Crop Water Use Curves for Irrigation Scheduling

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Oregon State University, Corvallis
Authors: D. C. Hane is Instructor and F. V. Pumphrey is Agronomist at Oregon State University, Columbia Basin Agricultural Research and Extension Center, Hermiston, Oregon.

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D. C. Hane and F. V. Pumphrey

The relationship between water used by crops at various growth stages and pan evaporation provides information applicable to irrigation scheduling. The curves provided here have been constructed using the data most current and relevant to intensive irrigated agriculture. Data for the potato and winter wheat curves were developed at the Columbia Basin Agricultural Research and Extension Center, Hermiston, Oregon. The alfalfa, field corn, peas, and mint curves include data from Oregon, Idaho, and FAO irrigation and drainage papers.

These curves represent average conditions and allowances have to be made for individual conditions. The actual water used by a crop at a given growth stage can be modified by disease, weeds, insects, fertility, variety, slope exposure, and management factors for individual fields.

Pan evaporation can be obtained from local weather recording stations or from appropriate measuring devices at or near growers' fields. Pans should be located under conditions representative of irrigated crops. The standard U. S. Weather Bureau Class A evaporation pan is four feet in diameter, ten inches deep, filled with water to a depth of 7 1/2 inches, and elevated above ground five inches. A similar pan that can be used for determining evaporation has been suggested by Montana State University (1). They recommend a No. 1 or No. 2 galvanized washtub be set up similarly to a standard pan. The accuracy of the "washtub" pans is said to be similar to a Class A pan and is considerably cheaper.

These crop water use curves along with crop growth stage and pan evaporation provide an irrigation scheduling tool. The water use coefficient determined from crop growth stage and these curves is multiplied by pan evaporation to give estimated crop water use (water use coefficient \times pan evaporation = water used by crop). Irrigations are scheduled accordingly.
*Water use coefficient X pan evaporation = water used by plant.

(Doorenbos and Kassam, 1979)
(McVay, 1982; Wright, 1982)

Alfalfa is deeper rooting and can deplete soil moisture to a greater extent without suffering yield loss than most irrigated crops.

When the supply of water is limited, irrigating more acres rather than fully irrigating fewer acres will increase total production. A 20 percent deficit in water may reduce yield by only 10 percent.

Irrigating immediately after cutting encourages rapid regrowth if the soil is not moist from irrigating just prior to cutting.

Water use efficiency decreases during the growing season. This decrease in water use efficiency results from decreasing yield during the growing season and increasing plant water use mainly because of higher summer temperatures and lower humidity.
Grain yields are affected most by water supply from head emergence through flowering. A water deficit of 20 percent during this period can reduce grain yield as much as 50 percent. Grain yields are least affected by water deficits during tillering; a water deficit during this period may reduce grain yield by only 10 percent. If water is limiting growth during tillering and early jointing, an inch of water may increase the yield three bushels per acre. An inch of water applied to wheat suffering from severe moisture stress during flowering will increase yields as much as 10 bushels per acre.

Wheat, until the hard dough stage of growth, can take up 45 to 55 percent of the available soil water before suffering stress and yield reduction. Available water in the upper two or three feet of soil can be utilized after hard dough without loss in yield or quality.

Over watering during the vegetative stage of growth increases vegetative growth, the grain to straw ratio, the possibility of lodging, and may leach nutrients (mainly nitrate and sulfur) below the rooting zone. The worst possible water scheduling for wheat is abundant irrigation until head emergence and little or no irrigation after head emergence.

Water use coefficient X pan evaporation = water used by crop.

(Pumphrey and Hane, 1982)
The sensitivity of the potato plant to water stress prohibits soil water depletion of more than 30 to 40 percent if optimum yield and quality are to be obtained. The periods of stolonization through tuber initiation and yield formation are the most sensitive to water deficits. Water stress at these times will have the greatest adverse affect on yield and quality. The periods of very early vegetative growth and late tuber bulking are less affected by water deficits.

Over watering reduces yield and quality and increases problems related to storage.

Water use coefficient \( \times \) pan. evaporation = water used by crop.

(Hane and Pumphrey, 1982)
Field corn is most sensitive to water deficits during tasseling, pollination, and yield formation. Under watering by 10 percent during this time could result in a 20 to 25 percent reduction in yield. If a water deficit is anticipated, it should be directed towards the vegetative period prior to tasseling or the ripening period after the kernels have filled.
Peas are very sensitive to water deficiency during flowering and pod filling. Soil water depletion should be no more than 40 percent of available water in the upper two feet of soil during these growth periods.

When moisture is deficient, an inch of water during early vegetative growth will increase fresh pea yields 200 to 300 pounds per acre; an inch of water during flowering and pod filling will increase the yield 400 to 1000 pounds per acre. When moisture is deficient, irrigating during flowering increases the number of flowers, pods, and peas per pod.

Abundant moisture during the vegetative stage of growth and good soil fertility result in excessive vine growth. Abundant moisture throughout the growing season extends blooming and pod filling. With fresh pea production, greatly extending blooming and pod filling result in less uniformity in pea size, maturity, color, and increases "blonding" (pale green colored peas).

*Water use coefficient X pan evaporation = water used by crop.

(Doorenbos and Kassam, 1979)
(Pumphrey, 1974)
MINT

*Water use coefficient X pan evaporation = water used by crop.

(McVay, 1982)