What is a cloche?

“Cloche” (pronounced klōsh) is a French word for a bell jar or dish set over delicate plants to protect them from cold weather. The definition has expanded, however, to include many types of portable and permanent structures (image below) which shelter plants from wind and cold, thus serving as mini-green houses for homeowners. They have become increasingly popular in the coastal Mediterranean type climate of the Pacific Northwest USA where long cool springs and cooler summers mean lower heat units for growing crops and vegetables. For directions on how to build your own raised bed cloche follow this link: http://extension.oregonstate.edu/catalog/pdf/ec/ec1627-e.pdf

A cloche can also be warmed by using a series of heat emitting or incandescent bulbs at night to provide light for photosynthesis and increase temperature (Photo by Sam Angima)
A cloche allows for an increase in crop diversity and/or earliness and extends the growing season and harvest of crops late into the season. Depending on family size, cloche sizes can range from 8 X 4 to 12 X 4 feet and can cost $150-250 in materials. Crops can be grown in a cloche that may otherwise not mature at all, especially in the cooler areas of the Pacific Northwest. These crops include tomatoes, peppers, eggplants, and melons — crops that need to be planted after danger of frost and that generally mature late in the season.

One aspect of using a cloche is to understand watering and water use by plants in the cloche. There are two ways to use the cloche; gardeners close to the coast (0–1 mile) may maintain a closed (not regularly open) cloche system but gardeners situated more than one mile inland and those living in slightly warmer climates can maintain partially closed systems allowing for regulation of inside air temperature.

So how often should the plants in the cloche be watered? To help answer this question, Oregon State University (OSU) Extension approached *The Siletz Tribal Charitable Contribution Fund* with a proposal to study water usage in a cloche. The proposal was funded in 2010 and this article summarizes findings and recommendations from the study.

**Understanding Water Movement in Plants**

Plants get water by drawing it through the roots. This water is then transpired or lost through the leaves largely through the stomata. Of this water, only a small amount (about 0.1%) of the water taken up by plants is actually used to produce plant tissue and food. Therefore we can say that total water loss by plants over an entire growing season is literally the same amount of water drawn by the roots and transpired via the leaf system plus the water lost through evaporation from the soil surface.

In closed systems such as green houses and especially so in cloches, evaporation and transpiration reach an equilibrium when humidity approaches 100% and water is recycled within the confined growing space. In cases where evaporation from soil surface is minimal e.g. when using plastic mulch or straw mulch, keeping track of what may cause evapotranspiration through leaves can provide a very good indication of your water needs for specific plants in your cloche.

**Evapotranspiration**

Evapotranspiration (ET) is a term used to describe the water loss dynamics by plants over a period of time. Evapotranspiration is the water loss occurring from the processes of evaporation and transpiration. Evaporation occurs when water changes to vapor on either soil or plant surfaces. Transpiration refers to the water lost through the leaves of plants. The rate of transpiration is linked directly to plant growth and productivity. This is because transpiration occurs only when the stomata are open thereby also allowing
carbondioxide to enter into the leaf system accelerating photosynthesis when sunlight is not limiting.

Other than excess water that moves downward through the soil, we can rule out that water loss and therefore water use by plants is actually controlled by evapotranspiration. Evapotranspiration is controlled by two main factors:

- The local weather conditions and
- The crops being grown

Local weather conditions are important as they determine how fast water can be transposed into the atmosphere. Four parameters in the atmosphere contribute to local weather patterns: (a) solar radiation (b) temperature (c) humidity and (d) wind speed.

a) Solar Radiation (Sunlight)

Solar radiation is the amount of energy reaching the plants in the form of visible and near visible light. Only average daily solar radiation is considered in a 24 hour period, which means that in experiments where it is measured, night time values are considered to be zero, therefore values of zero are averaged with day time values.

The more sunlight you have on your Cloche, the more heat units generated resulting in higher temperatures that increase both evaporation from soil surface and transpiration from leaf surfaces. In a cloche system, most of the water vapor lost via these two forms will depend on how open or closed the cloche is. Closed systems retain upwards of 90% of the water in the soil system while open cloches loose water just like garden crops.

b) Temperature

In coastal Oregon, temperature is governed by three interrelated factors: sunlight, exposure/orientation, and wind direction. The more sunlight the higher the temperature assuming all other factors are constant. Exposure or orientation refers to the direction your garden or cloche is facing; south or north. Plants exposed to the south have higher average temperatures than those facing north. On wind direction, our summers are dominated by NW winds that are cooler than southerly warmer winds. Sometimes, cloudy days with southerly warm winds allow cloches to be warmer than sunny days dominated by NW winds. The warmer the temperatures, the higher the evapotranspiration rates and therefore more frequent watering requirements.

In cloche systems temperatures are governed by sunlight and whether a cloche is open or closed during the day. Data gathered in in this study in 2011 and 2012 indicated that temperatures at the top of a cloche in a closed cloche system reached 94-125 °F. At the soil surface inside the cloche, temperatures only reached a maximum of 74 °F. At the peak of these temperatures, the environment inside the cloche reached 100% humidity. This means essentially that water movement within the plants was active but net loss of water was minimal. Another observation at the coast was that plants did not show many signs of damage even at these high
temperatures, apart from slight scalding for very tender leaves especially if the leaves were in the top portion that got much hotter.

c) Humidity

Humidity is a term for the amount of water vapor in the air. In plant systems, we talk of relative humidity which is the amount of moisture in the air as a percentage of the most moisture that could be in the air at a certain temperature. For example if air has ½ the amount of moisture it could hold, then the relative humidity is 50%. Another common term is dew point. Dew point is the temperature that the relative humidity will be 100% when air is cooled.

