Determining the Irrigation Amount

How to calculate the number of hours to run your drip system in order to apply an accurate number of gallons per vine given the system's emission uniformity

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Step 1: Determine the vineyard's water use.

Step 2: Determine the application rate and application uniformity of the drip system.

Step 3: Determine the number of hours to irrigate.

Step 1: Determine the vineyard's water use.

1.0 Determining vineyard water use by using evapotranspiration (ET) estimates from either of two web sites: CIMIS [http://www.cimis.water.ca.gov/] or UC IPM [http://ucipm.ucdavis.edu/weather]. After you know how much water to replace per acre per week (in acre-inches), you will need to convert that to gallons per vine per week.

1.1 Assume full potential vineyard water use is 0.75 inch per week (in/wk) and you want to replace 100% of that amount.

1.2 Convert the in/week to gallons per vine/week.

ETc (gal/wk) = ETc (in/wk) x Vine Spacing (sq. ft) x 0.623

Example: *Assumptions:* *ETc = 0.75 in/wk*

7' x 11' vine spacing

ETc (gal per vine / wk) = 0.75 in/wk x (7' x 11') x 0.623

= 36 gal per vine / wk

You can also use Table 1 to determine gallons/vine/week.

Net Irrigation Amount is 36 gallons/vine/week.

Step 2: Determine the average application rate and emission uniformity of the drip system.

2.1 Sample your drip emitters! Drip emitter discharge may vary with the pressure in the drip system. For example, a 0.5 gallon per hour (gph) dripper may not actually be discharging at 0.5 gph.

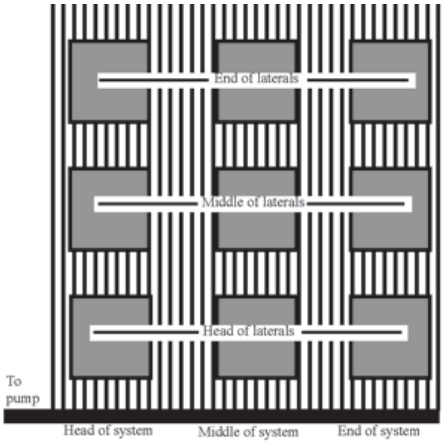
2.2 If there are multiple irrigation blocks, each block should be evaluated separately since they may be operating at different pressures.

2.3 Sample drip emitters at the following locations in an irrigation block. See attached Drip System Evaluation Form:

Head of the system - 4 near the head of the lateral
- 4 near the middle of the lateral
- 4 near the end of the lateral

Middle of the system - 4 near the head of the lateral
- 4 near the middle of the lateral
- 4 near the end of the lateral

Tail end of the system - 4 near the head of the lateral
- 4 near the middle of the lateral
- 4 near the end of the lateral



In addition, you might sample at any other spots where you suspect there could be a difference in the pressure and discharge rate. For example, low or high elevation spots in the vineyard. More emitters than suggested above should be sampled on large irrigation blocks (greater than 20 acres).

2.4 Collect water for 30 seconds in a 100 ml graduated cylinder (see Table 2) or in a 35 mm film canister (see Table 3). Use the appropriate table to convert the amount of water collected from each sampled emitter to the discharge rate in gallons per hour for that emitter.

The following *Example* is summarized on the attached Sample Data Sheet.

2A. Determine Average Application (Discharge) Rate:

For each irrigation block, calculate the average of all your discharge rate measurements. This is the average emitter discharge rate per hour (gph) of your emitters.

Example: If you measured the output of 36 drip emitters, find the average discharge rate (gph) of the 36 emitters. (See Sample Data Sheet*.)*

Average discharge rate of all emitters = 0.48 gph

Step 2: (Continued)

Example *cont.: There are 2 drip emitters per vine*

Application rate per vine(gph)	=	*0.48 gph per dripper*	*x*	*2 drippers per vine*	= *0.96 gph/vine*

Average Application Rate per vine is 0.96 gph/vine

2B. Determine the Average Emission Uniformity:

Each drip emitter in the vineyard will be discharging water at a different rate. This discharge variability is due to manufacturing variation between emitters, pressure differences in the system, and any emitter clogging which may be occurring. We need to compensate for the variability when we determine how much to irrigate.

The drip system's application uniformity is quantified using a measurement called the Emission Uniformity (sometimes referred to as the Distribution Uniformity). The Emission Uniformity (EU) is defined as:

$$\text{Emission Uniformity (\%)} = \frac{\text{Avg. discharge rate of the low 25\% sampled emitters}}{\text{Avg. discharge rate of all the sampled emitters}} \times 100$$

To determine the average discharge rate (gph) of the low 25% of sampled emitters, first rank (reorder) the discharge rate of each of the sampled emitters from low to high then average the lowest 25% of the discharge rates. For example, if 36 emitters were monitored, the average of the 9 emitters with the lowest discharge rates would be determined.

