MANAGEMENT OF TRAVELER GUN IRRIGATION SYSTEMS IN THE PACIFIC NORTHWEST

Introduction

The traveling or reel big gun (Figure 1 and Figure 2) irrigation system is one of the most popular forms of irrigation in northwestern Washington. According to WSDA Crop Data for 2019, the total acreage irrigated by big guns was 38,760 acres, 29% of all big gun irrigation systems in Washington State. Many growers prefer the traveling gun since it is easy to set up but lack information on proper system management for water use efficiency and yield productivity. Good irrigation system management is vital for crop uniformity and quality (Mohamed et al. 2019; Peters and McMoran 2010). The focus of this publication is to provide information on how growers can properly manage traveling gun irrigation systems which can save water and energy and increase crop productivity and profitability.

In traveling gun systems, irrigation water is delivered to the sprinkler gun either through a flexible hose dragged behind the machine or through a hard hose. The reel big gun machine uses a turbine or combustion engine to pump the water and a hydraulic drive mechanism to turn the hose reel. The applied irrigation water reaches the crop through one or more big gun sprinklers. These are large-nozzle diameter, high-pressure sprinklers (Smith et al. 2002).

Big gun sprinklers typically discharge between 100 and 600 gpm and irrigate a radius of 80 to 250 feet. Hose sizes range in diameter from 2.5 to 6 inches. The maximum length of the run is equal to the length of the hose, with typical hose lengths ranging from 330 to 1,320 feet. In general, the travel lane spacing is stated by the manufacturer as a fraction of the wetted diameter. The water source can be a well, ditch, canal, or pond.

There are many reasons why growers prefer big guns. However, many management problems are associated with these systems.

Figure 1. Big gun irrigation system. Photo by Don McMoran.

Figure 2. The big gun sprinkler reel-mounted on a tractor. Photo by Don McMoran.

Advantages of Big Gun Systems:

- Highly mobile and transportable from one field to another.
- Short setup time.
- Easy one-person operation.
- Well suited for different crops, such as fruits and vegetables as well as corn, alfalfa, potato, grass, other grains, turfgrass, and even tall-growing crops, such as orchard trees.
- Irrigate different field sizes, shapes, soils, and topographies.
- Operate without supervision, shutting down automatically at the end of each run.
- Capable of spreading wastewater without risk of plugging the nozzles because of the large nozzle size.

Limitations of Big Gun Systems:

- Poor uniformity of water applications.
- High operating pressures that cause higher energy costs.
- High vulnerability to wind drift and evaporation.
- Runoff and erosion that results in ponding water and nutrient loss.

Nozzles

Growers should carefully choose the right big gun nozzles to match the flow rate and discharge pressure for achieving the highest possible application uniformity and efficiency. It is highly recommended to discuss sprinkler head and nozzle orifice sizes with the system manufacturer when purchasing a big gun sprinkler. The manufacturer must be provided with field information, such as soil type, irrigated acreage, direction of irrigation, spacing and height of rows, crop type, wind speed, and budget size, as many brands come with various options, such as taper bore, taper ring, and ring nozzle (Figure 3). Choosing the most suitable nozzle can be confusing because it depends on many factors, the most important being the prevailing wind direction and speed in the field. For instance, taper bore nozzles have the longest water jet throw distance and least wind distortion. Ring nozzles have better stream jet breakup for operation at lower pressures (Figure 4) and are better for delicate crops or when the big gun sprinklers are shifted between different capacity water sources. Taper ring nozzles combine the variability of a ring nozzle with the improved efficiencies of a taper bore nozzle.

Application Rate

The depth of applied water depends on the travel speed, pressure, and nozzle size (and therefore the flow rate [gpm]) as well as the soil characteristics and lane spacing. The USDA Natural Resources Conservation Service Web Soil Survey (USDA NRCS 2019) gives the soil type and the available water holding capacity for any given area in the US in inches of water per inch of soil.

Washington State University's Irrigation in the Pacific Northwest website (2020) provides a calculator to determine the water application rate from traveling big gun systems.

The travel direction is usually in a straight line as the reel pulls down the big gun sprinkler towards it with the flexible hose. Most big gun systems are set up to make a pass through the field in either 11 or 23 hours. This allows the sets to be changed in either 12 or 24 hour intervals, allowing one hour to move the traveler. The machine run time can be calculated as:

Desired time in minutes = (length of run in feet)/(travel speed).

