Gardening in Raised Bed and Containers in the Northern Great Plains

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Why raised beds? Or containers?

Is it difficult to bend over to work in your garden? Do you have concerns about limited mobility, either now, or in the future? Do you struggle with poor soil – or even contaminated soil? Maybe you want to cover over a paved area ... or perhaps the spot in your yard with enough sunlight also happens to be where water pools after a rain. Perhaps you have pets that wander into your garden and dig up – or lay on – the plants. Do you constantly fight perennial weeds such as quackgrass or thistle in your garden? Have limited space? Any of these issues may inspire you to investigate raised bed or container gardening. There are many options to choose from, but here you will find some basic considerations and guidelines for both raised beds and container gardening.

Raised Beds

Gardeners may want to consider raised beds because they tend to warm up and dry out more quickly in the spring for early planting, and they allow you to garden regardless of soil condition since they often have less compaction, better drainage, and don't require tilling. If you're new to gardening, small, raised beds are a manageable space to maintain, and the height and accessibility can be modified to accommodate people of all ages and abilities. Raised beds also make it easier to incorporate season extension techniques like row covers or add shade cloth or insect netting to protect your plants.

Figure 1. Raised garden bed

Types

On the ground

- A simple raised bed can be formed by mounding soil onto the desired bed area; often with several inches of compost mixed in. Sometimes this bed will be covered with plastic to help it retain its shape, but sometimes it is simply left with sloping sides. Sides should be sloped at a 45-degree angle to decrease erosion. It is best to use drip irrigation or soaker hoses with uncovered beds, so the sides do not wash away. The "hills" that some people use for cucumbers could be considered a very small raised bed.
- Most raised beds on the ground have their sides enclosed with some sort of material – ranging from wood, concrete, steel, old tires, plastic or resin, etc.

Most often these do not have a constructed bottom, though landscape fabric or cardboard is sometimes placed at the bottom of the structure to discourage perennial weeds with rhizomes (underground runners) from invading the bed. If there is a constructed bottom to the bed, ensure that water can drain out of it. You may need to line the bottom with hardwire cloth to keep out small rodents such as gophers and voles.

- Hügelkultur beds: A hügelkultur bed is prepared by digging a shallow trench and filling it with old logs, sticks, leaves, and mulch. The woody material is layered with compost, straw, or other organic matter, and then a final layer of soil is added before it is planted. Alternatively, these layers can be constructed on the ground to create a taller bed.

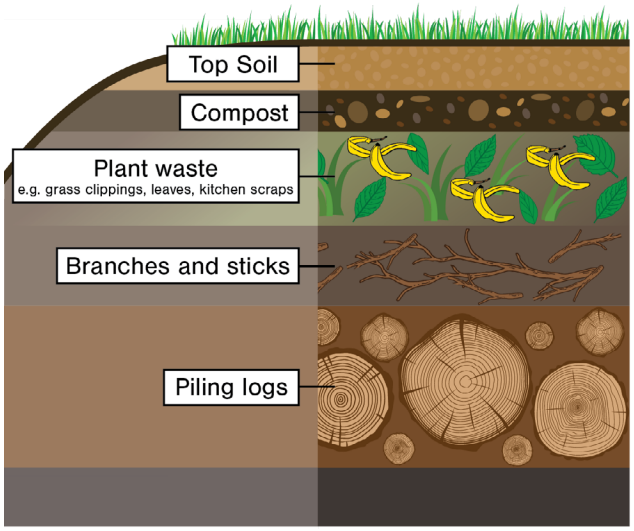

Figure 2. Hügelkultur raised bed

The decomposing wood retains moisture and releases nutrients into the soil. Hügelkultur beds can reduce the frequency of watering, use up waste wood, and can increase the surface area of your garden in a small space. One drawback of hügelkultur beds is that using fresh wood can deplete the nitrogen available in the soil. To prevent this, do not use freshly cut wood and pack nitrogen rich organic material around the wood. Make sure that you have enough soil in the top layer so that plant roots are not reaching down into the wood layer. Note: Some trees are allelopathic and will hinder the growth of your plants. Avoid using wood from black walnut, hackberry, cottonwood, red oak, sugar maple, American elm, and black locust trees.

