

How Much Does it Cost to Water This Tree?

By: Adam Flett, Department of Forest Resources Extension and Outreach, University of Minnesota

Technical Advisors: Gary Johnson, Department of Forest Resources

and John Lamb, Department of Soil, Water and Climate

Water is a biological necessity for all trees, whether in a landscape or woodland setting and must be available over an entire growing season (June through October). Healthy trees are the result of efficient watering; not supplying so much that the roots die from lack of oxygen or too little makes all the difference.

Whether the water source is rain, a well or a local utility, there is often a need for water “budgeting” for economic and ecological reasons. This fact sheet will help determine the maximum amount of irrigation water per dose (amount of water needed at each irrigation) for three different tree sizes. A number of variables affect the amount needed, but the calculations provided represent a situation where water is assumed purchased and one dose is applied per week from the beginning of June to the end of October. This is an unlikely event in Minnesota, but presents a perfect “worst-case” scenario for water costs.

THE LIVES OF 3 TREES

Three specific tree life stages will be used as common examples. The first is a newly planted tree with a 2” trunk caliper (caliper is the width or thickness of the trunk measured 6-12 inches above ground). The second is an established tree with a 10” DBH (DBH is Diameter at Breast Height, measured roughly 4.5 feet above the base of the trunk). The third stage is a mature tree with a 30” DBH.

This factsheet uses a “worst-case” assumption. Soils are assumed to be sandy-loams that are well drained with no groundcover. A dose means filling a volume of soil to field capacity to an 8” depth (field capacity is the most water a soil can hold) and sandy-loam soils have the ability to hold the greatest amount of water. This “worst-case” also assumes that by the end of one week, the soil contain no available water for the trees to use (permanent wilting point).

HOW MUCH WATER IS NEEDED & AT WHAT COST?

Newly Planted Trees

As suggested by Gilman, Black, and Deghan (1998), newly planted trees need about 1-1.5 gallons of water per caliper inch of trunk diameter. For example:

$$2" \text{ Caliper} \times 1.5 \text{ gal. /inch} = 3 \text{ gallons per dose (2 cents per irrigation)}$$

Established and Mature Trees

The critical root area (the root area that takes up most of the water) is calculated by using a ratio of inches at DBH to feet of root radius, where one inch in DBH accounts for 1.5 feet of critical root radius from the trunk base. The calculations for 10” and 30”DBH established trees are:

Established: 10" DBH x 1.5 feet per inch DBH= Radius (r) = 15 foot radius

Mature: 30" DBH x 1.5 feet per inch DBH= Radius (r) = 45 foot radius

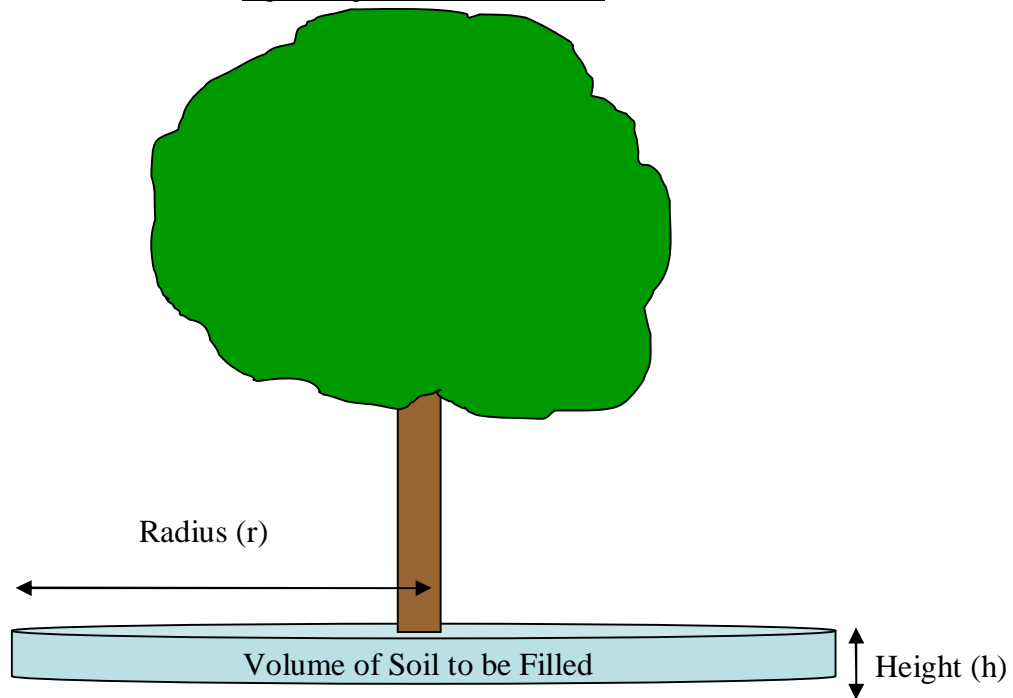
Extending from the base of the tree, the radius should account for most of a tree's root surface area.

Volume of Soil to be Watered

Calculating the volume of soil to be watered will require a little bit of math, the radius identified above and the following equation for calculating the volume of a cylinder.

