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Effectiveness of “Butterfly” rotary sprinkler on dry land

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Abstract: Sprinkler irrigation is an irrigation application technology, which has high efficiency in the use of water; it is very appropriate to be applied in a relatively dry area. In its application, the high effectiveness of sprinkler irrigation systems can only be achieved if properly designed irrigation system and is operated properly. This research was conducted by designing irrigation networks. The irrigation application uses a butterfly sprinkler with a nozzle diameter size of 2 mm and 4 mm and pressure treatment to get the effectiveness of the irrigation system performance. Butterfly sprinkler with a nozzle diameter of 2 mm, effectively used at a pressure of 10-20 Psi, with a spray radius of 3.90 - 5.70 meters, watering discharge 6.49 - 8.10 liters/minute and water uniformity distribution 88.3 - 90.8 %. As for the 4 mm nozzle diameter, it is effective used at a pressure of 15-30 Psi, with a spray radius of 4.90 - 6.00 meters, a watering discharge of 9.98 - 14.83 liters/minute and a water uniformity distribution of 90.4 – 91.7 %.

1. Introduction

Indonesia has dry land with a dry climate covering 7.7 million ha. Climate change, due to global warming, causes the rainy and dry seasons to shift. Low annual rainfall with several dry months of more than seven months, so it often experiences water shortages which results in low soil productivity [1].

To anticipate water shortages on dry land, the application of water-saving irrigation technology will be very helpful. Estimating plant water requirements appropriate is one of the prerequisites for good and efficient irrigation system management. Adequate irrigation water greatly affects crop yields and productivity [2,3]. The use of sprinkler irrigation is an alternative to high-efficiency irrigation technology, so it is very effective used on dry land. In its application in the field, the high effectiveness of a sprinkler irrigation system can only be achieved if the irrigation network is properly designed and operated properly [4].

Sprinkler irrigation or often called Overhead Irrigation is irrigation, which is given by spraying water into the air and dropping it around plants like rain. Spraying is made by flowing pressurized water through a sprinkler or nozzle head. The pressure is usually obtained from pumping [5]. To obtain a uniform distribution of water requires the selection of the nozzle size, operational pressure, and the appropriate sprinkler sprinklers.

2. Materials and Methods

The study was conducted by designing the 'Butterfly 988' Rotary sprinkler irrigation network and its equipment, related to the distance between the nozzle and the irrigation network. Irrigation application

uses four nozzles with a diameter of 2 mm and four nozzles with a diameter of 4 mm, each with pressure treatment of 10 Psi, 15 Psi, 20 Psi, 25 Psi, and 30 Psi and two replications.

Measuring sprinkling radius and calculating sprinkling discharge, uniformity coefficient [6], irrigation water depth and water consumption rate [7], each with the equation:

Figure 1. Butterfly rotary sprinkler

$$D = AR\,xT \tag{1}$$

Note: D = average irrigation water depth (m)
AR = Water consumption rate (m/hour)
T = Watering time (hours)

$$AR = (96.3xq)x(SlxSm) \tag{2}$$

Note: AR = Water consumption rate (m/hour)
q = average sprinkling discharge (m^3/hour)
Sm = distance between lateral on the main pipe (m)
Sl = Distance between nozzles on lateral pipes (m)

Make a distribution pattern and water sprinkling propyl using a surfer program

3. Results and discussion

3.1. Sprinkling discharge

water pressure affects the sprinkling discharge so that it affects the pattern of water distribution. The greater the pressure used, the watering discharge on each nozzle will be even greater. This is in accordance with the statement of [8], which states that the discharge of water produced by a nozzle depends on the pressure applied; if the pressure is high, then the resulting water discharge is also large.

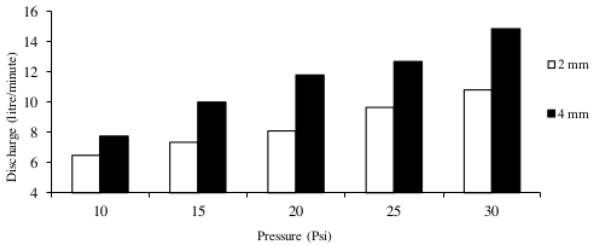

Figure 2. Sprinkling discharge at pressure variation

Testing the performance of the sprinkler system shows that the sprinkling discharge depends on the pressure and diameter of the nozzle. Discharge is directly proportional to pressure. The relationship between discharge capacity and pressure are presented in figure 3.

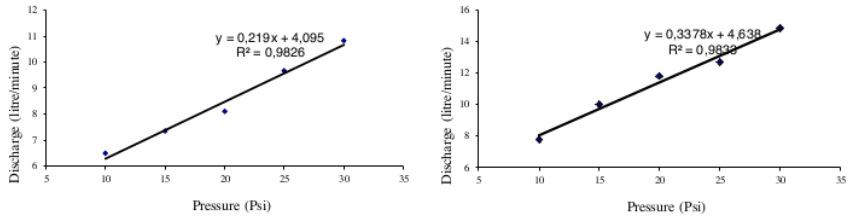

Figure 3. Relationship of sprinkling discharge and pressure for Nozzles 2 and 4 mm

3.2. Sprinkling radius

The irrigation system sprinkling radius is influenced by pressure and nozzle diameter. In [9], it is said that sprinkler irrigation operation, the pressure is divided into low pressure 5-15 Psi, middle pressure 15-30 Psi and high pressure 60-100 Psi. Nozzles with a diameter of 2 mm and 4 mm, the pressure used are 10 - 30 Psi.

