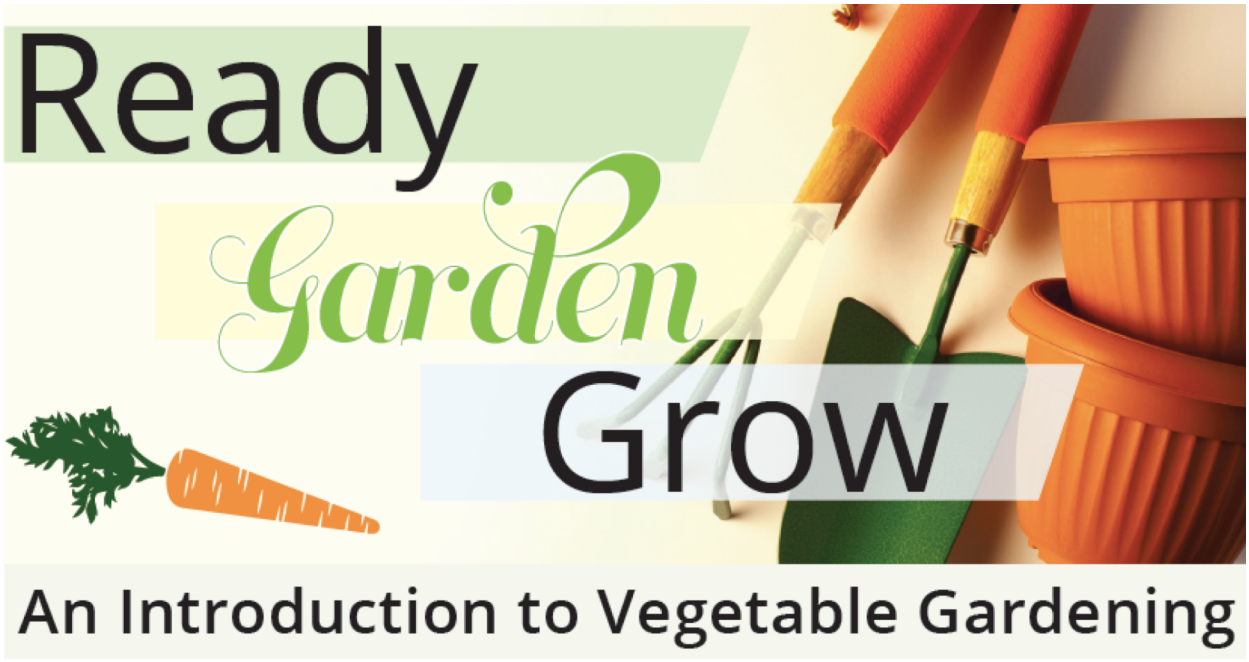

North Carolina Extension Master Gardener Volunteers

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Sherman, R. 2016. Composting, Chpt 2. In: K.A. Moore, and. L.K. Bradley (eds). Extension Gardener Handbook. NC State Extension, Raleigh, NC. <http://content.ces.ncsu.edu/2-composting>

Frank, S., L.K. Bradley and K.A. Moore 2016. Integrated Pest Management, Chpt 8. In: K.A. Moore, and. L.K. Bradley (eds). . Extension Gardener Handbook. NC State Extension, Raleigh, NC. <http://content.ces.ncsu.edu/8-integrated-pest-management-ipm>

Crouse, D.A. 2016. Soils and Plant Nutrients, Chpt 1. In: K.A. Moore, and. L.K. Bradley (eds). Extension Gardener Handbook. NC State Extension, Raleigh, NC. <https://content.ces.ncsu.edu/extension-gardener-handbook/1-soils-and-plant-nutrients>

Colf, A., L.K. Bradley, F. Louws, D. Orr. 2016. Organic Gardening, Chpt 17. In: K.A. Moore, L.K. Bradley (eds). Extension Gardener Handbook. NC State Extension, Raleigh, NC. <http://content.ces.ncsu.edu/17-organic-gardening>

Shultz, C., 2016. Glossary. In: K.A. Moore, L.K. Bradley (eds). Extension Gardener Handbook. <https://content.ces.ncsu.edu/extension-gardener-handbook/glossary>

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Table of Contents

Objectives

Ready-Garden-Grow covers the basics of vegetable gardening. It's goal is to help a beginner gardener successfully grow vegetables. The material in this book will help a gardener with the followng:

1. Determining the type of garden that works best for a given environment and interests.
2. Properly planning a vegetable garden.
3. Preparing soil, planting, and caring for a vegetable garden throughout the year.
4. Identification and management of the major pests and diseases that affect vegetable crops.
5. Harvesting vegetables

Ready-Garden-Grow was developed by the Wake County Extension Master Gardener Volunteers to promote vegetable gardening in North Carolina. EMG Volunteers work with the North Carolina Cooperative Extension to provide non-commercial gardeners in their communities with unbiased, research based information on gardening. To become an EMG, volunteers complete a certification program, participate in continuing education and actively engage in volunteering in their community. For more information on the North Caronia Cooperative Extension EMG program, including how to become an EMGV and how to contact your local volunteers for help, please go to:

http://www.ncstategardening.org/extension_master_gardener/

A Vegetable Garden for Every Lifestyle

In this Chapter:

- Determining the type of garden that works for you
- Selecting a garden site
- Types of gardens
- Gardening techniques
- Organic gardening

Many gardeners grow vegetables for the outstanding flavor and freshness of homegrown produce or to reduce the family food budget. Others are inspired by the wide variety of options and easy access to hard-to-find and unusual varieties. For example, a grocery store may have only three types of squash, whereas a seed catalog may have 49 or more. Still others view vegetable gardening as a relaxing escape from everyday pressures. The food they produce may be secondary to the sense of joy and accomplishment they get from tending the garden and sharing produce with neighbors and friends.

Successful vegetable gardening begins with selecting a site, planning what to grow, and preparing the soil. Once the garden area is ready, vegetables are selected, planted, and nurtured until the produce is ready to harvest. Vegetable gardening can be accessible to anyone with a sunny space, some seeds, water, fertilizer, and patience.

Determining the Type of Garden that Works for You

Before donning garden gloves and putting seeds in the soil, give careful thought to the type or types of vegetable gardens that work best for your lifestyle. Consider the size of your family, the vegetables you wish to grow, the health of your soil, and how much time and money you have to invest in a vegetable garden. You can always start with a small garden and expand it later

If you have a sunny backyard with space to spare and good quality soil, you have the option of planting a traditional in-ground vegetable garden. If your soil is poor, you may wish to consider planting in raised beds. Front yards are often overlooked—underused spaces that could provide food if located in a neighborhood with no restrictions. Many vegetable plants are beautiful. If your landscape is already well-established and you have no room for a traditional

vegetable garden, planting vegetables in your ornamental beds, known as “edible landscaping”, is a great option. Edible landscaping is also an easy first step to try vegetable gardening if you are unsure about dedicating a new space to vegetables. Many vegetables thrive in containers, and container gardening is ideal for those with limited outdoor space.

Vegetables cannot survive indoors without supplemental light, but growing plants indoors hydroponically is an option that is gaining popularity Hydroponics allows the gardener to control temperature, light, and nutrients, all without as many pathogen pressures as plants grown outdoors. It can involve a large initial investment, so it may not be the best choice for someone new to growing plants.

These methods are not mutually exclusive. For example, you could grow cucumbers and corn in a traditional in-ground garden bed in your backyard while growing carrots and broccoli in a raised bed in your front yard. At the same time, you could plant kale and Swiss chard in a perennial border, grow herbs in containers on your back patio, and produce microgreens hydroponically inside your home.

Selecting a Garden Site

Prior to selecting a site, consider previous uses of the land and potential contaminants. Review Extension publication AGW-439-78, “Soil Facts: Minimizing Risks of Soil Contaminants in Urban Gardens,” which provides indicators for concern, guidelines for when to have the soil tested for contaminants, directions on how to interpret the results, and strategies for minimizing risks—for example, using raised beds with imported soil or containers.

The most important factor to consider when selecting a garden site is sunlight. A vegetable garden must receive *at least* 6 hours of direct sunlight each day; 8 to 10 hours is ideal. Vegetables should be planted away from the shade of buildings, and the shade and competing root systems of trees and shrubs. Some vegetables tolerate shade better than others. Those vegetables that produce edible stems and leaves (such as broccoli, cabbage collards, kale, lettuce, parsley, and spinach) as well as those that produce edible roots (such as beets, carrots, radishes, and turnips) are more tolerant of shade. Plants that flower and set fruit, such as eggplants, melons, peppers, and tomatoes, require more light.

Figure 1: Examine potential vegetable garden sites after a heavy rainfall. The lower part of this yard would not be an ideal location because there is standing water.
Kathleen Moore CC BY - 2.0

Good soil drainage is also very important. Observe your yard after a rain. Areas where water pools form have poor drainage and without serious remediation would not be a good site for a garden (Figure 1).

Placing a garden near the home or near a pattern of foot traffic through the yard ensures easy access for garden tasks and facilitates frequent inspections. Consider convenient availability to clean water sources when locating your garden. Access to a hose bib or irrigation system saves the effort of hauling water during dry months.

Another important consideration is good air movement. Avoid locating the garden in a low spot, such as at the base of a hill. These areas are slow to warm in the spring, and frost forms more readily in them because

Got Shade? Very few plants grow well in dense shade. However, if you have partial or filtered shade, you may be able to grow some vegetables. Select large-leafed plants from which you harvest the roots, stems, or leaves. Producing flowers, fruits, and seeds (part of a plant’s reproductive process) requires more sunlight. In shade, try collards, spinach, cabbage, carrots, kale, turnips, parsley, radishes, and lettuce. Avoid planting tomatoes, beans, eggplant, and other plants from which we harvest flowers, fruit, and seeds.

cold air cannot drain away. Vegetable gardens located on high ground are more likely to escape light freezes, which permits an earlier start in the spring and a longer harvest in the fall. If access to land is a problem, explore opportunities at a community garden.

Types of Gardens

There is a garden type, or a combination of types, to fit each gardener's need. Gardens can be grown in-ground, in a raised bed, or in containers. In addition, a variety of techniques can be used to manage the garden. Plants can be laid out in traditional rows or intensely planted, or can take advantage of vertical spaces. Review the following types and techniques, and select the strategies that work best for your unique situation.

Figure 2: An In-ground garden bed planted in rows. Woodleywonderworks, Flickr via Compfight CC By 2.0

In-Ground Gardens

In-ground gardens (Figure 2) are less expensive, the water does not drain away as quickly, and the roots stay cooler in the summer. While water does not drain as quickly from in-ground beds, it can be difficult to supply water only to planting beds and not to adjoining areas. An in-ground garden generally requires more space than raised bed or container gardens. Care must be taken to create paths for traffic to avoid compaction of planting areas. Weeds from adjacent pathways can be challenging to manage.

Raised Bed Gardens

Raised beds (Figure 3) are garden spaces elevated 8 inches or more above ground. They are connected to the native soil beneath them and they may or may not have constructed sides. They can consist of soil piled high with a flattened top, or they can

Figure 3: Raised beds with walls. Local Foods Initiative, Flickr via Compfight CC By 2.0

be framed with logs or rocks, constructed out of lumber boards, or made of straw bales. Raised beds, arranged just wide enough to reach to the center, are ideal for growing vegetables. Having defined beds not only makes a garden attractive, it also limits foot traffic in the bed, which can compact soil. Soil raised above ground will likely drain well and warm up earlier in the spring. Plants in raised beds do require more frequent irrigation than those planted in a traditional in-ground garden. As a higher percentage of the available growing space is used, there is less room for weeds to grow and water can be used more efficiently. When planted properly, one 4-foot by 8-foot raised bed can supply the majority of produce during the growing season for one or two people. Raised beds are generally 8 to 12 inches high, 3 to 4 feet wide, and as long as desired or as dictated by the materials used.

If the raised bed has sides, they should be made of a rot-resistant material. Wood products can be naturally rot-resistant or can be comprised of wood shavings mixed with synthetic materials such as plastic. Naturally rot-resistant woods include eastern red cedar, redwood, and black locust.

Using Treated Lumber and Pallets in the Garden

Do not use creosote-treated railroad ties or certain types of pressure treated lumber for the sides of a raised bed.. Freshly treated creosote lumber can leach into the soil for several years and continue to give off vapors for seven to nine years. Pressure-treated lumber using chromated copper arsenate (CCA) as a preservative is a concern because of the carcinogenic potential of leached arsenic. CCA manufacturers no longer manufacture products for residential uses, but the U.S. Environmental Protection Agency (EPA) has not banned CCA and does not require the removal of existing structures made with CCA-treated wood or the surrounding soil. Do not use any remaining stock in raised beds for growing food crops. Alkaline copper quaternary (ACQ) is another preservative choice for pressure-treated lumber. Although AQC does not contain arsenic or chromium, it does contain copper, which can leach into the soil from treated lumber. Although copper is an essential element for both plants and animals, excessive amounts can be harmful.

Pallets have become a popular choice for garden construction because they are inexpensive and readily available, but exercise caution before using wood pallets in a garden. Understanding the stamps and markings on a pallet helps in making an educated choice (Figure 4).

Figure 4: A pallet stamp gives information about the pallets origin and how the wood was treated. This pallet has the IPPC logo, ES is the abbreviation for Spain, and was heat treated and debarked. It is safe for garden use. Oaktree B, Wikimedia CC by SA 4.0

Pallets are marked with these identifiers:

- Country of origin
- An International Plant Protection Convention (IPPC) logo, for pallets that are used and shipped internationally
- How the pallet was treated (HT: heat treated, DB: debarked, KD: kiln dried, MB: methyl bromide, or a combination of these)
- Possibly a numerical code and a logo identifying the inspector

Pallets that are safe to use in vegetable gardens are marked with HT, DB and KD. Pallets marked with MB should not be used.

If a pallet is unmarked, it may be safe to use. It is better, however, to reject a pallet without origin and treatment information.

Container Gardens

Growing edibles in containers is a popular way to produce food for the home. Many vegetables can be grown in containers that are deep enough to support their roots. Container size is directly related to gardening ease and success - larger is better. Vegetables that thrive in containers include beans, beets, carrots, collards, cucumbers, eggplants, garlic, kale, leeks, lettuces, mustard greens, peas, peppers, potatoes, spinach, squash, Swiss chard, and tomatoes.

For more information on container gardening, see Chapter 18 of the NCSU Extension Gardener Handbook.

Gardening in containers is particularly useful for people with limited space, soil problems, or heavy wildlife pressure. Containers can be placed on a rooftop, balcony, patio, deck, entrance area, or walkway. Containers should be placed in locations that favor the growth of the crop being grown. For instance, a container can be moved to a sunny spot if growing tomatoes, a partly shady area when growing lettuce, or a protected microclimate during the winter for growing year-round rosemary.

Container gardening of edibles offers more flexibility than traditional gardening and is great for children, renters, new gardeners, people with physical limitations, or experienced gardeners wanting to downsize. With container gardening, there is no digging or tilling and crops are virtually weed-free. Container gardening can also be a way of containing aggressive herbs, such as mint, that may otherwise take over traditional

garden spaces. Plants grown in containers do require more care than plants grown in traditional garden beds in the ground. In hot summers they require frequent watering; often daily watering is needed.

Gardening Techniques

Row Gardening

Single-row planting started when mules were used to cultivate the garden. Out of habit, many gardeners still use this system for in-ground, and even some raised beds. If space is not an issue, a traditional row garden is an option. Create wide rows or planting "beds" with rows planted close together to shade out weeds (Figure 5).

Figure 5: Row garden.
Brownpau, Flickr via Compfight CC by 2.0

If you are making traditional garden rows, make them straight to aid in cultivation, weed management, and harvesting. To make a straight row, drive a stake into the ground at each end of the row and draw a string taut between the stakes.

Intensive Gardening

The purpose of an intensively grown garden is to harvest the most produce possible from a given space. Intensive gardening has become a popular model as urban areas have become more crowded and yards have become smaller. Many home landscapes cannot accommodate the traditional row garden, and intensive gardening provides a viable alternative. Intensive gardens optimize the use of space but they require careful planning. Although intensive gardens are often in raised beds, they can also be in-ground gardens or even in large containers.

One method of intensive planting is "square foot gardening" (Figure 6) an approach that was formalized by Mel Bartholemew in his 1981 book Square Foot Gardening and his subsequent 2006 All New Square Foot Gardening. The French were using these intensive gardening techniques in the late 1800s, but Bartholemew popularized the concept. Vegetables are grown in 1-foot by 1-foot squares within a raised bed. Beds are designed to be no more than 4 feet across so they can be managed from the outside. The gardener never compacts the soil by stepping where the vegetables grow. Gardeners can arrange their square-foot beds in multiple ways to fit the available space. Beds are marked in 1-foot squares using a wood lattice, string, plastic tape, or re-used slats from window blinds. These markings help clearly define planting spaces and make it easy to follow planting density recommendations. Within each square, any vegetable can be grown. The spacing is determined by the ultimate size of the vegetables grown within that square. Large plants, such as broccoli or tomatoes, may require multiple squares to allow each plant

Figure 6: Square Foot Gardening
Karen Jevsevar

For a family of four people, an area of 625 square feet should be adequate space to provide most of the produce needs during the growing season. Start small and expand the garden as you have time and interest. Be careful not to start with too large a space; it is easy to become overwhelmed by the weeds and work of creating a new garden. Once you get started, it is easy to expand. Using the intensive planting technique can reduce your space requirements.

to grow to full size. Smaller plants (like beets) can be planted up to 16 plants per square, while others (such as carrots) can have 32 per square. Unlike traditional row gardens, where there is generally as much empty space as plant-occupied space, no wasted space occurs within a square-foot garden. And in intensive gardens, the fertilization, watering, and management efforts are concentrated on the planting beds. In traditional beds with rows the entire garden is amended—both the rows and the pathways.

Succession Planting

There are two types of succession gardening. The first means replacing a crop that has a short growing season with another crop after harvest. Instead of replanting the entire garden bed, you remove a single crop when it's harvest is finished to make way for a new one. For example, if you remove a tomato plant because it has finished producing in the late summer, plant kale or rutabaga in its place to grow through the late fall and perhaps even over the winter.

The second type of succession planting is a technique used to extend the harvest of a crop. If you want to have a huge harvest of beans all at once, so you can do all your canning in one weekend, this strategy is not for you. In addition to enabling an extended harvest, succession planting also buffers against total crop failure as another group of plants is in the queue. The easiest strategy for succession planting is to plant different varieties of the same vegetable that have different days to maturity. These crops naturally stagger their harvest times. The second strategy is to plant the same variety multiple times. For example, you plant radishes and then 2 weeks later plant more radishes so they don't all mature at the same time. Succession planting can be done in multiple interval intervals for a single crop.

Interplanting

Another method of intensive gardening is interplanting, or growing two or more types of vegetables in close proximity to one another. This technique has been practiced for thousands of years by American Indians, but is now regaining widespread support in this country. The benefits include increased yield and a decrease in weeds.

Proper planning is essential to obtain high production and improved quality of the crops planted (Figure 7). The following factors must be considered for each plant combination.

- The length and pattern of growth. Is the vegetable tall, short, below ground, or above ground?
- Allelopathy, the possible negative effects of one crop on another. Some plants, such as sunflowers, produce toxins that impede the growth of other crops.
- The length to maturity. Mixing up maturity rates helps to extend harvesting.
- Light, nutrient, and moisture requirements of the plants. Using plants with like cultural requirements ensures optimal health of all the crops.

Possible plant combinations include planting long-season, slow-maturing plants and short-season, quick-maturing ones at the same time. An example of this combination would be cabbage and radishes. The radishes are harvested before they begin to be crowded by the cabbage. Another example of combining growth patterns is planting smaller plants close to larger plants, such as radishes at the base of beans or broccoli. Shade-tolerant species, such as lettuce, spinach, and celery, can be planted in the shadow of taller crops, like beans or squash. Interplant heavy feeders, such as cabbage, with less demanding plants, such as peas, Swiss chard, or carrots.

Figure 7: When using the three sisters intensive planting technique the corn provides a trellis for the beans, the beans give nitrogen to the corn, and the squash sprawls out conserving water and suppressing weeds. Abri le Roux, Flickr via Compfight CC by 2.0

Another type of interplanting is to grow flowers among vegetable plants. This brings insect pollinators, predators, and color to a vegetable garden

Interplanting can be accomplished by alternating rows within a bed (plant a row of peppers next to a row of onions), by mixing plants within a row (leeks and parsley), by distributing various varieties throughout the bed, or by planting edibles among ornamentals. Swiss chard could be planted between azalea shrubs, or carrots could pop up along a walkway between perennial beds.

