A New Method of Characterizing Sprinkler Distribution Patterns

Edward Norum, P.E., Consultant
The Center for Irrigation Technology
California State University, Fresno

Procedures for characterizing sprinkler irrigation overlap patterns have progressed very little since J.E. Christiansen first formulated the uniformity coefficient (CU) in 1942. The fundamental weakness lies in the fact that the proposed evaluation parameters lack understandable physical significance. This leaves the quality of coverage to be judged by arbitrary standards defining what is acceptable or unacceptable. A serious consequence of this arbitrary evaluation procedure is that sprinklers are not sold on their actual ability to save water.

Any good sales representative knows all the arguments for selling against arbitrarily set uniformity coefficient standards. These arguments range from the effects of wind on a distribution pattern to how water is redistributed in thatch and the root zone. The issue may quickly become so confusing that the customer can no longer follow the logic. Unfortunately this can lead to products being sold on perception, price and minor features. Marketing efforts will use carefully chosen verbiage to develop the perception of improved uniformity. There is little incentive for a manufacturer to develop a product that truly has an ability to spread water more efficiently, particularly if it is more expensive.

What would be beneficial is a non-arbitrary evaluation procedure that is grounded in science and, most importantly, is easily understood. The framework for this proposed procedure is presented in this paper and in Figures 1 through 5. This effort was inspired by the author's work in developing of the testing protocol for "Climatologically-Based Controllers." This protocol requires the use of a run time multiplier and knowledge of sprinkler application efficiencies. Unfortunately, there is currently no hard science providing data on these two parameters. This paper then is a proposed method for filling that need.

Figure 1 is a plot of the overlapped distribution pattern for a representative pop-up spray head on 14 ft X 14 ft spacing. The experimental data can reasonably be represented by a straight line function (Y=1.454 - .00893 X, $R^2 = 0.979$). The d/mean values shown on the ordinate are dimensionless. The d is simply the amount of deposition in the catchment device (catch can). The mean is the average of all catchment values. The quality of the pattern is determined by quantifying its adequacy and efficiency. In this case, if the effective application is assumed to be the mean application, 11% of the root zone will be in deficit and the pattern loss will also be 11%. It is probable that leaving 11% of the root zone in deficit will have a noticeable effect on turf quality. Christiansen's uniformity coefficient for this pattern would be approximately 70%.

Figure 2 shows the pattern with the effective application reduced to 83% of the mean. This has the effect of reducing the deficit to 5% and increasing the pattern loss to 22%. The suggested 5% deficit value needs to be verified by field studies. However, if some general agreement is reached on this value, the pop-up's uniformity performance is effectively characterized by the resulting pattern loss of 22%.

Figure 3 is a plot of root zone deficit as a function of d/mean. The graph is useful in determining the d/mean value after the allowable deficit has been determined.

Figure 4 is a plot of pattern loss as a function of d/mean. Note particularly that if the deficit was eliminated, the pattern loss for this sprinkler would be 45%. For comparison purposes, the low quarter d/mean value for this pattern is 0.67 and the pattern loss is 34%. The low half d/mean value is 0.78 and the pattern loss is 25%. The deficits are 0.7% and 3.6% respectively.

Figure 5 is a plot of the overlapped distribution pattern for a representative pop-up spray head equipped with a Nelson MP 2000 Rotator on 14 ft X 14 ft spacing. Contrast Figure 1 to Figure 5 to get a sense of the value of uniformity. Using a d/mean value of 1.0 results in a deficit of only 1.8% (vs. 11%) and a pattern loss of 1.8% (vs. 11%). For practical purposes the pattern in Figure 5 is uniform.

The purpose of this paper is to demonstrate an analytical procedure that quantifies the effectiveness and efficiency of sprinkling devices. The patterns shown are real but for illustrative purposes only. With some general agreement on the allowable deficit, the sprinkling devices effectiveness is characterized by the pattern loss value. This characterization does not however address questions of operational and spray losses.