Off the ground

Some raised beds are raised off the ground for aesthetic purposes, accessibility, or because of the materials used.

Figure 3. Raised bed off the ground.

These may dry out much more quickly and be subject to greater temperature variation than beds in contact with the ground. However, they may provide protection against animals such as rabbits, moles, ground squirrels, etc. Hügelkultur methods can be adated to tall, raised beds or raised beds off the ground as well, and can decrease the amount of soil mix needed to fill the beds.

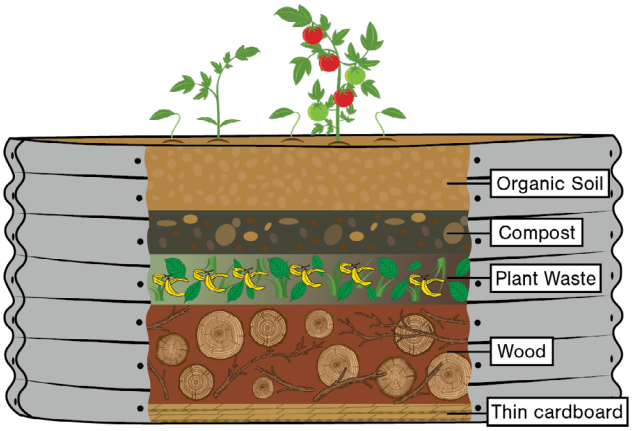

Figure 4. Modified hügelkultur system in a deep raised bed.

Location

Adding raised beds and containers to your gardening space allows you to get creative with the location. Some considerations to keep in mind when deciding where to place your beds are how much space you have, how close a water source is, and what you plan to grow. It's best to place raised beds on level ground and avoid low-lying areas that may have standing water after a rain. Remember, wherever you place your raised bed or container, most vegetables need 8 hours of sunlight per day; salad greens can get by with 4 to 6 hours.

Materials

Wood

Wood is a commonly used material in raised beds.

Figure 5. Raised bed made from wood.

Any wood in contact with the soil should be rated for ground contact (UC4 under the American Wood Protection Association rating system). Untreated pine may last several years, on average, whereas pressure treated wood can last for 30 years or more. Some growers have success by lining the beds with heavy-duty plastic as a moisture-barrier. At one time, arsenic was used to treat wood, but this is no longer the case; currently copper is used and is much less toxic than arsenic. Wood of naturally rot-resistant species such as redwood, cedar, or juniper may last 15-30 years but will cost more. Do not use creosote-coated railroad ties for growing edible plants or in locations where pets or humans will come into repeated contact with them.

Cement

Cement blocks can be used without mortar for beds up to two feet high – if built higher than that, they will require mortar or other reinforcement such as rebar. Blocks can sometimes be obtained from a construction site for nominal cost. Frost heaving may cause cracking on mortared walls. Cement can be painted to reflect heat. Blocks may sometimes contain fly ash that can leach toxins into the soil, so gardeners may want to line the bed with heavy plastic, and/or avoid placing food plants near the edges of the bed.

Stone

Stone raised beds can be very beautiful and long-lasting. Many farmers are willing to give away fieldstone if gardeners are willing to come and load it.

Plastic/Synthetic wood

Recycled plastics are often formed to resemble wood. HDPE plastics are particularly stable and UV resistant.

Metal/Galvanized Steel

Metal is easy to install and can be bent to desired shapes.

Figure 6. Raised beds made from galvanized steel.

At least one of our community gardens in South Dakota uses steel frames. Stock tanks come in a variety of sizes and can be used with good success (remove the bottom plugs so excess water can drain out easily). Wood accents can be added to enhance the appearance of the beds. Taller beds will require rebar or other supports to keep sides from bowing.

Discarded tires

Tires are an inexpensive option that have been used for many years; however, there are some potential hazards with using tires. Tires can contain small amounts of various heavy metals and other toxins that may be released as they degrade. For this reason, it is best to use tires for ornamental flower beds rather than food plants, and small children should be discouraged from climbing on them.

Raised bed dimensions

Width: Keep the bed to a width that allows you to easily reach the middle – four-foot-wide or less if you can reach from both sides. If the bed is accessible from only one side, keep it to 3 ft. or less.

