



A MORE IN-DEPTH LOOK AT FOOD GARDENING WITH LESS WATER

This is a companion piece to “Food Gardening with Less Water”ⁱ and is a compilation of information from a variety of sources.ⁱⁱ The purpose of this document is to provide Sonoma County Master Gardeners and home gardeners with science-based information in order to make the most of limited landscape water.

Sonoma County receives about 30 to 50 inches of rainfall in a normal year – differing amounts depending on distance from the ocean, elevation, mountain shadows and weather patterns. Only a small fraction of that, however, is stored in the soil and made available to plants in the spring when growth starts. Most of it runs off. Even less moisture is available to plants in a drought because the ground’s reserve is depleted by sunny winter days and insufficient replenishment. After several years of low rainfall, essentially all sources of drinking water and irrigation water are very limited. Therefore, water-wise strategies are required.

WATER IN THE SOIL

One of soil’s functions is to serve as a water-holding reservoir. Each soil type – sand, loam and clay – has a different water-holding capacity. Sandy soil holds less and clay soil holds a bit more but on the average our common loam soils hold about two inches of water per foot of rooting depth, which is equivalent to about 1.25 gallons per cubic ft of soil.

Soil type or depth does not determine how much water a plant uses. Rather, soil type and rooting depth means that there are different amounts of water stored for the plants to use. Once the soil absorbs its maximum, any additional water runs off or percolates deeply beyond the rooting zone. Supplemental irrigation is needed after plants deplete the water that the soil is holding.

Growing plants without any irrigation limits landscape options. Choices include, but are not limited to: growing early or late season plants that are summer-dormant and thrive in cool weather; growing drought-tolerant ornamentals; or maintaining deeply rooted trees grown in deep soils. Even then, orchard yields can be very low, fruit size is smaller and vegetative growth can be short or sunburned leading to poor fruiting the following year.

In a vegetable garden, the top six inches to a foot of soil is considered the active root zone. A number of vegetables, such as tomatoes and corn, can send their roots deeper with an active root zone between one and two feet. In the past, gardeners were encouraged to water deeply so that roots grew deep into the soil and were protected from drying out. However, when water supplies are limited, gardeners are advised to water only the active root zone. This practice assumes that they are using three to four inches of mulch on top of the soil to keep the soil cool and inhibit weeds, making more stored water available to food crops.

HOW MUCH WATER DO PLANTS USE?

The amount of water plants use is primarily influenced by temperature, i.e., how hot it is for how long. It is influenced by relative humidity and wind velocity as well, but to a lesser extent. Consequently, water demand is lower in the spring and fall when days are cooler and shorter. The rate at which plants use water is known as the evapotranspiration rate (ET). ET refers to how much water is lost from evaporation at the soil surface and from transpiration which is water vapor lost from leaf surfaces.

Plant water use - or the ET rate - in the spring and fall in Sonoma County is about 0.10 inches per day or about one inch of water use per ten days. During the hot, long days of summer, water use or the ET rate can climb to about 0.25 inches per day or about an inch of water use every four days. Daily ET rates can be found in *The Press Democrat* or on the California Irrigation Management Information System (CIMIS) website.ⁱⁱⁱ

These ET rates are “potential” use rates that plants will use if there is plenty of water available to them. Limited water availability will cause plants to reduce photosynthesis and grow less, while also using less water. As water stress increases, plants almost completely shut down and stop growing in an attempt to survive. In that case, they use much less water than full ET. But, of course, they do not look good or perform very well. Under severe water stress conditions, leaves wilt and sunburn or plants die – depending on their tolerance to drought stress.

Vegetables planted in cool months require less water than warm season plants because they are growing at a time of year when water demand is lower. Growing broccoli, cauliflower, peas, lettuce, onions, spinach, mustard greens and other cool season vegetables during the heat of the summer – when they normally would not grow well anyway – requires lots of extra water just to help them stay cool. Consequently, we do not recommend this!

