Assessment of Stage-Specific Irrigation Water Requirements for Okra (*Abelmoschus Esculentus*) using the Cropwat8.0 Model in Ikole Ekiti, Nigeria

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ORIGINAL RESEARCH

Abstract— Agriculture is the cornerstone of the Nigerian economy, though dry-season crop production is severely limited by moisture stress and high evaporative demand. Okra is a vital vegetable crop in southwest Nigeria, yet its productivity is often hindered by inadequate water management strategies. This study addressed the gap in location-specific data by using the CROPWAT 8.0 model to assess the irrigation water requirements of okra across different physiological growth stages in Ikole Ekiti. The methodology involved a field-based observational approach integrated with FAO CROPWAT version 8.0 simulations and a Randomised Complete Block Design. Meteorological data from NiMet and local soil characterisation were used as primary inputs to the model, while water was supplied through a gravity-fed drip irrigation system. Findings revealed a total seasonal crop evapotranspiration of 554.4mm and a net irrigation requirement of 547.5mm compared to a negligible effective rainfall of 7.3mm.The peak water demand of 8.05mm per day occurred during the mid-season stage in April, coinciding with flowering and fruit development. The results showed an overall deviation of 14.4% between simulated and field-observed irrigation, with the initial stage requiring 161.3% more water in the field to support seedling establishment. The study concludes that the CROPWAT model is a reliable decision-support tool for optimising water-use efficiency. It is recommended that farmers synchronise irrigation with stage-specific needs to enhance productivity, and further research should explore different cultivars and soil types to improve the local applicability of these findings.

Keywords— CROPWAT8.0, Crop Water Requirement, Drip Irrigation, Irrigation Scheduling

1 INTRODUCTION

Agriculture remains the cornerstone of Nigeria's economy, providing livelihoods for millions of rural households and contributing significantly to national food security and economic growth (Osai Azubuike et al., 2023; Bello et al., 2024). In southwest Nigeria, agricultural activities are widespread due to favourable climatic conditions, fertile soils, and a tropical climate characterised by distinct wet and dry seasons (Naswem & Ejembi, 2017; Okunlola et al., 2019). However, crop production during the dry season is constrained by low rainfall and high evapotranspiration, which increase dependence on irrigation, particularly for vegetables such as okra, tomatoes, and leafy greens that are extensively cultivated across the region (Abewoy, 2018). This climatic variability necessitates robust management techniques to mitigate the vulnerability of vegetable crops (Tunde, 2019). Vegetables play a crucial role in food and nutrition security in developing countries, including Nigeria, as they supply essential vitamins, minerals, dietary fibre, and antioxidants that promote human health and reduce the risk of chronic diseases (WHO, 2004; FAO, 2018). In addition to their nutritional importance, vegetable-based farming systems support agro-based entrepreneurship, income generation, and employment creation, while also helping reduce rural-urban migration (Oladimeji et al., 2020). Improving vegetable productivity, therefore, aligns with national efforts to enhance dietary diversity and reduce micronutrient malnutrition (Ebert, 2020).

Okra (Abelmoschus esculentus) is one of the most important vegetables cultivated in Nigeria, particularly during the dry season, due to its short growth cycle, high market demand, and adaptability to warm climates (Ojo et al., 2011; Bolarinwa & Osun, 2025). The crop is nutritionally rich and economically valuable, providing a stable source of income for smallholder farmers across West Africa (Akinyele, 2009; Farhan & Sugirtharan, 2023). Furthermore, the post-harvest quality and chemical attributes of okra in the region are significantly influenced by processing and management techniques, underscoring the importance of optimizing primary production stages (Oyefeso et al., 2024). Hence, okra cultivation plays a significant role in Nigerian agriculture despite various production challenges (Araba et al., 2025). However, dry-season okra production is highly dependent on supplemental irrigation, as the period from November to March is characterised by minimal rainfall and elevated evapotranspiration rates, thereby exposing crops to moisture stress (Tunde, 2019).