Length: The length of your raised bed may be dictated by the materials used. If this is not the case, it can be as long as you want. Keep in mind that if you are working from both sides of the bed you won't want to have to make a long trek to get to the other side!

Soil Depth: The roots of many vegetable plants will grow down 6" to 12", and some brassicas and cucurbits roots can grow 18" to 24" deep. The deeper the bed, the longer it will take to dry out after watering, but it will also require more soil to fill it. A hügelkultur system can be used to decrease the amount of soil needed to fill deeper beds.

Height: Even a low (6") raised bed will be easier to work with than nothing at all, but for full handicap

accessibility, plan on a bed that is 28 to 34" high. If a bed is built to allow a wheelchair to fit underneath, that space needs to be at least 28" from the ground and at least 30" wide.

Between beds: Allow 3 to 4 feet between beds. This enables you to access the beds with a wheelbarrow or utility cart. For wheelchair accessibility, allow at least 3 feet between beds. If the beds are long, consider having enough space between beds (minimum 5 feet) for a wheelchair to turn around easily instead of having to go all the way to the other end.

Plants

When growing in raised beds, you may not have as much space as in traditional in-ground gardens. Make sure you're choosing varieties that you want to grow to make efficient use of your space. Growing techniques like companion planting and square foot gardening can help utilize your space to get the most plant numbers and varieties, while also making sure that your plants stay healthy and attract beneficial insects and pollinators too! It's also important to practice crop rotation and add more nutrients to the soil with fertilizer or compost after harvest, as the soil can harbor pests and lose nutrients when plants are grown in smaller spaces and limited soil.

Containers

Many vegetables can be grown successfully in containers. The key is to match the size of the container with the size of the plant and to have a system for watering the container as needed. Containers can dry out quite quickly, so plants may need to be watered daily, or even twice a day during hot windy periods if the container isn't large enough.

Container shape: Flat vs. Tall

Which will have better drainage – a flat wide container or a tall narrow one? If you are not sure, take a saturated sponge, and hold it flat until it stops dripping. Now hold it vertically. See how much more water drains? If you have a plant that needs good drainage, a tall container will allow better drainage.

Potting or container soil is generally the best medium for use in containers. Don't use straight garden soil. Garden soil may contain weed seeds or diseases, and when it is transferred to containers the soil structure is lost, aeration and drainage will be poor, and roots will have more trouble growing into it. See more under "Soil/Potting Media" below.

Do not add rocks or gravel to the bottom of a container. This used to be a common practice that was thought to enhance drainage; however, adding rocks or gravel creates what is called a "perched water table" that will prevent drainage from the soil into the rock/air mix below. The water will remain in the container above the rock/gravel layer and may cause the roots to rot due to water saturation and decreased oxygen (You can demonstrate this by placing a saturated sponge on dry sand. Not much of the water will drain into the sand.) Be sure that your containers have drain holes. Several drain holes are needed in larger containers.

Materials

Clay or Ceramic Pots

Clay and ceramic pots are heavy and are less likely to blow over on windy days. Uncoated clay pots "breathe", allowing better aeration for roots, but are also more prone to dry out quickly. White salts may build up on the clay surface over time, but this can be cleaned off by soaking empty pots in vinegar.

Grow bags

Grow bags constructed out of mesh fabric are available in a range of styles and sizes. You can even sew your own from good quality landscape fabric.

Plastic or resin

Plastic pots or bins come in a plethora of sizes, shapes, colors, and designs. Make sure they have adequate drainage holes. See Table 1 for suggested minimum sizes for various vegetable crops. Although plastic containers are much lighter weight, remember a 5-gallon plastic bucket ½ full of water weighs 20 lbs., so a filled and watered container can be quite heavy.

Wood

Wooden planters or barrels cut in half make attractive containers, but they can be quite heavy when filled with moist soil, so do not plan on moving them around without a cart.

What to grow

There are many new compact vegetable varieties suitable for growing in containers. If you are growing vegetables such as tomatoes or squash, look for "bush" types or ones that specify that they are suitable for containers.

