Horticulture Crop ET

AgWeather Evapotranspiration:

Knowing the daily evapotranspiration rate can help you determine the best time to irrigate commercial horticultural crops. Watering based on the actual water use of plants reduces irrigation costs, conserves Oklahoma water resources, and helps you grow healthier plants. Evapotranspiration is an estimate of the water that evaporates from the soil surface ("evapo" in evapotranspiration) and the water a plant loses through transpiration ("transpiration" in evapotranspiration).

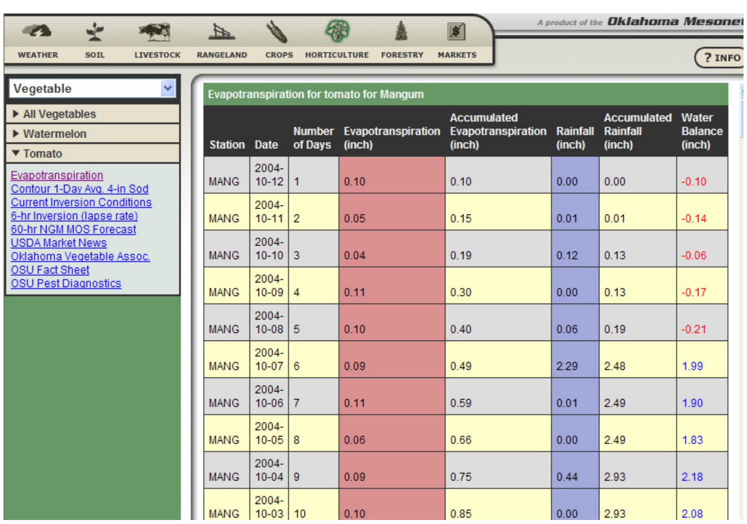
The evapotranspiration products available on the Oklahoma AgWeather web site (**http://agweather.mesonet.org**) are weather-based tools that estimate daily water loss from the plant canopy and exposed soil surface. Using weather data from the closest Oklahoma Mesonet tower, evapotranspiration rates are calculated for some of Oklahoma's important commercial horticulture crops. These include grape, peach, pecan, tomato, turfgrass, and watermelon.

Oklahoma AgWeather evapotranspiration charts provide daily and accumulated evapotranspiration rates back to the crop planting date or the beginning of the growing season. Included in the evapotranspiration chart is the daily rainfall and accumulated rainfall. This provides a season-long perspective of plant water needs and the amount of rain that has fallen to meet those needs. Rainfall amounts reported are those collected at the nearest Oklahoma Mesonet tower and may not reflect rainfall received at your location. While a variation in rainfall amount might change when you water, it does not affect the accuracy of the calculated evapotranspiration rates.

Reference evapotranspiration rates are calculated to represent a well-watered short crop canopy, similar to cut grass, or a well-watered tall crop canopy, similar to alfalfa. These reference evapotranspiration rates are located in the Atmosphere section, under WEATHER on the Oklahoma AgWeather web site.

AgWeather Evapotranspiration Chart:

To use the evapotranspiration rates to irrigate you need to think backwards. The evapotranspiration chart (see image below) shows the evapotranspiration rate in inches of water for each day in the red colored column. The most current date is at the top of the chart, descending through past dates as you scroll down the table. The chart shows the Mesonet station code, Date, Number of Days (descending), daily Evapotranspiration, Accumulated Evapotranspiration, daily Rainfall amount (blue colored column), Accumulated Rainfall, and Water Balance. The Water Balance values are calculated by subtracting the Accumulated Evapotranspiration from the Accumulated Rainfall. All evapotranspiration and rainfall amounts are in inches of water lost or gained.



