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TEXAS A&M AGRILIFE EXTENSION

10 Steps to Vegetable Garden Success

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Figure 1. A large garden from yesteryear.

A generation or two ago, most Texans lived in rural settings and had the space and time to grow large amounts of produce. They needed large vegetable gardens to provide plenty of food during the growing season and to preserve for the winter (Fig. 1). These country gardens were economical and produced a significant portion of the family's food.

Figure 2. A typical modern-sized garden.

In contrast, today's typical home garden is much smaller—about 20 by 20 feet, or consisting of a few raised beds (Fig. 2). And it is relatively expensive to produce: A garden this size would cost an estimated $200 to establish. Costs include seeds, cages, fertilizer, pesticides, transplants, railroad ties, rooting media, and an irrigation system. Small gardens are initially not a good economic return for the money and time required to produce a crop.

Unlike the early Texans who gardened out of necessity, nowadays we can buy fresh produce that is affordable and available year round. Gardening has become mainly a hobby, with the major benefits being not economy and survival but instead health, nutrition, and recreation. Modern vegetable gardens:

- Provide a way to relax and alleviate job stress
- Produce the flavor and nutrition of fresh, home-grown vegetables
- Can be enjoyed by people of all ages
- Offer a hands-on way for children to learn where food comes from and what is required to produce it
- Teach children the values of responsibility and reward

The 10 steps

1. Begin with a plan
2. Choose the site
3. Prepare the site
4. Choose the vegetables
5. Plant the garden
6. Take care of the plants
7. Clean up the garden
8. Plan rotations
9. Keep learning
10. Have fun and keep gardening

Figure 3. Two layouts for spring gardens.

- Give adults and children opportunities to be more physically active
- Offer the enjoyment of literally "eating the fruits of your labors"

At the outset, it is difficult for most people to justify vegetable gardening on the basis of reducing food bills. The economic value of the first tomato you harvest in the first year of establishing a garden is at least $5.

In later years, expenses plummet and are limited to seeds/transplants and pesticides/fertilizers. Then, vegetables cost less than those at grocery store.

The following 10 steps are based on personal experience and input from "master" gardeners with extensive gardening knowledge.

Step 1: Begin with a plan

In early spring, when the weather warms up and most of us catch spring fever, we impulsively buy a six-pack of tomato transplants, just because "they were there and looked good." For enthusiasm, we get an A+; but for planning, we deserve a failing grade.

Planning should begin at least a couple of months before the planting season. Experienced gardeners start preparing for their spring gardens (Fig. 3) as early as September of the previous year. Similarly, planning for a fall garden in Texas starts in June of that year.

A well-thought-out plan (Fig. 4) can eliminate potential problems and improve your chances of success. Among the decisions to be made are what, when, where, how, and how much to plant. When planning your garden, consider the following points:

- How much space is available?
- Where are east and west in the garden?
- Does the area have enough light, or is it heavily shaded?
- Is the garden shaded in the morning or in the afternoon?
- Does the site drain well?
- Is the source of water nearby? Is the water plentiful and suitable for gardening?
- How fertile is the soil? Is the texture (sand, loam, or clay) appropriate for a garden?
- Does the garden need a fence to keep out deer and other animals?
- Where will you store your tools and pesticides?
- If you plan to have a compost bin, where will you place it?
- Will you install an irrigation system?

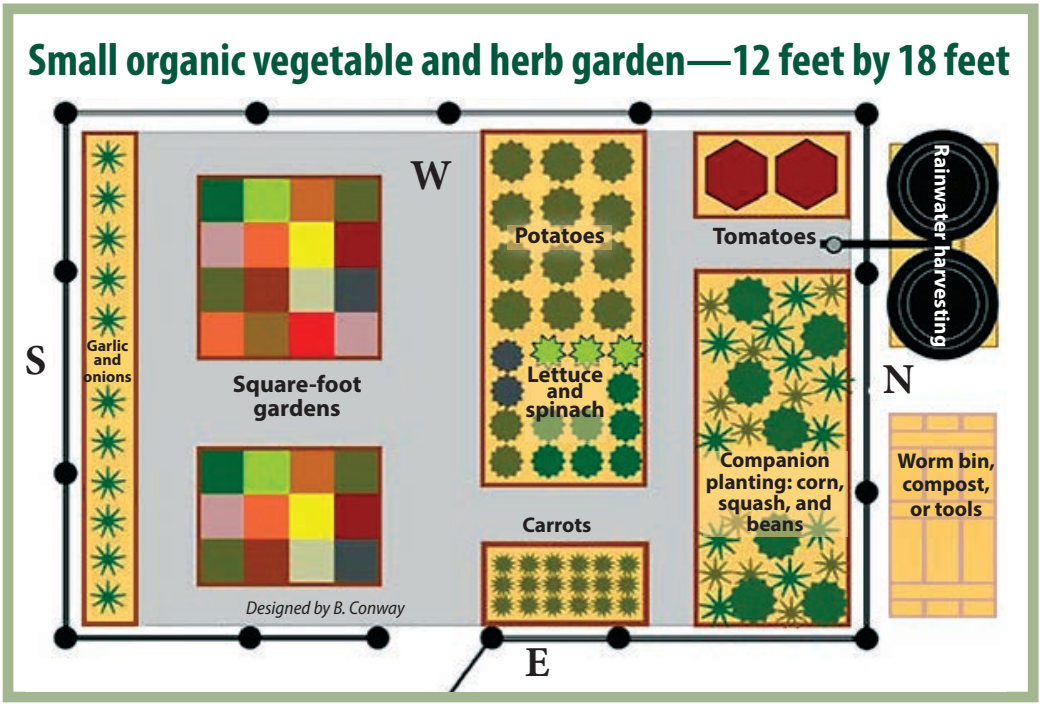


Figure 4. Plans for an organic vegetable and herb garden.

