1992

G92-1099 Estimating Effective Rainfall

Joel E. Cahoon
University of Nebraska-Lincoln, joelc@montana.edu

C. Dean Yonts
University of Nebraska - Lincoln, cyonts1@unl.edu

Steven R. Melvin
University of Nebraska--Lincoln, smelvin1@unl.edu

Cahoon, Joel E.; Yonts, C. Dean; and Melvin, Steven R., "G92-1099 Estimating Effective Rainfall" (1992). *Historical Materials from University of Nebraska-Lincoln Extension*. 1198.
http://digitalcommons.unl.edu/extensionhist/1198

G92-1099-A

University of Nebraska Lincoln
NebGuide
IANR
Published by Cooperative Extension, Institute of Agriculture and Natural Resources,
University of Nebraska-Lincoln

Estimating Effective Rainfall

How irrigators can estimate effective rainfall, and use that estimate to schedule irrigations properly.

Joel Cahoon, Assistant Professor, Biological Systems Engineering
Dean Yonts, Associate Professor, Biological Systems Engineering
Steve Melvin, Extension Agent, Nuckolls County

Scheduling irrigation based on crop demand (see NebGuide *G85-753 Irrigation Scheduling Using Crop Water Use Data*, on the checkbook method) requires an estimate of effective precipitation or rainfall. Effective rainfall estimates are also important for planning cropping sequences in both dryland and irrigationd crop production. Effective rainfall is the amount of rainfall stored in the crop root zone. Rainfall that runs off the soil surface or passes through the root zone does not contribute to crop growth and yield.

There are two steps to estimating effective rainfall accurately. First, the total rainfall amount must be measured accurately. Second, the amount stored in the root zone must be determined.

Measuring Rainfall

The location of the rain gauge is important for accurate rainfall recording. Locate the gauge near to and slightly above the surface of the crop canopy. If it is not possible to locate the gauge very near the canopy, place it at least 30 feet from the field edge and away from other obstructions. Place the rain gauge in a location where the wind conditions are similar to the majority of the crop canopy. It should not be sheltered or more exposed to the wind than the crop itself.

Rainfall amounts can vary considerably even across short distances. It may be convenient to place a gauge at each irrigation well or other points that are easily accessed and visited often. A minimum of one rain gauge for every quarter section is recommended, but having four or more gauges per quarter section provides a more accurate estimate of rainfall across the field.

Here are things to look for when choosing a rain gauge:

1. The area of the opening of the collector should be at least 5.5 square inches (a 2.5" x 2.25" rectangle or a 2.5" diameter circle).
2. The rim of the collector should have a sharp edge that falls away vertically on the inside and is steeply beveled on the outside.
3. The scale for reading amounts should be accurate, scaled properly, and easy to read.
4. The gauge should be designed so water doesn't splash in or out.
5. The part of the gauge that stores water should be narrower than the opening to restrict evaporation. A very small amount of oil can be placed in the gauge to prevent evaporation. Always try to read the gauge soon after the event to assure an accurate reading.

The University of Nebraska has tested various types of rain gauges. These results and details on the variability of rainfall and placement of gauges, can be found in NebFact *NF91-39, Precipitation and Sprinkler Irrigation Monitoring for Managing Irrigation Scheduling*.

Estimating Effective Rainfall

Factors that influence effective rainfall are soil slope, soil texture and structure, plant cover or crop residue, and storm intensity and duration. Effective precipitation is important in irrigation scheduling decisions, is used to design new irrigation systems, and is a guiding factor for planning crop production practices.

Rainfall may be separated into components: runoff, infiltration, interception (rainfall that is caught on the plant surfaces), and evapotranspiration (ET). ET is defined as the sum of transpiration and evaporation from plant and soil surfaces. ET is discussed in detail in NebGuide *G90-992, Evapotranspiration (ET) or Crop Water Use*. Interception and ET are often disregarded when identifying rainfall components because they represent a small portion of the total rainfall. These simplifications leave the approximation:

RAINFALL is nearly equal to INFILTRATION + RUNOFF

Estimating the portion of a rainfall that leaves a field as runoff is difficult. One method is to estimate the percentage of the rainfall lost to runoff based on observation. A more sophisticated method has been developed by the Soil Conservation Service (SCS, 1972). The SCS method requires information concerning the cropping practice, soil characteristics, pre-rainfall moisture status, and the rainfall amount. Infiltration may be calculated if runoff is estimated and rainfall is measured. The amount of moisture in the root zone before the rainfall influences the balance between rainfall that is stored in the root zone and the amount that percolates through.

Figure 1 was prepared for general row crop conditions while *Figure 2* is for row crops grown on the contour. The difference between *Figures 1* and *2* involves the slope of the furrows, not necessarily the field. If straight rows are used on fields with little or no slope (less than 1%) then it would be appropriate to use *Figure 2*. Many furrow irrigators should use *Figure 2*, even with crops grown on straight rows. *Figures 3* and *4* are similar to *Figures 1* and *2*, but should be used when wetter pre-rain soil conditions are present. Rainfall events on soils wetter than those shown in *Figures 3* and *4* are often assumed to fully refill the root zone since the soil profile is already near capacity. The soil groups used in the graph are described in *Table I* (portions reproduced from Schwab et al., 1981).

