Journal of Agrometeorology

ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 27 (1) : 114-116 (March - 2025)
https://doi.org/10.54386/jam.v27i1.2798
https://journal.agrimetassociation.org/index.php/jam

Short communication

Optimizing water usage for chilli (Capsicum frutescens L.) through drip irrigation using CROPWAT in Malang Regency Indonesia

ANGELINE OKTAVIA[1], WIDOWATI[1*], AGNES QUARTINA PUDJIASTUTI[2], LINDA PRASEYORINI[3], I MADE INDRA AGASTYA[1], UTIK TRI WULAN CAHYA[1] and RETNO WILUJENG[1]

[1]*Agrotechnology Study Program, Agricultural Faculty, Tribhuwana Tunggadewi University, Jl. Telaga Warna, Tlogomas, Lowokwaru District, Malang City, East Java, Indonesia*
[2]*Agribusiness Study Program, Agricultural Faculty, Tribhuwana Tunggadewi University, Jl. Telaga Warna, Tlogomas, Lowokwaru District, Malang City, East Java, Indonesia*
[3]*Department of Water Resources Engineering, Faculty of Engineering, Brawijaya University, Jl Veteran, Malang City, East Java, Indonesia*
**Corresponding Author: widwidowati@gmail.com*

Chilli (*Capsicum frutescens* L.) is one of Indonesia's most popular horticultural crop having high economic value. This is an essential kitchen spice and its need continues to increase but its productivity is not increasing. The reason may be various factors, including suboptimal cultivation, pest attacks, and unfavourable soil and climate conditions (Sudarma *et al.,* 2024). On the other hand, East Java Province has the highest chilli production in Indonesia. According to the Central Statistics Agency (2019), East Java Province contributed 42% of domestic chilli production. It shows that East Java has great potential to develop chilli plants. The underlying reason for this consideration is due to favorable climatic conditions and extensive agricultural land. Some studies have shown that chilli plants need a lot of water at the beginning of growth to support the vegetative growth process (Nurwanto *et al.,* 2017). In addition, proper water application is a concern in the growth phase, as it has been shown to increase chilli productivity (Lictawa and Malamug, 2023). According to Wini *et al.,* (2022), irrigation according to the growth phase in chilli plants is known not to interfere with plant growth. The potential for developing chilli production by paying attention to the water needs of each growth phase will be the right solution for increasing national chilli productivity.

Implementing the drip irrigation technique is essential for optimizing water resource utilization during each stage of plant development. This irrigation system facilitates accurate and effective water distribution, minimizing water waste, enhancing plant water availability, and influencing production. (Asmuti and Awalina, 2021; Sharma *et al.,* 2024). Drip irrigation is one of the modern irrigation methods designed to maintain root zone moisture (Jusoh *et al.,* 2020; Nazir *et al.,* 2024), which can increase water use efficiency through direct water delivery to the root area of plants (Gui *et al.,* 2022) then supports optimal plant growth. Proper application of drip irrigation systems can increase the productivity of chilli and reduce excessive water use (Cartika *et al.,* 2023).

Data was collected in Bocek Village, Karangploso District, Malang Regency, East Java Province. Bocek Village is situated in the Karangploso District of Malang Regency, East Java, encompassing an area of 14.787 km². Geographically, it is located at an elevation of approximately 715 m above sea level. Bocek Village experiences relatively significant precipitation, with approximately 2400 mm yearly rainfall. This climate undoubtedly fosters a variety of horticultural crops, including chilli. Chilli is predominantly cultivated during the rainy season, specifically in the second week of October or November. Farmers rely solely on rainwater as the water source for the crops. The harvest period occurs approximately 120-150 days after planting. Daily climatological data from 2013–2022 were obtained from the Indonesian Meteorological, Climatological, and Geophysical Agency (IMCGA/BMKG) Karangploso station (coordinates: 7.90°S, 112.60°E; elevation: 590 m above sea level). Parameters include monthly average data of average temperature, air humidity, wind speed, length of irradiation, and rainfall. Crop data was taken from the research reference source of Doorenbos and Kassam (1979), the value of the crop coefficient (Kc) of chilli peppers was 0.4, 0.75, 1.1, and 1 in four growth phases- initial stage, crop development stage, middle season, and late season respectively. The stages of analysis using CROPWAT Version 8.0 software according to Prastowo *et al.,* (2016). Plant water requirements can

Article info - DOI: *https://doi.org/10.54386/jam.v27i1.2798*
Received: 5 November 2024; Accepted: 14 January 2025; Published online : 1 March 2025

Table 1: Potential evapotranspiration (ETo) and effective rainfall (Re)