Vertical Gardening

The use of trellises, nets, strings, cages, or poles to support growing plants constitutes vertical gardening. This technique is especially suited to gardeners with a small garden space. It can also help prevent disease by keeping plants off the soil and improving air circulation. Vining and sprawling plants, including cucumbers, tomatoes, melons, and pole beans, are obvious candidates for this type of gardening. Some plants twine themselves onto the support; others require tying. Vertical plantings cast a shadow, so place them on the north side of a garden bed to reduce shading, and plant shade-tolerant crops near the vertical ones. Plants grown vertically take up much less ground, and though the yield per plant may be less, the yield per square foot is much greater. Because vertically growing plants are more exposed, they dry out faster and require more water than if they were spread over the ground. This fast drying is advantageous to plants susceptible to fungal diseases. A higher rate of fertilization may be needed, and the soil should drain well to promote a healthy root system. Vertical gardening is often used with raised beds.

Figure 8: A garden taking advantage of vertical space. Shizzi, Flickr via Compfight CC BY-ND - 4.0

Organic Gardening

Interest in home gardening, sustainable use of natural resources, and organic practices continues to rise with increasing concern about the health and safety of families, pets, and the environment. Generally, organic gardeners focus on practices that enhance soil health and plant nutrition, as well as suppress weeds. Organic gardeners manage weeds and other pests (including disease organisms) without the use of synthetic fertilizers or pesticides. Organic and conventional gardening share many similarities; topics in this handbook are generally applicable to both.

The definition of organic methods varies because there is no organic gardening standard for home gardens. Organic gardeners generally subscribe to the

following principles, each of which will be discussed in greater detail in subsequent sections of this handbook:

- A strong emphasis on building healthy garden soil, which has a diverse microbial population, adequate organic matter, proper pH, and good fertility.
- Building a nutrient reservoir into the soil, as opposed to relying heavily on fertilizer applications.
- A holistic approach to pest management.
- Use of only naturally-derived fertilizers and pest control products, and sparing usage of them.

For more information on organic gardening, see Chapter 17 of the NCSU Extension Gardener Handbook

Summary

In summary, any of these garden types and techniques can be used in isolation or combined to create a garden that works best for a given space. A raised bed can be planted intensively, or a container garden may use vertical gardening to its advantage. Whichever garden type or combination of types and techniques you choose, remember to start small, select plants that thrive in the light you have, make amendments to the soil based on a soil test report, manage the weeds and diseases, and only plant what you can manage easily and joyfully. As your interests and skills expand, so can your garden space.

Planning Your Vegetable Garden

Now that you have determined the type of garden and gardening techniques that suit you, it is time plan your garden. Planning includes deciding want you want to grow and organizing your garden to put vegetables where they will thrive the best.

In this Chapter:

- What to grow
- North Carolina Common Crop Chart
- Creating a garden schematic
- Organizing your garden

What to Grow

The simple answer to that question is this: “Grow what your family likes to eat, what you have space for and what will grow in our area.” If you are planting in a limited space, consider vegetables that give the highest yield for the least amount of space, such as leafy greens, root crops, pole beans, and tomatoes; this is referred to as “relative value” (Table 1). If you have plenty of square footage in your garden, you can plant crops like pumpkin, squash, and corn. If you are an adventurous chef or want to try new things, try planting vegetables that are unusual or expensive to buy at the market, such as broccolini, kale sprouts, or shallots. If your family hates zucchini, by all means, avoid planting any.

Be sure to consider the growing season when deciding what to plant. What to plant is influenced by when you plant and vice versa. North Carolina has three main growing seasons – spring, summer and fall. Some plants can survive into the winter using season extension techniques (see Season Extenders in the Appendix)..

Most vegetables are annuals and reach maturity in one growing season. They are grouped according to the season that best meets their growth requirements.

Spring and fall have short, cool days, so vegetables that do best during these times are called “cool-season annuals”.

Cool-season annuals include beets, broccoli, brussels sprouts, cabbage, carrots, mustard, onions, peas, potatoes, radishes, rutabagas, spinach, swiss chard, and turnips. These vegetables grow well and produce leaves and roots in the cool temperatures of early spring and fall. Some cool-season annuals can be planted in the late summer and if they are well established, can survive the winter and continue growing again in the early spring.

Summer is hot with long days; vegetables that do best during this season are called "warm-season annuals." Warm-season annuals include beans, corn, cucumber, eggplant, melons, peppers, squash, sweet potatoes, and tomatoes. These vegetables grow best when the weather and soils warm up in the late spring and summer. Warm-season vegetables are generally not planted in the ground until after the last frost date.

Some crops live for more than one season or year. Biennial crops, such as artichokes and parsley, grow in the first year, and flower, fruit, and die in the second year. Perennials live for many years once established. Examples include asparagus horseradish, and rhubarb.

North Carolina Common Crop Chart

The North Carolina Common Crop Chart (Table 2) is a summary of vegetables that grow in the central region of our state. It is organized by cool- and warm-season crops and includes information useful in selecting your plants and planning your garden:

- Varieties that grow well in central NC
- When to use seeds or transplants
- Planting windows for each season
- Planting depth
- Days to maturity (days to harvest)
- Footprint, that is, how much space the plant needs at maturity.*
- Plant height
- Sun requirements / shade tolerance
- Whether succession planting can used
- Plant family

*Note: footprint can vary by variety. See the Intensive Planting Guide in the Appendix for typical footprint ranges by crop.

Table 1: Relative Value of Garden Vegetables*

Warm Season Crops

High Value	Medium Value	Low Value
Herbs	Beans, bush	Corn
Cucumber	Cantaloupe	Peas, southern
Eggplant	Okra	Pumpkin
Peppers	Squash, Summer	Squash, winter
Tomatoes		Sweet Potatoes
Beans, pole		Watermelon

Cool Season Crops

High Value	Medium Value	Low Value
Herbs	Beets	Cabbage, head
Asparagus	Cabbage, chinese	Collards
Fennel	Broccoli	Peas, garden
Green onions	Brussel sprouts	Onions, bulb
Kale	Carrots	Potatoes
Lettuce, leaf	Cauliflower	Rutabaga
Leeks	Garlic	
Mustard greens	Kohlrabi	
Peas, edible pod	Lettuce, head	
Swiss Chard	Parsnips	* Vegetables arranged alphabetically within each category
	Radishes	
	Spinach	
	Turnip	

Plant families are comprised of plants that share common traits, for example similar nutrient needs and growth characteristics. Most common vegetable plants can be grouped into nine families: beet, cabbage, carrot, grass, legume, nightshade, onion, squash and sunflower. To help prevent problems like diseases, nutrient depletion from the soil and pest issues, crops from the same plant family are planted in a different location every year.

Figure 9: Plan plant spacing for the mature size of the plant. These tomato transplants will require 2-foot spacing for mature plants that are vertically staked. Kurt Morrow, Flickr CC by 2.0

TABLE 2 - NORTH CAROLINA COMMON CROP CHART

CENTRAL NC - COOL SEASON VEGETABLES

Vegetable	Variety	Seed or Trans-plant	Planting Windows		Planting Depth (in)	Days to Maturity		Footprint	Plant Height	Some shade	Succes-sion Planting	Plant Family
			Spring Garden	Fall Garden		Seed	Trans-plant					
Arugula	Runway, Rocket	S	2/1-3/15	8/1 - 9/15	0.25	40-50		9x9	short	Y	N	SU
Asparagus	Mary Washington, Jerey Giant	Crown	2/15-3/15		6	2 years		15x15	tall	Y	N	F
Beets	Ruby Queen, Red Ace,	S	3/1-4/7	7/15-9/7	0.5	55-60		3x3	short	Y	Y	B
Broccoli	DeCicco, Packman	T	2/15-4/7	8/1-9/7			70-80	12x12	med.	N	Y	C
Brussel Sprouts	Long Island Improved, Jade Cross Hybrid	T		7/1-8/30			90-100	18x18	tall	N	Y	B
Cabbage	Round Dutch, Early Jersey Wakefield	S/T	2/1-4/7	7/15-8/7	0.5	90-120*	63-75	12x12	med.	Y	Y	C
Cabbage, Chinese	Pak Choi, Bok Choi	S/T	3/15-4/1	8/1-8/31 9/15-10/15(S)	0.5	75-85	45-55	12x12	med.	Y	Y	C
Carrots	Danvers Half Long, Thumbelina, Scarlet Nantes	S	2/1-3/15	6/15-9/7	0.25	75-80		2x2	med.	Y	Y	Ca
Collards	Vates, Moris' Improved, Carolina	S/T	2/15-6/15(T)	7/15-8/7	0.5	60-100	32-72	15x15	short	Y	N	C
Garlic	New York White Neck	Bulb		9/15-12/1	4	180-210		6x6	short	Y	N	O
Green Onions	Silverskin, Yellow Globe Danvers or Ebenezer'	S/T	2/1-3/15(S) 3/1-3/30(T)	9/1-9/15 (S) 8/15-9/15(T)	1	60-70	42-56	2x2	short	Y	Y	O
Kale	Curled Scotch, Early Siberian, Vates, Blue Knight	S/T	2/15-6/30	8/1-9/30	0.5	40-50	14-22	6x6	med.	Y	Y	C
Kohlrabi	Grand Duke	S	2/15-6/30	8/1-9/15	0.5	50-60		4x4	short	Y	Y	C
Leeks	Arkansas	S/T	2/15-6/30		0.5	120-150	50-80	4x4	short	Y	Y	O
Lettuce, head	Ithaca, Great lakes	S/T	2/1-3/15 3/15-4/30(T)	8/15-9/15(T) 8/15-9/30(T)	0.25	70-85	45-60	10x10	short	Y	Y	SU
Lettuce, leaf	Salad Bowl, Red Sails, Buttercrunch, Romaine	S/T	2/1-3/15 3/15-4/30(T)	8/1-9/1 9/15-10/15(T)	0.25	40-50	15-25	6x6	short	Y	Y	SU
Mustard	Southern Giant, Tendergreen	S	2/15-6/30	8/1-9/30	0.5	30-40		2X2	med.	Y	Y	C
Onions, seed	Texas1015, Granex 33	S	1/1-3/31	8/1-12/30	0.5	90-120		4x4	short	Y	N	O
Onions, sets	Ebernezer, Excell, Early Grano	Bulb	3/1-3/30	9/1-9/15	1	75-105		4x4	short	Y	N	O
Parsnips	All American	S	2/15-5/15	8/1-9/30	0.5	100-130		3x3	med.	Y	Y	Ca
Peas(edible pod)	Sugar snap, Mammoth, Melting Sugar	S	1/1-3/1		1	54-72		3x3	tall	Y	N	L
Peas, garden	Green Arrow, tall telephone	S	1/1-4/15		1	54-60		3x3	tall	Y	N	L
Potatoes, Irish	Kennebec, Red Pontiac, Yukon Gold	Tuber	2/15-4/1		5	95-120		12x12	med.	Y	N	N
Radish, Daikon	April Cross, H.N.Cross	S	2/1-6/15	8/1-9/15	0.5	60-75		2X2	short	Y	Y	C
Radish	Early Scarlett Globe, Cherry Belle, White Icicle	S	2/1-4/1	8/1-9/16	0.5	20-25		2X2	short	Y	Y	C
Rutabagas	American Purple Top, Laurentian	S	2/1-4/15	7/1-9/30	0.5	70-80		6x6	short	Y	Y	C
Spinach	Hybrid 7, Bloomsdale, Tyee	S	2/15-6/30	8/1-10/15	0.5	50-60		6x6	short	Y	Y	B
Swiss Chard	Lucullus, Rhubarb Chard	S/T	3/1-5/1	8/1-9/15	0.5	60-70	32-42	6x6	med.	Y	Y	B
Turnips	Purple Top White Globe, Toyko Cross	S	2/1-6/15	8/1-9/15	0.5	55-60		4x4	short	Y	Y	C

* Start seeds indoors for later transplant into the garden. Do not plant seeds directly in the garden.

Family: (B) Beet, (C) Cabbage, (Ca) Carrot, (F) Fern, (G) Grass, (I) Ipomoea, (L) Legume, (M) Mallow, (N) Nightshade, (O) Onion, (S) Squash, (Su) Sunflower

TABLE 2 - NORTH CAROLINA COMMON CROP CHART

CENTRAL NC - WARM SEASON VEGETABLES

Vegetable	Variety	Seed or Trans-plant	Planting Windows		Planting Depth (in)	Days to Maturity		Footprint	Plant Height	Some shade	Succes-sion Planting	Plant Family
			Summer Garden	Fall Garden		Seed	Trans-plant					
Beans, lima(bush)	Fordhook 242, Bridgeton, Early Thorogreen	S	4/15-7/30		1.5	65-80		6x6	med.	Y	Y	L
Beans, lima (pole)	King of Garden, Carolina Sieva	S	4/15-6/15	7/15 7/30	1.5	75-95		6x6	tall	Y	N	L
Beans, snap (bush)	Roma (flat), Tenerette, Harvester, Astro	S	3/15-9/30		1	50-55		3x3	med.	Y	Y	L
Beans, pole,	Kentucky Wonder 191, Stringless Blue Lake, Kentucky Blue, Romano (flat)	S	4/1-9/31		1	65-70		6x6	tall	Y	N	L
Cantaloupe	Classic, Ambrosia, Honey Brew	S/T	4/15-7/15		1	80-120	85-99	24x24	short	N	Y	S
Corn, sweet	Silver Queen, Bodacious, Merit	S	4/15-6/1		1.5	85-90		12x12	tall	N	Y	G
Cucumbers, pickling	Carolina Calypso, County Fair 83	S/T	4/15-8/15		1	56-65	28-37	12x12	med.	N	y	S
Cucumbers, slicling	Poinsett, Sweet slice, County Fair 83, Salad Bush	S/T	4/15-8/16		1	56-65	28-37	12x12	med.	N	y	S
Eggplant	Florida Highbush, Special Highbush, Ichiban	S/T	4/15-6/15(T)	8/1-8/30(T)	0.5	150-155*	90-95	24x24	med.	N	N	N
Okra	Clemson Spineless, Lee, Annie Oakley	S/T	5/1-5/31	8/1-8/31	1	60-70	18-28	18x18	tall	N	N	M
Peas, Southern	Mississippi Silver, Dixilee	S	3/15-6/31	8/1-8/30	1	55-65		4x4	med.	Y	N	L
Peppers, hot	Habanero, Red Chile, Cayenne, Jalapeno	S/T	4/15-6/15(T)		0.5	145-150*	75-80	12x12	med.	N	N	N
Peppers, sweet	California Wonder, King Arthur, Yolo Wonder	S/T	4/15-6/15(T)		0.5	145-150*	75-80	12x12	med.	N	N	N
Pumpkins**	Autumn Gold, Howden's Field, Spookie (small)	S	5/1-7/16		1.5	115-120		48x48	short	N	N	S
Squash, Summer	Seneca Prolific (yellow), Zucchini Elite (green), Sunburst(scallop)	S/T	4/1-8/15	8/1-8/15	1.5	50-60	30-40	24x24	med.	N	Y	S
Squash, Winter	Spaghetti, Cream of the Crop, Table Ace	S/T	4/15-8/15	8/1-8/15	1.5	70-95	42-67	24x24	med.	N	N	S
Sweet Potatoes	Jewel, Porto Rico 198	Tuber	5/1-6/15			95-125		12x12	short	Y	N	I
Tomatoes	Whopper, Mt Pride, Celebrity, Better Boy, Husky Gold, Patio, Big Beef	S/T	4/15-8/15(T)		0.5	125-135*	75-85	24x24	tall	N	Y	N
Watermelon**	Congo Sweet Princess, Golden Crown, Yellow Doll, Tiger Baby	S	4/15-6/30		1.5	90-100		60x60	med.	N	N	S

* Start seeds indoors for later transplant into the garden. Do not plant seeds directly in the garden (Days to Maturity column.)

** Not recommended for intensive planting. Fruit requires a lot of space to grow and is too heavy for vertical support.

Family: (B) Beet, (C) Cabbage, (Ca) Carrot, (F) Fern, (G) Grass, (I) Ipomoea, (L) Legume, (M) Mallow, (N) Nightshade, (O) Onion, (S) Squash, (Su) Sunflower

Extension Master Gardener
NC COOPERATIVE EXTENSION

Consolidated by Wake County Extension Master Gardener Volunteers Sources: Central NC Planting Calendar for Annual Vegetables, Fruits & Herbs, NC Extension; Home Vegetable Gardening: Getting Startred, Wake County EMG; NC Extension Gardener Manual

This is called “crop rotation” (Figure 12). When possible, wait 4 years or longer to plant the same family in the same location. If this isn’t possible, a later chapter will describe other things you can do to help prevent plant problems.

Making a Garden Schematic

Once you have decided on the location and the type of garden that suits your needs, a rough sketch of your garden area will help with further planning. Your sketch should include:

- Garden beds and dimensions
- Large objects by the garden including buildings, sheds, trees, shrubs and fences
- The location of your water source
- The orientation of your garden – north, south, east and west
- Walkways or paths

If you plan to use a wheelbarrow between beds, a 3-foot path is a commonly recommended width to allow easy access, although paths can be narrower. Footpaths are typically 12- to 18-inches wide. (Figure 10)

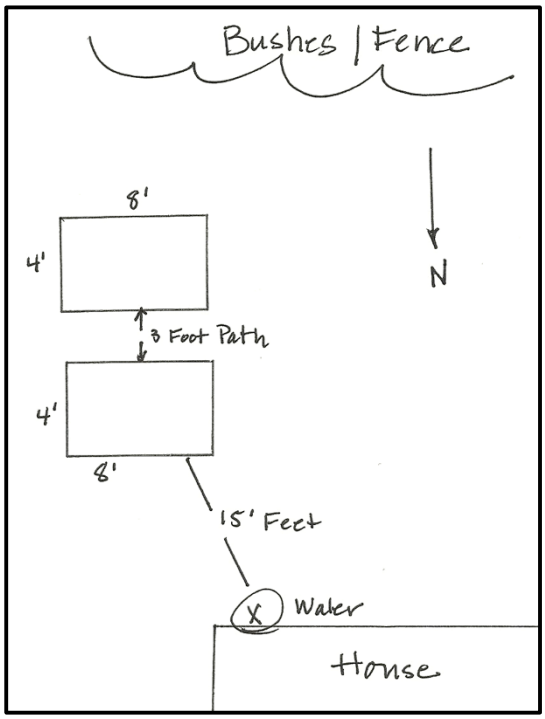


Figure 10: A garden schematic captures basic information about your garden site.

Organizing Your Garden

With proper planning, your vegetable garden can provide produce almost year-round. Keeping track of planting and harvest dates, however, can be a challenge without an effective system. Writing planting and harvest dates on a calendar is a tactic many farmers and gardeners use. Using a planting plan and a planting map can also help with planning and are even more powerful tools if you add your actual planting and harvesting dates to them. Through careful planning, even a small space can realize its full potential for vegetable production.

Create a Planting Plan

Once you have decided what vegetables you want to grow the next step is to create a planting plan (Figure 11). This plan is simply a summary of vegetables and their growing requirements which can be found in the NC Common Crop Chart.

You can also include the quantity of each vegetable and planting notes. For example, note if you plan to use a trellis for vertical support or if you want to succession plant in 2-week intervals. Having the information in one place makes the step of organizing your garden into a planting map easier and is a good way to keep track of what you plant each year.

Create a Planting Map

A planting map is a diagram that shows how you want to organize the plants in your garden (Figure 13) and is your “blueprint” for planting your garden. Several factors need to be considered in this step:

- The gardening techniques you are using (row, intensive, vertical, succession, interplanting).
- The footprint and number of plants determines how much space you need for each vegetable. Plan for the footprint of your plants at maturity.
- Group tall crops and trellised vines together on the north side of the garden to avoid shading shorter plants.
- Group vegetables by plant family to make crop rotation easier (Figure 12).

A planting map can be made for each season for the same bed. See Figure 13 for examples of cool- and warm-season planting maps for a 4’ x 10’ bed. Save your planting maps to reference when planning your next garden.

Planting Plan

Season/Year:

Crop	Varieties	Seed or Plant	Planting Date	Plant-ing Depth	Days to Harvest	Footprint	Height	Shade	Single	Family	# Plants /SQF	Notes

Figure 11: A planting plan captures the key information you need to know to organize, plant and harvest your garden

Crop Rotation – Two Examples

	Bed 1	Bed 2	Bed 3	Bed 4
Year 1	A	B	C	D
Year 2	B	C	D	A
Year 3	C	D	A	B
Year 4	D	A	B	C

Figure 12A: A four-year crop rotation plan for a garden with four beds growing vegetables from four different plant families.