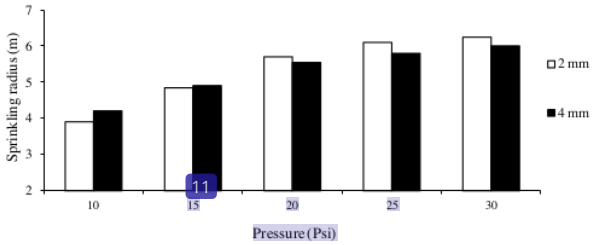

Figure 4. Sprinkling radius at pressure variation

The sprinkler of Butterfly type with 2 mm diameter nozzles, effectively used at pressures of 10-20 Psi. The higher pressures will produce smaller droplets of water. The size of the granules that are too small will easily evaporate, so that a lot of water is wasted, resulting in low irrigation efficiency. Whereas the Butterfly type Sprinkler with a diameter of 4 mm, is effectively used at a pressure of 15-30 Psi because it produces a wider sprinkling radius and better water granular. At lower pressure will produce large granular of water.

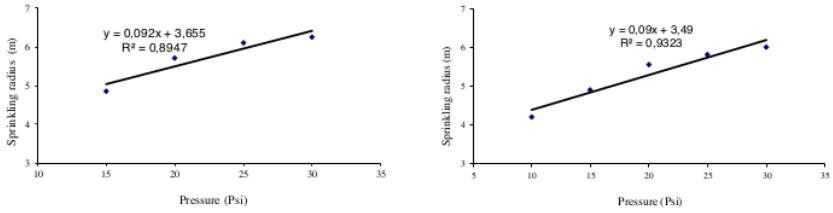

Figure 5. Relationship of sprinkling radius and pressure for Nozzles 2 and 4 mm

The size of the grains that are too large will damage plants (especially vegetables) and cause splash erosion, which results in soil compaction. Figure 4. shows that the greater the pressure the greater the sprinkling radius. This is consistent with the statement of [9], who stated that the greater the pressure acting on the same nozzle, the farther the shower.

The relationship between the sprinkling radius with pressure is presented in Figure 5. The greater the pressure, the sprinkling radius is also higher. This shows that the wetting area will be even greater with a smaller watering intensity if using high pressure.

3.3. Distribution of uniformity

Generally, the distribution of water will be a lot of it is near the sprinkler and reduced towards the tip. With the distance between the sprinkler 6 m, resulting distribution of uniformity 85.5 - 90.8%, with overlapping watering 15 - 55%, for nozzles with diameter two at the pressure of 10-30 Psi. Whereas the 4 mm diameter nozzles, resulting distribution of uniformity 88.9 - 91.7%, with overlapping watering 20 - 50%, at the same pressure.

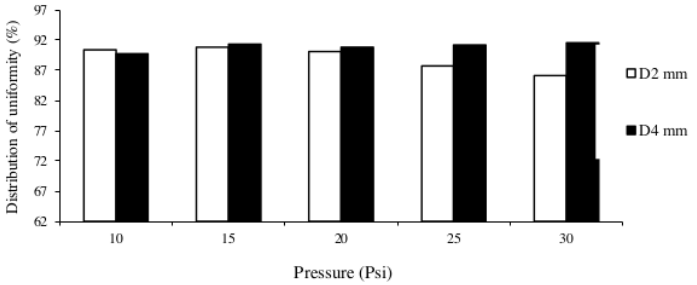

Figure 6. Distribution of uniformity at pressure variation

According to Haman et al. [10], the pattern of distribution of water uniformity is influenced by the direction and speed of the wind, because it can cause water spray particles from the nozzles to fall to the surface of the land far from the irrigated area, thus resulting in unequal distribution of water to the land. The pressure of a sprinkler system must match the size of the nozzle. The use of pressure that is not appropriate will cause damage to the nozzles and produce poor water droplets [11].

3.4. Depth of irrigation water

The depth of irrigation water is an indicator of the amount of water used during watering, in units of depth (meters). The depth of irrigation water during 1-hour operation ranged from 0.02-0.13 m for 2 mm nozzle diameter, and the 4 mm nozzle, irrigation water depth was 0.05 -0.37 m. The depth of irrigation water can be adjusted to the plant water requirement by regulating the length of operation of the irrigation system.

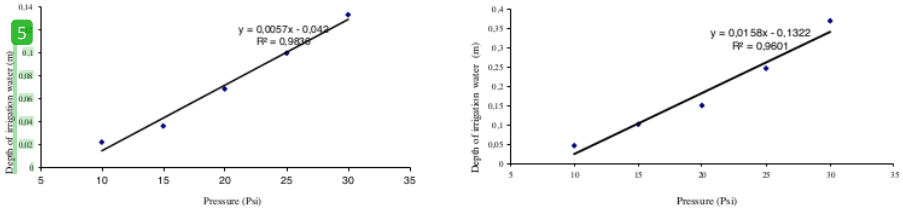

Figure 7. Relationship of water depth and pressure for 2 mm and 4 mm nozzles

Figure 7 shows that the depth of irrigation water is affected by pressure. The depth of water is directly proportional to pressure. The higher the pressure, the greater the depth of irrigating water. Likewise, with nozzle size, greater the nozzle size, higher the depth of irrigation water at the same pressure.

4. Conclusion

Butterfly sprinkler with a nozzle diameter of 2 mm, effectively used at pressures of 10-20 Psi with a spray radius of 3.90 - 5.70 meters, watering discharge 6.49 - 8.10 liters/minute, and water uniformity distribution 88.3 - 90.8 %. As for the 4 mm diameter nozzle, effectively used at a pressure of 15-30 Psi, with a spray radius of 4.90 - 6.00 meters, watering discharge 9.98 - 14.83 liters/minute, and water uniformity distribution 90.4 - 91.7 %

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