INVESTIGATION OF THE SPRINKLER IRRIGATION SYSTEM'S HYDRAULIC PERFORMANCE IN THE PRODUCTION OF SWEET POTATOES

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ABSTRACT

The irrigation system is essential in sweet potato cultivation to obtain optimal yields. The appropriate type of irrigation system is required to ensure that the water supply to the crops can be given ideally. Sweet potato farmers commonly use the sprinkler irrigation system to carry out crop irrigation operations. Therefore, the evaluation of the hydraulic performance of the irrigation system is required to ensure that the irrigation system operates in the best condition. This study aimed to assess the hydraulic performance of sprinkler irrigation for sweet potato crops. The field experiments were conducted on a sweet potato planting plot at MARDI Bachok Kelantan. The sprinklers were set up at 12m x 10m spacing and 1.7 m height. The hydraulic performance of the sprinkler irrigation system was evaluated according to ASAE standards. The hydraulic parameters involved in this study are coefficient uniformity (CU), emission uniformity (EU) and application rate (I). The results indicate that CU is in the good classification, with a CU efficiency greater than 81 per cent. The EU value was 72%, implying an average classification. Meanwhile, the application rate (I) is 8.67 mm/hr. The results of this study showed that the performance of this sprinkler irrigation system is acceptable, as the hydraulic parameters evaluated met the ASAE standard's minimum classification requirements.

Keywords: hydraulic performance, sprinkler irrigation system, coefficient uniformity, sweet potato

INTRODUCTION

The most crucial input for agricultural operations that stabilizes food production is water. The significant use of water is agriculture, which uses 90% of the water in developing countries and more than 70% of the water consumed globally (Dwivedi et al., 2015). Proper irrigation ensures that crops receive an adequate and consistent supply of water, which is crucial for their growth and development. This, in turn, leads to higher crop yields and better-quality produce. Efficient irrigation systems, such as drip or sprinkler systems, can significantly reduce water wastage compared to traditional methods like flood irrigation (Glenn & Marcel, 2012).

Sprinkler irrigation systems are commonly employed, mainly where the terrain's topography makes conventional irrigation impractical (Dwivedi et al., 2016). Applying water over the soil surface in the form of sprays or droplets, similar to what occurs naturally during rain, is known as sprinkler irrigation. Through tiny holes or nozzles, water is forced under pressure to create the spray. A sprinkler irrigation system works well for nearly every crop. Water can be sprayed on row crops and beneath tree crop canopy.

The most crucial factor in assessing an irrigation system's performance is uniformity in how water is distributed to crops. As a result, choosing an appropriate sprinkler is essential to ensure the performance of sprinkler irrigation in good condition. In this present study, the hydraulic performance of a sprinkler system is assessed by measuring the radius of throw, application rate, distribution uniformity, discharge, and Christiansen's uniformity coefficient (Christiansen, 1942). This uniformity coefficient has been employed as a validated standard to determine water distribution uniformity and is extensively used by researchers worldwide. A helpful word for quantifying the uniformity of application for irrigation systems is distribution uniformity (DU).

Sprinkler nozzle characteristics and water distribution styles determine the consistency level in water distribution. Spreading water evenly without creating surface flow or excessive root zone drainage is the fundamental purpose of sprinkler nozzles. According to Keller and Bliesner (1990) and Wilson and Zoldoske (1997), the entire system's productivity and efficiency depend on the sprinkler nozzle's performance. In an assessment of the micro jet sprinkler's performance, Singh et al. (2001) found that, at pressures between 0.5 and 1.7 bar, the emission uniformity was greater than 90%. Ahaneku (2010) used catch-can tests to assess the sprinkler system's performance. The findings showed that, when utilizing the standard protocols established by the American Society of Agricultural Engineers (ASAE), the average Christiansen's uniformity and delivery performance ratio were 86% and 87%, respectively. According to Frank's (2009) performance study of the sprinkler system, the Christiansen's uniformity

(CU) was 91% and 87%, and the application rates at 12 × 12 and 18 x 18 meters were 10.4 mm/h and 4.7 mm/h, respectively. The study's results above show that sprinkler irrigation can provide good performance if using the proper protocol and design.

Irrigation performance assessment is essential for promoting sustainable water management, improving agricultural productivity, and addressing water scarcity and climate variability challenges. The evaluation of irrigation performance directly impacts crop productivity. A well-managed irrigation system ensures crops receive suitable water at the right time, improving yields and crop quality. Many irrigation systems operate below their potential (Dwivedi et al., 2015). Water distribution might become uneven and unpredictable as a result of this circumstance. Thus, evaluating the performance of the current irrigation systems is an excellent place to start to find places where the system design is flawed and improve it. Therefore, this study was carried out to evaluate the hydraulic performance of sprinkler irrigation in sweet potato cultivation according to ASAE standards.