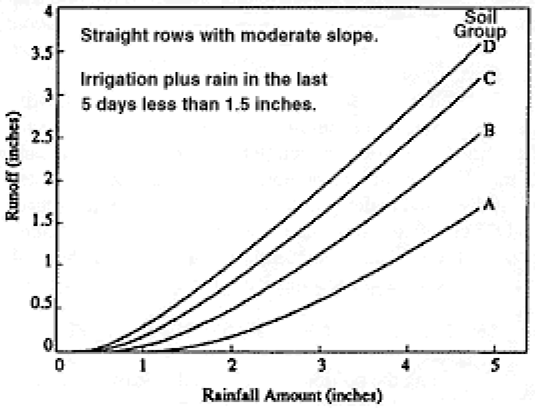

Figure 1. Runoff curves for straight row crop conditions with moderate slopes and relatively dry soil.

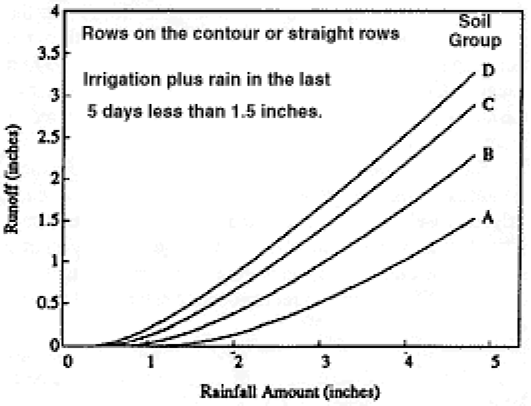

Figure 2. Runoff curves for row crops grown on the contour, or straight rows having little slope, and relatively dry soil.

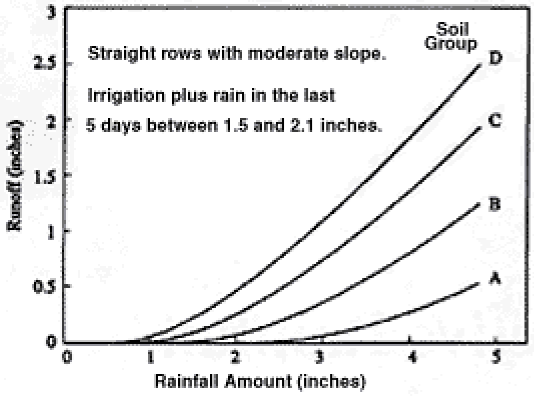

Figure 3. Runoff curves for straight row crop conditions with moderate slopes and wetter soil.

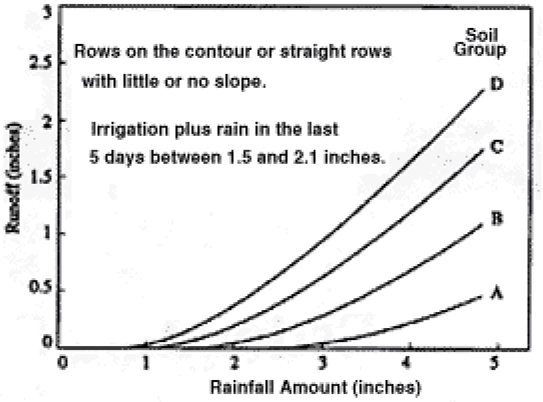

Figure 4. Runoff curves for row crops grown on the contour, or straight rows having little slope, and wetter soil.

It will often be necessary to modify the runoff results from *Figures 1-4* based on field observations. The most common reason for adjustment is to account for unusual rainfall intensity. For example, slow steady rain causes less runoff, while intense storms generate more runoff. The results could also be modified to account for unusual slope or residue conditions. Heavy residue and small slopes cause less runoff than do light residue conditions or steep slopes. Remember, these graphs provide a starting point for runoff estimates but you may need to modify that estimate based on field observations.

Infiltration is estimated by subtracting the amount of runoff from the rainfall amount measured with the rain gauge. Infiltrated water can either refill the soil profile, or if the profile can't hold the infiltrated water, the excess percolates below the root zone. If the infiltrated depth is greater than the root zone can hold, the effective rainfall equals the amount the root zone can hold and the soil profile is fully replenished. If the amount the root zone can hold is greater than infiltration, the effective rainfall equals the infiltrated depth and the available water is increased by that amount.

