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Irrigation Notes

Scheduling Irrigation

Water is an important natural resource, and we must do all we can to conserve it, especially as it becomes increasingly scarce. One step we can take is to be sure our irrigation systems are properly scheduled. But there is more to this than simply reducing the watering time. The systems also must be properly "tuned." For instance, if the operating pressure at the sprinkler heads is too high, severe misting and wind drift will occur. Also, the sprinkler heads may need to be raised to grade, aligned properly (so they are not watering sidewalks, for example), and the filters may need to be cleaned.

Assuming the equipment is functioning correctly, let's consider the following factors to determine the optimum irrigation schedule: evapotranspiration rate, precipitation rate, efficiency and uniformity, restricted hours or days, crop coefficient, soil texture, root depth, and unusual conditions.

Evapotranspiration Rate

Evapotranspiration (ET) is a measure of how much moisture is lost to the atmosphere from plant and soil surfaces (how much they "sweat") during the course of the day. The moisture that is lost is removed from the bank of moisture available to the root system; thus, the moisture bank is steadily reduced until replenished with irrigation water or rainfall.

The daily ET rate for your area may be available from the local weather service, or you can use the approximate values in Table 1.

Precipitation Rate

This is a measurement of the average amount of water applied to the landscape, expressed in inches per hour (in./hr.). The precipitation rate should be calculated for each individual zone using this formula:

$$\text{Precipitation Rate} = \frac{(\text{GPM for } 360^\circ \text{ sprinkler}) \times 96.25}{\text{Head Spacing (ft.)} \times \text{Row Spacing (ft.)}}$$

where GPM is gallons per minute, and 96.25 is a constant that converts cubic inches of water to inches per hour. Head spacing is the distance between sprinkler heads and row spacing is the distance between rows of sprinklers, (see Figure 1).

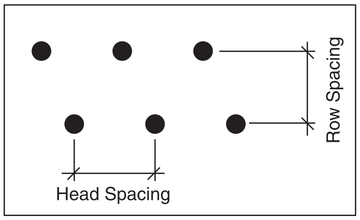

FIGURE 1

For sprinklers with odd arcs, use the following formula:

$$\frac{34650 \times \text{GPM (for any arc)}}{\text{Degrees of Arc} \times \text{Head Spacing} \times \text{Row Spacing}}$$

TABLE 1

POTENTIAL EVAPOTRANSPIRATION RATES*

CLIMATE TYPE**	DAILY LOSS (in inches)
Cool Humid	0.10 - 0.15
Cool Dry	0.15 - 0.20
Warm Humid	0.15 - 0.20
Warm Dry	0.20 - 0.25
Hot Humid	0.20 - 0.30
Hot Dry	0.30 - 0.40

* These potential evapotranspiration rates are the maximum average ET rates for the climate types. Actual daily ET rates typically are less than these values.

** "Cool" applies to areas with average high temperatures in mid-summer of under 70˚F. "Warm" refers to mid-summer highs between 70˚F and 90˚F. "Hot" indicates mid-summer averages over 90˚F. Areas in which the average relative humidity is over 50% in mid-summer qualify as "Humid," while under 50% is considered "Dry".

Efficiency and Uniformity

Uniformity, which is a component of efficiency, is a measure of how evenly water is applied. Efficiency is a measure of how well the system is designed, installed and managed.

Many factors influence the efficiency and uniformity of a system. The best equipment for the situation must be selected, and proper maintenance procedures must be followed, or the system cannot perform at peak efficiency. A system can have good uniformity and still be inefficient. However a system with poor uniformity can not be efficient.

Properly designed and maintained turf sprinkler systems could have efficiency ratings as high as 80%. Poorly designed and maintained systems can have efficiencies of 40% or lower. Most systems fall into the 50% to 70% range. For our examples, we will assume an approximate efficiency of 65%.

Restricted Irrigation Hours or Days

Many sites have restrictions on when irrigation can take place. For instance, school playgrounds are usually watered at night, recreational softball fields might be watered after late evening games, and in locales with watering restrictions, watering may be limited to a narrow time window. In addition, the days of the week on which irrigation can take place may be limited by watering restrictions, or by maintenance schedules. These limitations will have the effect of either increasing or decreasing station run times.

Crop Coefficient

This factor takes into account the various moisture needs of different vegetation types. Table 2 supplies crop-coefficient figures. For example, if watering warm season turf you may use 0.70. If you were watering small shrubs you might use 1.00.

Soil Texture

The soil texture affects the rate at which water can be absorbed without runoff (see Table 3). The texture and soil depth also determine the ability of the soil to retain moisture (see Table 4). This is because soils composed of large particles, such as sand, have less combined surface area for the water to “cling” to, while soils composed of smaller particles, such as clays, have more surface area and hold water longer.

Further, if your soil is poor and you add a soil amendment to it, this treatment is effective only to the depth the amendment is mixed into the soil. For example, adding peat moss to a sandy loam and tilling it to a depth of six inches benefits only the top six inches of the soil. Therefore, the moisture-holding ability of the top six inches of soil will be different than the next six inches of soil.