Watering

Getting the proper amount of water in a container can be tricky. Small young plants do not absorb much water, so it is easy to overwater early in the season. On the other hand, a sunny, windy day can lead to

Table 1. Suggested minimum container sizes for growing vegetables.

Vegetable	Minimum size	Plants per container	Rooting depth	Notes
Asian Greens; Arugula	1-2 gal.	1-5	12-18”	
Basil, Parsley	2 gal.	2-4	12-18”	
Beets	2 gal.	2-3” apart	18-24”	
Broccoli	5 gal.	1	12-18”	
Cabbage	2-5 gal.	1	12-18”	
Carrots	2 gal.	2-3” apart	18-24”	Container should be at least 1” longer than expected carrot length
Cucumber	2-5 gal.	1	18-24”	Bush type!
Eggplant	2-5 gal.	1	18-24”	
Green beans	2-5 gal.	1-2	12-18”	Bush types
Leaf lettuce	1 gal.	4-6 plants	12-18”	
Head Lettuce	1-2 gal	1-2 plants	12-18”	
Pepper	2-5 gal.	1	18-24”	Chili peppers require less space
Radishes	2 gal.	1-2” apart	4-6”	
Spinach	1-2 gal.	2-4” apart	12-18”	
Squash (Zucchini or Summer squash)	5 gal.	1	18-24”	
Tomato	5 gal.	1	18-24”	

high evaporation rates, especially with smaller pots and larger plants. If you have an automatic watering system for your containers, be sure to check your pots frequently to make sure they are not too dry or too soggy.

A word of caution

If the growing medium in a container dries out, it can shrink and leave a gap along the inside of the container. When this happens, water will drain quickly down the gap without moistening the soil around the plant. This is quite common when the growing medium contains peat moss, which tends to repel water when it is dry. If a plant seems to be wilting despite regular watering, check to make sure that the soil around the roots is actually moist.

If this happens, repeated watering will be needed to rehydrate the soil, or a hose can be left to drip slowly for a few hours. A drop of dish soap in a gallon of water may help the media to absorb the water. If the container is small enough it can be immersed halfway in a bucket, tote, or sink filled with water and left until the surface of the soil is moist.

Applying too much water too often and not having enough drainage for excess water are the leading causes of root rot and other diseases. Signs can include wilting and/or yellowing leaves. Empty saucers under the container after watering or after a rainfall event. Use pot feet to raise containers to allow for better drainage.

Fertilizing

Most types of growing media will require extra fertilizer for good yields. Commercial media mixes may include some fertilizer, but this is usually absorbed by the plants within the first few weeks. The simplest way to fertilize is to look for materials formulated for vegetables or for a specific vegetable crop. For example, fertilizers marketed for tomatoes will contain extra calcium to help reduce blossom end rot (and will also work well for peppers, squash, and other fruiting vegetables). Read the label directions carefully. In general, organic sources such as fish emulsion are less concentrated than other types of fertilizer and will need to be applied more frequently or in larger amounts. Watch your plants for cues. If your plant is growing vigorously and has healthy green leaves, it has sufficient nutrients. If it is spindly with small leaves, it may need additional feeding. If the lower leaves are yellowing, it likely needs additional nitrogen, and possibly other nutrients as well.

Soil/Potting Media

On the ground raised beds are often formed from mixing the existing soil with added organic matter. If the underlying soil is of poor quality, the raised beds may be filled with soil brought in from elsewhere. In either case, organic matter in the form of compost, manure, or amendments such as peat moss or coir is often added. These forms of organic matter can help supply nutrients and help keep the soil moist, but not too wet. Organic matter can also help alleviate problems with compaction, which can occur when soil is moved from one location to another.

Desired Characteristics

The optimal growing medium facilitates healthy root growth by retaining moisture while allowing excess water to drain away so that roots can "breathe." It will provide nutrients but not be high in salts. The desired weight of the growing medium may differ, especially for containers, depending on whether the container will be hanging or whether it needs to be heavy enough to avoid being blown over by the wind or toppled by a top-heavy plant.