Figure 5. A well-planned garden, above.

Figure 6. A raised-bed garden, right.

- Do you know how to can, freeze, or otherwise preserve excess produce? Or, do you have a plan to give it away or a market it for sale?

The garden shown in Figure 5 was the result of careful planning. The brick pathway and raised beds were built before any plants or seeds were set in the ground. Much forethought went into this garden's design.

Still, unexpected problems can arise. The rose bush in the upper right corner of the photograph is shading the corner bed and must be hedged back for the gardener to make full use of the bed.

If the area available in your landscape drains poorly or has shallow, unfertile soil, consider raised-bed gardening (Fig. 6). Raised beds provide excellent drainage and allow gardening in areas where native soil is unsuitable.

Raised beds can be built with cinder blocks, landscape timbers, railroad ties, treated or untreated wood. If you plan to use treated wood, avoid wood treated with chromate copper arsenate (CCA), which contains arsenic compounds. Instead, use wood treated with micronized copper azole (MCA) or micronized copper (MCQ), which are proven to be safe for vegetable production.

The beds should be at least 6 inches deep, but the deeper the better. An 18-inch-deep bed is better than one 12 inches deep, which is better than 6 inches deep. Keep in mind, though, that the costs of soil and building materials increase with the height of the beds.

A good soil mix consists of ⅓ top soil, ⅓ sand or coarse perlite, and ⅓ compost. Another good mixture is ½ sand and ½ compost. Many garden centers sell complete soil mixes ready for immediate use.

When deciding where in the garden to set out a plant, note whether the plant is upright or vining. Place the shortest plants on the east side of the garden and the taller plants to the west of them (Fig. 7). In other words, plant short to tall from east to west. This will keep the taller plants from shading the shorter ones in the morning.

Figure 7. Proper placement of vegetables in a garden from west (taller plants) to east (shorter plants).

In Figure 8, the bean plants are losing sunlight

Figure 8. Low-growing species growing between taller plants.

and nutrients to the taller species planted on the right and the left sides. However, the plantings were timed so that the sweet corn (right) would be harvested and removed just as the beans become established and begin to flower. The gardener is intercropping, or growing two crops at the same time in the same place without losing yield to either.

Morning sun is the ideal for vegetable gardens:

- In the morning and until about 2 p.m., the conditions are best for plants to make sugars through photosynthesis. The conditions for photosynthesis are less conducive in areas that have morning shade and afternoon sun.
- The risk of disease infections is lower when the morning sun dries dew, precipitation, and irrigation water from the leaves. Disease spores germinate and develop readily in water droplets on foliage. Therefore, the faster the foliage dries in the morning, the lower the chances of a disease infection.

Over the years, gardeners have been told that vegetables grow best if they receive full sunlight for a whole day. However, that advice doesn't apply in Texas, where we have excess sunlight. Six to 8 hours of sunlight, or until about 2 p.m., are enough to grow a productive vegetable garden here. The plants might actually benefit from partial or full shade after 2 p.m. because they are often heat-stressed in late afternoon.

Garden designs range from classic (Fig. 9a) to aesthetic (Fig. 9b). Check the Web for help in designing your garden. The following sites offer design ideas for handicap-accessible gardens:

- http://aggie-horticulture.tamu.edu/travis/lg_e_vegetables.htm
- www.inthecountrygardenandgifts.com/jspece/gardening/accessible.html
- www.gardeners.com/kitchen-garden-planner/kgp_home,default,pg.html

Step 2: Choose the site

Consider these factors when deciding where to establish your garden:

- **Light:** Use the landscape area that receives the most light until at least 2 p.m. As mentioned earlier, sites that get morning sun are better than those with sun in the afternoon.
- **Soil type:** Sandy loam soils are best; if none is available, choose the area that has the lightest soil type (one that contains the most sand).
- **Drainage:** The area should drain well—most vegetable crops cannot stand "wet feet," or waterlogged roots.
- **Convenience:** Plant the garden near the house and a water source.

Do not locate the garden near large shrubs or trees. Figure 10 shows a shaded area with root

Figure 9. a) A classic garden design, above, and b) one designed to be aesthetically pleasing.

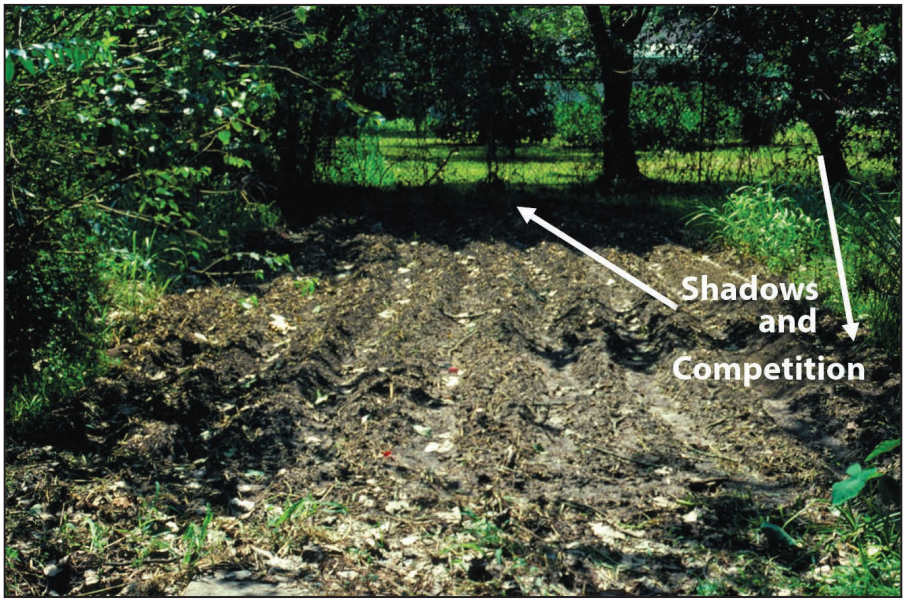


Figure 10. A shaded area with poor drainage and root competition from surrounding trees and bushes.