TABLE 2

CROP COEFFICIENT (K_c)

VEGETATION TYPE	COEFFICIENT
Mature Trees	0.80
Vines & Shrubs (taller than 4 ft.)	0.70
Small Shrubs (smaller than 4 ft.)	1.00
TURF:	
Warm Season	0.50-0.70
Cool Season	0.60-0.80
Arid Climate Natives	0.35

TABLE 4

MOISTURE AVAILABLE

(in inches per foot of soil depth)

SOIL TYPE	AVERAGE IN./FT. SOIL DEPTH
Sand	0.75
Sandy Loam	1.25
Loam	2.00
Silt Loam	2.25
Clay Loam	1.85
Clay	1.25

Adapted from Fundamentals of Soil Science, by Henry D. Foth, 6th ed.

TABLE 3

SOIL TEXTURE	MAXIMUM PRECIPITATION RATES (INCHES PER HOUR):							
	0 to 5% slope		5 to 8% slope		8 to 12% slope		12% + slope	
	Cover	Bare	Cover	Bare	Cover	Bare	Cover	Bare
Coarse sandy soils	2.00	2.00	2.00	1.50	1.50	1.00	1.00	0.50
Coarse sandy soils over compact subsoils	1.75	1.50	1.25	1.00	1.00	0.75	0.75	0.40
Uniform light sandy loams	1.75	1.00	1.25	0.80	1.00	0.60	0.75	0.40
Light sandy loams over compact subsoils	1.25	0.75	1.00	0.50	0.75	0.40	0.50	0.30
Uniform silt loams	1.00	0.50	0.80	0.40	0.60	0.30	0.40	0.20
Silt loams over compact subsoil	0.60	0.30	0.50	0.25	0.40	0.15	0.30	0.10
Heavy clay or clay loam	0.20	0.15	0.15	0.10	0.12	0.08	0.10	0.06

Root Depth

The approximate root depth, combined with the soil texture, determines the "bank" of available moisture from which the plants can draw. With more moisture held in the soil, plants can survive longer without irrigation. For example, a sandy loam, three feet deep, could store 3.75 inches of water in reserve for the plants: 3 ft. x 1.25 in./ft. (from Table 4) = 3.75 in. However, if the root system of the plants is only 18 inches deep, then calculation of the available moisture must be based on 18 inches of soil, regardless of the actual soil depth.

Unusual Conditions

The effects of atypical conditions also should be considered. For example, in extremely shady areas the ET rate is reduced, while in windy areas it is increased. Also, since water obeys the law of gravity, the moisture content of soil at the top of a slope is depleted more quickly than at the bottom.

Calculating the Irrigation Time

Now considering all of these factors, the optimum irrigation time is determined using the following formula:

$$T = \frac{60 \times ET \times Kc}{PR \times EA}$$

where T is the irrigation time in minutes, ET is the evapotranspiration rate, Kc is the crop coefficient, PR is the precipitation rate, and EA is the application efficiency.

With this simple calculation, it is possible to determine efficient irrigation schedules that do not waste our most precious natural resource.

Various sources were consulted while preparing this document; contact Hunter Industries if you desire bibliographic information.

EXAMPLE 1

A valve in your system is irrigating warm-season turf. The average precipitation rate is 0.49 in./hr. The system is located in San Diego, CA. The daily moisture loss (ET) to be replenished is 0.20 inches. The system has an application efficiency of 65%. The soil is sandy loam. Calculate the daily irrigation time for the zone.

The formula is: $T = \frac{60 \times ET \times Kc}{PR \times EA}$

$$T = \frac{60 \times 0.20 \times 0.70}{0.49 \times 0.65}$$

$$= \frac{8.4}{0.32}$$

= 26 minutes run time

This is the total necessary irrigation time each day; however, the time could be split into cycles to avoid runoff. To calculate the run time for a weekly period in which you have only five days to water, assuming no rain has fallen, and using the same ET rate, use the formula:

As run times become longer, it becomes more important to split the daily irrigation time into cycles to avoid runoff.

$$T = \frac{\text{daily run time (minutes)} \times 7}{5}$$

$$T = \frac{26 \times 7}{5}$$

= 36 minutes for 5 days a week

EXAMPLE 2

A valve in your system is irrigating cool-season turf. The average precipitation rate is 1.6 in./hr. The system is located in Norfolk, VA, and the ET rate is 0.15 in. The system has an application efficiency of 65%. The soil is clay loam. Calculate the daily irrigation time for the zone.

The formula is: $T = \frac{60 \times ET \times Kc}{PR \times EA}$

$$T = \frac{60 \times 0.15 \times 0.80}{1.6 \times 0.65}$$

$$= \frac{7.2}{1.04}$$

= 6.9 minutes run time

Seven minutes is the irrigation time required each day.

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