

Water Management for Raised-bed Gardens

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Introduction

Raised-bed gardens are a form of gardening in which the soil is raised above the surrounding soil, sometimes enclosed by a frame generally made of wood, rock, or concrete blocks, and may be enriched with compost (**Figure 1**).



FIGURE 1: Raised-bed garden. Source: Wilkinson (2013)

Managing water in raised-bed gardens is a bit more challenging than in a traditional garden. Raised-bed gardens are often well drained and therefore the growing plants will rarely suffer any stress caused by overwatering. However, overwatering increases the amount of water loss through seepage from the base of the bed. Water deficit stress associated under-watering is a bigger challenge for raised beds since more plants are grown per square foot making the soil to dry out faster. Hence they require more frequent watering than traditional in-ground row plots.

Failure to supply sufficient water, especially for deeper beds, can lead to delayed maturity and lower yields. To overcome the water-holding limitation inherent in raised beds, sufficient water should be supplied frequently and evenly. The amount and frequency of

watering depend on the *water holding capacity* of your soil, *weather conditions* and *water requirements* of your plants.

Soil Water Holding Capacity

Apart from supplying nutrients to plants, one of the main functions of soil is to store moisture between rainfalls or irrigations. After irrigation or rainfall event, water is lost from the soil by the process of evaporation from the soil surface, transpiration by plants, and by deep percolation. If the water content becomes too low, plants become stressed. The capacity of the soil to provide storage and buffer the plants from dry spells is related to the **soil water holding capacity**. The availability of water for plant use depends not only on the amount of water present in a soil, but also on the energy status of that water. This energy status is referred to as **matric potential**, defined as that portion of the total water potential due to the attractive forces between water and soil solids and is always a negative value. When soil is **saturated**, all the pores are full of water. However, the loosely held water, referred to as **gravitational water**, will drain out of the soil subject to gravitational pull (Figure 2). The content of water that remains 2 to 3 days after the drainage of a previously saturated soil is referred to as the **field capacity** of the soil. At field capacity plants draw out water readily from the soil pores. As the soil dries out, plants will continue drawing water but at increasing difficulty until no more can be withdrawn, as the soil reaches the **permanent wilting point**, estimated to be the water content at -1,500 kPa of soil matric potential.

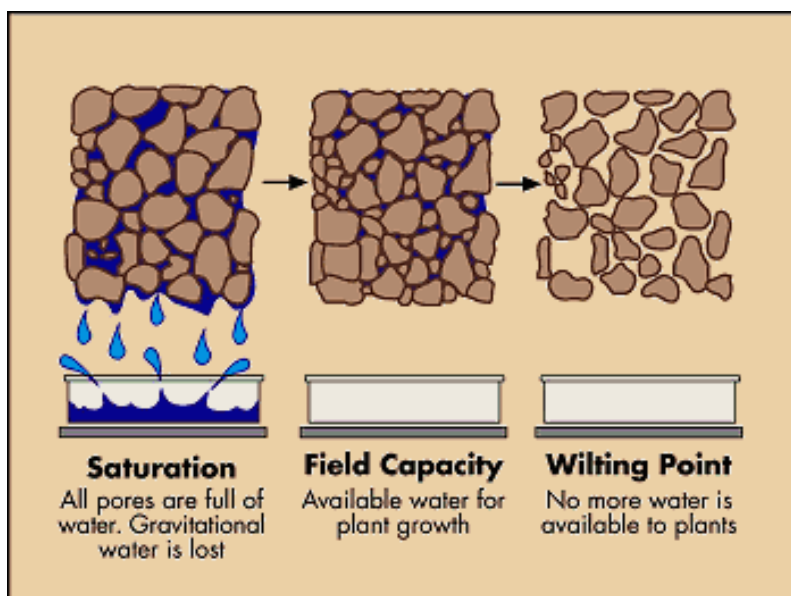


FIGURE 2: Water status in the soil.
Source: Dep. of Agriculture Bulletin 462 (1960)

The **soil water holding capacity** is defined as the difference between the water held in the soil at the field capacity and the permanent wilting point. Other terms with similar meanings are available water, plant available water, and available water capacity. Water in the soil is readily available for plant use between the field capacity and halfway between the field capacity and the permanent wilting point. That point marks the beginning plant stress (**Figure 3**).