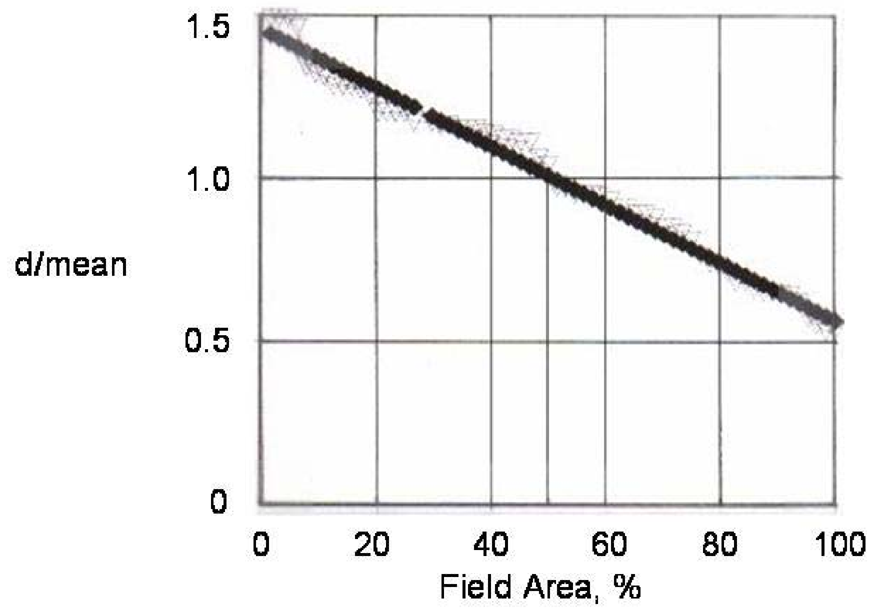

Figure 1. Overlapped distribution pattern for a popup spray head with a 15F (360°) nozzle at 30 psi (3.60 gpm) spaced 14 ft x 14 ft