MATERIALS AND METHOD

The experiment was performed at the MARDI Bachok research plot in Kelantan using sprinkler 323 with a single nozzle 0.3-1.22 m3/h flow rate and 10 m radius. A set of 25 sprinklers with 12 x 10 m spacing was used in the experiment. A matrix of catch cans was installed at ground level using the spacing of a 10m x 10m grid covering the entire experimental area. In this study, the sprinkler used in the irrigation system was the 323 types (Figure 1). The layout of the irrigation system configuration is shown in Figure 2. Volumetric methods (Figure 3) were used to determine the flow rate for each dripper. Measuring cylinders, stopwatches, and trapped cans were used to measure the sprinkler flow rate.

Hydraulic Performance of sprinkler Irrigation System

In order to determine the irrigation system's actual capacity, hydraulic performance was measured. The coefficient of uniformity (CU), distribution uniformity (DU) and application rate influenced the hydraulic performance efficiency. These hydraulic parameters were then determined by following the equations 1 to 2 and indicators listed in Table 1, as described by the American Society of Agricultural Engineers (ASAE, 2003).

Coefficient of uniformity (CU)

The coefficient of uniformity was measured according to equation defined by (Christiansen, 1942) as follows:

$$Cu= 100(1- \sum \Delta q/qn) \quad (1)$$

Where:
Cu = Christiansen's uniformity coefficient in percentage
Δq = average deviation of individual emitters discharge (l/h).
q = average discharge (l/h).
n = number of observations.

Table 1. Equation and classification involved in hydraulic performance calculation. Source from American Society of Agricultural Engineering (ASAE, 2003).

Parameter	Performance indicator	
Coefficient of uniformity (CU)	≥ 90%	Excellent
	80 – 90%	Good
	70 – 80%	Fair
	60 - 70%	Poor
	> 60%	Unacceptable
Distribution uniformity (DU)	≥ 90%	Excellent
	80 – 90%	Good
	70 – 80%	Fair
	≤ 70%	Poor

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Δq = average deviation of individual emitters discharge (l/h).
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n = number of observations.

Distribution uniformity (DU)

According to (Keller and Blaisner 1990) the distribution uniformity is defined as follows:

$$DU\% = 100\ (qn/qa) \qquad (2)$$

Where:
DU = Distribution uniformity
qn = average rate of discharge of the lowest one fourth of the field data of emitter discharge readings (l/h)
qa = average discharge rate of all the emitters checked in the field (l/h).

Application rate, (I)

The depth of water sprayed on the soil surface by the sprinkler per unit of time is known as the application rate, or (I). It was estimated according to the following formula,

$$I = \Sigma X/(n \times t) \qquad (3)$$

Where, I= application rate, mm/h
ΣX = total depth of water collected in the catch cans (volume/ area of can), mm
n = number of catch cans t = time of operation, h (hour)

Figure 1. Sprinkler used in this study

Figure 2. Layout of irrigation system configuration

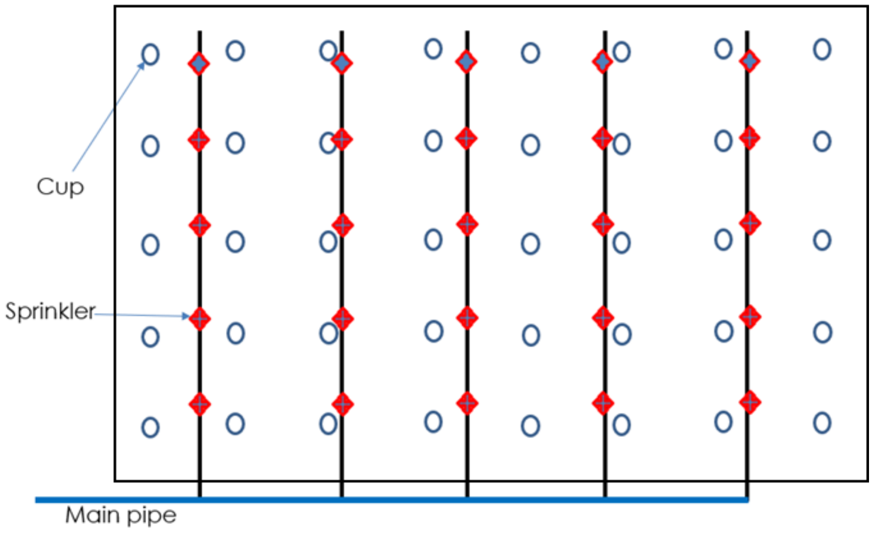


Figure 3. Volumetric method (catch can and measuring cylinder)

