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Optimization of Drip Irrigation System to Improve Water Use Efficiency and Tomato Crop Productivity

Pratiwi Mulianda[1], Annisa Purnamasari Damanik[2], Satria Adi Surya[3]
[1,2,3]*Politeknik Pertanian Negeri Payakumbuh, Indonesia*

Email: Pratiwimulianda3@gmail.com

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Abstract
This literature review explores the optimization of drip irrigation systems to improve water use efficiency (WUE) and tomato crop productivity, particularly under dryland conditions. Four key studies were analyzed, focusing on hydraulic performance, integrated technologies, and agronomic outcomes. Sharu and Razak (2020) demonstrated that hydraulic modeling using EPANET achieved excellent water emission uniformity (CU and EU > 95%) with potential for energy savings through optimized pump power. Nurazila and Anggraini (2022) reported that drip irrigation significantly enhanced vegetative growth and WUE compared to manual irrigation. Suvitha et al. (2021) highlighted that drip fertigation with medium frequency and high NPK dosage maximized yield and WUE in sandy soils. Ramakrishna et al. (2024) found that combining drip irrigation with black plastic mulch resulted in the highest plant growth, fruit yield, and WUE by reducing evaporation. Collectively, the findings confirm that integrating supporting technologies—such as hydraulic modeling, fertigation, and mulching—can significantly enhance drip irrigation efficiency, conserve water, and improve tomato productivity, offering strong potential for adoption in water-limited agricultural regions.

Keywords: Dryland Agriculture; Drip Irrigation; Fertigation; Hydraulic Modeling: Mulch; Tomato; Water Use Efficiency

Introduction

Water is a crucial factor in the success of agricultural cultivation, especially in areas with low rainfall and limited water resources. As the demand for food increases and water availability decreases, the use of efficient irrigation technology becomes increasingly important. One system proven to be efficient in water use is drip irrigation, which delivers water directly to the plant root zone in controlled amounts. Research has found that drip irrigation is the best method compared to other irrigation methods due to its high uniformity. Drip irrigation systems typically use 30 to 50% less water than other irrigation systems because they only supply the water that the plants need (Almajeed et al., 2013). Drip irrigation is a water-saving irrigation method that is important worldwide and offers outstanding benefits, including water conservation, reduced labor, and increased crop yields (Hamani et al., 2023). It is considered the most effective method in terms of water and labor use; however, due to its complexity, drip irrigation systems must be properly designed, installed, and maintained (Ahmad et al., 2015).

In modern agricultural systems, efficient water use is a major challenge, especially in arid and semi-arid regions. Drip irrigation is known as one of the most efficient methods for delivering

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water directly to the plant root zone, reducing water loss due to evaporation and percolation. This article integrates research findings from four studies that discuss aspects of hydraulic performance, supporting technologies, and their effects on tomato growth and yield.

Sharu and Razak (2020) demonstrated that a pressurized drip irrigation system modeled using EPANET achieved high water emission uniformity, with CU and EU values above 95% and a CV below 0.03, which is categorized as excellent. The modeling further revealed that the system was over-powered and capable of irrigating four times the area with the same power consumption, indicating substantial potential for energy efficiency.

Nurazila and Anggraini (2022) emphasized that drip irrigation significantly impacts tomato plant growth, including greater plant height and a higher number of leaves compared to manual methods. Moreover, this system has been proven to improve water use efficiency, making it a more water-saving alternative for dryland areas.

According to Suvitha et al. (2021), the use of drip fertigation with moderate frequency and a high dose of NPK (D3F2) resulted in the highest tomato yield, with optimal water and nutrient use efficiency. These findings highlight the importance of integrating irrigation and fertilization into a single efficient system.

Ramakrishna et al. (2024) found that combining drip irrigation with black plastic mulch produced the highest plant growth, fruit number, and water use efficiency. This demonstrates that the synergy between soil moisture conservation and controlled water delivery strongly supports optimal tomato growth.

Literature Review

Drip irrigation is a micro-irrigation technique that delivers water slowly and continuously directly to the plant root zone through emitters. The advantages of this method include reducing water losses due to evaporation and percolation, improving water use efficiency (WUE), and maintaining stable soil moisture (Sharu & Razak, 2020). Technically, system performance is measured using hydraulic parameters such as the Coefficient of Uniformity (CU), Emission Uniformity (EU), Coefficient of Variation (CV), and Emitter Flow Variation (EFV).

Study by Sharu and Razak (2020) utilized EPANET software to model pressure and discharge distribution in a pressurized drip irrigation system at MAEPS, Malaysia. The modeling results showed prediction errors of less than 3% and CU/EU values above 95%, classified as “excellent.” This study emphasized that hydraulic modeling can assist in designing efficient systems and reducing energy consumption, especially by adjusting pump power according to field requirements.

According to Nurazila and Anggraini (2022), applying drip irrigation in tomato cultivation under dryland conditions improved vegetative growth (plant height, leaf number) and accelerated harvesting compared to manual irrigation. Water use efficiency increased significantly, making this technology recommended for areas with limited water resources.

Fertigation, the simultaneous application of fertilizers with irrigation water, has been proven to enhance water and nutrient use efficiency. Suvitha et al. (2021) reported that in sandy soils, a combination of medium fertigation frequency and high NPK dosage resulted in the highest tomato yield and a WUE of 12.2 kg/m³. This demonstrates that drip fertigation is not only efficient in resource use but can also maximize crop yield.

Ramakrishna et al. (2024) evaluated the effect of combining drip irrigation with various types of mulch. Results indicated that black plastic mulch combined with drip irrigation produced the

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highest fruit number, yield weight, and WUE compared to other treatments. Mulching reduces evaporation and maintains soil moisture, thus optimizing irrigation system performance.

