Optimizing Sprinkler Application Rates: Pressure, Nozzle size and Lateral Spacing

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Introduction

Although the use of drip has steadily increased in the Salinas Valley, solid set and hand move sprinklers remain a common sight during the growing season. Overhead sprinklers are less expensive than drip irrigation and the predominant method for establishing cool season vegetable crops. Some vegetables are almost exclusively irrigated with sprinklers, as the case with broccoli because of its lower value compared to other commodities, or because in the case of spring mix and baby spinach, the production practices are not compatible with drip.

Operating sprinklers to evenly distribute water helps produce uniform crops, as well as save water and minimize run-off. Also of importance for minimizing run-off, is to match the application rate of the sprinklers with the infiltration rate of the soil. Sprinklers that are running at high pressure or with large nozzles, or close lateral spacing may result in an application rate that considerably exceeds the infiltration rate of the soil. On some soils, especially if recently saturated from a previous irrigation, a high application rate will quickly lead to significant amounts of run-off. For example, on soils on the east side of the upper Salinas valley, which are prone to crusting, we have often measured as much as 20% of the applied water running off the lower end of fields.

Because of the wide spread use of the ½ inch brass impact sprinkler head on the central coast, we reexamined the relationship among nozzle size, pressure, and lateral spacing on the application rate of overhead sprinklers. We conducted our tests using new Rainbird 20JH impact heads and made repeated measurements of flow rates from nozzles of varying orifice diameters under a range of pressures. We also measured the distribution profile of these sprinkler heads at varying nozzle orifice diameters and under different pressures and used *Sprinkler Profile and Coverage Evaluation* (SPACE) software from the Center for Irrigation Technology at Cal State University Fresno to estimate distribution uniformities under different lateral spacings and pressure scenarios.

Results of sprinkler head tests

The flow rates from Rainbird 20JH sprinkler heads for varying pressures and nozzle orifice diameters are presented in Table 1. The corresponding application rates to the field in units of inches per hour are presented in Tables 2-4 for lateral spacings of 30, 33.3, and 40 feet, respectively. Flow rates measured for the 20JH sprinkler head were about 0.3 gallons per minute (gpm) greater than values published by the Rainbird company. However, the relationship among pressure, nozzle orifice diameter, and flow rate was similar to previously published values.

Effect of pressure on application rate Raising pressure from 45 to 65 psi increased application rates by an average of 13% for all nozzle sizes (Table 1). Likewise, raising pressure from 40 to

60 psi increased application rates by average of 14% for all nozzle sizes. The percentage increase in applied water was highest for the smallest nozzles (3/32 inches), but the amount (gallons per minute) that the application rate was increased with increasing pressure was greatest for the largest orifice size (5/32 inches).

Effect of nozzle orifice diameter on application rate On average, increasing the orifice diameter from 7/64 inch to 1/8 inch increased the application rate by 31% for all pressures (Table 1). Increasing the orifice diameter from 7/64 inch to 9/64 inches increased the application rate by an average of 62% for all pressures.

Effect of lateral spacing on application rate Assuming sprinkler pipe lengths of 30 feet are used, then reducing the spacing between lateral lines from 33.3 feet (10, 40-inch beds) to 30 feet (9, 40 inch beds) would increase application rates by 11% (Tables 2 and 3). Reducing spacing from 40 feet (12, 40 inch beds) to 33.3 feet would increase the application rate by 20% (Tables 3 and 4).

Optimizing application rate and distribution uniformity Although increasing spacing between lateral pipes or reducing nozzle orifice diameter could be effective strategies to reduce application rates, in many instances, these changes would also reduce the distribution uniformity of the sprinklers. For example, a previous analysis that we conducted on sprinkler uniformity using 7/64 inch nozzles demonstrated that increasing the distance between lateral lines beyond 30 feet decreased the uniformity of the applied water (Figure 1). In contrast, reducing pressure can lower application rates without significantly affecting uniformity. Results of another study that we conducted on sprinkler uniformity, demonstrated that decreasing pressure from 65 to 45 psi reduced the application rate by 18% but only reduced the uniformity by 1 to 2 percent (Figure 2).

Summary and conclusions

The application rate and distribution uniformity of overhead sprinklers can be optimized by using an appropriate combination of nozzle orifice diameter and lateral pipe spacing. Commonly in the Salinas Valley, growers use 7/64- inch nozzles with 30 to 33.3 foot spacing between lateral pipes or 1/8 inch diameter nozzles with 40 foot spacing between lateral pipes to achieve a high distribution uniformity with solid-set sprinklers and an application rate ranging from 0.24 to 0.28 inches per hour. Using nozzle sizes and/or lateral spacings substantially different from these combinations may adversely affect distribution uniformity or lead to high application rates. Operating overhead sprinklers at high pressures (>45 psi) is also unlikely to significantly improve uniformity of overhead sprinklers, but would increase run-off and waste money.

