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Original Research Article

Preliminary Evaluation of Drip Irrigation System Performance in Watermelon Cultivation

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Abstract: In watermelon production, irrigation is the most significant factor in achieving good yields. Properly selecting an irrigation system may provide successful irrigation for excellent crop quality and productivity. Drip irrigation is a popular approach for this purpose. Drip irrigation can successfully deliver water to plants based on the amount required by the crop. However, this irrigation system's performance should be investigated to guarantee that it can run in the best possible conditions. This study aimed to assess the preliminary version of drip irrigation for watermelon crops. The field experiments were conducted on a watermelon planting plot at MARDI Kundang Selangor. The drip irrigation system performance was evaluated based on hydraulic parameters such as coefficient uniformity (CU), emission uniformity (EU), coefficient of variation (CV), and emitter flow variation (EFV) according to ASAE standards. The results indicate that CU is in excellent classification, with a CU efficiency greater than 91 per cent. The EU value was 86%, showing a reasonable variety. However, the CV value was 0.1, indicating a marginal classification. Meanwhile, the emitter flow variation (EFV) is 19% which is considered acceptable. The results of this preliminary study showed that the performance of this drip irrigation system is satisfactory, as the hydraulic parameters evaluated met the ASAE standard's minimum classification requirements. The distribution of discharge data was similarly shown to have no significant difference using a one-sample t-test, with a p-value of 0.096.

Keywords: Drip irrigation, coefficient uniformity (CU), emission uniformity (EU), coefficient of variation (CV), and emitter flow variation (EFV

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1. Introduction

Global irrigated land for agriculture has grown steadily during the past century, with a 13.6% rise in irrigation water consumption predicted by 2025 (Rosegrant & Cai 2002). The rising water demand increases the global freshwater shortage (Martinez *et al.,* 2022). Irrigation is a critical component in achieving optimal yields in watermelon production. To achieve this purpose, a suitable irrigation system must be used. Sprinkler and drip irrigation are two prominent types of irrigation in Malaysia. Most farms use drip irrigation for watermelon irrigation. Drip irrigation is more convenient and makes monitoring the water applied to the plants more accessible. Drip irrigation systems use 30 to 50% less water than conventional ones since they only provide water directly to the plants as required (Almajeed & Alabas, 2013). Furthermore, drip irrigation might help to avoid water waste throughout the irrigation process. With a drip irrigation system, farmers can minimize water use and produce more crops (Gireesh *et al*., 2018).

Drip irrigation systems could boost crop production by up to 50% (Sivanappan, 1994). Although the initial cost of installing this sort of irrigation is significantly high, especially when considering the cost of pipes and drip tape, it is considered more cost-effective in the long run (Dhawan, 2000). The cost of the pump can also be reduced by using a pump with less power and less flow rate than other irrigation methods (Robert, 2005).

However, the irrigation system's performance should be evaluated to ensure it can operate in the best possible conditions. Testing in the field is essential to verify that drip irrigation can achieve the desired level of irrigation efficiency. This is to guarantee that the irrigation system is performing at its best. The success of a drip irrigation system is determined by the operating pressure used to carry out irrigation (Tyson & Curtis, 2009). Using suitable operating pressure may guarantee that the dripper's flow rate follows the dripper's specifications (Sharu & Ab Razak, 2020). Farmers typically utilize pressure-compensated drippers to achieve this purpose, ensuring that each dripper's flow rate is uniform. This dripper, on the other hand, is pricier. Employing an uncompensated dripper, such as drip tape, is less expensive than using a pressure-compensated dripper. Moreover, using the correct operating pressure may maintain a consistent flow rate.

Uniformity is one of the most critical factors in determining the irrigation system's performance. Uniformity ensures that each plant receives the same quantity of water, providing more even plant growth and improving productivity. The coefficient of uniformity (CU), emission uniformity (EU), coefficient of variation of emitter flow (CV), and emitter flow variation (EFV) are commonly used in drip irrigation system performance assessments (ASAE, 1999). According to studies by Sharu & Ab Razak (2020), a compensated pressure dripper functioning at the proper operating pressure can give an outstanding hydraulic performance in greenhouses. This means using the correct operating pressure is critical for ensuring effective irrigation performance. This study evaluated the hydraulic performance of a drip irrigation system using uncompensated pressure drip tape for watermelon crops in plantations.

2. Materials and Methods

The study was conducted on a watermelon planting plot at MARDI Kundang, Selangor (3.27206648482933, 101.5143848133917). MARDI Kundang is a MARDI station undertaking research on vegetables, fruits, etc. The soil conditions in the MARDI Kundang are sandy. This drip irrigation system (Figure 1) comprises eight rows, each 50 metres long. It has a drip tape spacing of 10 centimetres between each emitter. The drip tape's maximum flow rate per emitter is 1 l/hr. 1 bar is the recommended minimum operating pressure. During this study, the working pressure was 2 bar.