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The water requirements of okra vary substantially across its physiological growth stages, including germination, vegetative growth, flowering, and fruiting, which necessitates precise irrigation management to sustain optimal growth, yield, and fruit quality (Dahiya et al., 2007; Sharma et al., 2021). Among these stages, flowering typically exhibits the highest water demand due to increased evapotranspiration and reproductive development (Sharma et al., 2021). Failure to synchronise irrigation practices with these stage-specific water requirements often results in inefficient water application, leading to moisture deficits, reduced yield, and compromised crop quality (Farhan & Sugirtharan, 2023).Despite the recognised importance of irrigation in dry-season vegetable production, many farmers in Nigeria continue to rely on conventional irrigation methods that do not account for the dynamic water needs of crops such as okra (Ojo et al., 2011; Yunusa et al., 2025). These practices contribute to water wastage and limit productivity gains, particularly in water-scarce environments. The challenge is especially pronounced in locations such as Ikole Ekiti, where seasonal water scarcity, coupled with high evaporative demand, exacerbates irrigation inefficiencies and constrains sustainable vegetable production (Ayejoto et al., 2023). Recent assessments of rainfall trends in Ekiti State further highlight the need for climate resilience in local agriculture (Olaleye et al., 2026).

Consequently, drip irrigation has emerged as an effective, water-saving technology that delivers water directly to the crop root zone, minimises conveyance losses, and improves water-use efficiency compared with traditional irrigation systems (Lakhiar et al., 2024; Godase et al., 2025). When combined with proper irrigation scheduling, drip irrigation can mitigate the adverse effects of dry spells and climatic variability, leading to improved crop yields and enhanced economic stability for farmers (Ahmed et al., 2023). However, the effectiveness of drip irrigation largely depends on accurate estimation of crop water requirements and timely water application (Ahmed et al., 2023; Yang et al., 2023). The Food and Agriculture Organisation's CROPWAT model is a widely accepted decision-support tool for estimating crop water requirements and developing irrigation schedules based on local climatic data, soil characteristics, and crop parameters (Aliku & Oshunsanya, 2016a; Roja et al., 2020; Solangi et al., 2022). Recently, Ehumadu (2024) highlighted the reliability of the CROPWAT model as an innovative approach to addressing uncertainties in water availability stemming from adverse climate change impacts in southwestern Nigeria. Model-based irrigation planning has been shown to enhance water use efficiency and promote sustainable agricultural practices (Soomro et al., 2023). Studies indicate that properly managed irrigation can increase okra yield relative to conventional methods (Dahiya et al., 2007; Aliku & Oshunsanya, 2016a; Badou et al., 2025). Nevertheless, there remains limited location-specific information on the stage-wise irrigation water requirements of okra under dry season conditions in Ikole Ekiti.

In response to this gap, the present study applies the CROPWAT model to assess the irrigation water requirements of okra at different physiological growth stages during the dry season in Ikole Ekiti, South West Nigeria. By generating stage-specific irrigation schedules and evaluating their potential benefits, the study aims to improve water-use efficiency, enhance dry-season okra productivity, and provide evidence-based guidance for sustainable irrigation management in similar agroecological environments.

2 MATERIALS AND METHOD

2.1 STUDY AREA

The study was conducted in Ikole Ekiti, located in Ekiti State, South West Nigeria. Ikole Ekiti lies approximately between latitudes 7.81°N and 5.50°E and longitudes 5.50°E and 5.50°E, as shown in Figure 1, within the tropical rainforest agroecological zone of Nigeria (Aliku & Oshunsanya, 2016b). The region experiences a tropical climate characterised by distinct wet and dry seasons. The rainy season typically spans from April to October, while the dry season occurs between November and March, with mean annual rainfall ranging between 1,200 mm and 1,800 mm (Solomon et al., 2025). The experiment was conducted during the dry season, from February to June, to cover the crop's full physiological growth cycle. The average temperature in the study area ranged from 22°C to 32°C, with relative humidity levels between 60% and 80% throughout the year. The soils in the area are predominantly Alfisols, known for moderate water-holding capacity, good drainage, and fertility suitable for vegetable cultivation, such as okra (Adekiya et al., 2021). Furthermore, agriculture is a dominant activity in Ikole Ekiti, making it an ideal location for evaluating okra's irrigation needs across different physiological growth stages (Olaleye et al., 2026).