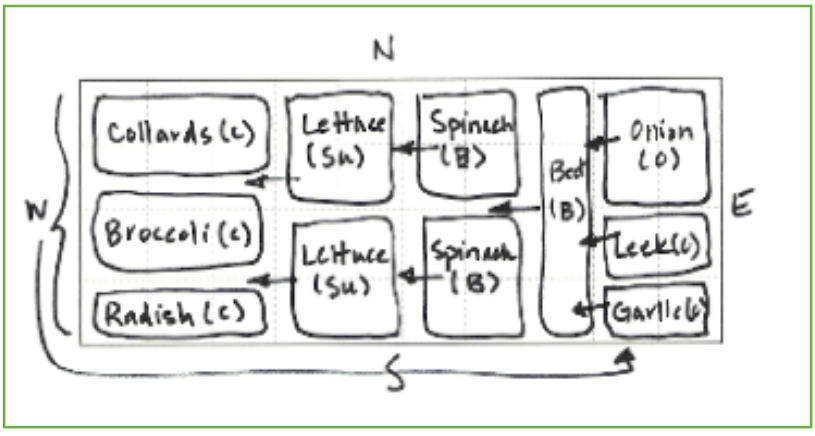
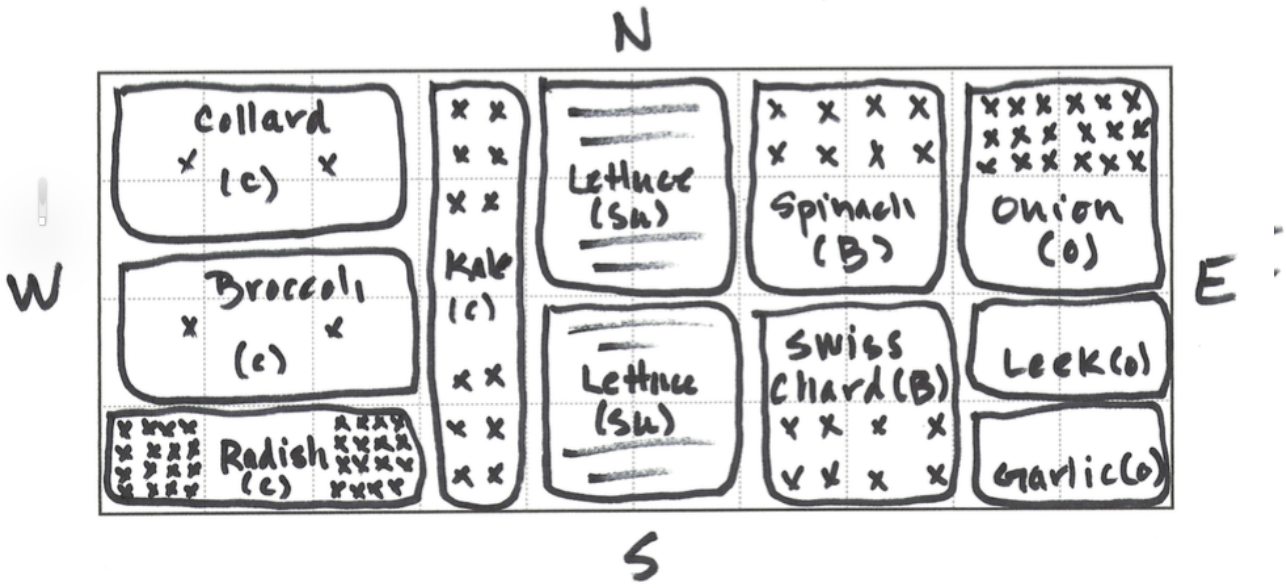


Figure 12B: The planting map for a 4’x10’ bed shows how plants are grouped by family. The following season, the plants in the cabbage family (collards, broccoli, radish) will be moved to the far right end of the bed and each of the other families will be shifted to the left.

Cool Season Planting Map



Warm Season Planting Map

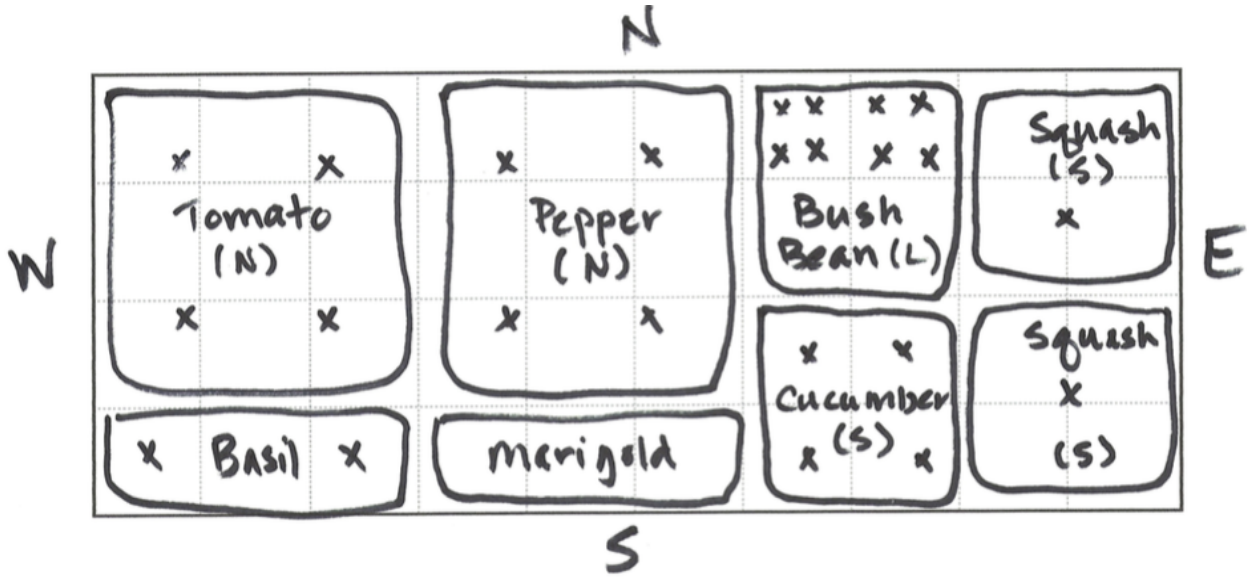


Figure 13: One 4' x 10'garden bed, two seasons of vegetables intensively planted..

Preparing Your Site

Preparing your site is more than making your garden bed or selecting the containers you want to grow in. One of the most important things a gardener needs to do is nurture a healthy environment for plants to thrive in and that starts with the soil you plant in. To grow quality vegetables, you need soil that is fertile, deep, easily crumbled, well-drained, and high in organic matter Many problems gardeners encounter are the result of having poor soil.

Building Healthy Soil

What is soil? Soil is made up of pore space (air and water) and solids. Soil solids are a blend of mineral materials and organic matter. The mineral materials are typically weathered rock of varying sizes called sand, silt, and clay. The organic matter consists of decaying plant and microbial residues. For plant growth, most soil scientists agree that 50% pore space, 45% mineral matter, and 5% organic matter make up an ideal soil.

The ideal garden soil is referred to as loamy. Loamy soil appears rich and dark brown and is usually moist to the touch. You can pick up loam and roll it into a ball, and it will crumble when touched. When you run water over loam, you will see that loam soil tends to drain very well and yet still retains its characteristic moisture. This ensures that the plants have a healthy base in which to grow without the roots being drowned under collected water.

Pore space is an important part of soil. It provides air roots need for healthy growth and keeps the soil loose so water and roots can move through the soil. To keep soil from becoming compacted you should avoid walking in your planting areas. Make permanent paths in in-ground beds and make raised beds 3 to 4 feet wide so you can reach to the middle of them from outside the bed.

In this Chapter:

To learn more about soil, see Chapter 1 of the NCSU Extension Gardener Handbook

A gardener is lucky to have loamy soil naturally; it is more common to have sandy or heavy clay soil. The fastest way to improve sand or clay soil is by adding organic matter to the soil.

Gardening in Containers? If you are gardening in containers, purchase potting soil or make your own mix by combining equal parts of compost, shredded pine bark and vermiculite. Never use soil from your yard in containers. Soil from the yard used in a pot likely has poor drainage and may have pathogens that would thrive in the container.

Compost

Compost is decomposed organic material. In addition to increasing the organic matter in soil, incorporating compost into a garden bed improves the physical properties of the soil. It attracts earthworms that tunnel through the soil creating spaces that help roots penetrate more easily, holds moisture, and provides aeration to plant roots. It contains microorganisms and beneficial bacteria that suppress some diseases and supply some essential nutrients. Compost can also be applied to the soil surface to conserve moisture, control weeds, reduce erosion, improve appearance and keep the soil from gaining or losing heat too rapidly.

Composting is a process that controls the decomposition and transformation of biodegradable material into compost. You can purchase ready-made compost or make it yourself. Many organic materials are suitable for composting. Yard wastes such as leaves, grass clippings, straw and plant trimmings can be composted. Branches and twigs greater than 1-inch in diameter should be ground up in a shredder or chipper. Kitchen wastes such as vegetable scraps, coffee grounds, and eggshells may also be added.

Making Compost

Gardeners who want to produce a high quality of compost at a fast rate will choose the "hot composting" method. It involves aerating the pile, checking temperatures and moisture levels, and getting the right mixture of materials and particle sizes.

A bin is not needed to make compost. Some choose to use a bin to keep the pile neat, help retain heat and moisture, and keep out pests, or they live in a neighborhood where a bin would be more appropriate than an open pile. Many people make their own compost bins using concrete blocks, wooden pallets or mesh fencing. Plans for three-compartment wooden bins that make managing the stages of composting easier can be found on the internet (Figure 14). There are a variety of manufactured composting bins available, including enclosed, spherical tumblers.

Composting can be done in a pile or some type of bin, but the size is important for maintaining heat--it should be 3 cubic feet

Using Composted Manure in the Garden

Manure can be a valuable addition to any garden soil, supplying nitrogen, potassium, and phosphorus. But take the following precautions before adding it to a vegetable garden:

Use manure from vegetarian animals, including cows, horses, chickens, goats, or sheep.

Make sure you know if any herbicides or other chemicals were used where the animals were grazing. Some herbicides can persist through an animal's digestive track, through the composting process, and remain active in the vegetable garden, where they affect your lettuce and tomatoes the same way they affected the broadleaf weeds they were initially purchased to manage.

Avoid manures from animals kept in a confined area; these manures may contain high amounts of salts from urine.

Fresh is not best. Use manure in a garden only after it ages for at least six months in an open pile or after the manure is composted. To compost, mix fresh manure with a high carbon source, such as straw or dried leaves, rather than adding to an existing compost pile. Or mix fresh manure into a garden bed that will remain fallow for an entire growing season.

Kiln-dried manure that has been heated to kill any pathogens can be purchased from a garden center.

Figure 14: Homemade 3-bin composting system. Lucy Bradley, CC by 2.0

(3-feet wide, deep and tall). Set it up in a convenient location that is over 6 feet away from the home or other wooden structures. To maximize food safety the compost should be downhill and as far away as possible from the vegetable garden. Choose a flat space that is protected from flooding or runoff to surface waters or wells. Keep the areas in front of and above the pile or bin clear so it can be worked without difficulty. Place it in a shaded area (to help it retain moisture) and within reach of a garden hose.

There are two basic styles of hot composting: **Single Batch**, where materials are added all at once to form a pile, and **Continuous Pile**, where organic materials are added as they become available. Build a pile 3-feet high and at least 3-feet in diameter so it can become self-insulating to retain heat. Add 4- to 5-inches of carbonaceous materials (browns), then two or three inches of nitrogenous materials (greens), and keep alternating the layers. Table 3 shows some of the brown and green materials commonly used to make organic compost.

Another method is to mix up browns and greens thoroughly before loading. Be sure to water each layer thoroughly to ensure that moisture is evenly distributed. Toss in a handful of soil on each layer to introduce more microorganisms. Top the pile with 4-to-5 inches of carbonaceous materials to keep out flies and other pests and provide a filter for odors.

After the pile is created, it should heat up within a few days and stay hot for several weeks if it is turned weekly. During this time, the pile will shrink and after about a month it may be about half of its original volume. It will take another 4 to 8 weeks for the pile to cure and be ready for use.

A simple compost recipe is to combine leaves, grass, food scraps, and coffee grounds at a ratio of 2-to-1 mix of browns and greens. There are some additives that can help to get a compost pile hot. Small amounts of one or more of the following in "meal" form can be dusted on top of the greens in a compost pile: alfalfa, bone, hoof, soybean, canola, cottonseed, or blood. A compost pile can also be activated by adding a mixture of water and molasses, sugar, syrups, or flat soft drinks.

Maple leaves have a perfect carbon-to-nitrogen ratio, so with the right moisture and frequent turning, they can break down in several weeks. Oak leaves have less nitrogen and contain high levels of tannins which are resistant to decay, so they take a lot longer to break down. Mixing oak leaves with high nitrogen materials will accelerate their decomposition.

Decomposition happens on the surface of materials, so *the particle size and shape are very important* to the composting process. By chopping, smashing, grinding or cutting materials into smaller particles (less than 2-inches in diameter), more surface area is created and decomposition happens faster. Use a chipper/grinder, a machete or place materials in a bucket and use a square-end shovel to chop them into pieces. Do not get carried away because very fine particles will prevent air from flowing into a compost pile. A low-cost method of reducing the size of fallen tree leaves is to run a lawn mower over them before or after raking. The shredded leaves can be collected directly if the lawn mower has an appropriate bag attachment. Rigid particles provide structure and ventilation to a pile, so it is good to layer in small batches.

The decomposition process will slow down if there is too little or too much moisture.

Table 3: Organic Compost Ingredients

Browns (Carbon)	Greens (Nitrogen)
Dry leaves, twigs, yard trimmings	Grass clippings
Straw	Garden waste
Shredded newspaper	Kitchen waste
Sawdust	Coffee grounds, tea bag
Dryer lint	leaves
Beer / wine making leftovers	Composted manure
	Hair, fur, feathers
NO: Meat, diary, bones, diseased plants, weeds, poop from meat eating animals	

Approximately 40% to 60% moisture is needed in the pile. At this moisture level, the pile should feel like a wrung-out sponge. The compost pile is within the right moisture range if a drop or two of water can be squeezed from a handful of material. If no water can be squeezed out, the materials are too dry. If the compost pile is too moist, it will slow the decomposition process and produce unpleasant odors. If that happens, add dry leaves, paper or sawdust to absorb the excess moisture. Most often, compost piles are too dry. Open piles can be covered with a tarp to hold in moisture.

Compost piles need ventilation. Anaerobic (no air) piles smell bad, compost slowly, and produce dense, wet, and smelly compost. Aerobic piles with oxygen throughout will produce little or no odor. To aerate the pile, turn the organic materials with a digging fork or shovel. If turning is not possible, poke it with an aerating device or broom handle to help air flow into the pile. Mixing the pile once a week by moving the material from the outside to the center will hasten the composting process. Turning also exposes seeds, insect larvae, and pathogens to lethal temperatures inside the pile. A pile that is not mixed may take three to four times longer to produce useful compost.

For additional information on making compost, common composting problems, and vermicomposting (using worms to make compost), visit the NC State Extension Composting website.

Herbicides in Compost

For more information see NC-CES publication Herbicide Carryover in Hay, Manure, Compost & Grass Clippings

Herbicides may persist during the composting process and harm plants grown in compost-amended soils. Hot composting piles can accelerate the breakdown of most herbicides, and they can also be deactivated by binding with organic matter. The source of herbicides in most home composting piles is usually lawn clippings. However, animal manure may contain composting-resistant herbicides. It is important to know the source and chemical history of any green material before it is used in the garden.

Adding Compost to Your Garden

When you first develop your garden, you should incorporate compost into your bed. Compost should also be added each growing season, every spring before planting and again in the fall after harvest to replenish the organic matter in your soil.

In a new bed, or if your soil is mostly heavy clay, spread a 2- to 6-inch layer of finished compost on top of the bed and till or dig it into the soil. In an established bed, as your soil improves and becomes looser and loamy, you should avoid disturbing the soil. You can spread finished compost on top of the bed and plant in it, or use a pitchfork to wiggle the compost into the soil. This will minimize disturbing the healthy microorganisms and earthworms in the soil and protect the soil's structure.

You can also try sheet mulching if you don't plan on planting for 4 to 6 months. Sheet mulching is essentially building a compost pile to form a bed. This will be covered later in this chapter as a technique that can be used to prepare a raised bed.

Cover Crops

You can also increase the organic matter in your garden bed and protect your soil using cover crops (Figure 15). Green manure crops—such as winter rye, ryegrass, oats or wheat—can be planted in the garden in the fall and turned under in the spring when growth is about knee-high. For best results, seed fall cover crops between September 15 and October 20 in the NC piedmont (one to two weeks later in the NC coastal plain, and one to two weeks earlier in the NC mountains). Cover crops are not limited to

Figure 15: Cover crop of white rye grass was planted in this annual flower bed. It is being turned under to add nutrients to the soil before planting.
Linda N., Flickr CC by 2.0

fall planting. Clover, southern peas, soybeans or buckwheat can be planted after harvesting early spring vegetables like lettuce or spinach and turned under in time to plant a frost-tolerant crop in the late summer. Seeding rates for cover crops vary; generally, 6 ounces or less is needed for a 100-square foot bed.

Caring for your Soil

Soil Testing

Two other aspects of having healthy soil are the pH and nutrient content of the soil. To measure the level of these in your garden bed you should test your soil when you first prepare your garden bed and repeat testing every two to three years before planting. Inexpensive soil test kits are unreliable. North Carolina provides homeowners with free soil analysis and soil reports during part of the year. The accuracy of these reports depends on the quality of the sample submitted. To learn how to take soil samples and where to send them for analysis, see Soil Testing in the Appendix.

Soil pH

Soil pH is a measure of the soil's relative acidity or alkalinity. The pH scale ranges from 0 to 14. A pH of 7 is a neutral state, representing the value found in pure water. Values above 7.0 are alkaline (basic), while values below 7.0 are acidic

The optimum pH for a plant varies with organic matter content and plant type. Plant nutrient availability is strongly tied to the pH in the soil solution. Decreasing soil pH directly increases the solubility of the plant nutrients manganese (Mn), zinc (Zn), copper (Cu), and iron (Fe). Acidic soils make these nutrients more available. At pH values less than about 5.5, toxic levels of Mn, Zn, or aluminum (Al), a non-nutrient element very common in our southern soils, may be released. The impact of pH on nutrient availability is very important—both for maximum plant availability and to avoid potentially toxic levels at very low or very high pH levels.

The optimal pH for growth differs among plants. Most vegetables prefer a slightly acidic soil with a pH of 6.0 – 6.5. Blueberries, a popular fruit in home gardens, are well-suited for a soil pH of about 5.0. A little research can help you identify the proper pH for the plants you wish to grow. After obtaining a soil test report, you can take measures to adjust soil pH or select plants that will thrive at the current pH. Extreme pH measures of 4.0 (acidic) or 10.0 (basic) will support little plant life and are very difficult to modify.

Adjusting pH

If the soil pH is too acidic, apply lime to raise the soil pH. Garden lime, calcium carbonate (CaCO) is widely available at garden centers, and can come with or without magnesium (Figure 16). If your soil is low in magnesium, this is one way to add it. Use pelletized lime verses powdered lime; pelletized lime is much easier to apply for the home gardener.

Lime moves slowly in the soil and will neutralize acidity only in the area where it is applied. To be effective, it should be mixed into the soil. It takes several months for lime to react in the soil. For vegetable gardens that require lime, apply the recommended amount up to 50 pounds of lime per 1,000 square feet (or 1.6 pounds for a 4' x 8'bed) in one application. For recommended rates over 50 pounds, wait several months to make a repeat application to avoid a surface buildup of lime.

For existing beds, sprinkle the lime on top of the bed and lightly work it into the soil. For new beds where the area will be tilled, the entire recommended amount of lime can be applied in one application and tilled into the soil.

Figure 16: The label on a bag of garden lime.
Kathleen Moore, CC BY - 2.0

If the soil pH is too basic for the desired plant, incorporating an acidic soil amendment such as pine bark or compost, or applying elemental sulfur, will lower soil pH. Apply sulfur with caution; too much can harm plants.

Soil Nutrients

Many people confuse plant nutrition with fertilization. Plant nutrition refers to the needs of the plant and how a plant uses the basic chemical elements. Fertilization is the term used when these elements are supplied to the soil as amendments. Adding fertilizer during unfavorable growing conditions will not enhance plant growth and may harm or kill plants.

To complete their life cycle, plants need 17 essential nutrients, each in varying amounts. Of these nutrients, three are found in air and water: carbon (C), hydrogen (H), and oxygen (O). Combined, C, H, and O account for about 94% of a plant's weight. The other 6% of a plant's weight includes the remaining 14 nutrients, all of which must come from the soil. Of these, nitrogen (N), phosphorus (P), and potassium (K), the primary macronutrients, are the most needed. Magnesium (Mg), calcium (Ca), and sulfur (S), the secondary macronutrients, are next in the amount needed. The eight other elements—boron, chlorine, copper, iron, manganese, molybdenum, nickel, and zinc—are called micronutrients because they are needed in much smaller amounts than the macronutrients.

Fertilizers

Fertilizers provide some nutrients that might be lacking in the soil and stimulate healthy, vigorous growth. How much and when to apply fertilizers should be based on observing plant performance, a reliable soil test, and an understanding of the factors that affect growth: light, water, temperature, pests, and nutrition. Simply applying fertilizer because a plant is not growing adequately will not solve many plant problems (for example, those caused by insects, disease, or poor drainage), and, in fact, excess nitrogen can often increase insect and disease infestation.