Data collection for measuring the drip irrigation system performance includes the dimensions of the drip irrigation system layout at the field and the hydraulic parameters, including drip tape flow discharges at the designated dripper. The dripper discharge (Figure 2) was measured with a graduated measuring cylinder, beaker, and stopwatch at eight rows with four points per row. The discharge measurement lasted for two min at each point location. Each emitter's collected water in the beaker was measured using a measuring cylinder (Figure 3). Next, the volume of water was divided by time to obtain the discharge (q) in litres per second (L/s)

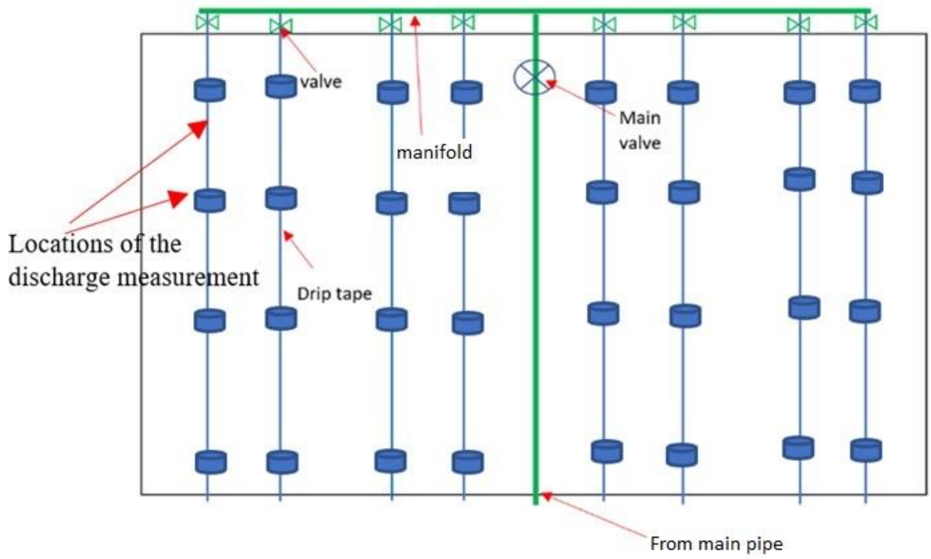

Figure 1. Drip Irrigation system layout at MARDI Kundang, Selangor.

Figure 2. Discharge data collection.

Hydraulic performance is calculated to obtain the actual performance of the irrigation system. The components involved in the calculation of hydraulic performance include the coefficient of uniformity (CU), emission of uniformity (EU), coefficient of variation (CV) and emitter flow variation (EFV). The classifications of hydraulic parameters are presented in Table 1.

Figure 3. Measuring discharge using a measuring cylinder.

Table 1 Equation and classification involved in hydraulic performance calculation Source from American Society of Agricultural Engineering (ASAE, 1999)

	Emission of Uniformity (EU)		**Coefficient of Variation (CV)**		**Emitter flow Variation (EFV)**		**Coefficient of Uniformity (CU)**	
Performance Indicator	**≥ 90%**	**Excellent**	**< 0.05**	Excellent	≤ 10%	Desirable	≥ 90%	Excellent
	80 – 90%	Good	0.05 – 0.07	Average	10 – 20%	Acceptable	80 – 90%	Good
	70 – 80%	Fair	0.07 – 0.11	Marginal	> 25%	Unacceptable	70 – 80%	Fair
	≤ 70%	Poor	0.11 – 0.15	Poor			60 - 70%	Poor
			> 0.15	Unacceptable			> 60%	Unacceptable
Equation	$\mathrm{EU} = 100(\frac{\mathrm{qn}}{\mathrm{qa}})$		$\mathrm{CV} = 100\frac{\mathrm{SD}}{\mathrm{qavg}}$		EFV = 100 [1- $\frac{Qmin}{Qmax}$]		$\mathrm{CU} = 100(1 - \sum\frac{\Delta \mathrm{q}}{\mathrm{qn}})$	
Definition	EU = Emission 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).		CV= the coefficient of variation of emitter discharge. SD = standard deviation of emitter discharge. qavg = average discharge in the same lateral lines (l/h)		EFV = emitter flow variation (%) Qmin = minimum emitter discharge rate in the system (l/h) Qmax = average or design emitter discharge rate (l/h)		Cu = Christiansen's uniformity coefficient in percentage Δq = average deviation of individual emitters discharge (l/hr). q = average discharge (l/h). n = number of observations	

3. Result

3.1. Hydraulic Performance Analysis

The discharge data was recorded and analyzed before being utilized to determine the drip irrigation system's hydraulic performance. Average discharge, coefficient of variation (CV), uniformity coefficient (CU), emission uniformity (EU), and emitter flow variation (EFV) were all measured and analyzed as part of the drip irrigation hydraulic performance study. Table 2 displays hydraulic performance data.