Example *cont.:* *Assumptions:*
Average discharge rate of all sampled emitters = 0.48 gph
Average discharge rate of the low 25% sampled emitters = 0.44 gph *

$$\textit{Emission Uniformity (\%)} = \frac{0.44\ \text{gph}}{0.48\ \text{gph}} \times 100 = 92\%$$

Average Emission Uniformity is 92% (This is quite good)

*See Sample Data Sheet

Step 3: Determine the number of hours to irrigate.

3.1 The irrigation amount (gross irrigation amount) should include the water needed to replace soil water used by the vine since the last irrigation (net irrigation amount) plus some additional water to account for the inefficiencies of the irrigation system. The gross irrigation amount is determined as:

$$\text{Gross irrigation amount} = \frac{\text{Net irrigation amount}}{\text{Irrigation efficiency (\%)}} \times 100$$

"Irrigation efficiency" is difficult to quantify but if drainage* and runoff is minimal, then irrigation efficiency can be approximated using the emission uniformity. The above equation becomes:

$$\text{Gross irrigation amount} = \frac{\text{Net irrigation amount}}{\text{Emission uniformity (\%)}} \times 100$$

Example *cont.: Assumptions:*

Net irrigation amount = 36 gallons per vine/wk (see Step 1)
Average Application Rate per Vine = 0.96 gph (Step 2A)
Average Emission Uniformity = 92% (Step 2B)

$$\textit{Gross irrigation amount} = \frac{\textit{36 gal/wk}}{\textit{92}} \times \textit{100} = \textit{39 gal/wk}$$

3.2 Convert gallons per week to number of hours to irrigate:

$$\text{Irrigation time per week (hrs)} = \frac{\text{Gross irrigation amount (gal/wk)}}{\text{Avg. application rate per vine (gph)}}$$

$$= \frac{39 \text{ gal/wk}}{0.96 \text{ gph}} = 41 \text{ hrs}$$

Number of hours to irrigate is 41 hours/week

* Drainage is water that has moved below the vine's root system.

Table 1.
Converting vineyard water use from inches/week to gallons/vine/week at various planting densities.

		Vine Water Use (gal/vine/week)										
Vineyard Water Use (inches/wk) →		**0.40**	**0.50**	**0.60**	**0.70**	**0.75**	**0.80**	**0.90**	**1.00**	**1.10**	**1.20**	**1.30**
Vine Spacing	**Vine-by-row ↓**											
	4' x 7'	7.0	8.7	10.5	12.2	13.1	14.0	15.7	17.5	19.2	20.9	22.7
	5' x 8'	10.0	12.5	15.0	17.5	18.7	19.9	22.4	24.9	27.4	29.9	32.4
	5' x 10'	12.5	15.6	18.7	21.8	23.4	24.9	28.1	31.2	34.3	37.4	40.5
	6' x 8'	12.0	15.0	18.0	20.9	22.4	23.9	26.9	29.9	32.9	35.9	38.9
	6' x 10'	15.0	18.7	22.4	26.2	28.1	29.9	33.7	37.4	41.1	44.9	48.6
	7' x 10'	17.5	21.8	26.2	30.5	32.7	34.9	39.3	43.6	48.0	52.4	56.7
	7' x 11'	19.2	24.0	28.8	33.6	36.0	38.4	43.2	48.0	52.8	57.6	62.4
	8' x 10'	19.9	24.9	29.9	34.9	37.4	39.9	44.9	49.9	54.9	59.8	64.8
	8' x 12'	23.9	29.9	35.9	41.9	44.9	47.9	53.9	59.8	65.8	71.8	77.8

Table 2.
Determining drip emitter discharge rate in gallons per hour (gph) using a graduated cylinder

Milliliters of water collected in 30 seconds	Drip emitter discharge rate (gallons/hour)
10	0.32
12	0.38
14	0.44
16	0.51
18	0.57
20	0.63
22	0.70
24	0.76
26	0.82
28	0.89
30	0.95
32	1.01
34	1.08
36	1.14
38	1.20
40	1.27

A 100 ml graduated cylinder works well. These are available in many hardware stores. To easily read the volume, purchase a very transparent plastic cylinder or if possible, a glass cylinder.