Soil

Evaluate your soil:

1. If there are plants growing in it, do they look healthy or do they struggle to grow? Testing the garden soil may help determine whether plants are growing poorly because of a high pH, high salts, or some other issue.
2. Does it have rocks that make it difficult to dig into?
3. When it is wet, could you form a clay pot from it? When it is dry, does it form deep cracks?
4. Is there reason to think it may contain chemicals such as herbicide residue or other hazardous waste?

If the answer to any of the above questions is "yes," consider bringing in soil from elsewhere. If you do so, be sure to work in some compost, as purchased soil may have lost most of its microorganisms after sitting in large piles or in plastic bags.

Compost

Compost can be mixed with soil to create a more fertile growing medium and increase the soil's ability to hold air and water. Compost quality and characteristics can vary widely depending on what materials were used to create it, as well as the composting process and age.

Because of the variability of compost, it is difficult to make recommendations regarding specific ratios of compost to soil, or whether to add additional nutrients or materials. However, many gardeners have found that their plants do not grow well in straight (100%) compost. In some cases, the compost may be packed down too tightly for good aeration. In other cases, it may not have a good balance of nutrients. Over time, the nitrogen in compost will be used up while the phosphorous may build up to levels that interfere with the uptake of other important nutrients. Compost created from feedstocks containing manure may have too high salt levels to be used undiluted (similar to trying to grow plants in straight fertilizer – or straight manure).

If compost dries out completely, it may become hydrophobic – that is, it will not absorb water. Beds filled with dry compost can repel water to such a degree that the top ½ inch may be soggy or even have standing water but be completely dry underneath!

For the above reasons, most gardeners will add compost to soil in a range of anywhere from 10% to 50% compost, with 25% compost perhaps being the most common. If the compost was made from manure or animal bedding it will have higher amounts of potassium and phosphorus, so smaller amounts should be used compared to compost made from only plant materials. As microorganisms break down the compost, the nutrients present will be released slowly and made available for plant uptake. Plants growing in raised beds will often need other sources of nutrients, especially early in the growing season. A quick-release fertilizer, either in a chemical or an organic form such as fish emulsion, can help get the plants off to a good start.

Manure

Small amounts of well-aged manure can be added to supply nutrients and contribute organic matter to the soil, which can improve aeration and water retention. These nutrients become available over time as microorganisms break down the manure and release the nutrients into the soil for the plant roots to absorb.

WARNING: Never use raw manure in your vegetable garden beds or containers

Manure should be aged at least six months, preferably longer. Never use dog or cat feces, even if they are aged, as these can contain particularly hazardous human pathogens.

If you plan to add manure to your soil, a soil test can help to determine how much to add – and even what source of manure may be most helpful. In addition to determining what nutrients are needed, the pH and EC (a measure of salts) of the soil may determine what

amount of a particular manure can be used without creating high pH or salts. Ideally, manure should be added at the end of the growing season, or a few weeks before planting, so the soil microorganisms can begin to stabilize before plants are seeded or transplanted into the soil.

Be aware that some manures, especially horse manure, can contain weed seed. Aging or composting can reduce the viable seed but may not eliminate it. Composting may decrease the amount of nitrogen in the manure and may also increase salts.

Herbicide residue in compost and manure

Herbicide residue in compost is a frequent problem, particularly if the compost is made from municipal yard wastes (i.e. lawn clippings) or manure. There are several common herbicides that are effective for hard-to-kill lawn weeds, but do not break down easily and can survive the composting process intact. Similar herbicides may be used for perennial or woody weeds in pastures where grazing animals ingest them. If the animals are subsequently penned in a barn or confined space and their manure is collected, it may not only contain the herbicide, it may be concentrated by the digestive tract of the animals.

How can a gardener know if compost is free of these harmful herbicides? Chemical laboratory tests can be quite expensive and difficult to interpret (e.g., what level of the chemical is safe?) A biotest is a low-cost alternative that anyone can do. Obtain a sample of the compost or manure and mix a small sample with soil, washed sand, or perlite, in the same ratio as will be used in your raised bed or container. Plant several bean seeds 1" deep, and water well; use enough seed to observe multiple plants – six is a good number for a medium-sized pot. Plant the same number of seed in a second pot without the compost or manure to use as a comparison. If the beans germinate and grow normally, your compost should be fine. If they do not germinate or look unhealthy (yellowish, or with distorted leaf shapes), do not use that compost. (It would likely be safe for growing corn or small grains – if in doubt, repeat the biotest with the desired crop.)