Based on the review of the four journals, it can be concluded that drip irrigation is highly effective in improving yield and water use efficiency in tomato cultivation. The adoption of supporting technologies such as hydraulic modeling, fertigation, and mulching has a synergistic effect that strengthens system performance. This technology has high potential for application in dryland areas or regions with limited water availability, both for smallholder farmers and commercial agriculture.

Research Method

This research is a literature review study aimed at discussing the application of drip irrigation systems in tomato cultivation. Each journal was analyzed based on its methodology, results, and scientific contributions to improving water use efficiency and crop yield.

Information was gathered by reviewing national and international journals published between 2015 and 2025. The literature sources were obtained from reputable databases such as ScienceDirect, ResearchGate, Google Scholar, Springer, PubMed, and various other credible scientific journal websites.

The selected literature consisted of publications relevant to the research focus, originating from indexed journals, and written in either Indonesian or English. The analysis process involved several stages: literature selection, quality assessment, data compilation, and information processing for the purpose of the literature review.

Results and Discussion

Based on the review findings, it can be concluded that drip irrigation systems make a significant contribution to water use efficiency and tomato crop yields. The study by Sharu & Razak (2020) showed that hydraulic modeling using EPANET is highly effective in designing efficient irrigation systems with high flow uniformity. The study by Nurazila & Anggraini (2022) demonstrated that the use of drip irrigation enhances tomato plant growth compared to manual methods. Meanwhile, Suvitha et al. (2021) emphasized the importance of fertigation integration in improving crop yield and water efficiency, and Ramakrishna et al. (2024) showed that the use of plastic mulch along with drip irrigation increases productivity and water use efficiency.

The four studies offer different approaches to optimizing drip irrigation systems. Hydraulic modeling assists in planning energy-saving and well-distributed water systems. Fertigation and the use of mulch have been proven to enhance efficiency and increase tomato yields. From an agronomic perspective, water efficiency greatly influences both vegetative and generative growth of tomato plants. In addition, all the studies demonstrate the high potential of implementing this technology in drylands or areas with limited water availability.

Sharu and Razak (2020) reported that the coefficient of uniformity (CU) and emission uniformity (EU) of the tested drip irrigation system were above 95%, categorized as excellent. Hydraulic modeling using EPANET produced pressure prediction errors of less than 3% and revealed that the system was operating in an over-powered condition, indicating potential for optimization to reduce energy consumption. Meanwhile, **Nurazila and Anggraini (2022)** found that drip irrigation in tomato cultivation on dryland significantly increased plant height and leaf number compared to manual irrigation. Moreover, water use efficiency (WUE) improved, with water savings of approximately 30–40%.

Similarly, **Suvitha et al. (2021)** showed that a combination of medium fertigation frequency with

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a high NPK dosage achieved the highest productivity and a WUE of 12.2 kg/m³, particularly effective in sandy soils that are generally low in nutrients. Comparable results on productivity improvement were also demonstrated by **Ramakrishna et al. (2024)**, who reported that black plastic mulch combined with drip irrigation produced the highest fruit weight and number of fruits, as well as increased WUE through reduced surface evaporation.

Overall, the results of the four studies confirm that drip irrigation can improve water use efficiency by reducing losses due to evaporation and percolation, enhance both vegetative and generative plant growth—particularly under water-limited conditions—and reduce operational costs when the system is designed according to field hydraulic requirements. From a technical perspective, **Sharu and Razak (2020)** demonstrated the importance of hydraulic modeling to ensure uniform water distribution and optimize pump energy use. From an agronomic perspective, **Nurazila and Anggraini (2022)** emphasized the benefits of drip irrigation in improving growth and yield in dryland cultivation. **Suvitha et al. (2021)** showed that fertigation can maximize nutrient and water utilization, while **Ramakrishna et al. (2024)** proved that the use of mulch as a complementary practice can further enhance the performance of drip irrigation systems.

Conclusion

Based on the review results, it can be concluded that drip irrigation is a highly effective and efficient method for tomato cultivation, especially under dry land conditions. The integration of technologies such as fertigation, EPANET modeling, and the use of mulch further enhances water use efficiency and crop yield. Uniform water distribution, fertilizer efficiency, and reduced evaporation are the main advantages of this system.

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References

Ahmad, M.A.G.; Mangrio, G.A.;Wahab, A. 2015. Design Evaluation and Irrigation Scheduling of Drip Irrigation System on Citrus Orchard. Pak. *J. Meteorol*., 12, 37–48.

Almajeed, A.; Alabas, M. 2013. Evaluation the Hydraulic Performance of Drip Irrigation System with Multi Cases. Glob. J. Res. Eng, 13, 2249–4596.

Hamani, A.K.M., Abubakar, S.A., Si, Z., Kama, R., Gao, Y., Duan, A., 2023. Responses of grain yield and water-nitrogen dynamic of drip-irrigated winter wheat (Triticum aestivum L.) to different nitrogen fertigation and water regimes in the North China Plain. *Agric. Water Manag* 288. https://doi.org/10.1016/j.agwat.2023.108494.

Nurazila, N., & Anggraini, A. (2022). *Efektivitas pertumbuhan tanaman tomat dengan teknik irigasi tetes pada lahan kering*. Agrotek UMMAT, 7(1), 50–56.

Ramakrishna, H., et al. (2024). *Drip irrigation and mulching effects on tomato growth, yield, and water use efficiency under dryland conditions*. Agricultural Water Management, 290, 108671. https://doi.org/10.1016/j.agwat.2024.108671

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

Suvitha, S., et al. (2021). *Effect of automated drip fertigation system on tomato yield and water use efficiency in sandy soil*. International Journal of Plant & Soil Science, 33(24), 69–75. https://doi.org/10.9734/ijpss/2021/v33i2430735