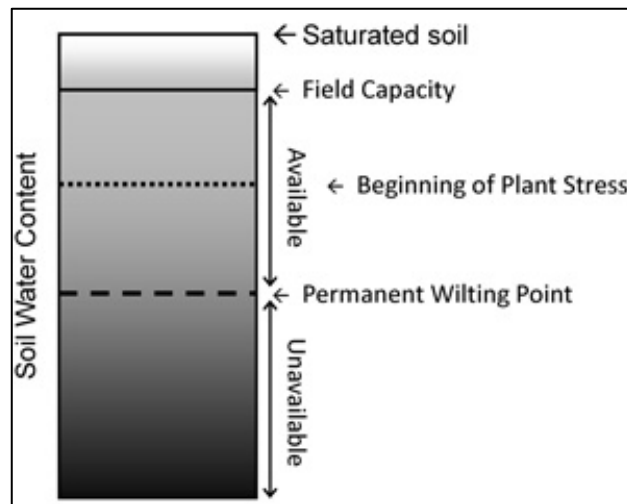


FIGURE 3: Schematic for soil water content. Source: Black et al. (2013)

The water holding capacity is dependent on soil composition, organic matter content, and soil texture. Soil texture refers to the relative fractions of sand, silt and clay. The USDA has defined twelve textural classes based on the relative composition of sand, silt, and clay. These classes are clay, silty clay, silty clay loam, silt loam, silt, clay loam, loam, sandy clay, sandy clay loam, sandy loam, loamy sand, and sand. Using the USDA soil textural triangle (**Figure 4**), you can determine the textural class given any two of the sand, silt, or clay proportions. For example, a soil with 30% clay and 60% sand would be classified as a sandy clay loam, while a soil with 40% silt and 40% sand will be classified as a loam soil. A fine-textured soil has smaller but more numerous pores than a coarse-textured one, which has bigger particles but it has less porosity, or overall pore space. Water can be held tighter in small pores than in large ones, so fine soils tend to hold more water than coarse soils.

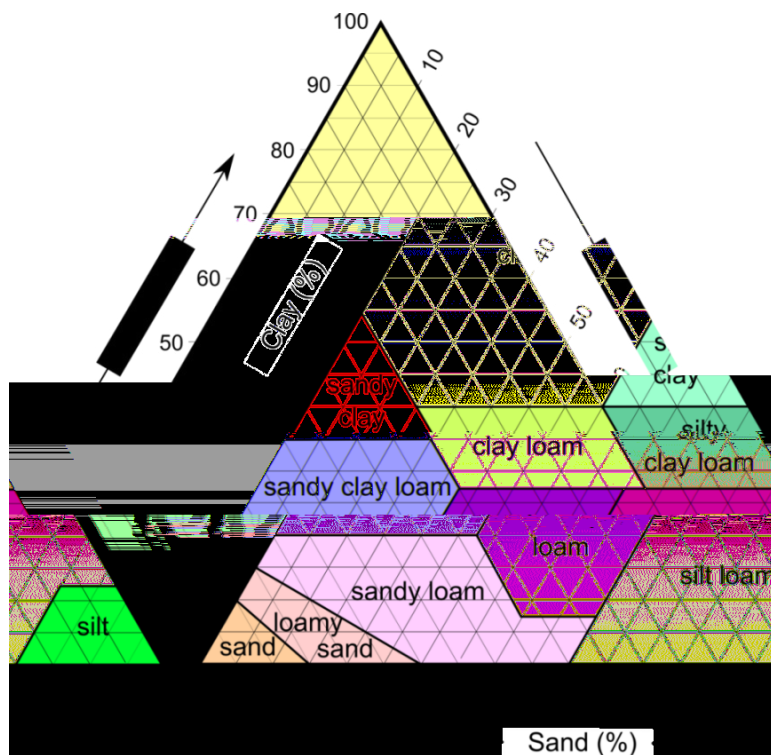


FIGURE 4: USDA Soil Textural Triangle

Table 1 shows relative soil available water capacity as influenced by the soil texture. All other factors being equal, a sandy soil will dry and require irrigation sooner than a loam soil.