2.2 EXPERIMENTAL DESIGN AND TREATMENT

The study adopted a field-based observational approach integrated with simulation modelling using FAO CROPWAT version 8.0. Okra (*Abelmoschus esculentus L.*) was selected as the test crop due to its economic importance and adaptability to Nigerian climatic conditions (Araba et al., 2025). The experiment was laid out in a Randomised Complete Block Design (RCBD). As illustrated in Figure 2, the layout consisted of a 4-by-4 grid, totalling 16 experimental units or subplots. This arrangement accommodated five irrigation treatments and three replications, with one additional plot utilised for control. Each sub-plot measured 1.2 m by 1.5 m. Irrigation scheduling was determined based on stage-specific crop water requirements (CWR) as simulated by the CROPWAT model (Aliku & Oshunsanya, 2016a; Soomro et al., 2023). The growth cycle was divided into four distinct physiological stages as stated by Aliku & Oshunsanya (2016a):

1) Initial Stage: Germination and emergence (0 to 7 days)
2) Development Stage: Seedling establishment (7 to 20 days)

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3) Mid-season Stage: Vegetative growth (20 to 40 days)
4) Late season Stage: Flowering and fruiting (greater than 40 days).

2.3 Land Preparation and Field Layout

The total experimental area measured 9.65 m by 6.68 m. The field was manually cleared and levelled to ensure uniform water distribution. Following clearing, plot demarcation was conducted using the compass survey method. The subplots were organised into four blocks. To minimise lateral water movement between treatments and to facilitate agronomic operations, a 0.7 m spacing was maintained between rows and a 0.36 m spacing was maintained between columns. The perimeter plots were positioned with adequate margins from the farm boundary to prevent edge effects

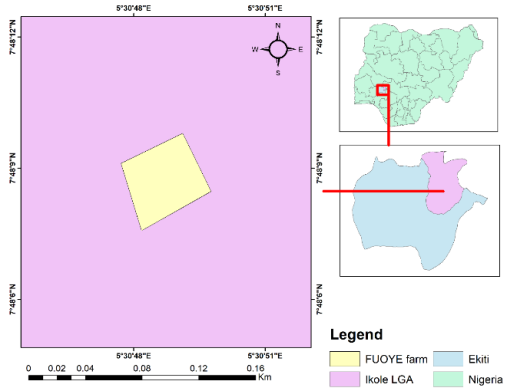

Fig. 1. Geographical location and map of the study area in Ikole Ekiti, Nigeria

2.4 Planting and Irrigation Installation

Okra was planted manually at a spacing of 30 cm × 60 cm, consistent with the recommended practices for the region (Makinde et al., 2021). Seeds were sown at a depth of approximately 0.5 cm with 3 to 4 seeds per hole and later thinned to one healthy plant per stand. To support early crop establishment, all plots received a uniform baseline irrigation of 10 L for the first 14 days post-planting. A low-cost gravity-fed drip irrigation system was installed using plastic reservoirs to provide the necessary hydraulic head. Water delivery was achieved through calibrated discharge orifices spaced at 30 cm intervals. This configuration ensured localised water application directly to each plant's root zone. The precise arrangement of the delivery lines and the plot dimensions are detailed in the experimental layout (Figure 3).