Figure 11. Long, thin stems of okra plants near standing water, indicating poor soil drainage.

competition from nearby trees and bushes. The feeder roots of the mature trees extend at least 15 feet around and into this garden. Shade from the surrounding bushes will limit the growth of summer crops such as eggplant, melons, peppers, and tomatoes.

Also, avoid sites where water pools after rainfall. Figure 11 shows an area that appears ideal, with no large trees shading the garden. However, the long, thin stems of the okra plants near the standing water indicate that the soil drains poorly. A possible remedy to the problem is to install a French drain to remove excess water from the garden.

Step 3: Choose the vegetables

A general rule is to grow vegetables that 1) are best suited or adapted to your area, and 2) you like to eat. For example: Rutabagas may easily grow in your area with little or fertilizer. But if you and your family dislike rutabagas, don't grow them.

How much should you grow? Table 1 lists the number of vegetable plants or the length of a seeded row needed for one person. Choose the crops and varieties according to your personal preference, the space available, and the amount of work you are willing to do. Labor-intensive crops include beans, cucumbers, squash, and tomatoes; herbs, sweet corn, radishes, and carrots require less labor.

It's easy to plant too much. For example, a tomato plant usually will yield 10 to 30 pounds—15 plants will produce 150 to 450 pounds of tomatoes. A family of four would end up with too many tomatoes and have to discard or give away most of them, unless they preserve the extras or plant cultivars with different harvest dates.

Table 1. Vegetable yields and harvest durations

Vegetable	Days to harvest	Length of harvest (days)	Yield/100 ft	Approximate planting/person	
				Fresh	Canned/frozen
Asparagus	730	60	30 lb	10–15 plants	10–15 plants
Beans, snap: bush	45–60	14	120 lb	15–16 ft	15–20 ft
Beans, snap: pole	60–70	30	150 lb	5–6 ft	8–10 ft
Beans, lima: bush	65–80	14	25 lb shelled	10–15 ft	15–20 ft
Beans, lima: pole	75–85	40	50 lb shelled	5–6 ft	8–10 ft
Beets	50–60	30	150 lb	5–10 ft	10–20 ft
Broccoli	60–80	40	100 lb	3–5 plants	5–6 plants
Brussels sprouts	90–100	21	75 lb	2–5 plants	5–8 plants
Cabbage	60–90	40	150 lb	3–4 plants	5–10 plants
Cabbage, Chinese	65–70	21	80 heads	3–10 ft	—
Carrots	70–80	21	100 lb	5–10 ft	10–15 ft
Cauliflower	70–90	14	100 lb	3–5 plants	8–12 plants
Chard, Swiss	45–55	40	75 lb	3–5 plants	8–12 plants
Collard (kale)	50–80	60	100 lb	5–10 ft	5–10 ft
Corn, sweet	70–90	10	10 dozen	10–15 ft	30–50 ft
Cucumbers	50–70	30	120 lb	1–2 hills	3–5 hills
Eggplant	80–90	90	100 lb	2–3 plants	2–3 plants
Garlic	140–150	—	40 lb	—	1–5 ft
Kohlrabi	55–75	14	75 lb	3–5 ft	5–10 ft
Lettuce	40–80	21	50 lb	5–15 ft	—
Muskmelon/ cantaloupe	85–100	30	100 fruits	3–5 hills	—
Mustard	30–40	30	100 lb	5–10 ft	10–15 ft
Okra	55–65	90	100 lb	4–6 ft	6–10 ft
Onions (bulb)	80–120	—	100 lb	3–5 ft	30–50 ft
Onions (seed)	90–120	—	100 lb	3–5 ft	30–50 ft
Parsley	70–90	90	30 lb	1–3 ft	1–3 ft
Peas, English	55–90	7	20 lb	15–20 ft	40–60 ft
Peas, southern	60–70	30	40 lb	10–15 ft	20–50 ft
Peppers	60–90	90	60 lb	3–5 plants	3–5 plants
Potato, Irish	75–100	—	100 lb	50–100 ft	—
Potato, sweet	100–130	—	100 lb	5–10 plants	10–20 plants
Pumpkin	75–100	—	100 lb	1–2 hills	1–2 hills
Radish	25–40	—	100 bunches	3–5 ft	—
Spinach	40–60	40	3 bushels	5–10 ft	10–15 ft
Squash, summer	50–60	40	150 lb	2–3 hills	2–3 hills
Squash, winter	85–100	—	100 lb	1–3 hills	1–3 hills
Tomato	70–90	40	100 lb	3–5 plants	5–10 plants
Turnip greens	30	40	50–100 lb	5–10 ft	—
Turnip roots	30–60	30	50–100 lb	5–10 ft	5–10 ft
Watermelon	80–100	30	40 fruits	2–4 hills	—

Although vegetable crops can be grown anywhere in Texas, a particular variety may be better suited to some areas than others, depending on local growing conditions such as soil type, water quality, and season length. For information on selecting vegetable varieties for specific areas of Texas, see http://aggie-horticulture.tamu.edu/publications/veg_variety/.

Another factor in determining what to plant is the size of your garden. Space is limited in most home garden sites. Choose crops that can fit in the space available (Table 2).