All fertilizers are labeled with three numbers, giving the percentage (by weight) of nitrogen (N), phosphorus (P), and potassium (K). This is referred to as the fertilizer grade.

A 100-pound bag of fertilizer labeled 0-20-10 has 0 pounds of N, 20 pounds of P (listed as P_2O_5), 10 pounds of K (listed as K_2O), and 70 pounds of filler. Filler is added to make the fertilizer easier to spread and to reduce the likelihood of burning plants with too much fertilizer (the salts in fertilizer can pull water out of the plant). A fertilizer may also contain secondary macronutrients or micronutrients

Fertilizer Terms

Fertilizer grade (or analysis): The minimum amount of each element in a fertilizer as stated on the label, such as 16-4-8.

Fertilizer ratio: The relative proportion of nitrogen (N), phosphorous (P_2O_5), and potassium (K_2O). The ratios of 16-4-8 and 8-2-4 are both 4:1:2, which means 4 parts N to 1 part P to 2 parts K.

Balanced fertilizer: A fertilizer containing equal parts of each major element, such as 10-10-10.

Complete fertilizer: A fertilizer containing nitrogen, phosphorus, and potassium. Examples of commonly used fertilizers are 10-10-10, 16-4-8, and 12-4-8.

Incomplete fertilizer: A fertilizer missing one or two of the macronutrients, such as 0-20-0.

Organic Fertilizer: A natural fertilizer that comes directly from plant or animal sources and that has undergone little or no processing. Examples include fish emulsion, kelp, bone meal and seed meal.

Chemical Fertilizer: A fertilizer manufactured in a chemical process. These are also called "synthetic", "commercial" and "conventional" fertilizers. They are sold as pre-packaged mixes.

Weed and feed fertilizers: A combination of fertilizer and herbicide. They are often used on lawns to prevent certain weeds from germinating, or to kill existing broadleaf weeds and should not be used in a vegetable garden.

not listed on the label because the manufacturer does not want to guarantee their exact amounts.

Organic and Chemical Fertilizers

You can successfully grow a garden using organic or chemical fertilizers. See Table 4 for advantages and disadvantages of each.

Organic fertilizers can be expensive. You can save money by making your own using ingredients that are easily found in garden centers and farm supply stores. Table 5 lists some of the ingredients that can be used to make fertilizer.

Figure 18: Fertilizer applied by banding three inches from the center of the row and slightly below the seed depth . Chris Alberti, CC BY - 2.0.

How to Apply Fertilizer

Apply fertilizer before or at planting time. The best way to fertilize a small garden is to sprinkle the fertilizer evenly across the top of the bed. For a traditional row garden, broadcast half to two-thirds of the total amount of fertilizer needed and apply the remainder by banding (Figure 18). To

the top of the soil with a cyclone or drop spreader in an east–west and north–south movement. For both types of gardens scratch or rake in the fertilizer and water the soil before planting.

Table 4 - Organic Vs Chemical Fertilizers

Organic	Chemical
Advantages: • Supports microorganisms in the soil • Contains micronutrients good for plant health • Release nutrients slowly, which means less damage to plants	**Advantages:** • Water-soluble so nutrients are immediately available after watering • Sometimes expensive
Disadvantages: • Nutrients take time to break down and are not immediately available to plants. They may take longer to break down in cool weather. • Can be more expensive	**Disadvantages:** • Micronutrients may not be included • Does not supply organic matter • Unless using a time release fertilizer, nitrogen is quickly released and not available to plants over a long time period • Easy to over apply and damage plants

Plant Nutrients and the Environment

Fertilizer misuse causes environmental and water quality issues. Nitrogen fertilizers, for instance, break down into ammonium and nitrate. The nitrate form of nitrogen, while essential for plant growth, is highly mobile and can move through the soil after rainfall or irrigation and contaminate drinking water supplies. Phosphorus holds tightly to soil particles and does not leach through the soil, but affects water quality through runoff and soil erosion. Excess nitrogen and phosphorus are associated with algal blooms (heavy growth of aquatic plants) and limited oxygen, and cause fish kills in lakes, bays, and non-flowing water bodies

There are several ways to reduce fertilizers' impacts on water quality:

- Only apply amendments that are recommended based on results of a soil test. If possible, use slow-release fertilizers and incorporate them into the soil. Avoid applying excess nitrogen and phosphorus fertilizer.
- Maximize water absorption by incorporating organic matter in planting beds.
- Prevent runoff by turning off irrigation when the soil is no longer absorbing water.
- Avoid applying fertilizer in natural drainage areas or ditches.

Table 5 - Making Fertilizer – N, P, K Sources		
Nitrogen (N)	**Phosphorous (P)**	**Potassium (K)**
Blood Meal	Bone Meal	Green Sand
Alfafalfa Meal		Granite Dust
Fish Meal		Potash
Soy Bean Meal		Sul-Po-Mag
Composted Manure*		Wood Ash
*For organic gardening, only use organic manure		

- Maintain a lawn border around planting areas and plant a grass strip between rows in fruit and vegetable gardens. Use a grass that will not spread into the garden.
- Plant cover crops on bare soil, such as barren vegetable gardens to prevent eroision.

Preparing Your Garden Bed

There are a variety of techniques you can use to build in-ground or raised garden beds. For all of them, you should start by staking out the location of your bed and removing any grass and weeds from the area unless otherwise noted. If you are making multiple beds, paths between beds should wide enough for wheelbarrow access and/or footpaths. It is tempting to get an early start on bed preparation in late winter or early spring, but don't rush into it. Wait until the soil is dry enough that it crumbles when you loosen it. If it is wet, you will end up compacting the soil. Also, before starting your beds, make sure you don't have any buried utility lines where you want to place your beds. Before you dig, call 811 in North Carolina for a free utility locating service. (See the Additional Resources section.)

In-Ground Beds

Soil for in-ground beds should be loosened to a minimum depth of 12 inches. Most tillers won't reach this depth, so be prepared to do some digging. If you have access to a tiller, you can use it to loosen the top of the soil and follow with the double-dig technique.

Double Dig Technique

Double digging is hard work, but it is a good way to turn compacted soil into a bed that can be planted right away. You will need a long handled shovel to double dig; a garden fork and mattock can come in handy to loosen the soil if you tackling a very compacted or rocky site.

1. Dig a trench 1 to 2 feet wide and 1 foot deep at one end of the bed. Put the soil you remove into a wheelbarrow or buckets to move it to the other end of the bed.

2. Add 2 to 4 inches of compost to the bottom of the trench. Mix the compost into the soil at the bottom of the trench using your tiller, or by pushing your shovel or digging fork into the soil and pushing it back and forth.

3. Dig another trench next to the one you just dug, placing the soil you remove on top of the compost mixture in the previously dug trench. Repeat step 2 in this trench.

4. Dig additional trenches, repeating steps 3 and 2, until you reach the opposite end of the bed.

5. In the last trench, add the soil you saved in step 1 to the bed.

6. If you need to add lime, this is a good time to do that by sprinkling the lime evenly across the bed. Finish by adding another 2- to 4-inch layer of compost on top of the entire bed. Mix the added compost and lime into the soil using a tiller, shovel or digging fork.

The soil level of the finished bed will be higher than the area around it and will settle over time.

Raised Beds

A raised bed is any garden that is at least 8 inches above ground level, with or without walls. There are several methods that can be used to a build raised bed, All of these will benefit from loosening the soil beneath the bed. You can accomplish this by tilling the soil, digging a shallow bed using the double dig technique (without adding compost as directed above) or by loosening the soil with a shovel or garden fork.

Where do I get soil for my raised beds?

Raised beds can take many forms, and so can the soil used inside the beds. For shallow beds with no support, use topsoil from neighboring pathways and mix it with existing soil and organic matter. Soil can be piled up and flattened to make a raised bed less than 6 inches high. To prevent soil erosion, gently slope the sides of the bed.

If making a taller raised bed or one in a framed box, you many need additional soil. If your soil is good quality loam, you can screen your soil into the raised bed and add 50% compost. You can also purchase raised bed garden soil blends bagged from a nursery. Or soil can be ordered by the cubic yard from a landscape company. To calculate how many cubic yards of soil you need, consider that one cubic yard of soil is:

3 feet × 3 feet × 3 feet = 27 cubic feet

To find out how many cubic feet you need in a raised bed, multiply the length by the width and depth of your raised bed (convert all measurements to feet). If your bed is 4 feet wide by 10 feet long by 18 inches deep, that would be:

4 feet × 10 feet × 1.5 feet = 60 cubic feet

Divide the number of cubic feet by the number of feet in a cubic yard (27):

60 cubic feet / 27 cubic feet = 2.22 cubic yards of material

Be sure to ask about the components of the blend. A quality blend consists of topsoil, compost, and a soilless mix, such as vermiculite. Where are the organic materials sourced? Is this blend high in animal manures? Have they been fully composted? Is it guaranteed to be topsoil free of pollutants, weeds, insect pests, diseases, and pathogenic nematodes? Simply purchasing a raised bed mix is not enough to maintain a garden over the long term. To keep nutrient levels high in the soil, raised beds need to be amended after each growing season by adding a 2 to 4-inch layer of organic material.

Basic Raised Bed

1. Loosen the top 3 to 4 inches of soil. Spread 2 inches of compost on top of the soil. If you need to add lime, you can add about half of it now by sprinkling it evenly across the bed. Using a shovel, gardening fork or tiller, mix the compost and lime into the soil.

Figure 19: A raised bed made of straw bales. Knit Steel, Flickr CC BY-ND - 4.0

2. Dig pathways around the bed. Add the soil from the pathway to the top of the bed. If adding lime, sprinkle the rest of it evenly across the bed and mix it in. If needed, you can add more compost to get the bed to an 8" height above the ground. Lightly mix the compost into the soil.
3. Rake the bed to level it. The sides of the bed should be sloped; the top of the bed will be smaller than the base.

For a raised bed with walls, you can use lumber as discussed in the first chapter or other materials like straw bales (Figure 19), for your walls. You should still loosen the soil on the bottom of your bed and then add soil as described above.

Sheet Mulching

This method was mentioned earlier in the composting section of this chapter. Sheet mulching turns compost components (the green and brown materials) into garden soil. It is also referred to as "lasagna gardening" and "compositing in place". If you use this method, you need to sheet mulch 4 - 6 months or more ahead of planting to allow enough time for the material to break down and be ready for planting. Fall is a great time to sheet mulch for spring planting.

1. Loosen the top 3– to 4-inches of the soil. Remove weeds from the bed; you can leave grass.
2. Cover the bed with 4 to 6 overlapping layers of cardboard or newspaper. This will kill the grass and break down to become part of the soil. Soak this layer with water and cover with a thin layer of nitrogen fertilizer.
3. Add a 1- to 5-inch layer of loose brown compost ingredients (for ingredients, see Table 3 in the Composting section).
4. Top with 1- to 5-inches of green compost ingredients (see Table 3). Make sure the brown and green layers are about the same thickness.
5. Repeat steps 3 and 4 until the height of the pile is about 18". Add a thin layer of nitrogen every third or fourth set of brown and green layers to speed up decomposition. End with a brown layer.

After you build the initial pile, you can add more layers as you collect more ingredients. Just remember they will all need to decompose before you plant. The bed is ready when the layers have broken done and you can no longer recognize them. If the pile gets too wet, cover it with plastic. The plastic will also help speed up composition by raising the heat level within the pile

Fast No-Dig Technique

This no-dig method is easy and fast, but it can be expensive because you use a purchased planting mix to start. Also, depending on how much mix you start with, you may have a shallow bed and may need to limit your plant selections to plants that have shallow or medium roots for several years.

1. Remove weeds. Cover the bed with 4 to 6 overlapping layers of cardboard or newspaper. This will kill the grass and break down to become part of the soil. Soak this layer with water.
2. Cover the newspaper or cardboard with 4 – 8 inches of pre-made planting soil. Over time, as you add compost to the bed and as some of the bed loosens beneath the cardboard with the movement of earthworms, you will be able to plant crops with deeper root requirements. See Table 5 for vegetables that have shallow roots.
3. Rake the bed to level it. The sides of the bed should be sloped, so the top of the bed will be smaller than the base.

Summary

No matter what technique you use to initially make your bed, you will need to add nutrients each year. As previously mentioned, adding compost before each planting season should be done. Cover crops also add nutrients and can be used in the fall or summer. In addition to these, you may need to add other amendments like lime and fertilizer depending on your soil test results. Some crops need supplemental nitrogen during the growing season; this will be covered in the next chapter.

Table 5 – Plants with Shallow Roots

Warm Season	Cool Season	
Cantaloupe	Broccoli	Garlic*
Corn	Cabbage	Green onions*
Herbs*	Cauliflower	Kale*
Parsley	Collard	Kohlrabi
Sweet Potato	Chard	Lettuce*
	Fennel	Onions
	Leek*	Radish, round*
	Mustard*	Spinach*
	Potato	

*Plants with very shallow roots

Planting Your Garden

Now that you've done all the work of selecting what you want to grow, planning your garden and preparing your beds, it's time to start planting.

Seeds vs. Transplants

The North Carolina Common Crop Chart contains information on when you should use seeds and when you should use transplants; for some crops, you can use either one. Seeds are cheaper than transplants and you can get a larger selection of crop varieties with seeds.

Transplants are more expensive, but good for crops that have a long maturity cycle like tomatoes, peppers and eggplant. They are started indoors before the weather is warm enough for planting, so they can be harvested sooner than if you started them from seed in the garden. Transplants also have benefit of crowding out weeds that can overtake seedlings.

When to Plant

The North Carolina Crop Chart has typical planting windows for each vegetable. Seed packets also contain information on the minimum soil temperature seeds need to germinate. Weather varies year-to-year, so be sure to adjust your planting dates based on your observations in the current year. One good rule is to plant warm season crops when you are well past the danger of frost.

Gardening Through the Year

With proper planning your vegetable garden can provide produce almost year round.

Spring. Cool-season annuals are cold-hardy plants that thrive in the early spring and fall when temperatures fall below 70°F. To get a jumpstart on the spring season, use a cold frame, low tunnel, or frost cloth. Warm-season annuals are frost-sensitive crops that grow well in the late spring when temperatures are above 70°F and soils have warmed up.

In this Chapter:

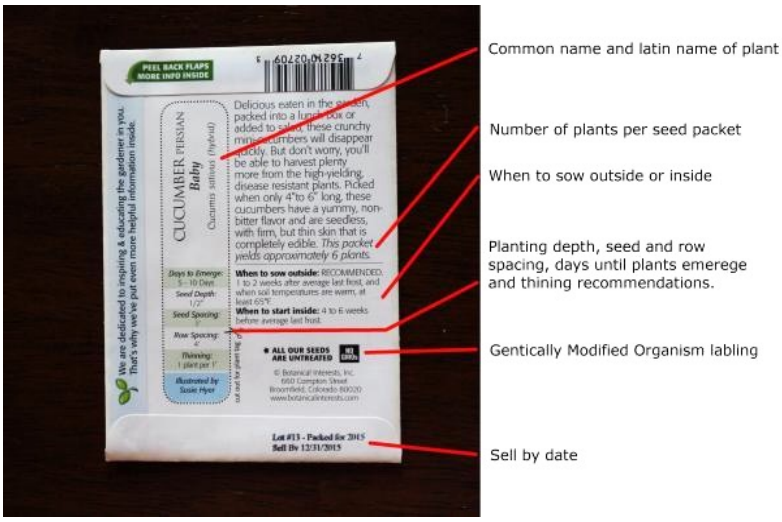


Figure 20: A seed packet contains a wealth of information to guide planting and harvesting. Brook Williams

Summer. As temperatures rise, cool-season crops bolt and become bitter. Use shade cloth or taller crops to provide shade and extend cool-season crops into summer. Warm-season crops planted in late spring grow until the first frost. Late summer is the time to plant cool-season annuals for a fall harvest.

Fall. Cool-season annuals that are well-established grow through cold temperatures and sometimes even moderate freezing.

Winter. Crops considered cold hardy (such as collards, kale, turnip greens, spinach, and Swiss chard) planted in fall may live through the winter or may go dormant for a period in the winter and flourish again in early spring. A cold frame or frost cloth can help protect and extend this growing season. Many of these plants bolt quickly in the spring.

For specific planting dates, consult seed packets or the NC Common Crop Chart. For more on season extension, see Appendix A.

Planting Seeds

Make sure the seeds are fresh. Old seeds bought on sale may not be a bargain because their germination rate may be reduced and the resulting seedlings can be weak and grow very slowly. Check the date stamped on the seed packet to make sure the seeds were produced for the current gardening year. Many vegetable seeds are viable for three to five years if kept in a dark dry place that stays below 85°F. Seed packets can be a wealth of information, and it is worth becoming familiar with all the information on the back of the packet (Figure 20).

Bulk vegetable seeds sold by the ounce or pound in garden centers and farm supply stores are shipped to the store in a container or bag with a date and germination rate label attached. Look for the information before making a purchase. Seeds with high germination rates should be the first choice.

Fall Gardening:

Growing a productive fall vegetable garden takes thoughtful planning and good cultural practices. August is the main planting time for fall gardens. Vegetables that have a 60-day to 80-day maturity cycle should be planted around August 1 in the NC piedmont. Seeding of shorter-season vegetables, such as turnips and leafy greens, can be delayed until September 1 in the NC piedmont. Keep in mind that the planting dates can be as much as 10 to 20 days earlier in western North Carolina and 7 to 14 days later in the NC coastal plain. Be sure to adjust the planting dates for a specific location by noting the frost date and counting backward on the calendar the days to maturity of the vegetables.

Before preparing the soil for a fall garden, remove the remains of the spring garden. In most cases, the spring-planted crops have already matured and the warm-season vegetables are beginning to decline.

Seeds should be planted deeper in the fall because the moisture level is lower in the soil and the soil surface temperatures are higher. In many cases, the planting depth may be 1½ to 2 times as deep as for spring planting of the same crop. The seeded area may need to be covered with burlap, newspaper, or boards to keep the soil cool and moist. Remove covers as the seeds begin to germinate

Direct seeding is often used in the fall for crops such as broccoli and collards. The success of this planting method, however, depends on having enough moisture available to keep the young seedlings actively growing after germination. If there is no irrigation source, buy vegetable transplants from a local garden center instead of seeding. Most fall vegetables benefit from an application of nitrogen three and six weeks after planting.

To be successful with directly sowing seeds, the garden soil should contain enough moisture at seeding to initiate germination. If it does not, water the soil thoroughly (4 to 6 inches deep) and allow the surface to dry before seeding. If preferred, water the areas where seeds wil be planted instead of the entire bed.

Seed packets will tell you how deep to plant a seed. Generally, in the spring and summer plant seeds 1 to 2 times as deep as their greatest diameter; in fall plant them 1½ to 2 times their spring planting depth.

Sowing Patterns

Row Planting:

Seed packets will tell you the spacing for the seeds and the spacing for rows. To get your rows straight, you can use stakes and string, a yardstick or some other straight edge to mark your row. Dig a furrow with your finger or trowel as deep as called for on the seed packet. Place seeds in the furrow at the recommended spacing. Since some seeds will not germinate, you should sow twice as many seeds as you need and thin later.

Small seeds like lettuce and carrots can be difficult to distribute thinly and evenly. To sow small seeds, tear off a corner of the seed packet, then move the packet along the furrow while tapping it with an index finger. You can also mix the seeds with dry sand or dry, pulverized soil to help with even distribution.

Once the seeds are placed, cover them with soil. Firm the seeds with the flat blade of the hoe or your hands. Be sure to plant seeds at the recommended depth; seeds covered with too much soil may rot before germinating or the seedlings may use up all its stored energy before it grows to the surface where they produce food by photosynthesizing. On the other hand, seeds planted too close to the surface may die from overheating or drought.

Banding:

Banding works well for seeds that are too small to handle individually, like lettuce seeds. Create a band by raking or troweling out a furrow at least 5 inches wide and as long as you'd like, digging down to 1 - 2 times the widest diameter of the seed. Sprinkle the seeds randomly and generously throughout the furrow. Cover the seeds with soil and water the soil.

Hilling and Drilling:

Seeds that are large enough to handle individually can be planted by hilling or by drilling (row planting). For hilling, make a small hill in the garden from surrounding soil and place several seeds in the hill at definite intervals. Squashes, pumpkins, and melons are often planted this way. Once the seeds germinate, the hills are thinned, leaving one or two plants per hill, depending on the vegetable. Drilling is spacing seeds evenly down the row in small holes (vs. a furrow). Beans and peas are planted this way. Plant them closer than the desired final spacing because after germination, extra plants can be removed. Planting extra seeds compensates for poor germination and loss of seedlings to disease and insects. If seeds

Some Hints about Hybrid and Open-Pollinated Seed

Hybrids are the result of intentionally crossing (breeding) two or more plants. Hybrid cultivars are often superior to older, non-hybrid cultivars because they combine such desirable traits as consistency of plant and fruit type, uniform maturity, disease resistance, improved quality, and vigor. Seeds saved from hybrids do not "come true": they do not appear and perform the same as the hybrid parents. Seeds from hybrids are either sterile or express a range of parental characteristics. Hybrid seeds are often more expensive than open-pollinated seeds.