Volume of a Cylinder: $3.14 \times (r)^2 \times \text{Height (h)}$

Fig. 1: Diagram of Volume of Soil



Height was established as 8" depth (or two thirds of a foot). *The calculations for volume of soil are only necessary for the established and mature trees. They are:*

$$\text{Established: } \frac{3.14 \times (15')^2 \times 8''}{12''} = 474 \text{ ft}^3$$

$$\text{Mature: } \frac{3.14 \times (45')^2 \times 8''}{12''} = 4241 \text{ ft}^3$$

Amount of Water Needed per Dose

Determining the amount of water needed to fill the volume of soil is the next step. The ratio is based upon the amount of water required to bring a sandy loam soil from

permanent wilting point (no available water in the soil) to field capacity. This will equal one dose. Calculations will require three steps. First, calculate the percentage of water needed to fill a sandy-loam to field capacity. This includes a constant supplied by Jeff Ball (2001) on Soil and Water Relationships. The constant is given in inches of water per foot of soil depth; sandy loam is given a range of 1.25-1.40 inches/foot of depth. For the purposes of this factsheet we will use the higher value, and 1 foot will be considered 12". The calculation is as follows:

$$\text{Percent Volume (Pv)} \times 12'' \text{ depth} = 1.40 \text{ inches/foot}$$

$$PV = 1.40/12''$$

$$PV = .1167 \text{ or } 11.67\%$$

D What does this mean?

The PV number (11.67%) shows the percentage of the soil volume in part B that can be filled with water (to field capacity). Using the values calculated in part B and the percentage above, the cubic feet of water needed to reach field capacity can now be calculated:

$$\text{Established Tree: } 474 \text{ ft}^3 \times .1167 = 55 \text{ ft}^3 \text{ of water (55.3 exactly)}$$

$$\text{Mature Trees: } 4241 \text{ ft}^3 \times .1167 = 495 \text{ ft}^3 \text{ of water (494.9 exactly)}$$

A spigot with an attached flow meter shows flow rates in gallons. If this is the case, use the ratio of gallons to cubic feet of water, where there are 7.48 gallons per cubic foot of water.

Total Seasonal Water Cost

Finally, calculate the total amount of gallons used and the relative costs (City of St. Paul Water and Sewage Rates 2009). The rate is the sum of water consumption charges and sewage rates June 1st through October. This assumes that all water entering the system (consumed) leaves as sewage (the most expensive way to buy water). Multiply the total cubic feet per dose by the number of weeks and by the summed rates (\$5.28/100 ft³):

$$\text{Established Tree: } 55 \text{ ft}^3 \times 21 \text{ weeks} \times \$5.28/100 \text{ ft}^3 = \mathbf{\$61 \text{ per season}} \text{ ($60.98 exactly),}$$

OR \$2.95 per dose

$$\text{Mature Tree: } 495 \text{ ft}^3 \times 21 \text{ weeks} \times \$5.28/100 \text{ ft}^3 = \mathbf{\$549 \text{ per season}} \text{ ($548.86 exactly),}$$

OR \$26.14 per dose

REDUCING THE AMOUNT AND COST OF WATER

- **Exposure** to wind and/or sun greatly affects the soil's ability to hold water over a weeklong period. If a tree is in a windy or sunny location, it loses water more

quickly, whereas if it is shaded or sheltered one dose every week and a half to two weeks may be sufficient.

- **Different soils** can drastically change the gallons per dose. Trees growing in sandy soils will most likely require more frequent watering due to lower water retention capacity. Trees growing in silty and clayey soils require less frequent irrigations because those soils tend to retain water longer.
- **The tree type** may also affect the frequency of irrigation. Trees that tend to grow in moist soils will require more frequent watering. Trees that grow in dry environments tend to survive without water for longer periods of time and require less water.
- **Competitive groundcovers** such as turf grasses significantly increase the amount of irrigation water necessary for healthy trees. Even weeds can lead to increased evaporative water loss by as much as 25% on a hot, sunny, summer day. If no groundcover is present there is no competition and all water is available for the tree (or evaporation).

An organic ground cover of any sort (such as woodchips) will help retain water for the tree, reduce evaporation and decrease the frequency of irrigation. According to at least one experiment, when compared to bare soil a relatively thin layer of organic mulch (1.5 inches) reduced water loss due to evaporation by as much as 35% (Chalker-Scott, 2007).

WATERING OPTIONS

- **Water bags:** Water-filled bags are placed around the trunk of the tree and drip water to the immediate root area at the base of the tree over a few hours. This allows water to be absorbed by the tree rather than running off.
- **Soaker Hose/Drip irrigation:** Cut slits or poke holes into a hose to allow water to seep into ground rather than spraying (which loses water through evaporation). Keep flow rate low to allow for seeping. Or, buy soaker hoses.
- **Water tape:** a flat, hose like device, water tape is highly efficient for irrigation. It seeps at a very low rate, only at points of perforations, and is commonly used in nursery operations.
- **Sprinklers:** the least desirable due to high rates of evaporation and low efficiency ratings.
- **Water gauges:** there are many water gauges available, ranging from less than \$40 to more than \$500, and measure the exact amount of irrigation water per dose regardless of flow rates or watering equipment.

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Referenced Reading: Ball, Jeff. 2001. Soil and Water Relationships. Ag News and Views Soils: September 2001. On-line. 23 Jan. 2009. www.medicagotruncatula.org/Ag/Soils/SoilWaterRelationships ; City of St. Paul. 2009. Water Rates. On-line. 12 Feb. 2009. <http://mn-stpaul.civicplus.com/DocumentView.asp?DID=3493> ; Chalker-Scott, Linda. 2007. Impacts of Mulches on Landscape Plants and the Environment – A Review. *Journal of Environmental Horticulture* 25(4): 239-249 ; Gilman et. Al. 1998. Irrigation Volume and Frequency and Tree Size Affect Establishment Rate. *Journal of Arboriculture* 24(1): 1-9