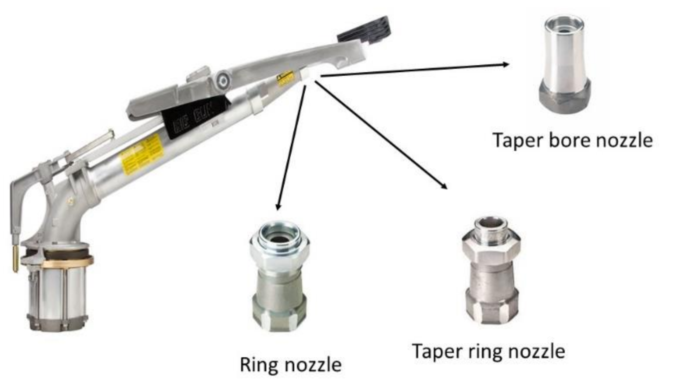

Figure 3. Nozzle types of big gun. (Source: Nelson Irrigation Inc.)

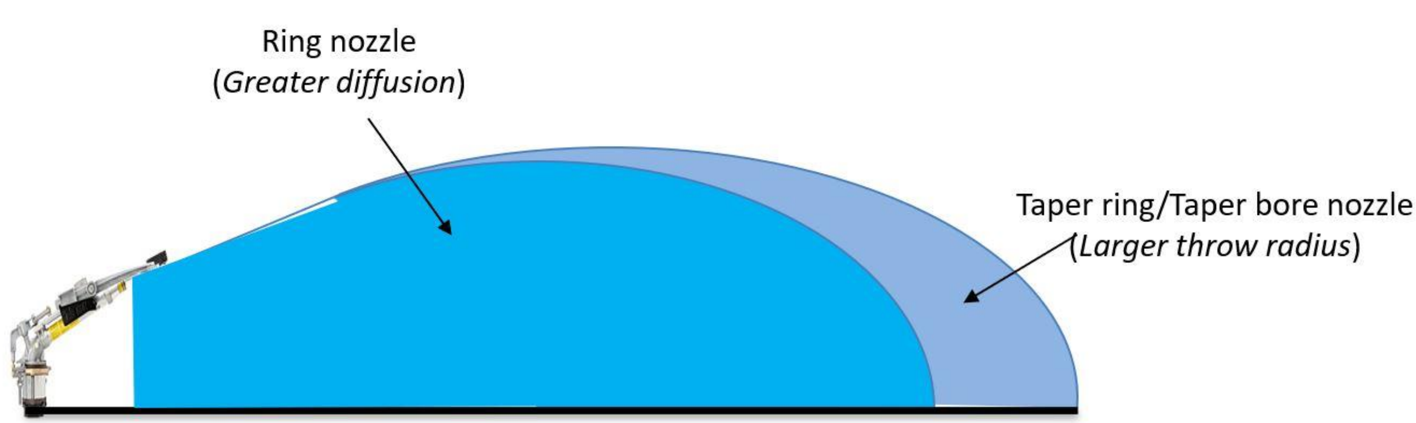

Figure 4. Difference between taper and ring nozzle trajectory pattern. (Source: Nelson Irrigation Inc.)

The lane spacing is a portion of the wetted diameter which is usually recommended by the manufacturer.

Big guns can be adjusted to irrigate full circle, half circle, and part circle (Figure 5). If the irrigator desires a dry path in front of the big gun sprinkler traveler path and no loss of water at the field boundaries, the part-circle sprinkler setup should be used. Although the water application rate of a part-circle sprinkler is much greater than the full circle of the same system capacity, the sprinkler cart will run in a dry track and have fewer problems with mud. However, if the lowest application rate is needed due to ponding and runoff concerns, the full circle should be used.