Open-Pollinated seeds are those that are naturally pollinated through wind, birds, insects, or other natural mechanisms. Open-pollinated cultivars do "come true" from seed in the same way that children resemble their parents. “Heirloom varieties” refer to historically grown seeds that were prized for their superior taste and texture. By saving seeds from the healthiest plants that produce the best tasting fruit, a gardener gradually creates their own cultivar. If plants are selected over time in a region, those cultivars are specially adapted to a region’s climate, soil, and pests. Heirloom crops keep the gene pool rich and can offer gardeners a taste of the past.

are one year old or older, plant them thicker than fresh seeds.

Watering Seeds

Seeds and seedlings should be watered every day or two. Seeds need moisture to germinate and seedlings have shallow roots, so they need to kept moist until the roots grow deeper. The formation of a hard layer, or crusting, of the soil's surface developing shortly after seeding can prevent seedlings from emerging. Heavy rains or use of overhead sprinklers may cause soil crusting. To avoid this problem, water seeds and seedlings using a light spray or soaker hose. Let water soak in and spray again until the seedbed is evenly moist.

Thinning Seedlings

Anytime seedlings grow too close together, thinning can benefit the plants selected to remain. Thinning is the process of reducing the number of seedlings in the soil or container media, giving those that remain more room to grow. If seeds are sown at the desired rate from the beginning, as with square foot gardening, thinning may not be necessary.

Thinning is a valuable practice for several reasons:

- It reduces competition among the seedlings for soil nutrients, sunlight, and water.
- It can reduce some early disease problems by providing better air circulation around the plants.
- It contributes to higher yields by giving plants the proper amount of space in which to flourish

Figure 21: Thin seedlings by snipping with scissors rather than pulling. Brook Williams

Leaf lettuce, beets, radishes, carrots, spinach, turnips, and other plants with small seeds are easily overplanted. Start thinning when the plants have one or two pairs of true leaves. True leaves are leaves above the seed leaves; the seed leaf or leaves are the leaves that are nearest to the soil surface. Evening is a good time to thin because the remaining plants have the cool, dark night to recover from any disturbance. Pinch or cut out seedlings rather than pulling them out of the soil to avoid potentially damaging nearby root systems (Figure 21).

Figure 22: Choose transplants that are stocky, have good color, well-developed roots, and have not gone to flower.
Lucy Bradley, CC by 2.0

Planting Transplants

Seedlings may be referred to as starts, sets, or transplants. They are started in containers indoors or in a greenhouse and can help plants get a jumpstart on growth when weather outside is unfavorable.

Warm-season plants can be transplanted to the garden when the danger of frost has passed. Starting cool-season crops, like lettuce and spinach, from seed in a greenhouse can help them mature before high outdoor temperatures can cause bolting.

The most common vegetables bought as young plants for transplanting are broccoli, cabbage, cauliflower, celery, eggplant, lettuce, peppers, and tomatoes. If you buy vegetable transplants, larger and taller plants are not necessarily better. Tomato plants that have already started to flower are not optimal, because flowering places the plant

Figure 23: Plant tomatoes by digging a shallow trench and laying the stems down to promote more root growth. Kathleen Moore, CC by 2.0

under stress. Good-quality transplants are stocky and medium size with a healthy appearance and good green color (not too pale and not too dark), are free from insects and diseases, and have a well-developed root system (Figure 22). Allow the transplants to harden off gradually, acclimatizing them to the conditions in the garden prior to planting.

Before transplanting to the garden, make sure the soil has been prepared according to the earlier directions and determine that the timing is appropriate for the crop. To prevent wilting, try to transplant on a cloudy day or in early evening. Check the weather forecast for the days after you intend to plant to avoid conditions that could harm new transplants. Handle the plants carefully to avoid disturbing the roots and bruising the stem

For transplants grown in a container, dig a hole large enough to accommodate the container. Peat and other fiber pots can be set directly in the planting hole. Although the pots eventually disintegrate in the ground, remove any part that is above the ground as it may wick water away from the roots. For most vegetables, place the transplant in the ground at the same depth as it grew in the container.

Tomato plants are exceptions: They do develop roots all along buried stem tissue, dramatically expanding their root system. Plant by removing all but the top three sets of leaves, laying them sideways in a 3-inch to 4-inch-deep trench and burying all but the leaves (Figure 23).

Protecting New Transplants

If cold or windy conditions threaten spring transplants, place row covers, boxes, baskets, plastic milk jugs, or flower pots over the new transplants. Try to keep the covers from touching the plants, and do not leave them over the plants longer than necessary. If it gets warm during the day, remove the covers to provide proper ventilation. Summer transplants may need protection from heat for several days after they have been planted. A piece of wood or cardboard stuck in the ground at a slant on the south side of a plant can serve as a sunshade. Irrigation also helps to lower the air temperature. (For more information, see Season Extenders in the Appendix.)

Watering Transplants

It is best to gently water transplants at the base of the plant to avoid getting water on the foliage. A sprinkler can or hose with a light stream of water is good to use. Water after planting to help settle the soil around the plant and to keep the plant from drying out. Keep them well watered the first week or two to help the transplants roots take hold.

Caring for Your Garden

After planting your garden, careful maintenance of it will help keep your plants healthy and growing strong. In this chapter, you will learn about watering, weeding, fertilizing and disease and pest management.

In this Chapter:

- Watering
- Fertilizing during the growing season
- Weed management and mulching
- Disease and pest management
- Record keeping

Watering

Good watering practices helps plants develop strong root systems, so they are healthy and productive. In North Carolina vegetable gardens need more frequent watering during the summer because we typically get so little rainfall and have high temperatures in many areas. Common watering problems include frequent, shallow watering, overwatering, and waiting too long between waterings.

How Much to Water

Avoid frequent shallow watering, which promotes the development of roots in the top 1 to 2 inches of soil rather than at a greater depth. Developing plants need deep, infrequent watering to encourage root growth. Shallow rooted plants draw water from the top foot of soil; deep rooted plants draw water from deeper within the soil. For established plants, the top 2 – 3 inches of soil can dry out between waterings since the roots are getting moisture at a deeper depth. If your plants begin to wilt, you've waited too long between waterings, letting the soil dry out.

On average, vegetable gardens need 1 inch of water per week; provide only what is not supplied by rain. Keep a rain gauge in the garden to track precipitation, and adjust your watering times accordingly. Deeper rooted plants need more water when watering so the moisture penetrates deeper into the soil, but they can be watered less frequently. Water the soil, not the plant. Many diseases are spread by water splashing from the soil up on the leaves or from a diseased leaf to a healthy one. Organic mulches (straw, leaves, or compost) help conserve moisture and prevent splash.

When providing an inch of water to the garden, the goal is to wet the soil to a depth of 6 inches. After some experimenting it is easy to tell how long it takes for water to reach that depth. One way to check is to dig into the soil with a long trowel or shovel to see how far the water has penetrated the root zone. Another way is to measure how long it takes to apply 1 inch of water (which usually moistens the soil to 6 inches deep, depending on soil type) by placing small, straight-sided containers in a grid pattern over the area being watered. Check the containers every 30 minutes until they contain l inch of water. As a general guide, the average house spigot must be left running approximately l ½ to 2 hours to apply 1 inch of water to 1,000 square feet. Gardens with sandy soil must be watered more frequently than those with a high percentage of clay. Failure to provide adequate moisture stresses the plants and reduces yields. On the other hand, overwatering can lead to insect and disease problems, as well as washing nutrients away, converting a valuable garden resource into pollution in nearby streams.

When to Water

From a water conservation perspective, the most efficient time to water plants is at night. During a hot, dry, summer, this may be ideal as night-time temperatures remain high. Cooler night temperatures in the spring or fall, however, can keep water from evaporating. The longer water stays on the leaves, the higher the likelihood of disease problems. If it is cool and wet enough for dew to form on plants, the best time to water is mid-morning after the dew has dried. Watering the soil directly instead of overhead not only promotes water conservation but also saves money on your water bill.

Watering Methods

When watering, you should keep water off the plant leaves. (For things like greens that grow close together it is ok for water to get on leaves.) If your garden is not too big, you can water by hand using a hose or a sprinkling can to provide water gently directly to the plant roots. Do not use a strong stream of water; this disturbs the soil and can promote disease by splashing soil onto leaves.

Drip and trickle irrigation systems allow a gardener to irrigate slowly and efficiently. A soaker hose is the least expensive and easiest to use. It operates at low pressure and delivers small amounts of water to the soil very slowly. A full drip irrigation system provides water to individual plants and can be controlled by a timer. Gardeners can install these systems or hire a contractor. Periodically check the emitters to ensure all the heads are functioning properly.

A portable lawn sprinkler is also an option, but be sure to keep the application rate is low enough that water does not run off the soil. Also, make sure that the vegetable plants themselves do not interfere with the application pattern. Often this requires mounting the sprinkler on a small platform above the plants.

Fertilizing During the Growing Season

Some vegetables including cabbage, corn, peppers and potatoes need a lot of nitrogen for healthy growth. These plants quickly use the nitrogen in the soil season and need extra nitrogen during the growing season to keep them growing rapidly and continuously. Side-dress individual plants or hills with 1 level tablespoon of a high nitrogen fertilizer per plant (Figure 24). For widely spaced plants, such as cucumbers or cantaloupe, place the side-dressing fertilizer in bands 6 inches from the plant's base. Vegetable plants should be side-dressed about midway through their maturity cycle, except when grown on sandy soils and during periods of

For organic fertilizer alternatives and application rates, see Chapter 17 of the NCSU Extension Gardener Handbook

Figure 24: Side dressing a potato plant with one tablespoon of high nitrogen fertilizer.
Kathleen Moore, CC by 2.0

excessive rainfall; these conditions require more frequent side-dressing applications. Crops such as tomatoes, eggplant, and okra require two or three side-dressings per season because of their long growth cycles

Weed Management and Mulching

Weeds compete for available soil nutrients, water, air and sunlight, and provide a home for insects and diseases. A steel hoe is one of the most effective weapons in fighting the war against weeds, although it can be difficult to use in an intensively planted garden. When used regularly, it is effective and inexpensive. It is not possible, however, to control all weeds with a hoe alone. Weeds at the base of the plant should be pulled by hand rather than running the risk of damaging the roots (Figure 25).

Figure 25: When cultivating around plants, be careful not to disturb the roots. Consider weeding by hand. Brook Williams

Do not allow weeds to become well-established before they are removed because pulling large weeds can damage the root system of vegetable plants. Do not let weeds go to seed – that only results in planting seeds for a new crop of weeds to battle. Weed seeds can live up to 7 years in the soil, so you'll be battling weeds for a long time if you let weeds go to seed.

Weed Triage

If you don't have enough time to get rid of all the weeds in your garden, prioritize what is most important.

- First remove weeds going to seed.
- Second remove grasses and invasive weeds.
- Last remove other less invasive weeds.

Disposing of Weeds

Do not put weeds in your compost pile; they may re-sprout from a small piece of stem or root. Weeds should be thrown in the trash or put in a yard waste bin.

Mulching

Mulch can significantly decrease the amount of weeding needed (Figure 26). Mulches help retain soil moisture and reduce weed growth. Mulches fall into two categories—organic types that decompose naturally in the soil and inorganic types that do not decompose and, therefore, must be removed after serving their purpose.

Organic Mulches

Organic mulches are by far the most common. Typical examples are bark chips, compost, ground corncobs, chopped cornstalks, grass clippings, leaves, shredded newspapers, peanut shells, pine needles, sawdust, and grain straw. Organic mulches conserve soil moisture and reduce the soil temperature by 8°F to l0°F during the summer. For this reason, they should not be used too early in the spring. If mulches are applied to cold garden soils, the soil warms up slowly, causing plant maturity to be delayed. After the soil warms in the spring, organic mulch may be applied to a depth of 2 to 4 inches around well-established plants. Be sure that there is adequate moisture in the soil before applying the mulch as dry mulch can pull moisture out of the soil.

Inorganic Mulches

Inorganic mulches, such as plastic sheeting that comes in good contact with the soil, can increase soil temperature early in the growing season and reduce the weed population by excluding light. Install plastic mulch after fertilization, but before planting, when the soil is neither too wet nor too dry. Bury the edges to prevent the wind from blowing it away. Make short slits in the material with a pocketknife when planting seeds or transplants. Black plastic, which can raise soil temperatures by 5°F to 6°F, is

recommended for crops that produce fruit on the ground, such as melons, cucumbers, squash, and tomatoes, because diseases are reduced when plant foliage has no contact with the soil. Clear plastic allows sun rays to penetrate and can increase the soil temperature more than any other type of mulch—by 8°F to 14°F. Because light can penetrate clear plastic, it is possible for weeds to grow underneath if temperatures do not get high enough. Plastic mulches have hidden financial and labor costs. Plants mulched with plastic need supplemental water as roots do not receive water from rainfall, and irrigation needs to be monitored carefully. Plastic mulches degrade and should be removed and replaced regularly. Unintended environmental cost is disposal in a landfill. There are some degradeable plastic mulches available on the market that can avoid this environmental impact.

Figure 26: Weeds can be a challenge with in-ground garden beds. Straw is used here as a mulch to help suppress weeds. *Chris Alberti, CC by 2.0*

Herbicides

Herbicides are chemicals that kill existing weeds or interrupt the germination. No single herbicide controls all weeds or can be safely used for all vegetable crops. It is difficult to apply relatively small amounts of the herbicide evenly to the garden surface. Miscalculation or faulty calibration of the application equipment can cause some areas of the garden to be treated with too much or too little herbicide, leading to growth problems for some vegetables.

Disease and Pest Management

It is not possible—or even desirable—to rid gardens of all pests. Monitoring and managing pest levels instead of eliminating pests can preserve the environment, reduce costs, protect the health of humans and animals, and maintain beneficial organisms such as birds, bees, butterflies, and other pollinators.

Pests as Part of a Natural System

Pests in a garden or landscape may include insects and mites, plant diseases, mammals, and birds. It can be tempting to look for a quick solution to an insect feeding on a garden plant. What we call "pests" are part of a natural system at work. An ecosystem has no pests. Only humans consider certain species pests when they occur in landscapes where they are not wanted. We will be more successful in managing unwanted species when we realize that these organisms follow predictable patterns that we can use to our advantage.

When modern pesticides were first developed, they were used extensively. Pests susceptible to a pesticide were quickly killed, leaving resistant ones to breed and multiply. It became clear that pesticides alone would not solve all pest problems. Scientists began to develop a new approach to pest control. This new approach was described as *integrated pest management* (IPM). *Integrated* refers to the fact that all control measures (cultural, mechanical, biological, and chemical) are considered and used as appropriate. An IPM program allows some level of pests in the environment. Pests are much less likely to survive a program that uses many different methods of reducing their populations.

Pesticides may be an attractive option for homeowners because the formulations can be inexpensive, easy to use, and can provide

quick results. However, they often also impact beneficial insects and other non-targeted organisms. An IPM plan may be slower to show results and could require more effort than spraying a chemical, but the reduced impact on the environment can be worth the investment. The more gardeners learn about biological and ecological processes, the more imaginative they will be in formulating and implementing IPM programs.

Formulating an IPM Plan

IPM begins with a careful evaluation of each pest infestation. The life cycle of the pest, possible damage, natural enemies, and effects of weather, among other factors, are considered before a control plan is implemented. Only then can one decide about the appropriate tactics necessary to suppress pests. IPM has 5 steps (Figure 27).

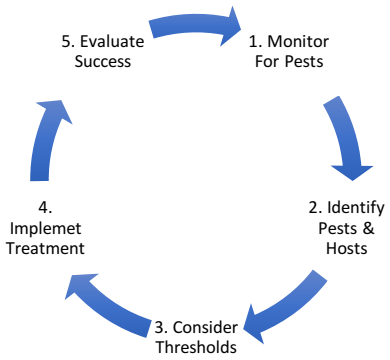


Figure 27: IPM is a continuous 5 step process starting with monitoring your garden.

Considering how many pests or how much damage you can tolerate (your "threshold") is an important part of IPM. A few caterpillars might be ok if they will hatch into beautiful butterflies. Leaves that have been munched may not be pretty but many corps can lose 25% - 35% of their leaf surface without impact on crop yield. Trading off aesthetic concerns for some damage can be beneficial to the environment and lighten the maintenance of your garden.

IPM Controls

Prevention is the first tool in pest management because it is the most effective, least expensive, most environmentally friendly solution. Choosing a healthy plant that thrives in the desired location with the available light, planting it carefully, and ensuring that it has adequate water and nutrients prevents stress and minimizes pest problems. Stressed plants can attract pests. The second most important tool in pest management is *early intervention*. Being present and observant in the garden ensures early detection. Reacting to problems quickly, before they have time to multiply, requires a less dramatic intervention. The third most important tool is *record keeping*; tracking what happens in the garden enables a gardener to recognize patterns and make informed decisions. Record planting dates, varieties, purchase location, dates of problem onset, weather conditions, management strategies and their effectiveness, and other kinds of information that help us recognize relationships and form gardening strategies.

Many safe, practical, nonchemical methods of plant protection and pest management may reduce or eliminate the need to spray. Other methods are most beneficial when used with pesticides. To implement management practices correctly and to minimize losses, gardeners should be aware of the types of pests that attack plants and understand pest biology. Scouting methods, equipment selection, timing, and other pest management practices all depend on an accurate knowledge of the pest.

Pest management methods fall into four groups: cultural management, mechanical management, biological management and chemical management. .

Cultural Management

Keeping plants healthy and preventing plant stress helps plants to better withstand and repair the damage caused by an insect or mite pest. Some evidence indicates that healthy plants resist infestation by pests better than plants with low vigor. The most effective and most important of all practices is to observe what is going on in the garden. Many serious disease or insect problems can be halted or slowed by regularly visiting the garden, knowing what to look for, recognizing potential problems, and intervening early. Cultural methods include preparing the soil, plant selection, crop rotation, interplanting and timing planting

dates to avoid pests. Managing weeds, which was covered earlier in this section, is another cultural management method.

Soil Preparation

Providing a favorable soil environment encourages the growth of healthy roots, increasing access to water and nutrients, preventing stress, and making the plant more resistant to pests and diseases than plants in poor soil. Conducting a soil test and applying only the recommended amount of fertilizer and lime maximizes the benefit to the plant while minimizing problems related to excessive use of fertilizer. Covering the soil with several inches of organic mulch protects the plant in several ways: reducing soil water loss to evaporation, minimizing weed competition, providing nutrients, and creating a suitable environment for earthworms and microorganisms that keep the soil loose for roots and break down organic material to release nutrients. Do not use manure or compost that has not thoroughly decomposed as a top dressing because it can encourage millipedes, white grubs, and other pests.

Plant Selection

Use disease-free and insect-free certified seeds and plants if available. Select plants that are healthy, with well-developed root systems. Avoid accepting plants from friends if there is any chance of also getting insects or diseases. Examine plants carefully (tops of leaves, bottoms of leaves, stems, and soil) before planting to be sure they are clean.

Consider planting cultivars identified as resistant to pests. Resistant cultivars are those that repel, are unattractive to, or otherwise are unsuitable as food for certain pests or that withstand feeding by certain pests with little reduction in yield or quality.

Crop Rotation

Planting two similar crops in successive years tends to increase pest problems. Many vegetables are closely related and have the same pests and diseases. Some insects hibernate or lay eggs in or on the host plant. Do not grow the same kind of vegetable in the same place each year. Use related crops in a site only once every three or four years. The rotation period for avoiding some tomato diseases may be five to seven years.

Interplanting

If you have a lot of space in your garden, avoid placing all plants of one kind together; instead spread them throughout the garden. Consider alternating groups of different plants within rows or patches (Figure 28). Insects that become severe on cabbage probably also infest nearby mustard, broccoli, and collards, but they may not spread to cabbage planted on the other side of the garden. Interplanting can also slow the spread of diseases, giving the gardener more time to develop a management strategy. Marigolds and garlic are two plants recommended as insect repellants; however, most of these recommendations are unproven. In some cases, the evidence indicates these plants are not effective repellants.

Figure 28: Zinnias interplanted with kale.
Kathleen Moore, CC by 2.0

Planting Dates

Time plantings so that most of the crop avoids the peak of insect infestations. Plant squash seeds or seedlings as early as possible in the season to avoid borers, which lay eggs in July. Early plantings of sweet corn may reduce occurrence of corn earworm, especially if crops are harvested

before July 15. Delay planting warm weather crops until after the soil has warmed to avoid seed and root rot and promote vigorous growth.

Limitations of Cultural Management

The use of cultural controls for pest management requires advanced planning on the gardener's part. Although it may sound simple to plant resistant vegetable varieties, these varieties must be located and purchased in advance. In some cases, varieties may not be available locally but special orders can sometimes be placed at a nursery or ordered online.