Month	ET_o (mm)	Rain (mm)	Re (mm)
January	110.9	295.5	154.6
February	99.4	356.5	160.7
March	115.0	246.7	149.3
April	113.7	161.3	119.7
May	116.2	110.7	91.1
June	105.9	66.3	59.3
July	110.6	45.8	42.4
August	123.9	40.3	37.7
September	147.5	36.5	34.4
October	146.4	127.5	101.5
November	128.9	222.2	143.2
December	105.0	334.0	158.4
Total	1423.7	2043.3	1252.2

Table 2: Irrigation water requirement of chilli

Variable	Fase Growth				Total
	Initial stage	Crop dev. stage	Middle season	Late season	
Age Plant	0-30	31-70	71-120	121-150	150
ETc (mm day^{-1})	1.9	2.27	3.3	3.1	408.3
P (mm)	135.0	180.0	225.0	135.0	675.0
Eff Rain (mm)	111.3	194.7	261.1	155.1	722.2
IWR (mm)	80.8	76.2	129.5	74.5	361.0
Drip irrigation (mm.$plant^{-1}$)	40.5	38.1	64.7	37.2	180.5

be calculated by the formula (Arif *et al.,* 2012)

$$IWR=ETc+P-Re \quad (1)$$

where IWR – irrigation water requirement (mm), ET_c – actual evapotranspiration (mm), P – percolation (mm), and Re – effective rainfall (mm). Drip irrigation can be calculated by dividing it with the provision that every square meter of land contains 2 plants.

Potential evapotranspiration (ETo) and effective rainfall (Re)

Potential evapotranspiration denotes the maximum rate of water loss that can occur from a surface through evaporation and plant transpiration. The Penman-Monteith method was used to calculate the ETo. The potential evapotranspiration value varies every month (Table 1). The maximum value of potential evapotranspiration occurred in September with 147.5 mm, while the minimum value occurred in February with 99.4 mm.

Effective rainfall constitutes the portion of total precipitation accessible for plant absorption, as not all rainwater that reaches the earth's surface is directly assimilable by vegetation. Typically, a portion of water is lost due to evaporation and interception. The USDA Soil Conservation Service approach is widely utilized for determining effective rainfall. The peak monthly rainfall is recorded in February at 356.5 mm, accompanied by an effective rainfall of 160.7 mm. The lowest monthly rainfall is observed in September at 36.5 mm, with an effective rainfall of 34.4 mm. The effective rainfall value is generally lower than the total rainfall value, as not all precipitation is accessible to plants; some water infiltrates the soil, some is held in the root zone, and the remainder contributes to groundwater replenishment.

Irrigation water requirement (IWR)

Irrigation water requirement refers to the volume required to provide evaporation, water loss, and crop needs by considering the amount of water obtained from rainfall and groundwater contribution. Irrigation water requirement (IWR) and drip irrigation for chilli is shown in Table 2.

The highest ETc value occurs in the middle season phase, 3.3 mm day^{-1}. The highest IWR occurs in the middle season and the lowest occurs in the late season. Table 2 supports the findings in the plant growth water balance, namely the existence of water deficits in all phases of growth, which can be used as a reference basis for determining the schedule and the right amount of irrigation for chilli, for the Karangploso area. During the planting of chilli in October, additional irrigation is needed to provide plant water needs and increase productivity. By knowing the water needs of plants, the results of drip irrigation water needs are also obtained, which includes the need for drip irrigation water in land units of mm.$plant^{-1}$. The highest total need for drip irrigation water occurs in the middle season of 64.7 mm. $plant^{-1}$ and the lowest in the late season of 37.2 mm. $plant^{-1}$. The need for drip irrigation water certainly varies at each growth phase, where the initial phase requires the most water on daily because the initial growth process is intensive compared to the vegetative phase.

This study concludes that chilli crop require varying irrigation water during its growth phase, with total drip irrigation needs at the initial stage of 40.4 mm each plant, crop development stage of 38.1 mm each plant, the middle season of 64.7 mm each plant and late season of 37.2 mm each plant. CROPWAT Version 8.0 allows accurate calculation of water requirements, and proper irrigation scheduling is essential to increase productivity and water use efficiency. This research contributes to sustainable agricultural practices in Indonesia.

ACKNOWLEDGEMENT

Thanks to the Ministry of Education, Culture, Research, and Technology of Higher Education in Indonesia for providing research funding through the Fundamental-Regular Grant for the year 2024.

Funding: Funding is associated with DIPA Number 023.17.1.690523/2024, revision 1, dated February 4, 2024.

Data availability: Data can be provided by the authors on request.

Conflict of interest:. The authors declare that there are no conflicts of interest associated with this study.

Authors' contribution**:** A. Oktavia: Gathering field data and analysis; Widowati: Supervision, designs the methodology; A. Q. Pudjiastuti: Ensures that all research procedures comply with ethical standards; L. Praseyorini: Supervises, planning and organizing; I M. I. Agastya: Editing and revising the manuscript; U. T. W.Cahya: Writing, literature reviewing and discussion; R. Wilujeng: Analysis and interpretation.