RESULT AND DISCUSSION

Hydraulic performance

Table 2 shows the hydraulic performance of sprinkler irrigation. The parameters of CU, DU, and I were examined. The results demonstrated that the sprinkler irrigation system worked well. The CU and DU parameters were recorded at 81.4 % and 71.9 %. This indicates that the irrigation system operates in good classification for CU and average for DU. Hydraulic performance analysis shows that the performance of this sprinkler irrigation system is acceptable because the hydraulic parameters evaluated meet the minimum classification requirements of the ASAE standard. The application rate for this study was recorded at 8.67 mm/hr. We could modify the watering schedule according to the crop's needs with this application rate. Currently, 45 minutes are required to satisfy the crop's needs for sweet potatoes.

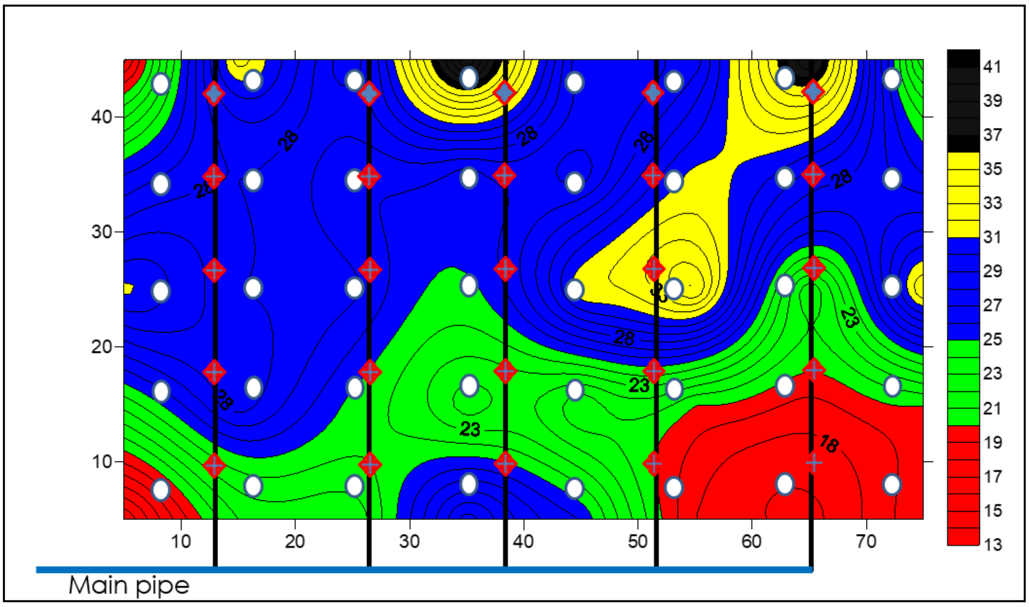
Table 2: Hydraulic parameters of sprinkler irrigation system values and classification

No	*Hydraulic parameter*	*Calculated value*	*Classification*
1	Coefficient of Uniformity, CU (%)	81.4	**Good**
2	Distribution Uniformity, DU (%)	71.9	**Average**
3	Application rate, I (mm/h)	8.67	

Water distribution map

Water distribution is essential to ensure that all crop areas are adequately irrigated. Figure 3 shows a map of water distribution in the entire study plot. The map shows the water distribution between 21-35 ml/cup with an average for the entire area of 25.6 ml/cup with a standard deviation of 6.1 ml. With this water distribution map, we can visually find out which areas need to be taken care of to ensure that the entire area is given enough water.

Figure 3. Water distribution map



CONCLUSION

This study concluded that the existing sprinkler irrigation system shows acceptable performance based on ASAE standards. The coefficient of uniformity (CU) was recorded at 81.4%, while distribution uniformity (DU) was recorded at 71.9 %. The Application rate is 8.67 mm/hr. Hydraulic performance data for this study is critical to ensure the irrigation system operates appropriately. Further studies need to be conducted to measure hydraulic performance based on different operating pressures and sprinkler spacing to ensure that the irrigation system works at the best level according to specific operating pressures and sprinkler spacing.

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