Values in Table 2 were calculated using the following equation:

Drip emitter discharge rate (gph) = Water (ml) collected in 30 seconds x 0.0317

Table 3.
Determining drip emitter discharge rate in gallons per hour (gph) using a 35 mm film canister

Seconds to fill a 35 mm film canister	Drip emitter discharge rate (gallons/hour)
26	1.28
28	1.19
30	1.11
32	1.04
34	0.98
36	0.92
38	0.88
40	0.83
42	079
44	0.76
46	0.72
48	0.69
50	0.67
52	0.64
54	0.62
56	0.59
58	0.57
60	0.55
62	0.54
64	0.52
66	0.50
68	0.49
70	0.48

Values in Table 3 were calculated using the following equation:

Drip emitter discharge rate (gph) = **33.29** ÷ **Time to fill 35 mm film canister (seconds)**

Drip System Evaluation Form

Location: _____ **Date:** _____

Observer: _____

Comments:

_____

_____

_____

_____

Drip System Layout (sketch) including emitter sampling locations:

Interactive Emission Uniformity Calculator is online:
Go to http://cesonoma.ucanr.edu/viticulture717/ then select "Vineyard Irrigation"

Drip System Evaluation Form

Sampled Drip Emitter	Location	Water (ml) collected in 30 seconds	Emitter discharge rate (gph)	Ranking
1	_____	_____	_____	_____
2	_____	_____	_____	_____
3	_____	_____	_____	_____
4	_____	_____	_____	_____
5	_____	_____	_____	_____
6	_____	_____	_____	_____
7	_____	_____	_____	_____
8	_____	_____	_____	_____
9	_____	_____	_____	_____
10	_____	_____	_____	_____
11	_____	_____	_____	_____
12	_____	_____	_____	_____
13	_____	_____	_____	_____
14	_____	_____	_____	_____
15	_____	_____	_____	_____
16	_____	_____	_____	_____
17	_____	_____	_____	_____
18	_____	_____	_____	_____
19	_____	_____	_____	_____
20	_____	_____	_____	_____
21	_____	_____	_____	_____
22	_____	_____	_____	_____
23	_____	_____	_____	_____
24	_____	_____	_____	_____
25	_____	_____	_____	_____
26	_____	_____	_____	_____
27	_____	_____	_____	_____
28	_____	_____	_____	_____
29	_____	_____	_____	_____
30	_____	_____	_____	_____
31	_____	_____	_____	_____
32	_____	_____	_____	_____
33	_____	_____	_____	_____
34	_____	_____	_____	_____
35	_____	_____	_____	_____
36	_____	_____	_____	_____
37	_____	_____	_____	_____
38	_____	_____	_____	_____
39	_____	_____	_____	_____
40	_____	_____	_____	_____

Avg. discharge rate of all sampled emitters = _____gph

Avg. discharge rate of the low 25% of sampled emitters = _____ gph

$$\text{Emission Uniformity (\%)} = \frac{\text{Avg. discharge rate of the low 25\% sampled emitters}}{\text{Avg. discharge rate of all the sampled emitters}} \times 100$$

= _____ x 100 = _____%

Sample Data Sheet
Drip System Evaluation Form

Sampled Drip Emitter	Location	Water (ml) collected in 30 seconds	Emitter discharge rate (gph)	Ranking (* low 25%)
1		17	0.54	31
2		14	0.44	3*
3		15	0.48	9*
4		16	0.51	24
5		15	0.48	10
6		17	0.54	32
7		15	0.48	11
8		16	0.51	25
9		14	0.44	4*
10		17	0.54	33
11		17	0.54	34
12		15	0.48	12
13		15	0.48	13
14		15	0.48	14
15		16	0.51	26
16		14	0.44	5*
17		15	0.48	15
18		16	0.48	16
19		13	0.41	1*
20		15	0.48	17
21		14	0.44	6*
22		15	0.48	18
23		16	0.51	27
24		13	0.41	2*
25		17	0.54	35
26		15	0.48	19
27		16	0.51	28
28		14	0.44	7*
29		15	0.48	20
30		15	0.48	21
31		17	0.54	36
32		16	0.51	29
33		15	0.48	22
34		16	0.51	30
35		14	0.44	8*
36		15	0.48	23

Avg. discharge rate of all sampled emitters = 0.48 gph

Avg. discharge rate of the low 25% of sampled emitters = 0.44 gph

$$\text{Emission Uniformity (\%)} = \frac{\text{Avg. discharge rate of the low 25\% sampled emitters}}{\text{Avg. discharge rate of all the sampled emitters}} \times 100$$

$$= \frac{0.44}{0.48} \times 100 = 92\ \%$$