Station	Date	Number of Days	Evapotranspiration (inch)	Accumulated Evapotranspiration (inch)	Rainfall (inch)	Accumulated Rainfall (inch)	Water Balance (inch)
MANG	2004-10-12	1	0.10	0.10	0.00	0.00	-0.10
MANG	2004-10-11	2	0.05	0.15	0.01	0.01	-0.14
MANG	2004-10-10	3	0.04	0.19	0.12	0.13	-0.06
MANG	2004-10-09	4	0.11	0.30	0.00	0.13	-0.17
MANG	2004-10-08	5	0.10	0.40	0.06	0.19	-0.21
MANG	2004-10-07	6	0.09	0.49	2.29	2.48	1.99
MANG	2004-10-06	7	0.11	0.59	0.01	2.49	1.90
MANG	2004-10-05	8	0.06	0.66	0.00	2.49	1.83
MANG	2004-10-04	9	0.09	0.75	0.44	2.93	2.18
MANG	2004-10-03	10	0.10	0.85	0.00	2.93	2.08

The Water Balance column numbers are negative (red) when the water lost through evapotranspiration exceeds the amount of rainfall. When the water gained in accumulated rainfall is higher than that lost from accumulated evapotranspiration, the Water Balance column numbers are positive (blue). It is time to water when the negative value reaches the amount of water you want to provide your plants. The following pages provide a step by step approach for determining when to irrigate based on evapotranspiration.

Using Evapotranspiration on OK AgWeather (http://agweather.mesonet.org):

Evapotranspiration rates provide a measure of the amount of water a commercial horticultural crop needs. Having a number that indicates plant water need can improve recordkeeping and provides a way to measure the effectiveness of irrigation decisions. There are a number of options and steps for each option to get the most out of using evapotranspiration rates to time irrigations. The following is a step by step approach to determine the amount of water loss to allow before the next irrigation.

STEP 1) Determine the basic soil type of the field. Using a shovel or post hole digger, dig a two to three foot hole in several field locations that are representative of the field. Note the soil type as you dig and any restrictive layers.

Each type of soil has different water holding characteristics. In addition to holding different amounts of water soils also differ dramatically on how much of the water in the soil is available for use by plants. This is known as the "Available Water Capacity" of the soil. The available water in the soil is like having money in a checking account. The more available water capacity of a soil, the longer a plant can go without water stress.

Available Water Capacity of Soil by Soil Texture

Soil Texture	Available Water Capacity inches per soil inch	Available Water Capacity inches per soil foot
Sand	0.08	0.96
Loamy Sand	0.11	1.32
Sandy Loam	0.12	1.44
Loam	0.15	1.80
Silt Loam	0.18	2.16
Silty Clay Loam	0.16	1.92
Clay Loam	0.15	1.80
Sandy Clay Loam	0.14	1.68
Silty Clay	0.13	1.56
Clay	0.12	1.44
Sandy Clay	0.11	1.32

The following are some ways to determine the soil type in your field.

- One source of soil information is from soil surveys available through the Natural Resources and Conservation Service (NRCS) office the serves your county. Their phone number is listed under US Government and the USDA Service Center. Online NRCS information is available at http://soils.usda.gov.

- You can submit a soil sample to your local county OSU Extension Office for analysis of soil textural class by the Oklahoma State University Soil, Water and Forage Analytical Laboratory. If you choose to submit a sample, this would also be a good time to test your soil for nutrients.

- The following is a system for determining soil texture by feel developed by S.J. Thein and first presented in the Journal of Agronomy Education Vol. 8, pages 54-55 in 1979. Here is the process:
  - Place a tablespoon of soil in your palm.
  - Add water drop wise and knead to break up aggregates. Add water and knead till soil has the consistency of moldable putty.
  - If the soil will not stay in a ball when squeezed and is not too wet, its soil type is **sand**.
  - If the soil tays in a ball when squeezed, gently squeeze soil with your thumb against your forefinger to form a ribbon of uniform thickness and width. If you cannot create a ribbon, the soil is a **loamy sand**.