The planting season—spring or fall—also dictates which species to plant. Table 2 lists cool-season crops that are suited to fall planting. However, large trees can affect the light intensity in a garden. In shaded areas, plant cool-season crops that can grow with less light in the spring.

Step 4: Prepare the site

A successful vegetable garden starts with good soil that can support healthy plants able to resist insects and diseases. The five major steps in preparing a garden site are soil testing, bed amendment, preplant irrigation, fertilization, and seedbed preparation.

Soil testing

A soil test will determine what the soil needs to help the plants grow and produce vegetables. It will also indicate how your activities are affecting soil health over time. Have the soil in a new garden tested every year for the first 3 years, then every 2 to 3 years afterward.

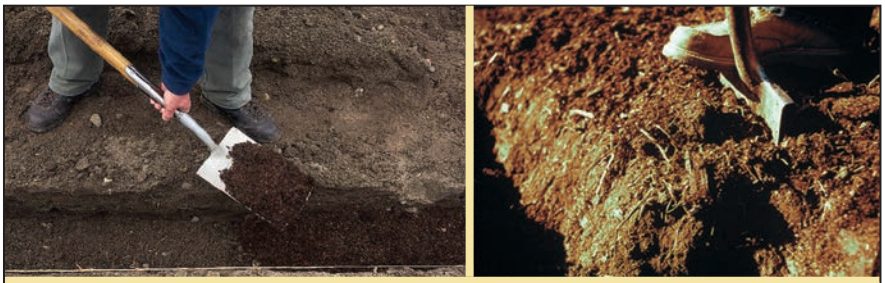
To collect and send samples properly, see *Testing Your Soil: How to Collect and Send Samples,* https://agrilifebookstore.org/product-p/e-534.htm publication E-534 on the Texas A&M AgriLife Bookstore website, or visit the website of the Texas A&M AgriLife Soil, Water and Forage Testing Laboratory at http://soiltesting.tamu.edu .

Although soil analysis is a good management tool, it does have some limitations:

- The results are site specific: You cannot use your neighbor's results to make fertilizer decisions for your site.
- A soil test conducted one year will not indicate the soil's nutrient status the next year.
- Soil analysis measures some elements more accurately than others.
- The type of laboratory technique used will affect the test results. Therefore, the lab running the analysis should be the one recommending nutrient needs. Your county Extension agent can make reliable fertilizer recommendations using the results from the Texas A&M soil test laboratory. To make recommendations based

Table 2. Vegetable crops that are suitable for small and large gardens; cool-season vegetables that are suited for shaded areas

Crop	Small gardens	Large gardens	Shaded areas
Beans, green	x	x	
Beets	x	x	x
Broccoli	x	x	x
Cabbage	x	x	x
Cantaloupes		x	
Carrots	x	x	x
Cauliflower		x	x
Collards		x	
Corn, sweet		x	
Cucumbers		x	
Eggplant	x	x	
Garlic	x	x	
Greens	x	x	x
Lettuce	x	x	x
Mustard		x	
Okra		x	
Onions	x	x	
Parsley	x	x	x
Peas, English	x	x	
Peas, southern		x	
Peppers	x	x	
Potatoes		x	
Pumpkins		x	
Radishes	x	x	x
Spinach	x	x	x
Squash, bush	x	x	



Double-digging improves aeration, nutrition, and the water-holding ability of the site. Products such as vermiculite can also improve problem soils.

Figure 12. Double-digging method of adding organic matter.

on results from a private lab, the county agent will need information about its extraction methods.

Bed amendment

Amendments are materials added to the soil to improve its physical properties, such as aeration, drainage, structure, and water infiltration. The goal is to improve the environment for the plants' roots. With few exceptions, most garden soils will need some amendments before planting to increase the amount and quality of vegetables produced.

The best way to improve plant productivity, soil aeration, and soil drainage is to add organic matter. Place 4 to 6 inches of organic matter on top of the soil and incorporate (mix) it into the native soil.

Compost can be incorporated easily with a rototiller or pitchfork. Another, more time-consuming method that offers similar benefits is double digging (Fig. 12), which involves these steps:

1. Dig out the top layer of the soil to about the depth of a spade, creating a shallow trench.
2. Loosen the next layer of soil by about the same depth and incorporate into it compost or similar organic material, and if needed some gypsum.
3. Dig a second shallow trench and use that topsoil to backfill the first trench.
4. Repeat the process until the entire bed has been dug; the last trench is backfilled with the top soil from the first trench.

Add organic matter every year. Most Texas soils contain less than 2 percent organic matter—the heat breaks down all organic materials within a year. Incorporate it before planting in the fall or spring.

Figure 13. Preplant irrigation.

Preplant irrigation

Water the garden before planting (Fig. 13). Many Texas soils lack moisture in July and August before the fall planting season. A garden may need several soakings; a raised bed will need only one good soaking.

The water will help the emerging seedlings develop quickly and avoid stress. Young plants are especially susceptible to stress because hot, windy conditions dry out the soil before the seedlings can develop adequate root systems.

Fertilization

To grow well, plants need primary nutrients, secondary nutrients, and micronutrients. Primary nutrients are needed in the largest amounts, followed by secondary nutrients, and then micronutrients.

Even after manure or compost has been incorporated, soils often need additional fertilizer to supply missing nutrients or to correct a mineral deficiency. To make sure your plants have what they need to produce well:

- Have the soil tested periodically, and use the test results to determine whether fertilizer is needed to correct deficiencies.

- Apply primary and secondary nutrients to the soil, not the leaves.
- Apply micronutrients to the leaves (foliar feeding) to correct deficiencies only.

Many gardeners apply too much fertilizer. The philosophy is "If a little is good, more is better." However, the goal should be to produce the best and most vegetables using as little fertilizer as possible. Excess fertilizer can harm the plants as well as pollute nearby land and waterways via runoff.