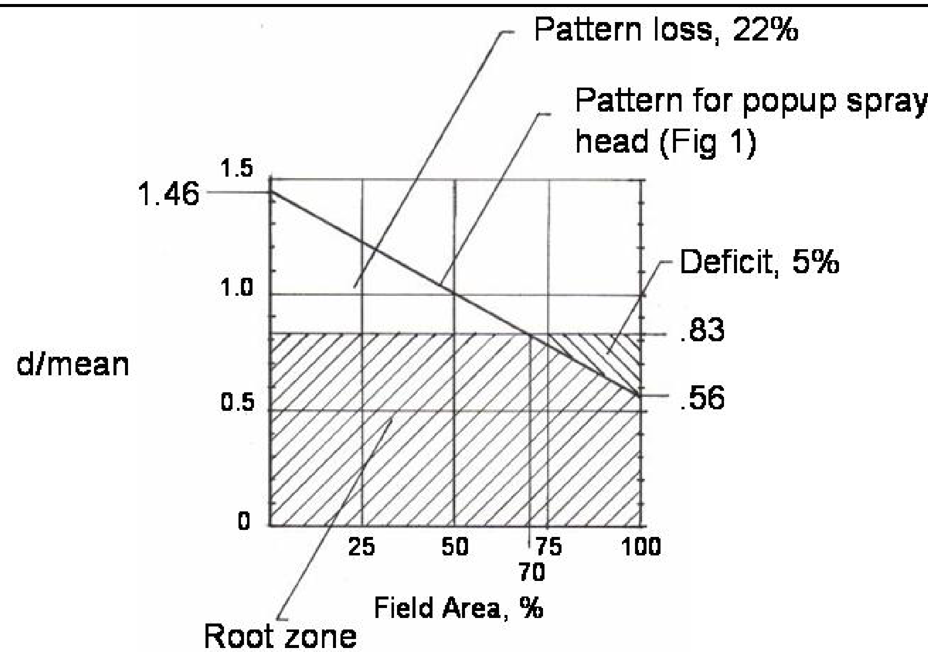

Figure 2. Definitions of proposed evaluation parameters

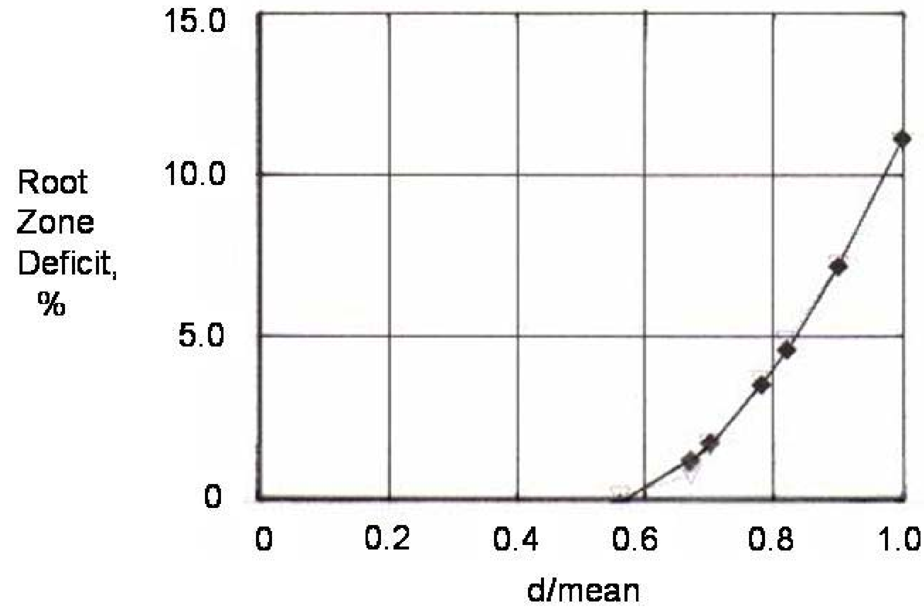

Figure 3. Root zone deficit as a function of d/mean

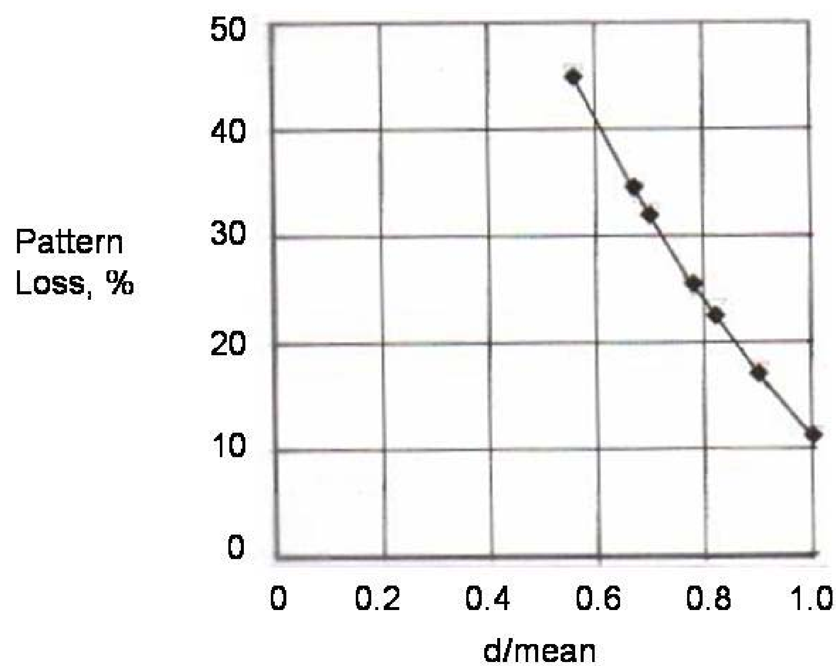

Figure 4. Pattern loss as a function of d/mean

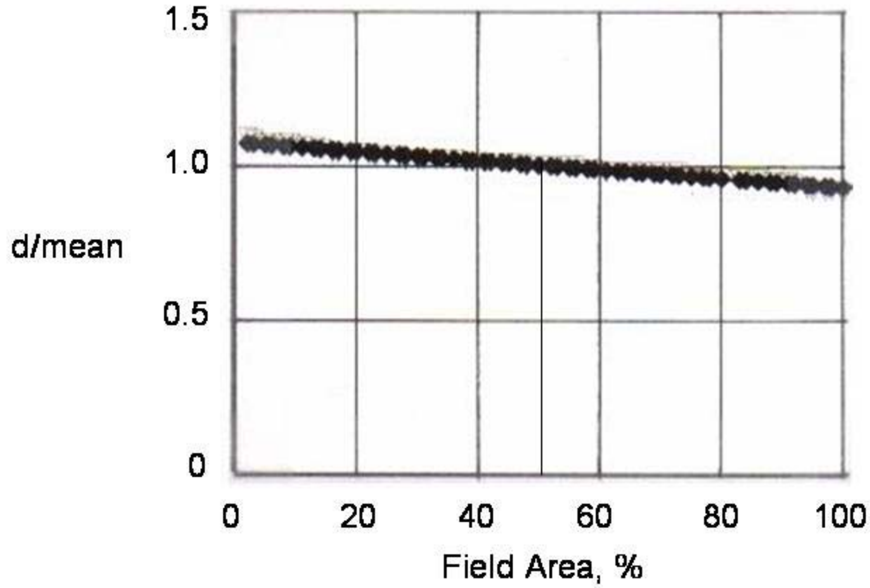

Figure 5. Overlapped distribution pattern for a popup spray head with a rotator (360°) at 30 psi (1.31 gpm) spaced 14 ft x 14 ft