Sprinkler Pattern

Evaluation tests were conducted in Skagit County in different fields occupied with various crops (dry beans, broccoli, and cucumbers) to investigate the big gun sprinkler pattern under different wind conditions. The soil texture of all fields was silty loam. Distribution uniformity (DU) measures how much water is applied and how uniformly the rate water is distributed. In general, a DU of 80% or better is desirable. The DU of the first evaluation was 56% due to significant wind (8.5 mph). Figure 6a demonstrates that the common sprinkler pattern had a little distortion due to the wind. However, in the second evaluation, the DU was 80% under no wind, the sprinkler pattern had no distortion (Figure 6b), and the application efficiency (the ratio of irrigation water used beneficially by the crop to the amount of water pumping through the system) was 96% for this system. This shows the second system's application efficiency is very high and the system is in very good condition without any leakage. In the third evaluation, the DU was 55% but in a 7.7 mph wind speed condition that distorted the sprinkler pattern (Figure 6c). This emphasizes that irrigation timing is the key to achieving high uniformity and avoiding water losses by wind drift.

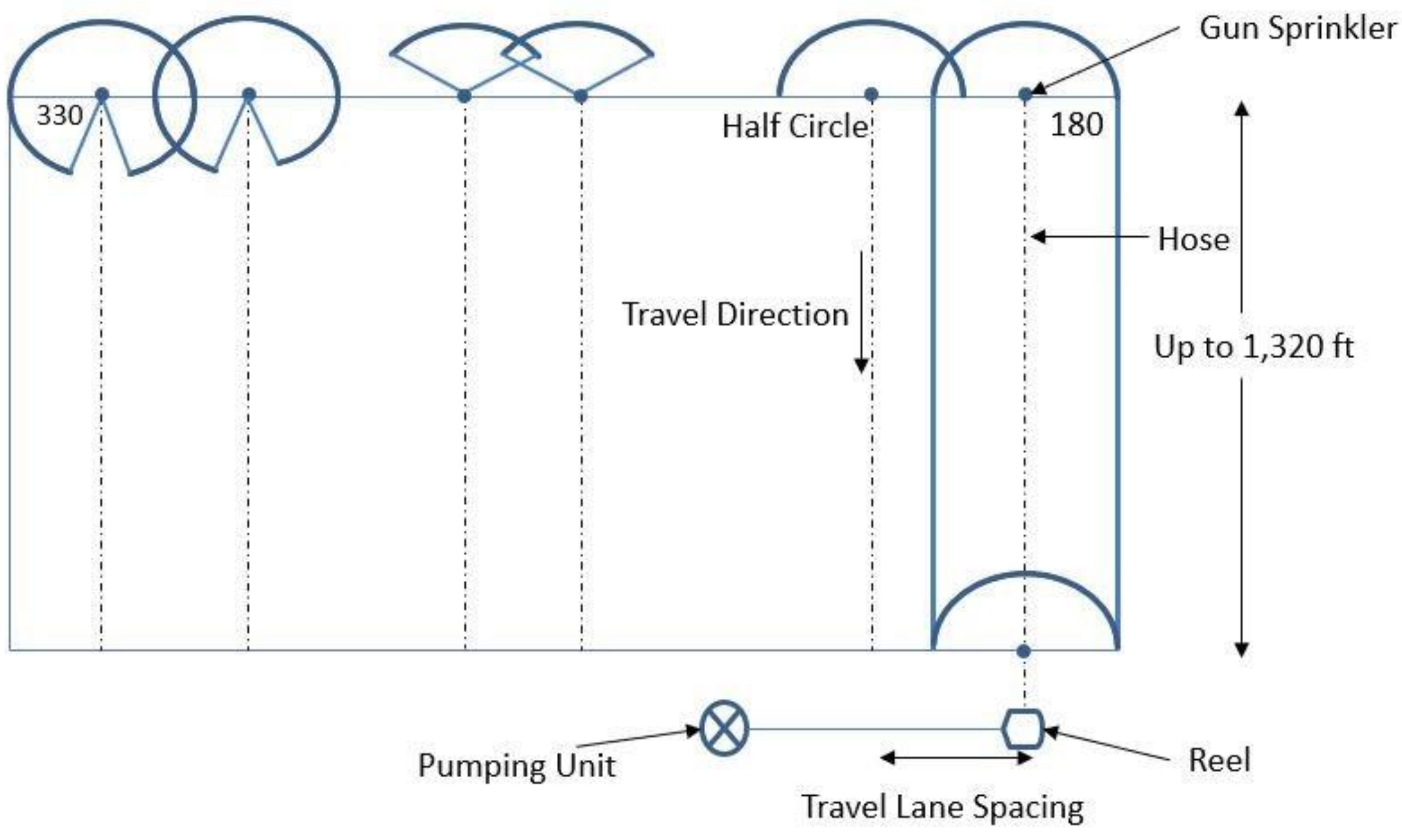

Figure 5. Traveler gun layout and nozzle patterns.