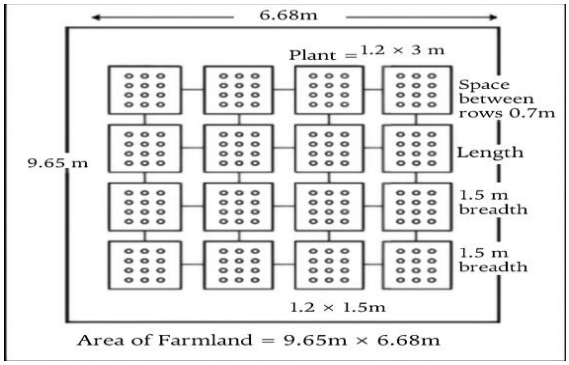

Fig. 2. Experimental field layout and plot arrangement at the study site

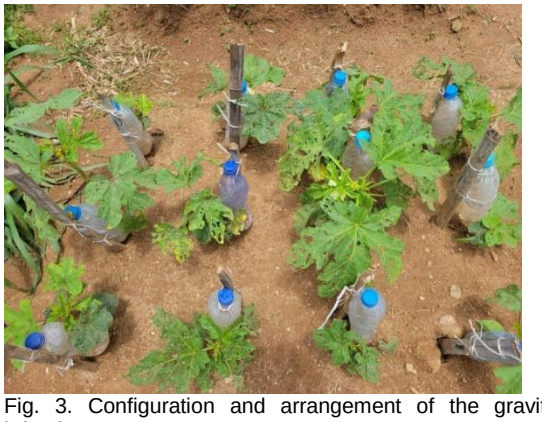

Fig. 3. Configuration and arrangement of the gravity-fed drip irrigation system components

2.5 Data Collection and Model Inputs

The data required for the experimental simulation and field monitoring were classified into agrometeorological, edaphic, and crop-specific parameters. Comprehensive meteorological datasets for the FAO CROPWAT version 8.0 simulation were obtained from the Nigerian Meteorological Agency (NiMet) and cover a 10-year historical period (2014–2023). These datasets consisted of monthly averages of maximum and minimum temperatures, relative humidity, wind speed, and sunshine duration, along with monthly rainfall totals. These parameters were utilized within the model to calculate reference evapotranspiration (ETo). Additionally, daily climatic records were monitored on-site throughout the experimental period to validate the model simulations against historical averages and account for seasonal variability (Aliku & Oshunsanya, 2016a). The datasets served as the primary drivers for estimating the reference evapotranspiration within the CROPWAT model framework.

Soil characterisationwas performed by collecting disturbed and undisturbed samples from the experimental site at depths of 0-30 cm. Laboratory analysis was conducted using standard procedures to determine the soil's baseline fertility and physical structure. Chemical analysis encompassed soil pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases, exchangeable acidity, electrical conductivity, and micronutrients. Particle size distribution was determined to classify the soil texture, which was identified as sandy clay loam. Critical hydrophysical properties, including bulk density, field capacity (FC), permanent wilting point (PWP), and available water holding capacity, were measured alongside in situ infiltration rates. The parameters were integrated into the CROPWAT model to facilitate accurate soil water balance estimations (Aliku & Oshunsanya, 2016b; Solangi et al., 2022; Soomro et al., 2023).

Crop-specific parameters for okra were utilised to calibrate the simulation for local conditions. Key modelling inputs included the planting date, the duration of individual physiological growth stages, and the yield response factor (Ky). The crop coefficient (Kc) values,

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representing the ratio of crop evapotranspiration to reference evapotranspiration, were initially adopted from FAO standards and subsequently adjusted based on field observations of rooting depth and canopy development. The calibration ensured that the simulated irrigation schedules and water requirement estimates reflected the specific agroecological performance of the cultivar under study (Aliku & Oshunsanya, 2016a). All field observations on water application and crop development were recorded to validate the stage-specific irrigation scheduling

2.6 Irrigation Scheduling and Water Requirements

Stage-specific irrigation schedules were developed using CROPWAT model outputs to maintain optimal soil moisture levels throughout the crop growth cycle. The primary objective was to ensure adequate hydration while preventing physiological water stress or anaerobic conditions caused by waterlogging (Bouman et al., 2005). Irrigation frequency was dynamically adjusted based on crop rooting depth development and the soil's Management Allowable Depletion (MAD) levels. Water application was executed via the previously described drip irrigation system to ensure high distribution uniformity and to minimise non-productive water losses through evaporation and surface runoff, thereby optimising water use efficiency (Araba et al., 2025).