Warm weather vegetable crops see their water demand increase as they get bigger – peaking at maximum plant size, usually in late summer. Note that plants with large leaf surfaces typically need more water because they have more surface area from which to lose moisture.

In general, irrigation is needed if vegetables wilt or show signs of drought stress. Some of the large-leaved vegetables, however, such as squash, pumpkin, cucumber, etc., will wilt in the afternoon as a response to heat, but recover later when the sun goes down. This is normal. It doesn't necessarily mean that they are in need of more water. If the leaves regain their upright position in the morning, they don't need additional water until the soil has dried out more.

Fruit trees are more deeply rooted (two to three feet) than annual vegetables and can tap into approximately four to six inches of stored water held in a loamy soil. They develop most of their leaves and shoots before the middle of June. This growth is important for next year's crop development and for fruit size. Therefore, minimizing drought stress early in the season is the least disruptive to fruit trees. Moisture stress later in the season primarily has the effect of limiting fruit size, but also tends to enhance fruit flavor.

If trees run out of water they adopt a semi-dormant condition. The first thing to suffer is fruit size. Since most of a fruit tree's vegetative growth (potential fruit production for future years) occurs in spring, water stress in the summer has little or no effect on flowering or fruit set next year. Fruit trees in deep soil that have received adequate seasonal rainfall to fill the soil to field capacity can survive and produce better because they have a longer reserve of spring moisture allowing them to grow normally. That is why we may have "dry-farmed" trees that seem to do quite well. They often can survive very dry conditions (one-half to one-fourth normal ET rates) later in the season because they already grew their new shoots, flowered, set fruit and fulfilled their life's cycle.

Almonds, figs and olives are the most tolerant of drought. Apples, apricots, cherries, pears and prunes are somewhat drought-tolerant. Nectarines, peaches and citrus are most dependent on adequate water. Removing most or all of the fruit from apples, pears, peaches, nectarines, plums (prunes) and citrus can help the trees survive a very dry year by using about 20 to 30 percent less water. Of course, fruit thinning also will improve the size of the remaining fruit. This is especially true of varieties that ripen late. Removing the fruit from olives, almonds, or walnuts, however, doesn't cause much of a reaction in the plant and saves little or no water.

BE SELECTIVE

The following chart provides general guidelines for selecting crops during low water periods. There may be some exceptions such as varieties specifically bred for drought tolerance. See both "Food Gardening with Less Water" and "Drought-Resistant Crops and Varieties"^{iv} for additional suggestions on how to be water-wise through careful crop and variety selection and gardening practices.

WHAT TO GROW	WHAT NOT TO GROW
<ul style="list-style-type: none">Plants that have been successfully dry farmedDeep rooted plants that can seek water that may be stored under the active root zonePlants where fruit size does not matterPlants that naturally tolerate water stressPlants that mature in winter & springShort season varieties (early maturing)Examples: oil olives, wine grapes, processing apples, pears, plums, prunes, apricots, potatoes, tomatoes, brassicas planted in spring or fall, radishes, peas, winter greens, winter alliums, bunch lettuce, melon	<ul style="list-style-type: none">Plants that sunburn and die from water stressPlants where fruit size is importantPlants that have shallow root systemsLate maturing varietiesPlants that need heat and waterExamples: strawberries, raspberries, blueberries, blackberries, table olives, table grapes, peaches, nectarines, pears, asparagus, peppers, eggplant, squash, cutting greens, spinach, watermelon, corn, beans, summer onion

HOW MUCH WATER DOES A HOUSEHOLD USE OVERALL?

Sonoma County Water Agency data, which combines both household and commercial use inside and out, shows an average per resident use of 119 gallons per day. Actual water use varies from household to household. Knowing how much water is used is essential in developing a conservation plan and in determining whether there is enough water to plant and maintain a food garden.