Crop rotation is a valuable cultural method for reducing insect and disease issues, but many gardeners do not have the room to sufficiently implement this practice. Where space is limited, it may be best to allow the garden to lay fallow for a year or two or more. Consider raised beds with new soil or plant in containers when you know a disease problem exists. At the very least, skip growing the crops, and crop families, that have experienced pest issues.

Mechanical Management

Handpicking

Inspect plants regularly for egg clusters, bean beetles, caterpillars, and other insects. If they are identified as harmful to the plant handpick as many as possible (Figure 29). To avoid the task of hand-squashing the pests, knock the insects and egg clusters into a coffee can or quart jar with a small amount of water and a bit of dish detergent.

Figure 29: Hand-picking large insects like caterpillars and throwing them in a bucket of soapy water is an effective physical management technique. *Kathleen Moore*, CC by 2.0

Traps

Insect traps can assist with detection and management. Use caution, however, as many traps are of limited use or may lure pests to the garden. Some traps are easy to make from materials around the home. A shallow tin of beer partially embedded in the soil makes an effective trap for slugs. Slugs hiding under boards during the daylight hours should be removed and disposed of daily. Yellow plastic dishpans filled with soapy water can attract aphids. Yellow sticky traps made with boards painted yellow and lightly coated with oil or grease catch whiteflies and cucumber beetles.

Figure 30: This squash plant has its stem wrapped in nylon stockings and foil to protect from vine borers. *Karen Jevsevar, CC by 2.0.*

Barriers

Mechanical barriers can help to exclude some pests but are not effective if the pest population is large. Aluminum foil and other reflective mulches can repel aphids. Crushed eggshells or hydrated lime spread around plants discourages slugs. Copper tape can be an effective barrier for slugs. While heavy mulch is good for weed management, it gives slugs a place to hide.

Collars made of cardboard, tin cans, or aluminum foil and inserted halfway into the soil are effective barriers to cutworms (Figure 30). They prevent cutworms from being able to feed on seedling stems.

Figure 31: A floating row cover can protect crops from flying insects. Aaron Bauger, CC by 2.0

Floating row covers of spun polyethylene are a little more expensive, but they can be quite effective at excluding insects (Figure 31). They can keep insects off plants, however they need to be removed when plants are in flower to allow pollination to occur.

Net-covered cages over young seedlings help prevent insect, bird, and rabbit damage. Electric fence barriers prevent large mammals such as deer or raccoons from feeding on plants, though fences can be expensive and time consuming to install.

Water Sprays and Irrigation

Aphids and other insects often feed on the underside of leaves. Spraying infested plants with a strong stream of water dislodges and kills many spider mites, aphids, and other relatively fragile insects. Rain is one of the greatest natural management strategies for spider mites; populations tend to build up during dry weather.

Hose adapters can be purchased that have a motion sensor and can spray a stream of water at an animal such as a squirrel, deer, or raccoon. These are most effective if pointed at a specific area needing protection, such as a vegetable garden bed.

Frightening Devices

Frightening is a management method that can vary greatly in its effectiveness. Popular examples are scarecrows and aluminum pans or CDs hung in the garden where they move in the breeze. For scarecrows to be effective they need to be frequently moved around the garden.

Limitations of Mechanical Management

Mechanical methods require time and can be more practical for small gardens. For example, the use of row covers to exclude pests can be effective. Depending on the size of the garden, however, it may be a large expense and time investment to place the row covers, remove them to allow for pollination, and replace after pollination. Handpicking also has limitations. Once crop damage is noticeable, it might be too late for handpicking to be effective. This is why observing is so important to any IPM strategy. Actively monitoring the crops and looking for the first signs of damage keeps the insect populations at a level that allows handpicking to be successful.

Biological Management

Biological management is the process of reducing a pest population by using predators, parasitoids (often called parasites), or disease organisms that ordinarily occur in nature. The greatest single factor in keeping plant-feeding insects from overwhelming the rest of the world is that they are food for other insects.

Parasitoids and predators

Parasitoids and predators are available through garden catalogs and gardening magazines, but some insects sold as biological control agents—such as praying mantises and lady beetles—are not very effective for home gardeners. This is because they are either highly mobile (lady beetles) or nonselective, eating as many beneficial insects as pests, and potentially cannibalistic (praying mantises). It is far more

Figure 32: A braconid wasp on rambling dock. Braconid wasps are parasitoids or parasites that kill their hosts which include aphids, beetles, caterpillars, squash bugs, and stinkbugs
John Tann, Flickr CC by 2.0

effective to create an environment that attracts and supports naturally occurring predators and parasitoids. Tolerate some pests in the yard; look at them as food for the beneficial insects (Figure 32). If beneficial insects have no food, they move to another location. Minimize the use of pesticides that can kill beneficial insects as well as pests.

Pathogens

Pathogens are disease-causing organisms, including viruses, bacteria, and fungi that kill or debilitate their hosts. They are usually specific to certain insects.

The most successful example of biological management is the use of bacteria to kill caterpillars. Bacillus thuringiensis (Bt) is a bacterium that infects larvae. Several formulations are available (under different trade names) that provide effective management of several types of caterpillars without harming people or domestic animals. More than 400 insect species are susceptible to this important insect pathogen. Be sure to use the proper strain for the pest under management.

Bacillus thuringiensis is quite slow in its action. For example, caterpillars that consume some of the spores stop eating within two hours, but may continue to live and move around until they die, which may be 72 hours later. When this occurs, the untrained gardener may assume the material was ineffective because of the continued pest activity and impatiently apply a chemical pesticide. Some insects have developed resistance to Bt because of its overuse on some crops.

Limitations of Biological Management

Biological management can be an effective means of killing harmful pests. Timing, however, can be a challenge. Purchased natural predators are often effective for only a short period because they tend to move out of the area in which they are released.

Chemical Management

If the pest has been correctly identified and is still a problem after other management strategies have been implemented, chemical options may be considered as a last resort. There is a wide range of pesticides available. Herbicides are available to kill weeds, insecticides to kill bugs, and fungicides and antibiotics to manage diseases. It is imperative that the selected chemical is labeled both for management of the offending pest and for use on the specific type of plant upon which it is to be sprayed.

All pesticides are chemical (whether they are categorized as botanical, inorganic, microbial, or petroleum-based). There are three categories of approved organic pesticides *of natural origin*:

- Plant-derived products that contain the active ingredients pyrethrin, rotenone, nicotine or other botanical chemicals
- Inorganic products, such as sulfur, copper, diatomaceous earth, kaolin clay, and boric acid
- Microbial products, such as beneficial nematodes, *Bacillus thuringiensis,* and spinosad

In addition, there are a select few synthetic pesticide products derived from fatty acids of potassium salts, such as insecticidal soap, and petroleum-based horticultural and dormant oils, used to smother scale and other soft-bodied insects. Horticultural oil in combination with bicarbonate salts, such as baking soda, may also be used to prevent powdery mildew on crops such as cucurbits.

Organic pesticides are not necessarily safer than synthetic insecticides, either to the user or the environment. For instance, products containing rotenone or pyrethrins are extremely toxic to fish. Insecticidal soaps are poisonous to some crops, and many organic pesticides are harmful to some beneficial insects. All pesticides, natural or synthetic, are toxins designed to kill pests, and should be treated as poisons. Read the label carefully and use the product only as directed. All users are legally required to follow the instructions on the pesticide label including the amount and timing of application.

Limitations of Chemical Management

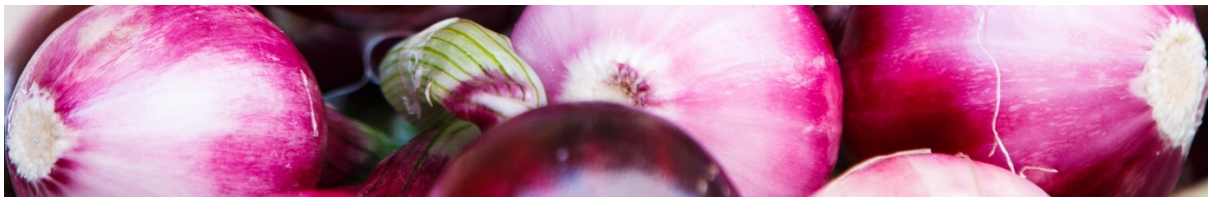
Misuse of pesticides can result in killing all the insects vulnerable to the active ingredients, leaving only the strongest to mate and reproduce. This results in pests quickly evolving resistance to the chemicals.

In addition, pesticides can kill beneficial insects as well as pest species. Because pest populations generally recover more quickly, the pest problem may soon be much worse than it was initially. Pesticide applications can also lead to outbreaks of secondary pests and can have adverse impact on non-target organisms that eat insects or leaves contaminated with pesticide. Pesticides may be carried into streams by storm water runoff and cause unintended consequences. Further potential problems with chemical management are direct hazards to the user and secondary exposure of family, friends, and pets to pesticide residue.

Record Keeping

Figure 33: A garden journal can be traditional pen and paper, like this one. Or entries can be recorded on a digital device.
Brewbooks, Flickr via Compfight CC by SA 2.0

As with other hobbies and important tasks, keeping a journal or record of what was done and how it worked is helpful. Information from previous years helps to assess what to do better when planning next year's garden. Records can be kept in a notebook, on a garden calendar or on-line (Figure 33). Items that can be included are a diagram of the garden, plant varieties, dates of planting, how many transplants were planted and how many survived, descriptions of diseases or pests with any action taken and its effect, dates of harvest, amount of rain, amount and type of fertilizer used, evaluation of overall results, ideas for next year, and photographs of plants. The planting plan and planting maps discussed in the Planning Your Vegetable Garden chapter are a great addition to your garden journal. See the Appendix for more information on keeping a garden journal.



Harvesting Your Vegetables

With good preparation of your garden and careful care during the growing season, you will have a bounty of vegetables to harvest.

In this Chapter:

- When to harvest
- Harvesting methods
- Harvesting guidelines
- Saving seeds

When to Harvest

Vegetable nutritional content, freshness, and flavor depend on the stage of maturity and time of day that vegetables are harvested. Overly mature vegetables are stringy and coarse. The harvesting guidelines in this chapter will help you identify when to harvest a specific vegetable.

When possible, harvest vegetables during the cool part of the morning and process them as soon as possible

Harvesting Methods

There are three techniques for harvesting most vegetables: cutting the vegetable, pulling the entire plant, and cut and come again. The harvesting guidelines will be helpful here as well.

Cutting the Vegetable

This technique is used for those vegetables that grow from a stem on the plant. You can use scissors, hand pruners or a knife to cut the fruit from the plant for cucumbers, squash, melons, tomatoes, peppers, eggplant, corn, broccoli cauliflower and okra. For others, like beans and peas,

gently hold the plant stem and pull the pods from the plant (Figure 34).

Figure 34: For snap beans, gently pull the pods off while holding onto the plant so you don't damage it. *Rob Bertholf*, CC by 2.0

Pulling the Entire Plant

This method is used for root vegetables like carrots, radishes, onions, beets, potatoes and parsnips (Figure 35). It is also used for head lettuce. For root vegetables, loosen the soil gently and pull up a plant to see how big it is. Root vegetables are more tender and delicate in flavor if eaten younger and smaller. As they get older and larger, they get tougher, woodier and more pungent. If that's okay with you, you can store some root crops right in the cold ground after the tops die. Spread a thick layer of leaves, straw or other mulch to keep them from freezing.

Figure 35: Harvest root vegetables like onions by pulling the entire plant out of the ground. *Kathleen Moore, CC BY - 2.0*

Cut and Come Again

This technique is used for leaf vegetables including lettuces (except head lettuce), spinach, mustard greens, collards and swiss chard. When leaves are young and tender, use scissors to cut the largest leaves individually from the plants. When the smaller leaves get big enough, harvest those. You will be able to come back to a plant, even as soon as after a few days, for additional harvests (Figure 36).

Figure 36: Swiss chard is harvested by cutting off the mature stems on the outside of the plant. Younger leaves will continue to grow for additional harvesting. *Kathleen Moore, CC BY - 2.0*

Harvesting Guidelines

Some brief guidelines for harvesting vegetable crops are provided below. Average yields shown are per square foot.

Asparagus (0.08 to 0.1 pounds). Harvest the spears when they are at least 6 to 8 inches tall by snapping or cutting them at ground level. Up to eight spears per plant may be harvested the second year after planting. A full harvest season lasts four to six weeks during the third growing season.

Beans, lima (0.08 to 0.17 pounds shelled). Harvest when the pods first start to bulge

with the enlarged seeds. Pods must still be green, not yellowish.

Beans, snap (0.38 to 0.6 pounds). Begin harvesting before seeds develop in the pod (when pods are about the diameter of a pencil). Beans are ready to pick if they snap easily when bent in half).

Broccoli (0.33 to 0.5 pounds). Harvest the dark-green, compact cluster or head (about 6 inches in diameter) while the buds are tight, before any yellow flowers appear. Smaller side shoots develop later, providing a continuous harvest.

Brussels sprouts (0.25 to 0.38 pounds). Harvest the lower sprouts (small heads) when they are about 1 to 1½ inches in diameter by twisting them off. Remove lower leaves along the stem to hasten maturity,

Cabbage (0.5 to 0.75 pounds). Harvest when the heads feel hard and solid.)

Carrots (0.5 to 0.8 pounds). Harvest when the roots are ¾-inch to 1 inch in diameter. The largest roots generally have the darkest tops. Mulched fall carrots can be left in the ground all winter and harvested as needed.

Cauliflower (0.33 to 0.5 pounds). Exclude sunlight (blanch) when the curds, or heads, are 1 to 2 inches in diameter by loosely tying together the outer leaves above the curd with a string or rubber band. Some varieties are self-blanching. Harvest the curds when they are 4 to 6 inches in diameter but still compact, white, and smooth. The head should be ready 10 to 15 days after tying.

Collards (0.33 to .67 pounds). Harvest older, lower leaves when they reach a length of 8 to 12 inches. New leaves grow as long as the central growing point remains, providing a continuous harvest. Whole plants may be harvested and cooked if desired).

Corn, **sweet** (36 kernels). Silks begin to turn brown and dry out as the ears mature. Check a few ears for maturity by opening the top of the ear and pressing a few kernels with a thumbnail. If the liquid exuded is milky, rather than clear, the ear is ready for harvest.

Cucumbers (0.2 to 0.5 pounds). Harvest when the fruits are deep-green, before any yellow appears. The length should be 2 to 3 inches for sweet pickles, 5 to 6 inches for dill pickles, and 6 to 8 inches for slicing. Pick cucumbers four to five times per week to encourage continuous production. Mature cucumbers left on the vine stop production of new fruits.

Eggplant (0.33 to 0.5 pounds). Harvest when the fruits are 3 to 5 inches in diameter and their color is a glossy purplish-black. (Lilac and white cultivars of eggplant are also available.) The fruit is getting too old when the color starts to dull or become bronzed. Because the stem is woody, cut—do not pull—the fruit from the plant. A short stem should remain on each fruit

Kale (0.33 to 0.67 pounds). Twist off the outer, older leaves when they reach a length of 8 to 10 inches and are medium-green in color. New leaves grow, providing a continuous harvest. Heavy, dark-green leaves are overly mature and are likely to be tough and bitter.

Kohlrabi (0.38 to 0.6 pounds). Harvest when the bulb (the edible part) is 2 to 3 inches in diameter. Cut off the plant just below the bulb. Stems become woody if the bulb is left too long before harvest.

Lettuce (0.33 to 0.4 pounds). Harvest the older, outer leaves from leaf lettuce as soon as they are 4 to 6 inches long. Harvest heading types when the heads are moderately firm and before seed stalks form.

Muskmelons (**cantaloupe**) (0.28). Harvest when the stem slips easily from the fruit with a gentle tug. Other indicators of ripeness are that the netting on the skin becomes rounded and the flesh between the netting turns from green to tan

Mustard (0.33 to 0.67 pounds). Harvest the leaves and leaf stems when they are 6 to 8 inches long; new leaves provide a continuous harvest until they become strong in flavor and tough in texture from temperature extremes.

Okra (0.29 to 0.33 pounds). Harvest young, tender pods when they are 2 to 3 inches long. Pick at least every other day during the peak growing season. Overly mature pods become woody and are too tough to eat.

Onions (0.5 to 0.8 pounds). Harvest when the tops fall over and begin to turn yellow. Dig the onions and allow them to dry out in the open sun for a few days to toughen the skin. Then remove the dried soil by brushing

the onions lightly. Cut off the stems, leaving 2 to 3 inches attached to the bulbs, and store them in a netted bag in a cool, dry place.

Peas, English and Southern (.07 to 0.13 and 0.13 to 0.2 pounds). Edible-podded cultivars should be harvested when pods are well-rounded, but before seeds are more than half of their full size. Harvest regular peas when the pods are well rounded and the seeds are fully developed but still fresh and bright-green. Pods are getting too old when they lose their brightness and turn light-green or yellowish-

Peppers (0.2 to 0.3 pounds). Harvest sweet peppers when the fruits are firm, crisp, and full size. Green peppers turn red if left on the plant. Allow hot peppers to attain their bright color (color depends on variety) and full flavor while attached to the vine; cut and hang them to dry (if desired.

Potatoes (**Irish**) (0.33 to 0.6 pounds). Harvest the tubers when the plants begin to yellow and die down. Store the tubers in a cool, high-humidity location with good ventilation, such as the basement or crawl space of the house. Avoid exposing the tubers to light. Greening, which denotes the presence of dangerous alkaloids, occurs even with small amounts of light.

Pumpkins (0.5 to 0.6 pounds). Harvest pumpkins and winter squash before frost and after the vine dries, the fruit color darkens, and the skin surface resists puncture from a thumbnail. Avoid bruising or scratching the fruit while handling it. Leave a 3-inch to 4-inch portion of stem attached to the fruit and store in a cool, dry location with good ventilation.

Radishes (0.08 to 0.11 pounds). Harvest when the roots are ½-inch to 1½ inches in diameter (Chinese radishes grow much larger). The shoulders of radish roots often appear through the soil surface when they are mature. If left in the ground too long, they become tough and woody.

Rutabagas (0.33 to 0.57 pounds). Harvest when the roots are about 3 inches in diameter. Mulched roots may be left in the ground and used as needed.

Spinach (0.23 to 0.36 pounds). Harvest by cutting all the leaves off at the base of the plant when they are 4 to 6 inches long. New leaves will grow, providing additional harvests.

Squash, **summer** (0.3 to 0.5 pounds). Harvest when the fruit is soft, tender, and 6 to 8 inches long (3 to 4 inches across for patty pans). The skin color often changes to a dark, glossy green or yellow, depending on cultivar. Pick every two to three days to encourage production.

Sweet potatoes (0.25 to 0.33 pounds). Harvest the roots when they are large enough for use and before frost. Avoid bruising or scratching during handling (damaged sweet potatoes rot easily in storage). Ideal storage conditions are a temperature of 55°F and a relative humidity of 85%. The basement or crawl space of a house may suffice

Swiss chard (0.33 to 0.67 pounds). Harvest by breaking off the developed outer leaves 1 inch above the soil. New leaves will grow, providing a continuous harvest.

Tomatoes (0.25 to 0.5 pounds). Harvest the fruits at the most appealing ripeness stage, up to fully red. (There are some yellow and purplish cultivars of tomatoes.) Flavor is best at room temperature, but ripe fruit may be held in the refrigerator at 45°F to 50°F for seven to 10 days.

Turnips (0.38 to 0.6 pounds). Harvest the roots when they are 2 to 3 inches in diameter, but before heavy frosts occur in the fall. The tops may be used as greens when the leaves are 3 to 5 inches.

Watermelons (0.17 pounds). Ripe watermelons produce a dull thud rather than a sharp, metallic sound when thumped. Other ripeness indicators are a deep-yellow rather than white color where the melon touches the ground, brown tendrils on the stem near the fruit, and a rough, slightly ridged feel to the skin surface).

Saving Seeds

Saving seeds dates back thousands of years and is the practice that moved humans from a hunting and gathering existence to the agricultural one we are familiar with today. Saving seeds from a garden can be a fascinating, fun way to develop an improved strain, with better qualities and better

adapted to the conditions of your garden. Seed-saving also saves money and provides another way to share your bounty. To maximize your success, follow these guidelines.

Select parent plants carefully:

Avoid hybrid plants, which are often sterile or do not reproduce offspring similar to the parent.

Many plants are self-pollinating so they produce seeds like the parent plant. Beans, eggplant, lettuce, peas, peanuts, peppers, and tomatoes are usually self-pollinating and remain true to type.

Open-pollinated plants that are pollinated by wind or visited by insects can cross-pollinate with plants from their own family and could produce disappointing offspring. Basil, beets, broccoli, cabbage, cauliflower, celery, corn, cucumbers, kale, melon, mustard greens, onions, parsley, pumpkin, spinach, squash, Swiss chard, radish, and turnips are open-pollinated plants. To ensure you have the original variety of these vegetables, grow only one type and be sure there are no other varieties within several hundred feet. This is often impractical for the home gardener, so cultivars can be isolated in screened cages or individual flowers can be covered and hand-pollinated. Timed isolation or timing plantings so that different varieties are flowering at different times is another strategy.