Net Irrigation Requirement (NIR) was calculated as the difference between the daily crop evapotranspiration (ETc) and the effective rainfall (Pe), following the standard water balance, as given in equation 1.

$$NIR = ET_C - P_e \quad (1)$$

Where, ET_C is crop evapotranspiration and P_e is the effective rainfall.

To determine the total volume of water required at the source, Gross Irrigation Requirement (GIR) was subsequently estimated by accounting for the system efficiency. This was calculated using equation 2:

$$GIR = \frac{NIR}{Irrigation\ Efficiency} \quad (2)$$

These calculations enabled precise quantification of water applied at each growth stage, ensuring the simulation remained grounded in empirical field conditions.

2.7 Statistical Analysis and Model Validation

Field observations and model-generated datasets were subjected to descriptive and inferential statistical analyses to evaluate the relationship between irrigation scheduling and crop performance. The analysis included estimating total seasonal water use and calculating Water Use Efficiency (WUE), defined as the ratio of economic crop yield to total water applied. Irrigation requirements were compared across the four physiological growth stages to identify periods of peak water demand.

The predictive accuracy of the CROPWAT model was assessed by validating its outputs against field observations to ensure local applicability. All statistical computations, including variance analysis and trend consistency checks, were performed using Microsoft Excel. This approach provided a robust framework for assessing the effectiveness of the proposed irrigation treatments.

3 RESULTS AND DISCUSSION

3.1 Crop Water Requirements and Irrigation Scheduling

The simulated crop evapotranspiration ETc, Effective Rainfall, and Irrigation Requirements for okra throughout the dry season in Ikole Ekiti are presented in Table 1. The results reveal a total seasonal irrigation requirement of 547.5 mm, which is significantly higher than the total effective rainfall of 7.3 mm recorded during the study period. This substantial disparity underscores the extreme dependency of dry-season crops on supplemental water and confirms that rainfall alone is insufficient to sustain okra production between February and June in this region (Tunde, 2019; Farhan & Sugirtharan, 2023).

The daily crop evapotranspiration ETc exhibited a progressive increase from the initial stage in late February (2.39 mm per day) to a peak of 8.05 mm per day during the second decade of April. This peak coincides with the mid-season stage, which is characterised by maximum canopy cover and high metabolic activity. The findings align with previous observations that the flowering and mid-season stages are periods of highest water demand due to increased reproductive development (Sharma et al., 2021; Aliku & Oshunsanya, 2016a).

The crop coefficient Kc values followed a typical physiological growth curve, starting at 0.53 during the initial stage, rising to a maximum of 1.86 during the mid-season stage, and subsequently declining to 0.79 by the end of the late season. The high Kc values recorded in April and May indicate that the crop requires substantial water to maintain physiological cooling and fruit development during the hottest months of the dry season (Soomro et al., 2023; Solangi et al., 2022).

Furthermore, the negligible effective rainfall ranging from 0.1 mm to 1.3 mm per decade underscores the moisture stress that okra plants would face without a structured irrigation schedule. The high evaporative demand, particularly in April, when ETc reached 80.5 mm per decade, suggests that any delay in water application during this period could lead to significant yield losses (Abewoy, 2018; Ayejoto et al., 2023). By utilising the CROPWAT model to identify peak demand periods, farmers can optimise water application and avoid the twin challenges of over-irrigation and moisture deficit (Roja et al., 2020; Ahmed et al., 2023). The results provide a robust baseline for implementing drip irrigation systems that deliver water specifically to the root zone during these critical physiological windows (Lakhiar et al., 2024; Godase et al., 2025).