- If the soil makes a weak ribbon that breaks before it is one inch long it is a **loam** soil. Excesivelly wet a small pinch of the soil and rub with your forefinger. If the loam feels very gritty it is a **sandy loam**. If it feels very smooth, it is a **silt loam**.
- If you can form a ribbon between one inch and two inches long, the soil is a **clay loam**. Excesivelly wet a small pinch of the soil and rub with your forefinger. If it feels very gritty, it is a **sandy clay loam** soil. If it feels very smooth, it is a **silty clay loam**.
- If you can make a strong ribbon 2 inches or longer before it breaks, the soil is **clay**. Excesivelly wet a small pinch of the soil and rub with your forefinger. If the clay feels very gritty it is a **sandy clay**. If it feels very smooth, it is a **silty clay**.

STEP 2) Determine the effective rooting depth of your crop. Below is a table of maximum effective rooting depth for fully grown plants when there is no soil restriction. Adjust rooting depth for your crop based on any rooting restrictions found when digging the test holes in STEP 1. Common soil restrictions found in Oklahoma are compacted plow pan layer, impermiable clay layer, or shallow sandstone formation.

Effective Rooting Depths of Various Vegetables

Shallow 18 inches to 2 feet	Moderately deep 3 feet	Deep 4 feet
Broccoli	Bean (bush or pole)	Asparagus
Cabbage	Beet	Pumpkin
Corn, Sweet	Canteloupe	Squash, Winter
Garlic	Chard (Swiss)	Sweet potato
Onion	Cucumber	Tomato
Potato	Eggplant	Watermelon
Spinach	Mustard (Collards)	
	Pepper	
	Squash, Summer	

From Knott’s Handbook for Vegetable Grower’s, 3rd edition, 1988.

Effective Rooting Depths of Select Fruits

3 feet	4 feet
Grape	Pecan*
Apple	
Apricot	
Peach	
Pear	
Plum	

From Soil Water Monitoring and Mesasurement, Pacific Northwest Publication (PNW0475), December 1994.
* Pecan rooting depth based on review of Mississippi, New Mexico, Oklahoma, and Texas university extension publications.

A hands-on approach to determine the rooting depth for plants in your field is to carefully excavate the soil along one side of three fully grown, healthy plants. Dig slowly and examine the soil for evidence of roots as you go. By digging until no roots are seen, you can determine the depths where the bulk of the roots exist in the soil.

STEP 3) Select the percentage of water depletion for the soil type in your field. Using the charts below you can determiine the minimum soil water capacity needed by the crop you are growing. The charts are arranged by the percent of water capacity you want to maintain in the soil. The evapotranspiration value is the maximum evapotranspiration loss that can occur and still maintain the indicated percent of available water in the soil. The first chart on page 4 provides suggested percent of available water quidelines for various horticultural crops.

Suggested % of Available Water to Maintain in the Soil

80%-70%	65% - 60%	50%
Cucumber	Bean (bush or pole)	Asparagus
Spinach	Beet	Garlic
Tomato	Broccoli	Onion
	Cabbage	Pumpkin
	Canteloupe	Squash, Winter
	Chard (Swiss)	Sweet potato
	Corn, Sweet	Watermelon
	Eggplant	
	Mustard (Collards)	Apple
	Pepper	Grape
	Potato	Peach
	Squash, Summer	Pecan

Accumulated ET value when water capacity would drop to 80% of available water in inches:

Root depth	Loamy sand	Silty clay loam	Silty clay
6 inches	-0.14	-0.22	-0.16
1 foot	-0.29	-0.43	-0.31
1.5 feet	-0.43	-0.65	-0.47
2 feet	-0.58	-0.86	-0.62
2.5 feet	-0.72	-1.08	-0.78
3 feet	-0.86	-1.30	-0.94
3.5 feet	-1.01	-1.51	-1.09
4 feet	-1.15	-1.73	-1.25
5 feet	-1.44	-2.16	-1.56
6 feet	-1.73	-2.59	-1.87
7 feet	-2.02	-3.02	-2.18
8 feet	-2.30	-3.46	-2.50
9 feet	-2.59	-3.89	-2.81
10 feet	-2.88	-4.32	-3.12