Using effective rainfall estimates with the checkbook method for irrigation scheduling is a very effective technique, especially when it is backed up periodically with field observations. The appearance and feel method for determining soil moisture status (NebGuide *G84-690, Estimating Soil Moisture by Appearance and Feel*) provides a good way to validate the checkbook procedure. A hand-feel sample

may also be evaluated a few days after the rainfall to back-check the calculation of effective rainfall.
Field Variability

Another challenge associated with estimating effective rainfall, and irrigation scheduling in general, involves the variability of events and conditions found in the field. Rainfall amounts vary within each field, but often only one rain gauge is used for the whole field. Other variabilities include soil texture, infiltration rates, slopes, residue cover, and soil depths. When making decisions concerning effective rainfall or irrigation schedules, it is customary to consider the dominant conditions based on relative areas. If most of a field is flat, and a small portion has severe slopes, decisions would usually be made for the flat areas. If there are relatively large areas having dramatically different conditions, decisions could be made separately for each area. If one decision is made for both areas, the conservative approach (least yield reducing) is appropriate.

Example 1

A farmer has been monitoring his irrigationd corn crop using the checkbook scheduling technique. The soil is a Holdrege silt loam with adequate residue and slope conditions often associated with furrow irrigation. The day before the rain, the available water content of the root zone was 2.1 inches less than capacity. The rain storm was fairly short and intense, with a total rain gauge amount of 3.7 inches. The soil was relatively dry when the rain occurred (less than 1.5 inches of rain or irrigation in the last five days). It is desired to estimate the effective rainfall and the corresponding increase in available water.

Table I indicates that the curve for soil group B should be used. Figure 2 should be used for relatively flat furrow irrigationd fields. Reading *Figure 2* from the horizontal axis at 3.7 inches to the curve labeled B, the corresponding value on the vertical axis is about 0.6 inches. Next, adjustments based on field observations should be made since the storm was of unusual intensity. Thus, it may be appropriate to increase the runoff estimate from 0.6 inches to 0.8 inches. This is purely a judgment call.

After determining that 0.8 inches of rain ran off the field, the remainder of the rainfall must equal infiltration. A rainfall depth of 3.7 inches minus 0.8 inches of runoff leaves 2.9 inches of infiltration. Since this is more than the root zone could hold (2.1 inches), the effective precipitation was 2.1 inches (meaning 0.8 inches of deep percolation occurred) and the soil moisture has been replenished to capacity for the active root zone.

Example 2

Another farmer has been monitoring his irrigationd soybean crop using the checkbook scheduling technique. The soil is a Crete silty clay loam with average residue. The field is not farmed on the contour and is center pivot irrigationd. The day before the rain storm, the available water was 2.8 inches less than capacity and the soil was relatively dry (irrigation plus rainfall for the last five days was less than 1.5 inches.). The total rainfall caught in the rain gauge was 0.9 inches. What is the effective rainfall and the post-rainfall soil moisture status?

Table I indicates that the curve for soil group D should be used. *Figure 1* is the appropriate graph for straight rows under the slope conditions often associated with center pivots. Reading Figure 1 from the horizontal axis at 0.9 inches to the curve labeled D, the corresponding value on the vertical axis is about 0.1 inches. No adjustments are needed based on field observations, because the storm was not of unusual intensity, and excessive field slope was not a factor.

A rainfall depth of 0.9 inches minus 0.1 inches of runoff leaves 0.8 inches of infiltration. Since the available water before the rainfall event was 2.8 inches less than capacity, it would then be 2.0 inches less than capacity (2.8 inches minus 0.8 inches), and all the infiltration was effective.

Table I. Soil groups.

Soil Group	**Description**[a]	**Example Soils in Nebraska**[b]
A	*Lowest Runoff Potential.* Includes deep sands with very little silt and clay, also deep, rapidly permeable loess.	Valentine Bankard
B	*Moderately Low Runoff Potential.* Mostly sandy soils less deep than A, and loess less deep or less aggregated than A, but the group as a whole has above-average infiltration after thorough wetting.	Hastings Holdrege Cozad McCook
C	*Moderately High Runoff Potential.* Comprises shallow soils and soils containing considerable clay and colloids, though less than those of Group D. The group has below-average infiltration after pre-saturation.	Reliance Richfield Alda
D	*Highest Runoff Potential.* Includes mostly clays of high swelling percent, but the group also includes some shallow soils with nearly impermeable subhorizons near the surface.	Butler Wood River Crete

[a] Source: U.S. Soil Conservation Service, *National Engineering Handbook, Hydrology.* Section 4 (1972) and U.S. Dept. Agr. ARS 41-172 (1970)

[b] A complete listing is found in the Nebraska Irrigation Guide, available for viewing at local SCS offices.

References

SCS, 1972 U.S. Soil Conservation Service, *National Engineering Handbook, Hydrology*. Section 4.
Schwab, G. O., R. E. Frevert, T. W. Edminster, and K. K. Barnes. 1981. *Soil and Water Conservation Engineering.* Third Edition. J. Wiley and Sons, New York.

File G1099 under: IRRIGATION
B-22, Irrigation Operations and Management
Issued June 1992; 10,000 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.