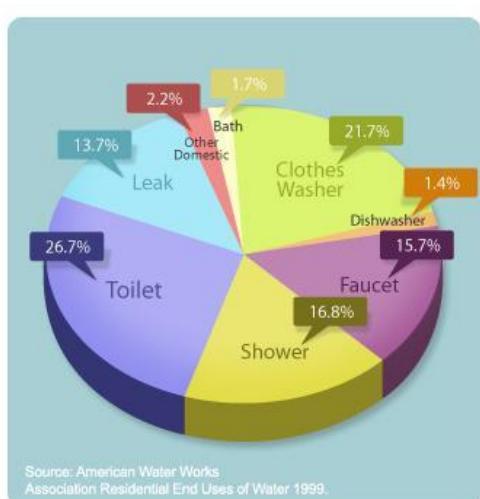
One method of calculating water usage is to check the water meter. Take a reading of the meter at the beginning and at the end of the week at the same time of day and subtract the difference to determine weekly water usage. For example, if there is a value of 10,000 cu ft at the beginning of the week and 10,500 cu ft at end of the week, 500 cu ft of water was used that week. Convert cubic feet of water into gallons by multiplying by 7.5 (the number of gallons in a cubic foot). In this example: 500 cu ft x 7.5 gal/cu ft = 3,750 gallons used that week. To know how much, on average, is used per day that week, divide 3,750 gallons by 7 to get 535 gallons/day.

The municipal water bill may have helpful information. For example, the City of Santa Rosa displays total gallons (thousands) used for each monthly billing period over the past year. If the irrigation system was shut off in the winter, the past summer months' water usage will provide a useful differential for making water-wise gardening decisions.

If using a well, the only accurate way of knowing how much water is used is to attach a flow meter. Looking at the electric bill for your pump only tells you how much power you have used to run your well pump in a given time period. It does not indicate how many gallons were pumped. Depending on the condition of the pump, it may or may not be pumping at full capacity or it may be pumping different amounts based on fluctuations in the level of well water. Water depth can be measured by dropping a weight on a measuring tape down the well casing. The only sure way of making well water last longer is to conserve as much as possible.

AVERAGE INDOOR HOUSEHOLD WATER USE

Knowing more about indoor water use can help identify areas for savings that then can be applied to the garden. The graph below from American Water Works shows how average household water is allocated.



High efficiency toilets only use 1.28 gallons per flush (GPF). Older toilets can use 1.6 GPF or between 3.5 and 7 GPF depending on the age of the toilet. Assuming 5 flushes per day, a high efficiency toilet uses 8 gallons per day. If the toilet uses 7 GPF, it uses 35 gallons per day.

Manufacturers may stamp the toilet's water usage per flush on the inside of the tank or on the neck of the toilet bowl. If there is no stamp, determining its age is the key to its water use. Federal plumbing standards passed in 1992 required that toilets use no more than 1.6 GPF. If the toilet was installed prior to 1992, it likely uses 3.5 to 7 GPF.^v

Appliance use represents approximations: top loading clothes washers use 40 to 45 gallons per load, while high efficiently front loading washers use 15 to 30 gallons per load^{vi}; showers and faucets use 2 to 5 gallons per minute^{vii}; and dishwashers made before 1994 use 10 to 15 gallons per load while high efficiency dishwashers use 4 to 6 gallons per load.^{viii}

USING ROOF WATER TO SUPPLEMENT AVAILABLE WATER

Catching water from the house roof or even the small roof of a greenhouse or shed can provide water that can be used in the garden. In some states this is illegal as it disrupts the return of rain water to aquifers. While we are not aware of Sonoma County restrictions at this time, consult local ordinances prior to catching rain water.

Food gardeners should not use roof water for watering food crops due to potential contaminants from bird and animal waste and chemicals from roof materials. Some recommend a precautionary approach. See "Safe Use of

Rain Barrel Water in the Food Garden.”^{ix} The concerned home gardener certainly can use roof water for ornamentals or turf, thus, freeing up available metered or well water for food crops.

When capturing rain water, it is best to locate a collection tank above a garden area so that you can use gravity feed to direct water to your plants.