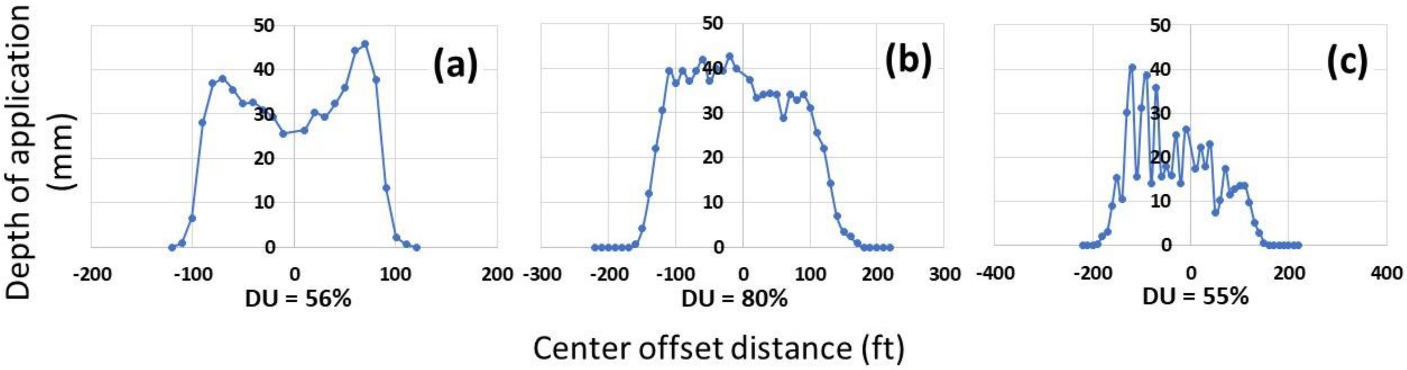

Figure 6. Nozzle pattern under different wind conditions.

Strategies for Improving the Uniformity of Applications

The poor performance of big guns is usually due to improper lane spacing, nozzle sizes, and travel speeds. Wind is the major constraint of big gun irrigation because it greatly counters application efficiency and distribution uniformity. The following is a list of approaches that could improve the uniformity of big gun irrigation applications:

1. Where prevailing winds exceed 5 mph, tow paths should be laid out so they are not parallel with the wind direction and must be accompanied by a decrease in travel lane spacing (Keller and Bliesner 1990).
2. Reducing lane spacing is sometimes considered impractical due to the field size and shape or labor availability. Closer spacing may also result in some overlap zones receiving more water than necessary. In these cases, it may be advisable to use tapered nozzles—or alter the angle of rotation—to increase the output of water to the outside edges and less towards the middle of the tow path. For example, a 330-degree rotation may be used instead of a half-circle rotation (Figure 3).
3. As the lane spacing is decreased, the travel speed must be increased to apply the same total water depth (Shull and Dylla 1976), as applying more water than the soil can hold in the root zone is not recommended. Increasing the travel speed will require more frequent lane changes and thereby increase the labor requirement.
4. Low-discharge sprinklers and slow travel speeds are advised if there are infiltration problems, such as with heavy-textured soils.
5. A sprinkler with low angles will give more uniform coverage in areas where winds above 10 mph are common.
6. The use of a part-circle rotation, as opposed to a full-circle rotation, results in better irrigation uniformity but increases the application rate and, therefore, may be more prone to ponding and runoff.
7. Some farmers prefer to use small nozzle sizes at the beginning of the season to generate smaller droplets through the germination stage and then change the nozzle as the season progresses to meet the crop's increasing water demands.
8. The sprinkler angle of rotation most commonly used is 330 degrees (Figure 3). However, this does not result in optimal uniformity. A 210-degree and 240-degree sprinkler rotation angle with lane spacings 80–95% of the wetted diameter is recommended instead (Solomon 1971).
9. The larger hose diameter increases the hose service life but can be more expensive—as well as heavier to pull when full of water.

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