- Determine the characteristics you want to select for flavor, color, fragrance, size, harvest time, vigor.
- Select fruits of plants that best express the traits you want to save.
- Select fruit from disease-free plants.

Harvest at the optimum point:

Seeds are ready when the fruit is ripe, and in some cases, overripe. For example, to save seeds from tomatoes, pick the fruit when ripe, remove the seeds, and eat the rest of the fruit. Rinse the pulp from the seeds and air dry thoroughly over the next few weeks. To save seeds from a pole bean, allow the pods to brown and dry on the vine. Place pods on a tray to further air dry and remove seeds.

To store seeds safely package the seeds in paper envelopes or glass jars labeled with the cultivar name and date (Figure 37). Plastic bags may cause the seeds to rot. Place the seeds in the freezer for two days to kill pests. Store in a cool, dark place. The fridge or freezer is ideal. Most seeds stay viable for several years in a freezer

Figure 37: Saving seeds in glass jars with tight fitting lids. Be sure seeds are thoroughly dry. Jars can be stored in the freezer to prolong the viability of the seeds. Kathleen Moore, CC BY - 2.0

Saving Your Vegetables

Your garden may be so prolific your harvest produces more vegetables than can be eaten fresh. There are many options for using the produce, including canning, freezing, pickling, and drying. These practices allow you to eat from your garden all year. Learn more about preserving your harvest from the NC State Extension— Family and Consumer Sciences website.

Herbs

Herbs are plants that add interest and flavor to our foods and perfume our homes. Herbs are pest-resistant plants that are relatively easy to grow. If you are adding herbs to your garden, start with the herbs that are used the most. For example, choose basil, fennel, and oregano for Italian cooking; lavender and lemon verbena for making potpourri; or chamomile and mints to make teas.

Growing Herbs

Some of the herbs familiar to North Americans, such as bay laurel, dill, lavender, marjoram, oregano, rosemary, and thyme, are native to the Mediterranean region. These herbs grow best in soils with excellent drainage, bright sun, and moderate temperatures.

When growing herbs, follow these basic guidelines:

- Plant herbs in average garden soil with organic matter added to improve texture and drainage.
- Choose a site that receives at least 6 hours of direct sun each day.
- Avoid ground where water stands or runs during rains.
- Compensate for poor drainage with raised beds.
- Apply balanced fertilizers sparingly to leafy, fast-growing herbs. Heavy applications of fertilizer, especially those containing large amounts of nitrogen, may decrease the concentration of essential oils in the lush green growth.

In this Chapter:

Figure 38: Planting herbs in containers is a popular way to grow herbs.
Kate Bolin, CC BY - 2.0

For information on specific herbs see the North Carolina State Plant Database website on the internet.

Most herbs require little special care after being established. Plan an herb garden by grouping herbs according to light needs, irrigation, and soil requirements. Most herbs enjoy full sun, but a few tolerate shade. Herbs can be classified as either annual, biennial, or perennial. Be aware of the growth habits of the plants before purchasing them. Some herbs—such as anise, borage, caraway, chervil, coriander, dill, and fennel—should be direct-seeded because they do not transplant well. Other herbs, such as mints, oregano, rosemary, tarragon, and thyme, should be transplanted to ensure production of the right plant and to obtain desired growth the first year.

To conserve moisture and prevent splashing mud on the plants, mulch an herb garden after planting. If you are planting from seed, wait until germination and establishment of the plants and then mulch. Use 1 to 2 inches of organic material. Many growers mulch with hardwood bark or a mixture of bark and sawdust.

When grown outdoors and given ample air circulation, sunlight, and water drainage, herbs rarely suffer severe disease or insect damage. Natural predators and parasites usually keep mite and aphid populations low. Traditional pesticides are not labeled for use on culinary herbs, so rely on cultural, biological, and physical management techniques. Insecticidal soap is useful against severe outbreaks of aphids, mites, and whiteflies. Hand -pick larger pests such as beetles and caterpillars.

Growing a diverse group of herbs can be attractive. Herbs provide color, fragrance, and interest throughout the season, and they help to keep pest problems at a minimum.

Harvesting Herbs

Most herbs grow healthier and fuller if they are harvested frequently. The method of harvesting depends on which herbs and their use.

- Begin harvesting herb leaves when the plants are well-established, but before flowering to keep leaf production high
- Harvest up to three-quarters of the current season's growth.
- Harvest early in the morning, after the dew dries but before the sun becomes hot.
- Herb flowers have their most intense oil concentration and flavor when harvested after flower buds appear but before they open.
- Herb flowers harvested to dry for craft purposes should be picked just before they are fully open.
- Annual herbs can be harvested until frost.
- Perennial herbs can be clipped until late August. Stop harvesting about one month before the frost date. Later pruning could encourage frost tender growth.
- Harvest lavender flowers in early summer, and then shear the plants to half their height to encourage a second flowering period in the fall.

Preserving Herbs

Herbs acquire their fragrance and flavor from oils that evaporate into the air when the leaves are crushed. Ideally, use fresh herbs

for cooking. But to preserve and retain quality for later use, freezing is one of the easiest methods. Rinse the herbs quickly in cold water, shake off excess moisture, and chop coarsely. Freeze generous pinches of herbs in filled ice cube trays to prevent freezer burn, or loosely spread the herbs onto a cookie sheet to freeze. Then transfer the herbs into a large plastic bag and seal. Thawed herbs are unsuitable for garnish, but they can be used in cooking.

Drying is the traditional method of herb preservation. Simply tie fresh herb stems into small bundles and hang upside down in a dark, warm, airy place (Figure 39). UV rays from the sun and moisture from dew and frost can discolor and severely reduce the quality of many herbs. Shade drying allows the crop to be dried more slowly and uniformly than in direct sun.

Figure 39: Drying herbs by hanging the upside down in a dry warm place.
Caitlin Regan, CC BY - 2.0

When the leaves are dry, separate them from their stems and package in rigid, light-proof containers. To preserve full flavor, avoid crushing the stems. Sage, thyme, summer savory, dill, and parsley are easy to dry. Basil, French tarragon, and mints mold if not dried quickly. An alternative method of drying is to spread the herbs out on window screens. Keep them out of the sun and turn them often.

Herbs can also be dried in a microwave. Lay a single layer of clean, dry leaves between dry paper towels and put them in the microwave for 1 minute to 2 minutes on high power. Let the leaves cool. If they are not brittle, reheat for 30 seconds and retest. Repeat as needed, until they are brittle.

Store dry herbs in an airtight bottle, preferably brown glass, in a cool place out of direct sunlight and away from heat. Use for cooking within a year for maximum freshness.

To air dry herbs with seeds, tie the herbs in small bundles and suspend inside a paper bag with holes. Suspend the bag in a dark area that has good air circulation. Collect the seeds when they are dry, and store in rigid, light-proof containers.

APPENDIX

Garden Tools

Gardening is much easier if you use the proper tools. Various kinds of gardening equipment are described in the following section. It is not necessary, however, for home gardeners to own all of these tools. A few of them are more useful for some crops than others. All are readily available at garden supply stores. Only buy what you need, and always buy the best tool you can afford. Quality tools last longer, do the job better, and are easier to use. Soon you will have a useful collection.

Types of Tools

Spades for digging and lifting

- A round pointed shovel is a good all-purpose tool that is useful for digging and turning soil and can also be used to harvest crops such as Irish potatoes and sweet potatoes.
- A spade with a sharp edge is used for cutting and digging heavy soil, removing sod, and incorporating organic matter.

Forks for turning and carrying

- ·A garden fork with thick, square tines is good for mixing a compost pile or loosening soil.
- ·A pitchfork with longer, thinner tines is good for moving light, loose material, such as straw.

Rakes for smoothing and gathering

- A bow rake is good for smoothing out soil, removing stones, and breaking up clods.
- A straight rake is designed so that its back can be used to smooth the seedbed and to compact soil over freshly sown seed for improved germination.
- Rakes can also be used to gather into piles dead or spent crop materials.

Hoes for cultivating and weeding

- A common hoe, also called a square-blade hoe, works for most garden jobs.
- A pointed hoe, also called a Warren hoe, is good for opening a furrow and for cultivating between plants.
- A scuffle hoe, made in several patterns with a flat bottom, cuts weeds off under the soil surface as it is pushed back and forth between the rows. It breaks up the crust layer on top of the soil without bringing weed seeds to the surface.

Trowels for transplanting vegetable plants

- **Bypass pruning shears for cutting**
- Shears can be used to prune plants and harvest produce.

Irrigation equipment

- A watering can is useful for gently watering transplants. Drip irrigation places water exactly where and when you want it. Garden and soaker hoses are good for general watering.

Compressed-air sprayer

- This is the most popular piece of equipment for applying chemicals because it gives good coverage, especially to the underside of plant leaves.

String and stakes for aligning rows

Measuring stick is useful for determining the distance between plants and rows

Wheelbarrow or garden cart

- Either of these makes moving mulch, compost, soil, stones, tools, and harvested vegetables much easier than doing so by hand.

Spreaders to apply lime and fertilizer

- A drop spreader covers less area than a broadcast spreader with each pass over the site, but the area covered is easier to detect.
- A rotary or cyclone spreader applies materials uniformly, although the margins of the area covered may be difficult to see.

Tiller

- A tiller makes soil preparation easy for gardeners who use it enough to make the purchase worthwhile. Three types are available, all of which are driven by gasoline or electric motors. On the most common and least expensive type, the tines are mounted in front. A second type has the tines mounted in the rear. Although more expensive, the rear-tine tiller is easier to operate. Many tillers with rear-mounted tines have a reverse gear that makes it possible to work in cramped areas. A third type is the center-mounted or mid -tine tiller, which combines the advantages of the other two types.

Maintenance

Once you have selected the right tools, it is important to provide regular maintenance. Clean tools after each use. Keep your tools sharp, as sharp tools are safer and more effective than dull ones. Regularly tighten loose nuts and screws. To prevent splinters, sand rough handles. Store tools in a dry, protected space, organized in a way that enables you to find what you need. Caring for the quality tools you have selected ensures that your investment lasts for many years.

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Intensive Planting Guide

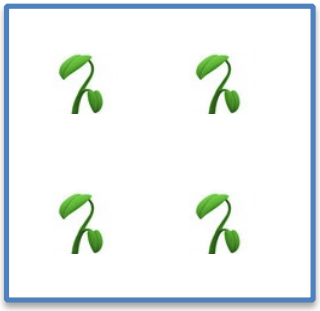
Plant	Distance between plants (Inches)
Asparagus	12
Bean, bush	2-3
Bean, lima	4-6
Bean, pole	6-12
Beets	2-3
Broccoli	6-12
Brussels sprouts	14-18
Cabbage	9-12
Carrot	2-3
Cauliflower	15-18
Chard, swiss	4-6
Collards	12-15
Corn, sweet	12
Cucumber	12
Eggplant	18-24
Endive	8-12
Kale	6
Kholrabi	4

Plant	Distance between plants (inches)
Leek	3-4
Lettuce, head	10
Lettuce, leaf	4-6
Mustard	4-6
Okra	12-18
Onion	2-4
Pea	1-3
Pepper	9-12
Potato	10-12
Pumpkin	24-36
Radish	1-2
Southern pea	3-4
Spinach	4-6
Squash, summer	18-24
Squash, winter	24-36
Tomato	18-24
Turnip	3-4

Examples of Intensive Planting

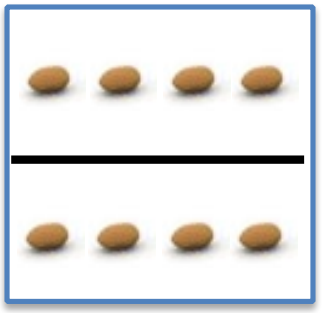
3”x3” footprint
16 plants per square foot

4”x4” footprint
9 plants per square foot

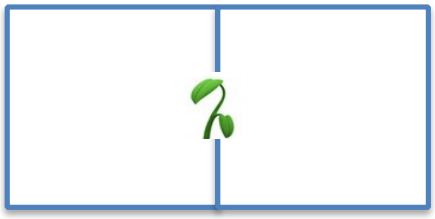


6”x6” footprint
4 plants per square foot

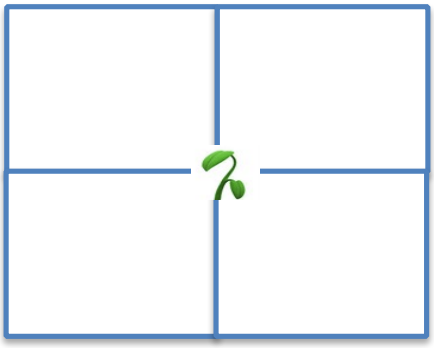
12”x12” footprint
1 plants per square foot



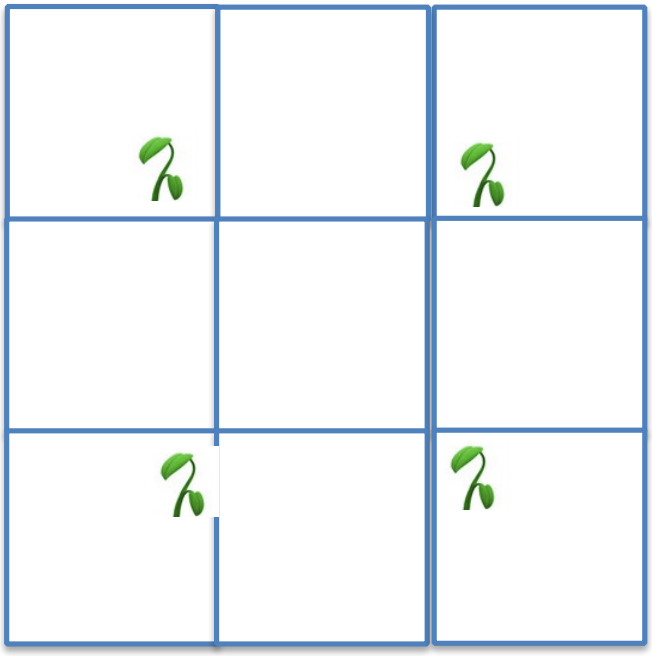
3”x3” footprint with trellis
8 plants per square foot



24”X24” footprint with
trellis
1 plant per 2 square feet



24” spacing
1 plant per 4 square foot



18” spacing
4 plants per 9 square feet

Soil Testing

Having proper nutrient levels and soil pH is important for growing healthy plants. You should have your soil tested each year for several years after establishing a new bed. Once key nutrients (potassium and phosphorous) and pH are at the proper levels and stay stable, you will only need to add nitrogen to your soil. After that, if your plants are having issues, you may want to test your soil again.

The State of North Carolina offers home gardeners the opportunity to have their soil tested for free certain times during the year, usually from April 1st thru Thanksgiving. (Free testing dates may change based on demand. Please check the Soil Testing Lab website to see when testing is free.) Soil samples can be dropped-off or mailed to the soil testing lab in Raleigh. During the "free period" you can also drop-off soil samples at the Wake County Extension Office. Soil boxes & soil information forms are also available at both locations.

Taking a Soil Sample: Needed supplies: a non-aluminum trowel, a non-metal bucket or container, a soil testing box and form, and a pen (not a pencil).

Tips for Collecting a Good Soil Sample

- Collect samples with stainless steel or chrome-plated tools. Using brass, bronze, or galvanized materials could contaminate the sample.
- The bucket in which material is collected should be made of plastic.
- Make sure the collection bucket is clean because even small amounts of residual lime or fertilizer can affect the test results.
- Avoid taking samples from areas that are obviously different from the norm, such as wet spots, compost piles, animal urine spots, and brush piles, or from under eaves or sites where trash has been burned.
- Remove large pieces of organic material, such as roots, stalks, and leaves, from the sample.
- For gardens, new lawns, and other cultivated areas, sample to the depth the soil has been, or will be, tilled. For established lawns, collect the sample 2 to 4 inches deep. For a vegetable garden, take a sample to a depth of 6" – 10". Take soil samples after compost has been added (if applicable). Even if the soil looks the same, take separate samples for flower beds, vegetable gardens, fruit orchards, shrub borders, and lawn areas.
- If using a trowel or spade, dig a hole, then take a slice of soil down one side. Repeat this procedure in five to eight spots for each area to be tested. Mix these cores together in the bucket to obtain one composite sample. If the soil is very wet, it could be more difficult to mix, but do not attempt to heat the soil to dry
- Use the pen to label your box, filling in your name, address and the boxes above **SAMPLE ID**
- Place about a pint of the composite sample for each area sampled in a soil testing box and label with a return address on the side of the box. Make up a code that will be easy to remember, such as "Veg01" for a vegetable bed. Any combination of letters and numbers can be used. Make notes about where the samples came from so that when you receive the results, you can easily Identify how to treat the areas differently based on the results.
- Do not tape the boxes in any way. The lids are removed before the boxes go in the soil lab ovens, and tape makes this process difficult. Do not put the soil in a plastic bag before placing it in the box as doing so will prevent proper drying in the lab oven.

- Using your pen, f*ill out your* ***Soil Sample Information*** form by filling in:
    - The center top of the form: last name, first name, address, phone, email address
    - The bottom left column: sample identification column (the code you wrote on your box), first crop column (e,g, vegetables) and code column (from back of form – e,g.024 for home vegetable garden). If testing for specific crops like blueberries or other things (flowers, lawn) look for the appropriate code on the back of the form.

Accessing your soil report:

By Email: If you provided an email address on your form, your results will be sent to you in an email from the Agronomic LIMS email id. This email might go to your junk or spam mail folder if the sender name is not recognized, so check there on a regular basis. It usually takes around 2-3 weeks to get your report. The email will contain a link to view and print your report.

By Internet search: If you don't get an email**,** go to the NCDA&CS website (see the URL in the Other Information section below). On the left hand side of the screen is a list of links. Click on "Find your Report (PALS)". In the Quick Search box that will appear on your screen, type in your last name and first name. This will bring up a list of names matching the one you entered, along with addresses. Click on the correct name/address combination. A list of reports for that name/address will be listed at the bottom of the screen. Click on "download" or "view" next to the report you would like to see.

Understanding your soil report: Your soil report may look a bit complicated, but there are two key areas to focus on. First is your pH level. If pH is low, a recommendation for adding lime will be provided. Second is a recommendation for fertilizer to help ensure proper N-P-K nutrient levels in your soil. Both recommendations will be in pounds for a 1,000-square foot garden, which is probably much larger than your garden. To calculate the correct amounts of amendments to be added, divide the pounds of lime or fertilizer recommended by 1,000 and then multiply by the square feed in your garden (for example, if your garden is 4 feet x 8 feet, multiply by 32). If the number you get is less than one, multiply by 16 to determine how many ounces of amendment you need to add.

If you want assistance in understanding your results and what you should do, you can contact your local NC Co-Operative Extension Master Gardener Volunteers for help at the number below.

Other Information:

NCDA&CS Agronomic Services Division (Soil Testing Lab)
Mailing Address: 1040 Mail Service Center, Raleigh NC 27699-1040
Physical Address: 4300 Reedy Creek Road, Raleigh NC 27607-6465
Phone: (919) 733-2655; FAX: (919) 733-2837
Website: **http://www.ncagr.gov/agronomi/**

Wake County Master Gardener Hotline
Address: 4001 Carya Dr, Raleigh, NC 27610 Phone: (919) 250-1084, M-F: 9am-12pm and 1pm-4pm

For other NC county contact information:
http://www.ncstategardening.org/extension_master_gardener/statewide/select_county

Season Extenders

For centuries, gardeners have used a wide variety of techniques for sheltering plants from cold weather—both in early spring and fall—to extend the growing season for a longer, larger harvest. Ambitious gardeners can harvest greens and other cool-weather crops all winter by providing the right conditions. Warm-season crops like tomatoes and cucumbers can get as much as a month's head start in the spring or last a month longer in the fall than their conventionally planted counterparts. There are many ways to lengthen the growing season, depending on the amount of time and money invested.

A continuum of season extenders from simplest to most complex

- Cloches
- Low tunnels and row covers
- Cold frames and hot beds
- High tunnels
- Greenhouses

Cloches

The cloche was originally a bell-shaped glass jar set over delicate plants to protect them from the elements and help them get an early start in the spring or extend the fall garden as long as possible. The definition has expanded, however, to include many types of portable structures that shelter plants from drying winds and cold air. They trap solar radiation and keep moisture from evaporating from the soil and plants. Cloches are generally lightweight, portable, and reusable. A cloche can be a wax-paper cone, a water-filled plastic cylinder, or simply a cut-off plastic milk container (It is preferable to have a design that can be closed completely at night to prevent frost damage, and opened or completely removed during the day for good air circulation. Cloches should be anchored or heavy enough that they do not blow away.