Other Materials

Peat moss

Peat moss is made of decomposed organic matter harvested from peat bogs and is a common component of potting soils/media. It is relatively sterile and is used primarily to retain moisture and nutrients. Some gardeners mix it into their beds as a source of organic matter. It may lower the pH slightly, but that is often helpful for gardens situated on South Dakota soils. Be aware that peat, like compost, can become hydrophobic if allowed to completely dry out. This can be corrected by adding a couple drops of detergent in the water used to re-wet it. Peat does not compact over time but retains too much water for plants to be grown in 100% peat. A common mix for containers is 50% peat: 50% perlite (see below). Neither the peat nor perlite will supply nutrients, so attention must be paid to fertilizing the plants throughout the growing season. Many gardeners are moving away from using peat as it is a non-renewable resource that takes thousands of years to form. Peat moss is most often harvested from peat bogs in Canada and occasionally in the U.S. When peat moss is harvested carbon dioxide is released into the air instead of being incorporated into the peat.

Coir

Coconut coir is made from the outer husks of coconut and is an alternative to peat moss. Coconut coir is a by-product of the food and cosmetic industry and is considered more readily renewable, although the shipping distance can be greater. Coir is pH-neutral and non-hydrophobic (i.e., won't repel water when it is dry). Like peat, it can improve water retention, but it provides better aeration, decomposes more slowly, and resists becoming compacted.

Perlite

Perlite is manufactured from volcanic glass that is heated to very high temperatures until it expands 4 to 20 times its original volume (like popping popcorn), forming light-colored, lightweight particles. Perlite is used to improve aeration and drainage and is often used as a growing medium in hydroponic production. Perlite comes in different sizes – the larger size is used for drainage, while the very fine size can help retain moisture. Regardless of size, plants can more readily extract water from perlite than from many other materials.

Vermiculite

Vermiculite is manufactured from mica heated to high temperatures so that it expands the layers. It absorbs and retains water and nutrients. Vermiculite is used more often in containers than in garden beds, as it deteriorates (packs down) much more quickly over time than perlite. Vermiculite makes an excellent seed-starting medium and is available in different sizes for different uses. The US EPA recommends avoiding breathing vermiculite dust, so use a dust mask when working with dry vermiculite.

Two examples of soil mix that can be used in raised beds gardens are:

Square Foot Gardening Foundation
- 1 part compost: 1 part peat moss: 1 part coarse vermiculite

Iowa State University
- 1 part topsoil: 1 part peat moss OR compost: 1 part sand

Raised bed gardens and containers allow you to grow your favorite plants regardless of space or physical ability. Feel free to get creative with location, materials, trellises, plant varieties and more! Once you get started growing healthy, abundant produce and flowers, there's no limit to the creativity you can use to come up with interesting and productive growing spaces.

Figure 7. Raised bed and container ideas for a small space.

Figure 8. Productive raised bed ideas with trellises.

Resources

All America Selections, Container Suitable Plants (all-americaselections.org/product-category/container-suitable/)

Iowa State University Extension, Toxicity Concerns About Raised Bed Construction Materials (extension.iastate.edu/smallfarms/toxicity-concerns-about-raised-bed-construction-materials)

Iowa State University Extension, What Would Be a Good Soil Mix for a Raised Bed (yardandgarden.extension.iastate.edu/faq/what-would-be-good-soil-mix-raised-bed)

North Dakota State University Extension publication H1597, The Facts of Square Foot Gardening (hcmga.org/wp-content/uploads/Square-Foot-Gardening-NDSU-h1597.pdf)

Oregon State University Extension, Herbicide Contaminated Compost and Soil Mix: What You Should Know-and What You Can Do About It (extension.oregonstate.edu/catalog/pub/em-9307-herbicide-contaminated-compost-soil-mix-what-you-should-know-what-you-can-do)

University of Wisconsin Extension, Vegetable Varieties for Containers (hort.extension.wisc.edu/articles/vegetable-varieties-for-containers/)

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