To estimate how much rainwater may be collected and stored, use the following formula:

$$A \text{ (sq ft of roof space)} \times R \text{ (inches of rain)} \times 0.623 \text{ gallons of water in an inch of rainfall per sq ft} = G \\ \text{(gallons of water for storage)}$$

For example, a shed roof area of 100 sq ft times 10 inches of rain (the amount of rainfall in inches we might get in a drought; if you expect more rain use a larger number), multiplied by 0.623, yields 623 gallons of water that potentially can be collected and stored. $(100 \text{ sq ft} \times 10 \text{ inches} \times 0.623) = 623 \text{ gallons}$. If the tank holds less than that amount, the overflow can be directed into the ornamental garden or turf.

WHAT SIZE VEGETABLE GARDEN CAN BE PLANTED WITH AVAILABLE WATER?

Some communities have implemented mandatory water restrictions. As of February 2014, Sonoma County had a voluntary 20 percent reduction while there is a mandatory 20 percent reduction in Healdsburg and 25 percent in Cloverdale. Restrictions are likely to change and are posted on the water agency's site.^x

If a household is restricted to 200 gallons a day and 175 gallons a day is used for cooking, bathing, and laundry, then 25 gallons a day can be applied in the garden.

How large a vegetable garden can be grown with only 25 gallons a day or 175 gallons per week? Use an average summer plant water usage rate of 1 inch for every 7 days or 0.623 gallons per sq ft of surface area. The area that can be irrigated will vary depending on the daily ET rate.

Using the 0.623 gallons per sq ft value, 25 gallons per day for seven days (175 gallons) can water 280 sq ft of vegetables per week (175 gal/week divided by 0.623 gal/sq ft per week = 280 sq ft per week).^{xi} Apply the 25 gallons per 280 sq ft every day in summer if you are using a drip system and the vegetables are full size.

ⁱ “Food Gardening with Less Water,” Sonoma County Master Gardeners Food Gardening Specialists and UCCE Sonoma County, Feb 2014, <http://ucanr.edu/sites/scmg/files/183770.pdf>.

ⁱⁱ UCCE Sonoma/Marin Farm Advisor Paul Vossen, *California Master Gardener Handbook*, Water and Sonoma County Water Agency.

ⁱⁱⁱ California Irrigation Management Information System, <http://wwwcimis.water.ca.gov/cimis/welcome.jsp>.

^{iv} “Food Gardening with Less Water,” <http://ucanr.edu/sites/scmg/files/183770.pdf> and “Drought-Resistant Crops and Varieties,” <http://ucanr.edu/sites/scmg/files/183771.pdf>, Sonoma County Master Gardeners Food Gardening Specialists and UCCE Sonoma County, Feb 2014.

^v Regional Water Providers Consortium, <http://www.conserveh2o.org/toilet-water-use>.

^{vi} SF Gate Home Guides, <http://homeguides.sfgate.com/many-gallons-water-average-washing-machine-hold-full-80612.html>

^{vii} Regional Water Providers Consortium, <http://www.conserveh2o.org/faucet-water-use> and <http://ga.water.usgs.gov/edu/qa-home-percapita.html>.

^{viii} USGS Water Science School, <http://ga.water.usgs.gov/edu/qa-home-percapita.html> and Energy Star, <http://energystar.supportportal.com/link/portal/23002/23018/Article/17719/How-much-water-do-ENERGY-STAR-dishwashers-use-Is-there-a-water-efficiency-metric-water-factor-for-ENERGY-STAR-dishwashers-like-there-is-for-ENERGY-STAR-qualified-clothes-washers>.

^{ix} “Safe Use of Rain Barrel Water in the Food Garden,” University of Rhode Island Cooperative Extension, <http://www.uri.edu/ce/healthylandscapes/Rain%20barrel%20bro.pdf>.

^x Sonoma County Water Authority, <http://www.scwa.ca.gov/current-water-supply-levels/>.

^{xi} “How Much Water Does My Food Garden Need?,” Sonoma County Master Gardeners Food Gardening Specialists, March 2014.