The data in Table 2 shows that this drip tape's irrigation system performs relatively well. The CU reading is at excellent classification, while for CV, it is at marginal category. For the EU, it is in the excellent classification, and for the EFV, it is in the acceptable classification. This indicates that the irrigation system's performance may be used to verify that the distribution and amount of water the crop receives are uniform.

Table 2. Calculated value and classification of hydraulic parameters of drip irrigation system.

	Hydraulic Parameter	Calculated value	Classification
1	Coefficient of Uniformity (%)	91.3	Excellent
2	Coefficient of Variation (%)	10.0	Marginal
3	Emission or distribution Uniformity (%)	86.4	Good
4	Emitter flow variation (%)	19.0	Acceptable

3.2. Discharge of Dripper

Table 3 shows the dripper flow rate data. The average flow rate reported is 0.968 l/hr, lower than the dripper manufacturer's standard of 1 l/hr when applying 1 bar of operating pressure. By using one sample t-test, the value of p is 0.096. So, the result is not significant at $p < 0.05$. The discharge data shows that the dripper's flow rate variation is insignificant. Therefore, it can be said that the flow rate of the dripper is uniform.

We utilize the mean absolute percentage error (MAPE) to assess the precision of prediction in statistics. Using 1 l/h as the predicted discharge from each emitter compared to the actual discharge, the Mean absolute percentage error (MAPE) recorded was 9.4%. This shows that the discharge from the emitter is good, which is less than 10% (Montano *et al.*, 2013).

Table 3 Average Discharge of Dripper

No	Parameter	Calculated value
1	Average Flow	0.968 l/hr
2	Deviation	0.084
3	Std deviation	0.10
4	variance	0.01

4. Discussion

Regarding hydraulic performance, the coefficient of uniformity (CU) data showed that the drip irrigation system performed well and met ASAE standards. However, the emission uniformity (EU) result was recorded at 86.4%, which is considered a reasonable classification. Meanwhile, the coefficient of variation (CV) is at the marginal classification at the rate of 10%. In comparison, emitter flow variation (EFV) is recorded at 19%, at the acceptable classification. This indicates that the irrigation system's performance may be classed as good since it met ASAE standards.

A study of the hydraulic performance of a drip irrigation system can help in determining the efficiency of an irrigation system. Knowing the uniformity of an irrigation system can ensure that the irrigated plants get a sufficient and uniform amount of water for all crops. This will provide more consistent plant growth. Furthermore, the irrigation time may be estimated more precisely with the availability of observed flow rate data. The findings of this study also suggest that implementing the planned pressure operation is critical to ensuring that the irrigation system performs as intended.

5. Conclusion

The findings of this preliminary study revealed that the performance of this drip irrigation system is good, as the hydraulic parameters tested met the minimal categorization requirements of the ASAE standard. The distribution of discharge data was similarly shown to have no significant difference using a one-sample t-test, with a p-value of 0.096. Drip irrigation system hydraulic performance studies will aid in identifying the proper operating pressure range and the irrigation time depending on the crop's demands.

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References

Almajeed, A., Alabas, M. (2013). Evaluation of the hydraulic performance of drip irrigation system with multi cases. *Global Journals of Research in Engineering*, *13*, 2249–4596

ASAE. (1999). Field evaluation of micro-irrigation systems. *American Society of Agricultural Engineers*. 792–797.

Dhawan, B. (2000). Drip irrigation: Evaluating returns. *Economic and Political Weekly, 35*, 3775–3780.

Gireesh, N., Agrwal, S., Tamrakar, M., *et al*. (2018). Design and hydraulic performance of drip irrigation system on vegetable crops. *The Andhra Agric. J, 65*(spl), 226–234.

Martinez, C. G., Wu, C. L. R., Farrdo, A.L., *et al*. (2022). Hydraulic performance evaluation of low-cost gravity-fed drip irrigation systems under constant head conditions. *IOP Conference Series: Earth and Environmental Science*, *1038*(2022), 012005.

Montano, J., Palmer, A., Sesé, A., *et al*. (2013). Using the R-MAPE index as a resistant measure of forecast accuracy. *Psicothema*, 25(4), 500–506. https://doi.org/10.7334/psicothema2013.23.

Robert, A. (2005). Irrigation of vegetable and small fruit crops. In *Natural Resource Engineering Specialist*. University of Missouri Extension: Columbia, MO, USA.

Rosegrant, M. W., Cai, X. (2002). Global water demand and supply projections. *Water International*, *27*(2). 170–82 https://doi.org/10.1080/02508060208686990.

Sharu, E. H., Ab Razak, M. S. (2020). Hydraulic performance and modelling of pressurized drip irrigation system. *Water*, *12*(8), 2295. https://doi.org/10.3390/w12082295

Sivanappan, R. K. (1994). Prospects of micro-irrigation in India. *Irrigation and Drainage System*, *8*, 49–58.

Tyson, T. W., Curtis, L. M. (2009). *Evaluating water distribution uniformity in micro-irrigation systems*. Retrieved from: https://studylib.net/doc/18713005/evaluation-water-distribution-uniformity#google_vignette