What to apply

Of the primary nutrients nitrogen, phosphorus, and potassium, the most important is nitrogen. Plants need more nitrogen than the other primary nutrients, and it is the one most deficient in Texas soils.

Nitrogen: Plants use nitrogen (N) to manufacture food. Plants deficient in N are light green to yellow and produce less, and what they produce is of lower quality. Because nitrogen dissolves in water very easily, it is readily washed out of the soil. Lighter soils and growing media generally lose nitrogen faster than do heavier soils.

Phosphorus: Plants need much less phosphorus (P) than nitrogen. Phosphorus is used for cell division, root growth, and the development of reproductive structures such as fruits.

Phosphorous is the most overused element in Texas. Apply it judiciously. Soils with too much phosphorus can cause serious problems such as deficiencies of iron and zinc, which become tied up by P and rendered unavailable to the plants.

Potassium: Most Texas soils have plenty of potassium (K) and need no supplemental applications of it. However, like nitrogen, potassium is soluble and readily leached from the soil. It can become deficient in sandy soils such as those in East Texas.

Potassium helps plants grow and improves the shelf life of produce. It is essential for water uptake and retention as well as the formation of starch and protein.

If P and K are needed, apply them before planting. Then only N will be needed during the growing season.

When buying fertilizer, check the label for three numbers separated by dashes. These numbers, known as the fertilizer grade, represent the primary nutrients nitrogen, phosphorus, and potassium.

The first number indicates the percentage of nitrogen in the product; the second is the percentage of phosphate; and the third, potash or potassium. For example: A 50-pound bag labeled 6-6-18 contains 3 pounds of nitrogen, 3 pounds of phosphate, and 9 pounds of potash. The remaining 35 pounds are filler, usually sand or granular limestone.

Apply only the nutrients and minerals that the soil test shows are needed. Most gardeners use 13-13-13 or 20-20-20 fertilizer, which contain equal amounts of nitrogen, phosphorus, and potassium. However, as mentioned earlier, most Texas soils already have enough phosphorus and potassium. Adding more only pollutes our soils and groundwater.

Fertilization methods

If fertilizer is needed, use the most effective application method for the type of deficit being corrected. You can avoid most nutrient deficiencies by applying fertilizer to the soil. However, deficiencies can still occur.

The main ways to correct nutrient or mineral deficiencies are via drip irrigation, banding, foliar feeding, and broadcast application, in which fertilizer is scattered on the ground with a mechanical spreader.

Drip irrigation: Drip irrigation systems apply fertilizer where and when it is needed—in the root zone during the cropping season. All you need is a water hose, an injection system such as a venturi siphon (Fig. 14), and a container such as a 5-gallon bucket to hold the stock solution.

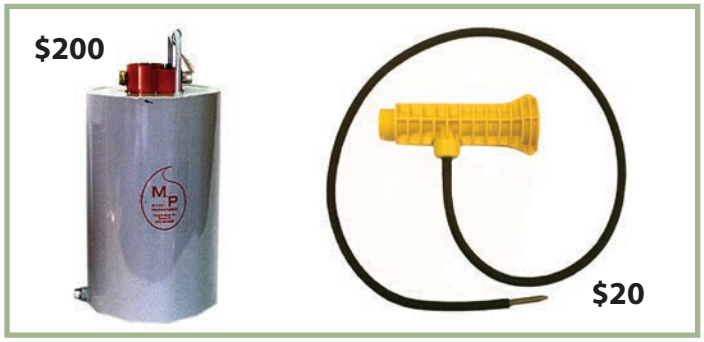


Figure 14. Venturi siphons available for commercial growers (left) and for homeowners (right).

If the soil test determines that your garden needs only nitrogen, you can easily apply it via drip irrigation if the nitrogen source is soluble, such as urea, ammonium nitrate, or ammonium sulfate.

Banding: If phosphorus is needed, apply it banded instead of broadcast. Apply it using the 2×2 concept: Place the phosphorus in a band on one side of the planting row 2 inches out and 2 inches below the seed or lower end of the transplant plug.

Banding offers significant benefits:

- You can apply 30 percent less phosphorus than is recommended without reducing yield.
- Because phosphorus doesn't dissolve or move readily in the soil, only one application will be needed.
- Phosphorus poses no danger to germinating seeds because it is not toxic to the developing roots.

Figure 15 shows a carrot root at harvest, about 90 days after seeding. The photo shows the phosphorus band that was applied at planting—it is still in a band and hasn't diffused into the soil, even 3 months after application.

Broadcast application: Potassium can be applied as a broadcast application or via a drip irrigation system. Broadcast application is also used to correct pH problems in soil.

The pH of a soil greatly affects its health and fertility. pH levels range from 0 (very acidic) to 14 (very basic). The best levels for soil fertility and plant yields are usually pH 5.5 to 7.3; at this range, most nutrients dissolve readily, and the roots and beneficial soil microorganisms are most active. Central and West Texas soils tend to be alkaline (pH 7.5 to 8.5); East Texas soils are usually acidic (pH 5 to 6.5).

Figure 15. Phosphorus band still visible 90 days after application.

To correct low soil pH, add agricultural lime. However, little can be done to lower the pH of most Texas soils because the water and soil contain large amounts of calcium. Calcium binds to the carbonate in the lime and makes it less effective in lowering pH.

Sulfur is also used to lower pH, but the process takes longer. You may need to apply sulfur several times and check soil pH to reach the desired pH level.