TABLE 1: Available water capacity as influenced by the soil texture (Ball 2001)

Textural Class	Available Water Capacity (Inches/Foot of Depth)
Coarse sand	0.25-0.75
Fine sand	0.75-1.00
Loamy sand	1.10-1.20
Sandy loam	1.25-1.40
Fine sandy loam	1.50-2.00
Silt loam	2.00-2.50
Silty clay loam	1.80-2.00
Silty clay	1.50-1.70
Clay	1.20-1.50

Crop Water Requirements

Crops have critical moisture periods when soil moisture stress can most reduce yield in an otherwise healthy crop (Table 2). Critical moisture period is not the only time in the life of the crop that moisture stress reduces yield, but the time when moisture stress will exert its greatest effect. Most vegetable crops are sensitive to drought during two periods: during harvest and 2-3 weeks before harvest.

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TABLE 2. Available water capacity, and suction and critical need stage for vegetables
(Modified from Sander, 1997 and Black et al., 2013)

Crop	Min. AWC¹ (cm³/cm³)	Min. Suction (centibars)	Critical water need stage
Asparagus	40	-7.0	Establishment and fern development
Bean, green	50	-4.5	Bloom and pod set
Bean, pinto	50	-4.5	Bloom and pod set
Beet, table	20	-3.4	Establishment and early growth
Broccoli	70	-4.5	Establishment and heading
Cabbage	70	-7.0	Uniform throughout growth
Cantaloupe	60	-20.0	Establishment vining to first net
Carrot	50	-2.5	Emergence through establishment
Cauliflower	60	-2.5	Establishment and 6 - 7 leaf stage
Celery	70	-3.4	Uniform throughout growth
Collards/kale	50	-4.5	Uniform throughout growth
Corn, sweet	50	-4.5	Establishment, tasselling and ear dev.
Cucumber	50	-4.5	Establishment, vining, fruit set
Eggplant	50	-4.5	bloom through fruit set
Garlic	70	-2.5	Rapid growth to maturity
Lettuce	60	-3.5	Establishment
Mustard green	70	-2.5	Uniform throughout growth
Okra	40	-7.0	Flowering
Onion	70	-2.5	Bulbing and bulb expansion
Pepper, bell	50	-4.5	Establishment, bloomset
Potato, irish	70	-3.5	After flowering
Pumpkin	40	-3.5	Bloom, fruit set and development
Radish	70	-2.5	Uniform throughout growth
Spinach	70	-4.5	Uniform throughout growth
Squash, sum.	70	-2.5	Fruit sizing
Squash, winter	40	-7.0	Fruit sizing
Sweetpotato	20	-20.0	First and last 40 days
Tomato	50	-4.5	Bloom through harvest
Turnip	50	-4.5	Root expansion
Watermelon	40	-20.0	Fruit expansion

¹ AWC (Available Water Capacity) is the water held between field capacity and permanent wilting point.

Leafy vegetables are planted at or near field capacity, and being shallow rooted, they benefit from frequent irrigation throughout the season. Leaf expansion relates closely to water availability; hence they are particularly sensitive to drought stress during the period between head formation and harvest. In addition, overwatering or irregular watering can result in burst heads for cabbage.

Root and bulb crops have yield that depends on the production and translocation of food from the leaf to the root or bulb. The most sensitive stage of growth generally occurs as these storage organs enlarge. Water stress causes the formation of small, woody, and poorly flavored roots. Uneven irrigation can lead to misshapen or split roots and early bulbing in onions.

Fruits and seeds vegetables are crops are most sensitive to drought stress at flowering and during fruit and seed development. Fruit set on these crops can be seriously reduced if water is limiting. An adequate supply of water can reduce the incidence of fruit cracking and blossom-end rot in tomatoes and peppers.

Irrigation Methods

Flood irrigation is the application of irrigation water where the entire surface of the soil is covered by ponded water.

Furrow irrigation involves a partial surface flooding method of irrigation where water is applied in furrows or rows of sufficient capacity to contain the designed irrigation system.

Sprinkler irrigation is a planned irrigation system in which water is applied by means of perforated pipes or nozzles operated under pressure so as to form a spray pattern.

Sub-irrigation involves applying irrigation water below the ground surface by using a buried perforated or porous pipe system that discharges directly into the root zone.

Drip irrigation is a system in which water is applied directly to the root zone of plants by means of applicators such as orifices, emitters, porous tubing, or perforated pipe. It is operated under low pressure with the applicators being placed either on or below the surface of the ground. It is the ideal application method for raised-bed gardens because it delivers a low-volume, steady supply of moisture in frequent doses.

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