In a closed cloche system, relative humidity ranges between 60-100%. The condensation on the plastic covering on the inside of the cloche is as a result of the temperature closest to the plastic being at dew point (at 100% humidity for that temperature). Even though the higher temperature inside the cloche is not at dew point, the temperature closest to the plastic is low enough to reach dew point due to the high humidity in the cloche (this is similar to when one blows warm moist air onto a mirror).

The moisture condensate, however, rolls back into the soil in the cloche helping recycle water and reduce net loss. It is important to note here that due to high temperatures in the cloche, stomata remain open and although the rate of transpiration is not as high as in an open field, plants are able to access lots of carbon dioxide for food production. This is one of the reasons why plants do well and grow faster in a cloche system. It is therefore important to make sure water is not lacking or limiting plant growth in a cloche system.

d) Wind Speed

We all think of wind when it is gustier but wind is always blowing due to imbalances in the atmosphere. Wind movements transport air and moisture particles from one location to another. The stronger the wind, the faster is evapotranspiration. Depending on whether the wind is dry (less humid) and/or warm or cold, determines how fast water will be lost from plants. In general, warmer less humid air blowing at higher velocity speeds up evapotranspiration and therefore increases water loss and water use by plants.

In a closed cloche system, wind speed is usually zero. Coupled with higher humidity, water loss is very minimal even at higher temperatures. Even with this high humidity, it is possible for scalding of leaves to occur especially for young tender leaves at higher temperatures. Therefore it is essential to have some air circulation or movement inside the cloche especially in summer when temperatures are high. Partially opening the cloche or introducing a fan to circulate the air will help in this situation.
How often should you Water Your Raised Bed Cloche?

In 2008, Oregon State University (OSU) Extension produced a publication entitled “How to Build Your Own Raised-Bed Cloche” that has gained popularity among gardeners along the Oregon coast for promoting early starting of vegetables. This color publication is free online at http://extension.oregonstate.edu/catalog/pdf/ec/ec1627-e.pdf. A cloche looks like a mini-greenhouse with a plastic that helps warm plants in a raised bed (see photo on page one).

A group of OSU Master Gardeners volunteered to raise beans (Derby bush beans) using a section of their cloche (3 feet by 4 feet – see photos below) and water the beans using different cycles. At each harvest, pods were weighed and recorded for comparison. The following photos show how the study was conducted.

Cloche was divided for study on one side and private use on other side (Photo by Sam Angima)
Three soil moisture sensors and soil thermometers were installed to monitor moisture and temperature in the soil (Photo by Sam Angima)

Beans (Derby bush beans) were planted to each experimental site and watered on scheduled cycles by an automatic watering device (Photo by Sam Angima)
Beans growth was monitored during the growing cycle (Photo by Bill Biernacki – OSU Master Gardener)

At harvest, pods were picked and weighed to compare production (Photo by Bill Biernacki – OSU Master Gardener)
Watering Cycles

The cycles were every 4 days, every 7 days and every 14 days. Each watering cycle used about 55 gallons of water using a soaker hose that delivered enough water to wet the whole 10-inch soil profile in the raised bed. Participants in this study were asked not to alter any of their day-to-day management on how they used the cloche. The following table shows pounds of produce and amount of water used at the end of the season:

<table>
<thead>
<tr>
<th>Distance from Ocean</th>
<th>Watering Cycle</th>
<th>Harvest lbs/12 Sq. ft</th>
<th>Harvest Tons/acre</th>
<th>Sun Exposure</th>
<th>Gallons of Water Applied/12 Sq. feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 blocks</td>
<td>4 days</td>
<td>1.8</td>
<td>3.3</td>
<td>Half day</td>
<td>1,100</td>
</tr>
<tr>
<td>6 blocks</td>
<td>4 days</td>
<td>1.5</td>
<td>2.7</td>
<td>Half day</td>
<td>935</td>
</tr>
<tr>
<td>1 mile</td>
<td>7 days</td>
<td>1.8</td>
<td>3.3</td>
<td>full day</td>
<td>550</td>
</tr>
<tr>
<td>7 miles</td>
<td>7 days</td>
<td>10.8</td>
<td>19.6</td>
<td>full day</td>
<td>660</td>
</tr>
<tr>
<td>2 miles</td>
<td>14 days</td>
<td>1.62</td>
<td>2.9</td>
<td>half day</td>
<td>385</td>
</tr>
<tr>
<td>1 mile</td>
<td>14 days</td>
<td>7.5</td>
<td>13.6</td>
<td>full day</td>
<td>385</td>
</tr>
</tbody>
</table>

From these results, we can make the following observations:

1) Watering very often did not translate to more production
2) Full day exposure helps translate watering into plant growth and more production
3) Gardeners can save upwards of 60% on their total water application (or bills) if they water once in 7-14 day cycles rather than every 4 days and still get comparable yields.

The further inland your location is away from the coast, the better the chances of converting water applied to higher yields. Of course, vegetables do not use water equally. Leafy vegetables use more water especially if the cloche is open for longer periods of time during warmer days. Based on these results, our recommendation is to water more deeply and less often at minimum once every week.

Summary

What this study has shown is that it is possible to conserve water especially in summer when less of it is available especially here in Oregon but still maintain good vegetable yields. This is very specific to those who use a cloche. Watering raised beds without a cloche will be different since many variables including wind speed and humidity are different compared to cloche systems. If each gardener with a cloche were to change their watering habits as per these recommendations, there is potential to save nearly half of the water currently being used.