Foliar sprays: Many gardeners believe that spraying fertilizer on the leaves is the way to correct deficiencies of the primary nutrients N, P, and K. But this method is ineffective because leaves cannot absorb enough of these nutrients to fix the problem. Some homeowners continue to use foliar feeding as their only source of fertilizer. This is acceptable because most of it ends up in the soil to be absorbed by the roots. They can absorb only 5 to 10 percent as much of these nutrients as can the roots. However, leaf sprays can remedy deficiencies of micronutrients.

Figure 16. Good drainage is essential.

Seedbed preparation

Because vegetable seeds are so small, they must be planted into seedbeds that are well prepared. Ideally, the soil should be pulverized and free of clods and plant debris (Fig. 16). Poor seedbeds result in weak stands, slow drainage, and more weeds.

Fall gardens can benefit from solarization (Fig. 17), a process by which the sun's heat is used to kill pests. Solarization greatly reduces diseases, insects, and weeds in the fall garden if done properly:

1. In July or August, saturate the soil with water.
2. Lay clear plastic sheeting on the soil and anchor the sides to prevent air circulation.

3. Wait 4 weeks, while the soil temperature under the plastic reaches sterilizing levels. The heat will kill most disease spores, insect eggs, and weed seeds.
4. Remove the plastic and let the soil cool down for about a week before planting.
5. Add and incorporate compost before planting.

Soil can be solarized on raised beds and traditional gardens.

Step 5: Plant the garden

You can establish your garden using seeds, transplants, or both. For most crops, the most efficient method is to use transplants, which become established 7 to 10 days earlier than seeds.

This early start is important in the areas of Texas where the spring gardening season ends by July 1. There, the growing season is too short to plant seeds of crops such as eggplant, peppers, and tomatoes.

For example, a 6-inch tomato seedling is about 6 weeks old; a similar pepper transplant is about 8 weeks old. If you plant seeds instead of transplants, the weather will heat up too fast before the plants can develop and bear fruit.

A disadvantage of transplanting is that few varieties are available unless you sow the seeds indoors, which you would need to do at least 6 to 8 weeks before moving them to the garden. Also, not all plant species can be transplanted easily (Table 3).

Table 3. Transplanting difficulty of various vegetable crops

Easy	Requires care	Difficult
Broccoli	Celery	Beans
Cabbage	Cucumbers	Carrots
Cauliflower	Eggplant	Greens
Peppers	Okra	Sweet corn
Tomatoes	Squash	

However, even though beans and greens are difficult to transplant, they germinate easily and are short-season crops; transplanting them offers no benefit anyway.

Seeds

Take care to plant the right amount of seed. Planting too many can lead to competition for water and nutrients. Planting too few can reduce yield, degrade quality when size control is an issue, and waste garden space.

Err on the side of overseeding. It's better to thin excess plants later than to underseed and waste valuable garden space.

Check the seed packet to determine the seed spacing and planting depth. If the information is unavailable, use the general planting depth of three times the width of the seed (Fig. 18).

The seed spacing for most greens and root vegetables is the size of the harvested crop. For

Figure 17. Soil solarization (left) in a raised bed, and (right) in a garden (the border hasn't been covered yet).

Figure 18. Planting from seed.

Figure 19. Broadcast seeding.

Figure 20. Thinning excess seedlings.

example, radishes grow to about 1 inch in diameter.

So plant the seeds about 1 inch apart. Because a mature head of lettuce is about 6 to 8 inches in diameter, depending on the cultivar, plant lettuce seeds at least 6 to 8 inches apart.

For crops such as mixed greens or arugula, broadcasting seed by hand or machine is sufficient (Fig. 18). Use one of these methods to ensure that the seeds are spaced properly:

- Scatter the seed and then rake the beds twice, the second time perpendicular to the first (Fig. 19).
- Mix the seed with dry sand, put the mixture into a container with holes in the lid, and sprinkle it on the ground.

If more seedlings emerge than necessary, thin them as soon after germination as possible. Protect the plants you want to keep by placing your fingers next to them on the soil surface when thinning out the extras (Fig. 20).

Seeds and seedlings need protection from weather extremes and insect damage. One protective measure is to use row covers, which are lightweight blankets made of polypropylene. Row covers can improve germination rates and protect seedlings and transplants from cold in the spring or heat in early fall.

In Figure 21, a matted row cover on the left protects the plants from insects and diseases during the early stages of establishment. On the right, foam coffee cups serve as physical barriers to protect young plants from worms and crawling insects.

Transplants

When buying transplants, choose those that have well-formed root systems and are free of insects and diseases (Figs. 22 and 23). Avoid plants that are sick,

Figure 21. Matted row covers (above), and foam cups (right).

yellow, or diseased. Check the roots to make sure they are white, have many fuzzy root hairs, and extend throughout the soil or planting media.

Starter solution

A mixture of water and soluble fertilizer—called starter solution—can help young plants get off to a good start and recover from transplant shock. Always use starter solutions for transplants. They help the seedlings:

- Repair the root systems injured by the transplanting process. The plants recover and become established faster, resulting in vigorous plants and better yields.
- Grow new root hairs, which the plants need to take up water and nutrients.

Starter fertilizers are available from stores that sell other kinds of fertilizer. A typical formulation of a starter fertilizer is 6-30-3, which has much phosphorus and little nitrogen and potassium.

If you are using a venturi-type irrigation siphon, look for the dilution factor on the siphon and dilute the fertilizer according to that factor.

For example, if the unit lists a 10× dilution factor, make the stock or fertilizer solution 10 times more concentrated than what is actually needed. The venturi unit will dilute the stock solution by 10× to bring the application to the desired concentration.

Figure 22. Transplants.

Figure 23. Selecting healthy transplants.

Figure 24. Plastic mulch (left) and straw mulch.