Disclaimer: The contents, opinions, and views expressed in the research article published in the Journal of Agrometeorology are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

Publisher's Note**:** The periodical remains neutral about jurisdictional claims in published maps and institutional affiliations.

REFERENCES

Arif, C., Setiawan, B. I, Sofiyuddin, H. A., Martief, L. M., Mizoguchi, M., and Doi, R. (2012). Estimating Crop Coefficient in Intermittent Irrigation Paddy Fields Using Excel Solver. *Rice Sci.,* 19(2):143-152. https://doi.org/10.1016/S1672-6308(12)60033-X

Asmuti, A., and Awalina, R. (2021). Design of Drip Irrigation for Chilli Plants*. IOP Conf. Series: Earth Environ. Sci.,* 757(1):012039. https://doi.org/10.1088/1755-1315/757/1/012039

Cartika, I., Murtiningsih, R., Sembiring, A., Sulastiningsih, N, W, H., Moekasan, T, K., Prabaningrum, L., Setiawati, W., and Hasyim, A. (2023). Drip Irrigation System: Useful Technique to Improve Chilli Production. *IOP Conf. Series: Earth Environ. Sci.,* 1183(1):012010. https://doi.org/10.1088/1755-1315/1183/1/012010

Central Statistics Agency and Directorate General of Horticulture. (2019). Production and productivity of red chilli, 2015-2019. Ministry of Agriculture, Republic of Indonesia. Retrieved from https://www.pertanian.go.id/home/?show=page&act=view&id=61

Doorenbos, J., A.H. Kassam. (1979). Yield response to water irrigation, FAO irrigation and drainage Paper 33. Rome (IT): Food and Agriculture Organization of the United Nations.

Gui, Y., Wang, Q., and Zhao, Y. (2022). On the Increased Precipitation Recycling by Large-Scale Irrigation over the Haihe Plain. *J Meteorol Res.,* 36: 450-461. https://doi.org/10.1007/s13351-022-1220-5

Jusoh, M. F., Adnan, N., Muttalib, M. F. A., and Katimon, A. (2020). Performance Evaluation of Drip Irrigation System and Water Productivity (WP) of Rock Melon Grow inside Netted Rain House Shelter. *IOP Conf. Series: Earth Environ. Sci.,* https://doi.org/10.1088/17551315/549/1/012094

Lictawa, G. B., and Malamug, V. U. (2023). Cooling Effect of Different Irrigation Methods in the Growth Stages of Chilli Pepper **(***Capsicum frutescens* L.). *E-DAWA An Intern. Multidisc. Res., J.*, 3:1-14. https://doi.org/10.56901/MDHL7608

Nazir, N. B., Pandey, Y., Qayoom, S., and Dadhich, S. M. (2024). Modelling of moisture movement and irrigation scheduling in drip irrigated tomato using CROPWAT and HYDRUS-1D. *J. Agrometeorol.,* 26(2): 215-219. https://doi.org/10.54386/jam.v26i2.2492

Nurwanto, A., Soedradjad, R., and Sulistyaningsih, N. (2017). Application of Various Dosage of Potassium Fertilizer and Compost Against Production of Chilli pepper Plants (*Capcisum frutescens L.)***.** *J. Agric. Sci.,* 15(2):181-193. https://doi.org/10.32528/agr.v15i2.1172

Prastowo, D.R., Manik, T.K., and Rosadi, R.A.B. (2016). Application of Cropwat Models to Estimate The Reference Evapotranspiration and Composing The Crop Water Balance of Soybean **(***Glycine Max (L) Merril)* in Two Different Location. *Jurnal Teknik Pertanian Lampung.,* 5(1) : 1-12

Sharma, V., Changade, N. M., Singh , Y. P., and Madane, D. A. (2024). Response of drip irrigated spring capsicum crop to pan evaporation-based irrigation levels in combination with varying nitrogen doses. *J. Agrometeorol.,* 26(3): 370-373. https://doi.org/10.54386/jam.v26i3.2635

Sudarma, I.M., Wiguna, P.P.K., Djelantik, A.A.A.W.S., and Wijana, I.M.S. (2024). Mitigation and adaptation of chilli farmers to climate change in Baturiti District, Bali Province, Indonesia. *Intern. J. Design Nature Ecodyn.,* 19(4): 1391-1403. https://doi.org/10.18280/ijdne.190432

Wini, P. A., Nugroho, B. D. A, and Setyawan, C. (2022). Effect of Extreem Rainfall Pattern on The Growth and Yield of Chilli Peppers. *Jurnal Tekik Pertanian Lampung.,* 11(1):117-129. http://dx.doi.org/10.23960/jtep-l.v11i1.117-129