The combination of operating a pump at a pressure that is higher than necessary and losing water as run-off adds substantially to overall pumping costs. Assuming an electric rate of $0.16 per kWhr and that a pump is lifting water from a 50 foot depth, the energy cost for pressuring sprinklers to 45 psi is $38 per acre-foot of water. If the pressure is raised from 45 to 65 psi, then the pumping costs are an additional $12 per acre-foot of water (30% higher costs). Also if 20% of the applied water is lost in run-off, then the additional water costs are $22 per acre-foot (total of $60 per acre-foot of water or 55% higher pumping costs).

Table 1. Sprinkler flow rates under varying pressures and nozzle diameters (Rainbird 20JH).

[redacted]

Table 2. Sprinkler application rate for varying pressures and nozzle diameters for a solid set spacing of 30 × 30 feet (Rainbird 20JH).

[redacted]

Table 3. Sprinkler application rate for varying pressures and nozzle diameters for a solid set spacing of 30 × 33.3 feet (Rainbird 20JH).

[redacted]

Table 4. Sprinkler application rate for varying pressures and nozzle diameters for a solid set spacing of 30 × 40 feet (Rainbird 20JH).

[redacted]

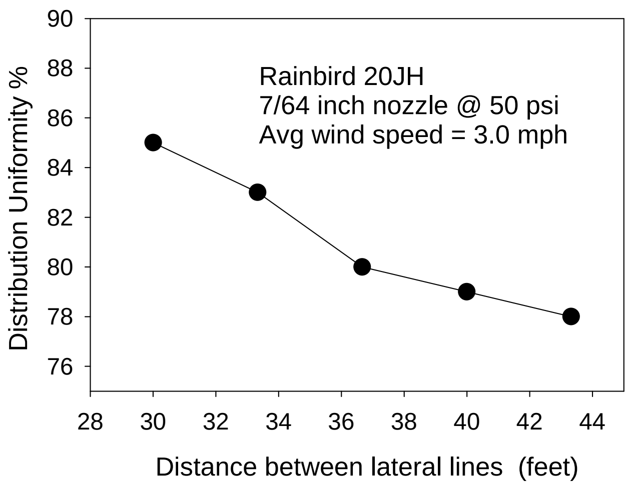

Figure 1. Effects of lateral line spacing on distribution uniformity of overhead sprinklers (head spacing on pipe is 30 feet.)

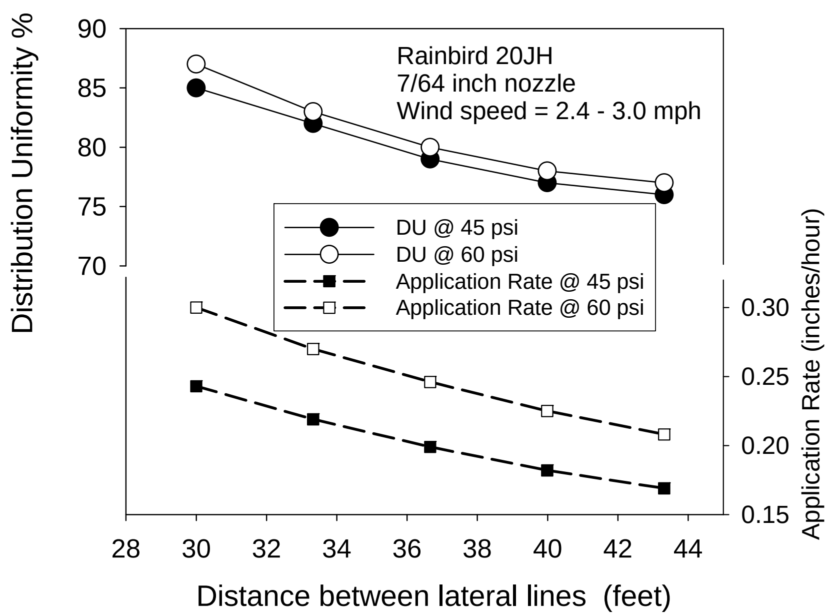

Figure 2. Effects of pressure and lateral line spacing on distribution uniformity and application rate of overhead sprinklers (head spacing on pipe is 30 feet.)