Step 6: Take care of the plants

During the growing season, you can improve yields by mulching, watering, controlling insects, and preventing the spread of diseases.

Mulching

A vital component in vegetable gardens is mulch (Fig. 24). The best garden is one with no bare soil visible. Mulch:

- Protects the fruit from contact with the soil, which can harbor disease organisms such as early blight or buckeye rot in tomato
- Keeps the moisture levels in the soil uniform, which reduces physiological problems such as blossom end rot
- Helps prevent weeds from emerging

Both plastic mulch and straw mulch are suitable. An advantage of plastic mulch is that it prevents weed emergence; straw does not. Other mulch materials include newspapers, cardboard, carpet remnants, and recyclables such as wood chips from your community compost company.

Mulch can be used with almost all vegetable species; add it immediately after transplanting.

Watering

Vegetable crops generally need a lot of water. You can reduce the effects of drought by supplemental watering, or irrigation (Fig. 25). Texans cannot rely on rainfall to produce a crop. However, avoid overwatering: More home garden crops in Texas are lost to excessively wet conditions than to drought.

The most efficient way to water vegetables is via drip irrigation, which places water where it is needed. Drip tape is sold at most garden supply stores; a typical 4-foot-wide raised bed needs at least three drip lines. Manage the drip system to prevent the water from flowing off the bed shoulder.

In general, a garden needs 1 inch of rainfall or irrigation per week to replace the water lost to evaporation or transpiration (the loss of water through plant pores, or stomata), commonly referred to as evapotranspiration. For a 12- by 4-foot bed, 1 inch amounts to about 30 gallons per week.

A typical drip irrigation system delivers water at 0.46 gallon per minute per 100 linear feet. A 12-foot-long raised bed with three lines will have 36 emitters that deliver about 0.17 gallon per minute. With this setup, you will need to irrigate for about 3 hours per week to deliver the 30 gallons of water that the plants need to continue growing.

The next question is how to apply this amount. Do you irrigate for 3 hours once a week or 1½ hours twice a week? It depends on the soil type. For a raised bed filled with compost or light, sandy soil, spread out the irrigation over two or three times a week. Unlike turfgrass, vegetables perform best when they are watered lightly and often instead of being soaked heavily once or twice a week. However, because heavy

Figure 25. Irrigation.

Figure 26. Examples of pesticide products for weed control (from left) Serenade, Trilogy, and powdered sulfur.

Figure 27. Insect control.

clay soil can hold more water, irrigate it only once a week.

Watering times change as the plants grow and develop. The schedule above is suitable for fast-growing, developing plants. Young transplants may require only 1 to 2 hours of watering per week to wet the soil to the roots. Older plants with deeper roots may need to be watered for longer periods.

Pest control

One option for controlling insects is to pick them off the plants by hand. Also, a wide variety of pesticide products (Fig. 26) are sold at garden stores. Always read the entire product label before using the pesticide.

Whether you use organic or inorganic pesticides, choose the right product for the targeted pest (Fig. 27). For example, Bt is a popular organic insecticide, but it is effective only on insect larvae—worms or caterpillars. It does not control adult insects.

Nematodes are microscopic worms that infect the roots, making them weak and sick. Even if your garden doesn't already have nematodes, it will probably get them via infested transplants or imported soil.

Methods to avoid or control nematodes, viruses, and other pests include rotating crops, growing plants with anti-nematode properties, culling diseased plants and plant parts, and planting trap crops (Fig. 28).

Trap crops are those that lure insects away from the garden. For example, you can plant white eggplants to attract Colorado potato beetles and indirectly protect your tomato plants. Once the eggplants become severely infested, you can cover them with a trash bag, pull them up, and throw them in the trash. If you remove the plants early in the morning when insects are not very active, you can eliminate the insect infestation without spraying any pesticide.

The roots of annual ryegrass and marigold produce substances that are toxic to nematodes. To

Figure 28. Trap crops.

Figure 29. Virus-infested tomato plant.

Figure 30. A tomato plant with the lower leaves removed to improve air circulation and reduce disease infestation.

control these pests effectively, you must plant enough of them to block the invading nematodes. Don't expect great results if you use one marigold plant in the middle of a 12- by 4-foot raised bed. Planting the whole bed with ryegrass for 1 season will reduce the nematode infestation in the following crops.

Viruses inhibit plant growth and dramatically reduce yields. Typical signs of a viral infection are stunted plants and deformed leaves (Fig. 29). Once established, viruses cannot be cured. Cull the infected plants as soon as possible to help keep the virus from being spread to healthy plants by insects such as thrips, whiteflies, or spotted cucumber beetles.

To help protect tomato plants from soil-borne diseases, remove the lower leaves that touch the ground. This reduces the chances of diseases such as early blight or buckeye rot from splashing on the leaves during rain or irrigation. Remove these leaves when the plants have reached the top of the cage (Fig. 30). This practice also improves air circulation, which inhibits disease infestations.

In areas that have strong winds or where the temperature often swings widely, wrap the tomato cages with matted row covers (Fig. 31). The covers will protect plants from cold and from sand blasting. Leave the cage uncovered on the top to enable the air to circulate freely.

Figure 31. Cages wrapped with matted row covers to protect against cold and wind-blown sand.

Step 7: Clean up the garden

Many gardeners harvest the last vegetable and then forget about the garden until spring. This is a serious mistake. Vegetable plants left in the garden become weeds. They serve as hosts for insects and diseases that will haunt you in the next growing season.

Cleanup at season's end is as important as preparation at the beginning. Clear the garden of cages, hoses, stakes, wiring, and other items. Compost, burn, or till under all plant material. Add compost annually or animal manure every 3 years.

In July and August, you can solarize the site to reduce weeds, insects, and diseases in the fall garden.