Accumulated ET value when field capacity soil would drop to 75% of available water in inches:

Root depth	Loamy sand	Silty clay loam	Silty clay
6 inches	-0.18	-0.27	-0.20
1 foot	-0.36	-0.54	-0.39
1.5 feet	-0.54	-0.81	-0.59
2 feet	-0.72	-1.08	-0.78
2.5 feet	-0.90	-1.35	-0.98
3 feet	-1.08	-1.62	-1.17
3.5 feet	-1.26	-1.89	-1.37
4 feet	-1.44	-2.16	-1.56
5 feet	-1.80	-2.70	-1.95
6 feet	-2.16	-3.24	-2.34
7 feet	-2.52	-3.78	-2.73
8 feet	-2.90	-4.30	-3.12
9 feet	-3.20	-4.90	-3.51
10 feet	-3.60	-5.40	-3.90

Accumulated ET value when field capacity soil would drop to 70% of available water in inches:

Root depth	Loamy sand	Silty clay loam	Silty clay
6 inches	-0.22	-0.32	-0.23
1 foot	-0.43	-0.65	-0.47
1.5 feet	-0.65	-0.97	-0.70
2 feet	-0.86	-1.30	-0.94
2.5 feet	-1.08	-1.62	-1.17
3 feet	-1.30	-1.94	-1.40
3.5 feet	-1.51	-2.27	-1.64
4 feet	-1.73	-2.59	-1.87
5 feet	-2.16	-3.24	-2.34
6 feet	-2.59	-3.89	-2.81
7 feet	-3.02	-4.54	-3.28
8 feet	-3.46	-5.18	-3.74
9 feet	-3.89	-5.83	-4.21
10 feet	-4.32	-6.48	-4.68

Accumulated ET value when field capacity soil would drop to 60% of available water in inches:

Root depth	Loamy sand	Silty clay loam	Silty clay
6 inches	-0.29	-0.43	-0.31
1 foot	-0.58	-0.86	-0.62
1.5 feet	-0.86	-1.30	-0.94
2 feet	-1.15	-1.73	-1.25
2.5 feet	-1.44	-2.16	-1.56
3 feet	-1.73	-2.59	-1.87
3.5 feet	-2.02	-3.02	-2.18
4 feet	-2.30	-3.46	-2.50
5 feet	-2.88	-4.32	-3.12
6 feet	-3.46	-5.18	-3.74
7 feet	-4.03	-6.05	-4.37
8 feet	-4.61	-6.91	-4.99
9 feet	-5.18	-7.78	-5.62
10 feet	-5.76	-8.64	-6.24

Accumulated ET value when field capacity soil would drop to 65% of available water in inches:

Root depth	Loamy sand	Silty clay loam	Silty clay
6 inches	-0.25	-0.38	-0.27
1 foot	-0.50	-0.76	-0.55
1.5 feet	-0.76	-1.13	-0.82
2 feet	-1.01	-1.51	-1.09
2.5 feet	-1.26	-1.89	-1.37
3 feet	-1.51	-2.27	-1.64
3.5 feet	-1.76	-2.65	-1.91
4 feet	-2.02	-3.02	-2.18
5 feet	-2.52	-3.78	-2.73
6 feet	-3.02	-4.54	-3.28
7 feet	-3.53	-5.29	-3.82
8 feet	-4.03	-6.05	-4.37
9 feet	-4.54	-6.80	-4.91
10 feet	-5.04	-7.56	-5.46

Accumulated ET value when field capacity soil would drop to 50% of available water in inches:

Root depth	Loamy sand	Silty clay loam	Silty clay
6 inches	-0.36	-0.54	-0.39
1 foot	-0.72	-1.08	-0.78
1.5 feet	-1.08	-1.62	-1.17
2 feet	-1.44	-2.16	-1.56
2.5 feet	-1.80	-2.70	-1.95
3 feet	-2.16	-3.24	-2.34
3.5 feet	-2.52	-3.78	-2.73
4 feet	-2.88	-4.32	-3.12
5 feet	-3.60	-5.40	-3.90
6 feet	-4.32	-6.48	-4.68
7 feet	-5.04	-7.56	-5.46
8 feet	-5.76	-8.64	-6.24
9 feet	-6.48	-9.72	-7.02
10 feet	-7.20	-10.80	-7.80

Total Available Water in inches:

Root depth	Loamy sand*	Silty clay loam*	Silty clay*
6 inches	0.72	1.08	0.78
1 foot	1.44	2.16	1.56
1.5 feet	2.16	3.24	2.34
2 feet	2.88	4.32	3.12
2.5 feet	3.60	5.40	3.90
3 feet	4.32	6.48	4.68
3.5 feet	5.04	7.56	5.46
4 feet	5.76	8.64	6.24
5 feet	7.20	10.80	7.80
6 feet	8.64	12.96	9.36
7 feet	10.08	15.12	10.92
8 feet	11.52	17.28	12.48
9 feet	12.96	19.44	14.04
10 feet	14.40	21.60	15.60

* Loamy sand available water 0.11 inches/inch of soil
* Silt loam available water 0.16 inches/inch of soil
* Silty clay available water 0.13 inches/inch of soil

STEP 4) Determine irrigation system water delivery rate and efficiency. Check the specifications of your irrigation system for water delivery rate. If your system has a slow water delivery, you will need to irrigate sooner. If irrigation is delayed until too much water is depleted from the soil, you may not be able to keep up with the water demands of your crop.

Range of Application Efficiencies by percent for Various Irrigation Systems*

Surface Irrigation	**Sprinkler Irrigation**	**Microirrigation**
Basin 60 - 95%	Handmove 65 - 80%	Point source emitters 75 - 95%
Border 60 - 90%	Traveling Gun 60 - 70%	Line source emitter 70 - 95%
Furrow 50 - 90%	Center Pivot & Linear 70 - 95%	
Surge 60 - 90%	Solid Set 70 - 85%	

* Efficiencies can be much lower due to poor design or system maintenance. These values are intended for general comparisons.
From Efficiencies and Water Losses of Irrigation Systems, Rogers, D.H., Lamm, F.R., Alam, M., Trooein, T.P., Clark, G.A., Barnes, P.L. and Mankin, K. Kansas State University Extension Publication MF-2243, May 1997.

STEP 5) Putting it all together. Here is an example of how to determine the accumulated evapotranspiration water loss when an irrigation would be done for a tomato crop and a pecan orchard.

From Step 1: Soil type was determined to be close to a **Silty Clay Loam**. Each one foot of this soil holds **1.8 inches** of available water.

From Step 2: The **tomato** crop is rooted **2 feet** deep. The **pecan** orchard has an average rooting depth of **6 feet**.

From Step 3: The **tomato** crop will be watered when **75% of the available water** is still in the soil for a 25% allowable water depletion. From the 75% of available water chart at a 1.5 feet rooting depth for Silty Clay Loam soil, the **accumulated ET value** to irrigate at is **-1.08 inches**.

The **pecan** orchard will be watered when **50% of the available water** is still in the soil for a 50% allowable water depletion. From the 50% of available water chart at a 6 feet rooting depth for Silty Clay Loam soil, the **accumulated ET value** to irrigate would be **-6.48 inches**.

From Step 4: The **tomato field** is irrigated by center pivot with an **application efficiency of 80%**. When the accumulated evapotranspiration of -1.08 inches reaches, the field will be watered with **1.35 inches of water**. The center pivot is capable of providing this amount of water without any runoff in a single irrigation pass.