Figure A–1. Garden cloches made from cut plastic bottles protect plants from frost
Mandy Prowse, CC by ND 4.0

Row Covers and Low Tunnels

Row covers and low tunnels employ a spun-bond polyester fabric or plastic laid over an entire row or rows of a crop and sealed along the edges to trap heat and block wind. Covers and low tunnels are often used in conjunction with plastic mulch and drip irrigation. These two systems differ only in that the "tunnels" in the low tunnel system are created with the use of wire hoops pushed into the soil to hold up the fabric so it does not come in contact with plant foliage. Both methods can offer 4 – 5°F of frost protection and have the added benefits of screening some damaging insects and diseases so that yields are not only earlier and larger, but often of better quality. Be aware that some insects may be trapped under the cover because they are already present in the soil or on the plants.

Figure A–2: Row cover made from polyester fabric
Kathleen Moore, CC by 2.0

For those crops that are sensitive to heat or require pollination, care must be taken to remove these covers in a timely manner. Daytime opening is necessary for crops such as tomatoes and peppers if the temperature under the cover is expected to exceed 90°F for several hours. Under such conditions, the easiest way to ventilate quickly is to make long slits at the top of the low tunnel—but this should be done in anticipation of the high temperatures, not after the fact. Cucurbits (melons,

cucumbers, and squash) are more tolerant of high temperature.

Cold Frames and Hot Beds

Cold frames and hot beds are relatively inexpensive, simple structures that provide a favorable environment for growing cool-weather crops in early spring, fall, and into the winter months. Some are elaborate and require a large investment, but most others are reasonably priced for those who are serious about extending the season of fresh vegetables.

Cold frames rely on the sun as their sole source of heat. During the day, the soil is heated by the sun; at night, a cover can be used to slow the loss of heat. Hot beds supplement the heat from the sun with heating cables or with fresh manure buried beneath the rooting zones of the plants. The ideal location for a cold frame is a southern or southeastern exposure with a slight slope to ensure good drainage and maximum solar absorption. A sheltered spot with a wall or hedge to the north provides protection against winter winds. Sinking the frame into the ground also provides some protection and insulation. Some gardeners make their cold frames lightweight enough to be moved from one section of the garden to another. In early spring a cold frame is useful for hardening seedlings that were started indoors or in a greenhouse. The cold frame provides a transition period for gradual adjustment to the outdoor weather. It is also possible to start cool-weather crops in the cold frame and either transplant them to the garden or grow them to maturity in the frame.

Use cold frames in spring and summer for plant propagation. Young seedlings of hardy and half-hardy annuals can be started in a frame many weeks before they can be started in the open. The soil in a portion of the bed can be replaced with media suitable for rooting cuttings, such as sand or peat moss.

Fall is also a good time for sowing some cool-weather crops in frames. If provided with adequate moisture and fertilization, most cool-season crops continue to grow through early winter in the protected environment of the cold frame. Depending on the harshness of the winter and whether additional heating is used, a frame may continue to provide fresh greens, herbs, and root crops throughout the cold winter months. Cold frames can be built from a variety of materials. Wood and cinder block are the most common. If wood is used, choose a species that resists decay,

Figure A-3: Herbs and lettuce growing in a cold frame. Chris Alberti, CC by 2.0

such as a good grade of cedar. Never use wood treated with CCA, creosote, or pentachlorophenol, because these substances are harmful to growing plants. Wood frames are not difficult to build. Kits may also be purchased and easily assembled. Some kits even contain automatic ventilation equipment.

There is no standard-sized cold frame. The dimensions of the frame depend on the amount of available space, desired crops, and permanency of the structure. Do not make the structure too wide for weeding and harvesting; 4 to 5 feet is about as wide as is convenient to reach across.

Insulation may be necessary when a sudden cold snap is expected. A simple method is to throw burlap sacks filled with leaves, old blankets, or tarps over the frame at night to provide some protection and aid heat retention. Bales of straw or hay may also be stacked against the frame.

Ventilation is most critical in the late winter, early spring, and early fall on clear, sunny days. A thermometer in the cold frame can be used to monitor the daily maximum and minimum temperatures. On warm days, the sash should be

raised partially to prevent the buildup of extreme temperatures inside the frame. Lower or replace the sash early enough each day to conserve some heat for the evening.

A few special precautions must be taken with cold frames and hot beds. In summer, extreme heat and intensive sunlight can damage plants. This damage can be avoided by shading with lath sashes or old bamboo window blinds. Also, the nearly airtight cold frame slows evaporation, so it is easy to overwater. To help reduce disease problems caused by overwatering, water early in the day so that plants dry before dark.

Convert a cold frame to a hot bed:

1. Dig out an area 8 or 9 inches deep (deeper if gravel is added for increased drainage).
2. Add an 18-inch layer of fresh horse manure.
3. Cover with 6 inches of good soil

High Tunnels

High tunnels are sometimes referred to as "hoop houses." They are constructed of PVC or metal bows that are attached to metal posts that have been driven into the ground about 2 feet deep. The PVC or metal bows are covered with one to two layers of 6-mil greenhouse-grade polyethylene and allow a gardener to walk inside. Tunnels are ventilated by manually rolling up the sides each morning and rolling them down in early evening. High tunnels are a nice compromise between unheated low tunnels and a heated greenhouse. They enhance plant growth, yield, and quality. Although they do provide some frost protection, their primary function is to elevate temperatures a few degrees each day over a period of several weeks.

Remember to remove covers! For crops requiring bee pollination, the covers are removed before flowers appear. For primarily wind-pollinated crops (tomato, pepper, eggplant) removal of covers is based on temperature, with a goal that the temperature not exceed 90°F for a few hours when the flower buds begin to open.

Figure A-4: A high tunnel is tall enough for a gardener to walk in. Kathleen Moore, CC by 2.0

Other Resources

Season Extension: Introduction and Basic Principles by Debbie Roos and Doug Jones

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For the full article, which includes information on greenhouses, see: Season Extensions and Greenhouses by Chris Gunter.

Additional Resources

Home Gardening

NCSU Extension Gardening Handbook

Vegetable Gardening

Home Vegetable Gardening, AG-06

Vegetable Gardening- A Beginners Guide, AG-12

Square Foot Gardening Foundation (website)

Container Garden Planting for Edibles in the Piedmont, AG-74

Planning your Garden

Vegetable Growing Guides, Cornell University Guides to 58 garden vegetables. Each profile contains detailed description of the vegetable and growing instructions, site and soil requirements. and solutions for managing pests and diseases.

Vegetable Gardening Guide, The National Gardening Association. A wealth of information on a variety of vegetables

North Carolina State University Plant Database, (website). Information on herbs.

Central North Carolina Planting Calendar for Annual Vegetables, Fruits and Herbs. Similar guides for Eastern and Western NC.

Companion and Interplanting, National Gardening Association

Preparing your Garden:

SoilFacts: Minimizing Risks of Soil Contaminants in Urban Gardens, AGW-439-78

A Gardeners Guide to Soil Testing, AG-614

Soil Test Forms & Information, NCDA&CS Agronomic Services (website). Includes access to and understanding soil reports.

Composting, NC State Extension (website)

Herbicide Carryover in Hay, Manure, Compost & Grass Clippings, North Carolina CES

Environmental Soil Issues: Garden Use of Treated Lumber by Penn State Extension

North Carolina 811 underground utility location service. 1-800-632-4949, www.nc811.org

Caring for your Garden

IPM for the Home Gardener, University of Arizona

Managing Diseases in the Home Vegetable Garden, AG-436

Texas Plant Disease Handbook, Texas A&M Extension

Insect and Related Pests of Vegetables, AG-295

North Carolina State University Plant Disease and Insect Clinic (website) Service to diagnose issues and recommend treatment and prevention actions.

Harvesting your Garden

Planting and Harvesting Guide for Piedmont Vegetables and Herbs, Chatham County Center, NC State Cooperative Extension

Home Food Preservation NC State Extension (website)

Herbs

Growing Herbs for the Home Vegetable Gardener, HIL-8110

Winterizing the Herb Garden, HIL-8112

Other Resources

NC Community Gardens Directory, North Carolina Community Garden Partners (NCCGP website)

A Small Backyard Greenhouse for the Home Gardener, AG-426

NC State University Extension Horticulture Publications (website)

NC State University Extension Horticulture Leaflets (website)

NC State University Department of Horticulture Science Extension Publications (website)

The National Gardening Association Learning Library

Glossary

Acid soil. Soil with pH below 7 on a pH scale of 1 to 14. The lower the pH, the more acid the soil.

Active ingredient. The chemical in a pesticide formulation that actually kills the target pest.

Aerobic. Active in the presence of free oxygen.

Allelopathy. The excretion by some plants' leaves and roots of compounds that inhibit the growth of other plants.

Anaerobic. Active in the absence of free oxygen.

Annual. Plants started from seed that grow, mature, flower, produce seed, and die in the same growing season.

Bacillus thuringiensis. A bacterium used as a biological control agent for many insect pests.

Beneficial fungi. Fungi used in controlling organisms that attack desirable plants.

Beneficial insect. An insect that helps gardening efforts. May pollinate flowers, eat harmful insects or parasitize them, or break down plant material in the soil, thereby releasing its nutrients. Some insects are both harmful and beneficial. For example, butterflies can be pollinators in their adult form but destructive in their larval (caterpillar) form.

Biennial. Plants that take two years, or a part of two years, to complete their life cycle.

Biological insect control. The use of beneficial organisms to control pest insect populations.

Bolting. Producing seed or flowering prematurely, usually due to heat. For example, cool-weather crops such as lettuce bolt during summer.

Botanical insecticide. An insecticide, such as rotenone or pyrethrum, derived from a plant. Most botanicals biodegrade quickly. Most, but not all, have low toxicity to mammals.

Broadcast. (1) To sow seed by scattering it over the soil surface. (2) To apply a pesticide or fertilizer uniformly to an entire, specific area by scattering or spraying it.

Calcium carbonate. A compound found in limestone, ashes, bones, and shells; the primary component of lime.

Cloche. A plastic, glass, or Plexiglas plant cover used to warm the growing environment and protect plants from frost.

Cold composting. A slow composting process that involves simply building a pile and leaving it until it decomposes. This process may take months or longer. Cold composting does not kill weed seeds or pathogens.

Cold frame. A plastic-, glass-, or Plexiglas-covered frame or box that relies on sunlight as a source of heat to warm the growing environment for tender plants.

Cole crops. A group of vegetables belonging to the cabbage family; plants of the genus Brassica, including cauliflower, broccoli, cabbage, turnips, and Brussels sprouts.

Compaction. Pressure that squeezes soil into layers that resist root penetration and water movement. Often the result of foot or machine traffic.

Companion planting. The practice of growing two or more types of plants in combination to discourage disease and insect pests.

Complete fertilizer. A fertilizer that contains all three macronutrients (N, P, K).

Compost. The product created by the breakdown of organic waste under conditions manipulated by humans. Used to improve both the texture and fertility of garden soil.

Cotyledon. A seed leaf, the first leaf from a sprouting seed. Monocots have one cotyledon, dicots have two.

Cover crop. (1) A crop planted to protect the soil from erosion. (2) A crop planted to improve soil structure or organic matter content.

Crop rotation. The practice of growing different types of crops in succession on the same land chiefly to preserve the productive capacity of the soil by easing insect, disease, and weed problems.

Cultivar. A cultivated variety of a species. Propagation of cultivars results in little or no genetic change in the offspring, which preserves desirable characteristics.

Decomposition. The breakdown of organic materials by microorganisms.

Determinate. A plant growth habit in which stems stop growing at a certain height and produce a flower cluster at the tip. Determinate tomatoes, for example, are short, early fruiting, have concentrated fruit set, and may not require staking. (See also Indeterminate.)

Diatomaceous earth. The fossilized remains of diatoms (a type of tiny algae) used to kill insect pests, snails, and slugs.

Direct seeding (direct sowing). Planting seeds into garden soil rather than using transplants.

Fallow. To keep land unplanted during one or more growing seasons.

Family. A sub-order in the classification of plants.

Fertility (soil). The presence of minerals necessary for plant life.

Fertilization. (1) The fusion of male and female germ cells following pollination. (2) The addition of plant nutrients to the environment around a plant.

Fertilizer. Any substance added to the soil (or sprayed on plants) to supply those elements required in plant nutrition.

Fertilizer analysis. The amount of nitrogen, phosphorus (as P_2O_5), and potassium (as K_2O) in a fertilizer expressed as a percentage of total fertilizer weight. Nitrogen (N) is always listed first, phosphorus (P) second, and potassium (K) third.

Fertilizer ratio. The smallest whole number relationship among N, P_2O_5, and K_2O.

Floating row covers. Covers, usually of a cloth-like material, placed over growing plants and used to protect the plants growing beneath from undesirable pests and climate.

Fungicide. A compound toxic to fungi.

Green manure. An herbaceous crop plowed under while green to enrich the soil.

Growing season. The period between the beginning of growth in the spring and the cessation of growth in the fall.

Hardening off. (1) The process of gradually exposing seedlings started indoors to outdoor conditions before transplanting. (2) The process of gradual preparation for winter weather.

Herbicide. A substance that is toxic to plants and is used to destroy unwanted vegetation.

Insecticide: A substance used for killing insects

Herbicide, contact. Herbicide that injures only those portions of a plant with which it comes into contact.

Herbicide, nonselective. Herbicide that kills or injures all plants. Some plant species may exhibit more tolerance than others. Examples include glyphosate (Roundup, Touchdown Pro), and glufosinate (Finale).

Herbicide, selective. Herbicide that kills or injures some plants without harming others.

Herbicide, systemic. Herbicide that is taken up through contact with the leaves or through the soil (via contact with the roots) and is moved throughout the plant to kill the whole plant.

Horticultural oil. An oil made from petroleum products, vegetable oil, or fish oil used to control insect pests and diseases. Oils work by smothering insects and their eggs and by protectively coating buds against pathogen entry.

Hot composting. A fast composting process that produces finished compost in 4 to 8 weeks. High temperatures are maintained by mixing balanced volumes of energy materials and bulking agents, by keeping the pile moist, and by turning it frequently to keep it aerated.

Hybrid. The results of a cross between two different species or well-marked varieties within a species. Hybrids grown in a garden situation will not breed true to form from their own seed.

Indeterminate. A plant growth habit in which stems keep growing in length indefinitely. For example, indeterminate tomatoes are tall, late-fruiting, and require staking for improved yield. (See also Determinate.)

Inorganic. Being or composed of matter other than plant or animal.

Insecticidal soap. A specially formulated soap that is only minimally damaging to plants, but kills insects. Usually works by causing an insect's outer shell to crack, resulting in its interior organs drying out.

Insecticide. A chemical used to control, repel, suppress, or kill insects.

Integrated control. An approach that attempts to use several or all available methods for control of a pest or disease.

Integrated insect control. The use of a variety of insect control methods, beginning with simpler.

Integrated pest management. A method of managing pests that combines cultural, biological, mechanical, and chemical controls, while taking into account the impact of control methods on the environment.

Intensive gardening. The practice of maximizing use of garden space, for example by using trellises, intercropping, succession planting, and raised beds.

Intercropping/Interplanting. The practice of mixing plants to break up pure stands of a single crop.

Leaching. Movement of water and soluble nutrients down through the soil profile.

Life cycle. The successive stages of growth and development of an organism.

Lime. A rock powder consisting primarily of calcium carbonate. Used to raise soil pH (decrease acidity).

Loam. A soil with roughly equal proportions of sand, silt, and clay partic

Macro pore. A large soil pore. Macro pores include earthworm and root channels and control a soil's permeability and aeration. . In a substrate, the larger spaces (or pores) that lies between component particles that hold air.

Macronutrient. Collectively, primary and secondary nutrients.

Microclimate. Climate affected by landscape, structures, or other unique factors in a particular immediate area.

Micronutrient. A nutrient, usually in the parts per million range, used by plants in small amounts, less than 1 part per million (boron, chlorine, copper, iron, manganese, molybdenum, zinc, and nickel).

Mulch. Any material placed on the soil surface to conserve soil moisture, moderate soil temperature, and/or control weeds. Wood chips, bark chips, and shredded leaves are mulches that eventually add organic matter to the soil; inorganic materials such as rocks are also used.

Nitrogen. A primary plant nutrient, especially important for foliage and stem growth.

N-P-K. Acronym for the three major plant nutrients contained in manure, compost, and fertilizers. N stand for nitrogen, P for phosphorus, and K for potassium.

Nutrient. Any substance, especially in the soil, that is essential for and promotes plant growth. (See also Macronutrient, Micronutrient.)

Oil. See Horticultural oil.

Open-pollinated seed. Seed produced from natural, random pollination so that the resulting plants are varied.

Organic. (1) Relating to, derived from, or involving the use of food produced with the use of feed or fertilizer of plant or animal origin without employment of synthetically formulated fertilizers, growth stimulants, antibiotics, or pesticides. (2) Being or composed of plant or animal matter. (3) A labeling term that refers to an agricultural product produced in accordance with government standards.

Organic fertilizer. A natural fertilizer material that has undergone little or no processing. Can include plant, animal, and/or mineral materials.

Organic matter. Any material originating from a living organism (peat moss, plant residue, compost, ground bark, manure, etc.).

Organic pesticide. Pesticides derived from plant or animal sources.

Parasite. An organism that lives in or on another organism (host) and derives its food from the latter.

Pathogen. Any organism that can cause a disease.

Perennial. A plant that lives more than two years and produces new foliage, flowers, and seeds each growing season.

Pesticide: A substance used for destroying insects or other organisms harmful to cultivated plants or to animal.

pH. The acidity or alkalinity of a solution on a scale of 0-14, with a value of 7 signifying neutral, values below 7 signifying acidic, and values above 7 signifying alkaline. Relates to the concentrations of hydrogen (H+) ions in the soil. pH values are logarithmic.

Phosphorus (P). A primary plant nutrient, especially important for flower production. In fertilizer, usually expressed as phosphate.

Pollinator. An agent such as an insect that transfers pollen from a male anther to a female stigma.

Potash. The form of potassium listed in most fertilizer analyses.

Potassium (K). A primary plant nutrient, especially important for developing strong roots and stems. In fertilizers, usually expressed as potash.

Pore space. The spaces within a rock body or soil that are unoccupied by solid material.

Primary nutrient. A nutrient required by plants in a relatively large amount (nitrogen, phosphorus, and potassium).

Processed fertilizer. A fertilizer that is manufactured or refined from natural ingredients to be more concentrated and more available to plants.

Quick-release fertilizer. A fertilizer that contains nutrients in plant-available forms such as ammonium and nitrate. Fertilizer is readily soluble in water.

Resistance. The ability of a host plant to prevent or reduce disease development by retarding multiplication of the pathogen within the host.

Rot. Decomposition and destruction of tissue.

Rotation. The practice of growing different plants in different locations each year to prevent the buildup of soil borne diseases and insect pests.

Row cover. A sheet of synthetic material used to cover plants in order to retain heat and exclude insect pests.

Sanitation. The removal and disposal of infected plant parts; decontamination of tools, equipment, hands, etc.

Secondary nutrient. A nutrient needed by plants in a moderate amount: calcium, magnesium, and sulfur. (See also Macronutrient, Primary Nutrient.)

Seed. Matured ovule that occurs as, or in, mature fruits.

Seed, certified. A seed lot inspected to meet minimum standards and to ensure trueness to type for a given cultivar.

Seed leaf. See Cotyledon.

Selective pesticide. A pesticide that kills only certain kinds of plants or animals; for example, 2,4-D kills broadleaf lawn weeds but leaves grass largely unharmed.

Side-dress. To apply fertilizer to the soil around a growing plant.

Slow-release fertilizer. A fertilizer material that must be converted into a plant-available form by soil microorganisms.

Soil solution. The solution of water and dissolved minerals found in soil pores.

Soil structure. The arrangement of soil particles or their aggregates.

Soil texture. How coarse or fine a soil is. Texture is determined by the proportions of sand, silt, and clay in the soil.

Species. A group of individual plants interbreeding freely and having many (or all) characteristics in common.

Sterile. (1) Material that is free of disease organisms (pathogens), as in potting medium. (2) A plant that is unable to produce viable seeds.

Succession planting. (1) The practice of planting new crops in areas vacated by harvested crops. (2) Several smaller plantings made at timed intervals.

Summer annual. Annual plant in which the seed germinates in the spring, and the plant develops, matures, and produces seed by the end of the growing season.

Synthetic fertilizer. Chemically formulated fertilizers, mainly from inorganic sources.

Synthetic pesticide. Chemically formulated pesticide, mainly from inorganic sources.

Systemic. Spreading internally throughout the plant.

Systemic pesticide. A pesticide that moves throughout a target organism's system to cause its death.

Thin. (1) To remove an entire shoot or limb where it originates. (2) To selectively remove plants or fruits to allow remaining plants or fruits to develop.

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Variety. In the wild, a plant growing within a species that is different in some particular characteristic from other members of that species. When grown from seed, a variety will maintain all of its particular characteristics. Also called a botanical variety.

Vermicomposting. Composting with worms. Although there are over 6,000 species of worm, only seven have been found suitable for bin composting. One in particular, *Eisenia fetida* (common name: red wiggler), is the most widely used.

Viable. Alive; seeds must be alive in order to germinate.

Viability. A seed's ability to germinate.

Weed. A plant growing where it is not wanted.