the Zea-later for applying this mixture. At harvest, gardeners can also simply break off the tips of ears of corn that have earworms.

The borer overwinters in debris from the previous year's corn, especially the lower end of the stalk. Destroying the stalks, fall plowing, a cold winter, or early spring plowing will reduce populations. Early signs of damage appear as shot holes in the young leaves as they unfold out of the whorl where the caterpillar is feeding. As the caterpillar grows it will bore into the stalk and you can find holes where it enters or broken tassels where the stalk is weakened. Bt will work on the young larvae if you can get it down into the whorl at the right time. A granular Bt product is on the market, but the best controls are crop rotation and destroying last year's stalks, unless you are surrounded by other fields of corn.

Photos by the authors

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