The **pecan orchard** is irrigated by a microirrigation system with a **90% application efficiency**. This pecan orchard would be irrigated when the accumulated evapotranspiration reaches -6.48 with **7.2 inches of water**. Since 3.6 inches of water is the maximum delivery to be provided during any single irrigation, the orchard will be watered when the accumulated evapotranspiration reaches -3.24.

STEP 6) Accessing Oklahoma Agweather Evapotranspiration Models. The following are the online locations and inputs needed to generate evapotranspiration tables from the Oklahoma AgWeather evapotranspiration models.

Corn (Sweet Corn):
- Click on CROPS, then Corn, next Evapotranspiration.
- Select the nearest Mesonet Site location.
- Enter the Relative Maturity Days for the corn variety planted.
- Enter the Planting Date.

Grape:
- Click on HORTICULTURE, then select Fruit and Nut, next choose Grape, then Evapotranspiration.
- Select nearest Mesonet Site location.
- For Season Start Date, use the default date or select a date close to when grape leaves appeared.
- Click on Get Grape Data.

Peach:
- Click on HORTICULTURE, then select Fruit and Nut, next choose Peach, then Evapotranspiration.
- Select nearest Mesonet Site location.
- Enter the Peach Relative Maturity for the peach variety you grow, Early-season, Mid-season, or Late-season.
- For Season Start Date, use the default date or select a date close to peach blooming.
- Click on Get Peach Data.

Pecan:
- Click on HORTICULTURE, then select Fruit and Nut, next choose Pecan, then Evapotranspiration.
- Select nearest Mesonet Site location.
- For Season Start Date, use the default date or select a date close to when pecan leaves appeared.
- Click on Get Pecan Data.

Tomato:
- Click on HORTICULTURE, then select Vegetables, next choose Tomato, then Evapotranspiration.
- Select nearest Mesonet Site location.
- Enter the Planting Date (transplant date) for your tomatoes.
- Click on Get Tomato Data.

Turfgrass, Cool-season (tall fescue, Kentucky bluegrass or perennial rye grass):
- Click on HORTICULTURE, then select Turf, then Evapotranspiration.
- Select nearest Mesonet Site location.
- For Grass Type, choose Cool-season.
- For Season Start Date, use the default date or select a date.
- Click on Get Turf Grass Data.

Turfgrass, Warm-season (bermudagrass or zoysiagrass):

- Click on HORTICULTURE, then select Turf, then Evapotranspiration.
- Select nearest Mesonet Site location.
- For Grass Type, choose Warm-season.
- For Season Start Date, use the default date or select a date.
- Click on Get Turf Grass Data.

Vegetables:

- Click on HORTICULTURE, then select Vegetable, next choose All Vegetables, then Evapotranspiration.
- Select nearest Mesonet Site location.
- Enter the Planting Date for the vegetable of interest.
- Click on Get Vegetable-General Data.

Watermelon:

- Click on HORTICULTURE, then select Vegetables, next choose Watermelon, then Evapotranspiration.
- Select nearest Mesonet Site location.
- Enter the Watermelon Relative Maturity for the watermelon variety you planted, Early-season, Mid-season, or Late-season. Or select the Relative Days to Maturity for the variety planted.
- Enter Planting Date.
- Click on Get Watermelon Data.

REFERENCES:

- Ley, TW, Stevens, RG, Topielec, RR and Neibling, WH. 1994. Soil Mwater Monitoring and Measurement, PNW0475. A Pacific Northwest Publication: Washington, Oregon, and Idaho.

- Lorenz, OA and Maynard, DN. 1988. Knott's Handbook for Vegetable Growers, Third Edition. Wiley Interscience Publication.

- Rogers, DH, FR Lamm, M Alam, TP Trooein, GA Clark, PL Barnes and K Mankin. 1997. Efficiencies and Water Losses of Irrigation Systems. Kansas State University Extension Publication MF-2243.

- Thein, SJ. 1979. A Flow Diagram for Teaching Texture-by-Fell Analysis. Journal of Agronomy Education Vol. 8, pages 54-55.