At the end of the season, the garden should look as it did at its beginning. It should be cleaned, tilled, and ready for planting (Fig. 16).

Step 8: Plan rotations

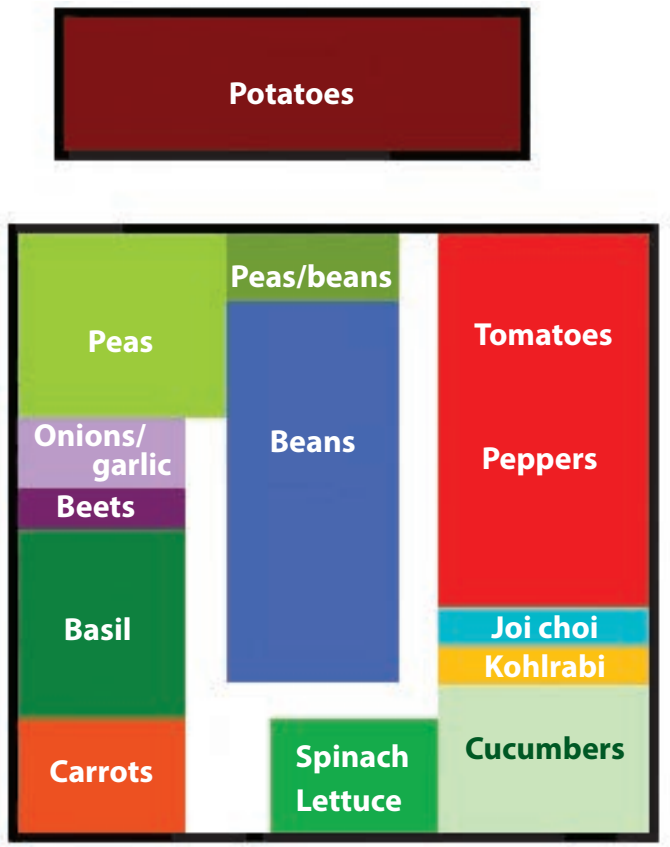
After harvest, begin planning next year's garden. The first step is to plan a crop rotation, which greatly reduces the buildup of soil insects and diseases. Always rotate between crop families, not individual crops (Fig. 32).

In a good rotation, no member of a similar family is planted in the same field, spot, or raised bed for 3 years or six planting seasons. If you follow this schedule, by the time you start the rotation again in Year 4, each area will have had five different families and 2½ years before a similar crop was planted again.

In a poor rotation, family members are planted in the same area in sequence during the year (such as tomatoes followed by Irish potatoes) or in successive seasons.

Rotating crops can seem unnecessary because problems may not emerge over several years of planting the same crop in the same spot. However, once a problem surfaces, it is difficult to eradicate.

To help with the rotations, keep records on the vegetables you grow and list them by plant family (Tables 4 and 5).



In the vegetable garden

Vegetable	Family	Nutrient needs
Basil	Labiateae	Light
Beans	Legumes	Medium
Beets	Chenopodiaceae	Light
Carrots	Umbelliferae	Light
Cucumbers	Cucurbits	Heavy
Garlic	Allium	Light
Joi choi	Brassica	Heavy
Kohlrabi	Brassica	Heavy
Mesclun mix	Compositae	Heavy
Peas	Legumes	Light
Peppers	Solanaceae	Heavy
Spinach	Chenopodiaceae	Heavy
Tomatoes	Solanaceae	Heavy

Outside the fenced garden

Vegetable	Family	Nutrient needs
Potatoes	Solanaceae	Light

Scattered in ornamental gardens

Vegetable	Family	Nutrient needs
Pumpkins	Cucurbits	Heavy
Zucchini	Cucurbits	Heavy

Figure 32. Visual aid for planning a planting rotation.

Table 4. List of vegetable families of common vegetable crops

Family	Vegetables
Amaryllidaceae	Chives, garlic, leeks, onions
Brassicaceae	Broccoli, Brussels sprouts, cabbage, collards, cauliflower, horseradish, kale, kohlrabi, mustard, radishes, watercress
Chenopodiaceae	Beets, Swiss chard, spinach
Compositae	Artichokes, cardoon, endive, escarole, lettuce, salsify, sunflower
Cucurbitaceae	Cucumbers, gourds, luffa, melons, squash
Gramineae	Corn
Leguminosae	Beans, peanuts, peas
Solanaceae	Eggplant, peppers, potatoes, tomatillos, tomatoes
Umbelliferae	Carrots, celery, chervil, cilantro, dill, fennel, parsley, parsnips

Step 9: Keep studying

A passionate gardener is always thinking about new varieties or crops to grow, such as komizune, okahijiki, or Malabar spinach. Your local garden center may not have information on how to grow these exotic crops, but books or online publications are available.

For many unusual crops, no information on production needs is available. In those cases, use information about closely related species to determine whether they might grow and produce well in your area.

Table 5. Examples of good and poor crop rotations

Year	Proper rotation	Poor rotation
1	Spring: tomato Fall: spinach	Spring: tomato Fall: Irish potato
2	Spring: bean Fall: mustard	Spring: bean Fall: snow pea
3	Spring: cantaloupe Fall: onion	Spring: cantaloupe Fall: pumpkin

Step 10: Have fun and keep gardening

Gardening offers many benefits beyond providing good food. Remember to also enjoy the exercise, fresh air, satisfaction, and stress relief that can come from growing vegetables in your home garden.

The only sure way to become an excellent gardener is by gardening—doing the work and learning from your successes and failures. No books can match the benefit of the actual work. The best vegetable gardeners I have met who have constantly put my knowledge to shame have never opened a book about gardening. Their knowledge comes from years of practice.

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