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Table 1. Crop Evapotranspiration ETc, Effective Rainfall and Irrigation Requirement at Different Growth Stages of Okra CROPWAT Output
Source: (Author)

Month	Decade	Stage	Kc (Coeff.)	ETc (mm/day)	ETc (mm/dec)	Eff. Rain (mm/dec)	Irr. Requirement (mm/dec)
Feb	3rd	Initial	0.53	2.39	12.0	0.1	11.9
Mar	1st	Development	0.53	2.20	22.0	0.2	21.7
Mar	2nd	Development	0.81	3.38	33.8	0.3	33.5
Mar	3rd	Development	1.26	5.31	58.4	0.5	57.9
Apr	1st	Mid-season	1.71	7.41	74.1	0.6	73.4
Apr	2nd	Mid-season	1.86	8.05	80.5	0.8	79.7
Apr	3rd	Mid-season	1.86	7.99	79.9	0.9	79.0
May	1st	Mid-season	1.86	7.49	74.9	1.0	73.9
May	2nd	Late-season	1.64	6.52	65.2	1.2	64.0
May	3rd	Late-season	1.12	4.39	48.3	1.3	47.0
Jun	1st	Late-season	0.79	2.71	5.4	0.3	5.4
		Total	—	—	**554.4**	**7.3**	**547.5**

3.2 Trends in Crop Evapotranspiration and Irrigation Demand

A visual representation of the relationship between crop evapotranspiration and irrigation requirements is shown in Figure 4. The data shows that the irrigation requirement bars consistently align with the ETc curve throughout the experimental period. This overlap confirms that rainfall made almost no contribution to the crop water balance during the dry-season months in Ikole Ekiti (Olaleye et al., 2026; Ayejoto et al., 2023).

Water demand started at a low level in February and rose sharply through March before peaking in April. This peak demand corresponds to the mid-season physiological stage of the okra crop when the canopy is most developed, and the environmental evaporative demand is at its highest (Sharma et al., 2021; Tunde, 2019). The simulated trend demonstrates that the CROPWAT model effectively captured the seasonal variation in moisture needs based on the local climatic parameters of Ekiti State (Aliku & Oshunsanya, 2016a; Solangi et al., 2022). By late May and early June, the water requirement began to decline. This downward trend is associated with the late-season stage, when crop growth slows and plants reach maturity (Soomro et al., 2023; Farhan & Sugirtharan, 2023). The results emphasise that precise water management is most critical in April to prevent moisture stress during peak evapotranspiration.

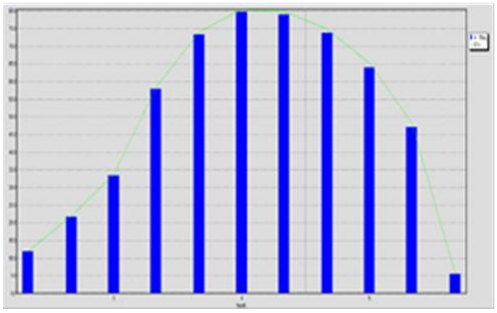

Fig. 4. Trend of Crop Evapotranspiration and Irrigation Requirement across the Growth Period

3.3 Analysis of Soil Moisture Depletion and Irrigation Frequency

The soil moisture depletion levels throughout the ninety-five-day growth cycle are presented in Figure 5. The red bars indicate the daily water depletion, while the solid lines represent the Readily Available Moisture and Total Available Moisture limits. The results show that soil water depletion remained within permissible limits throughout the experimental period. This indicates that the simulated irrigation schedule successfully maintained soil moisture above the critical threshold, preventing crop moisture stress (Farhan & Sugirtharan, 2023; Bouman et al., 2005).

The frequency of irrigation and the magnitude of depletion varied according to the crop growth stage. In the initial and development stages, the depletion bars were shorter, and the frequency of water application was lower. However, as the okra reached the mid-season stage between day forty and day eighty, the depletion rate increased significantly as evidenced by the longer red bars reaching closer to the Readily Available Moisture line. This intensification of water uptake aligns with the increased transpiration and reproductive development observed during this peakgrowth period (Sharma et al., 2021; Aliku & Oshunsanya, 2016a). The consistent return of the depletion bars toward the zero line confirms that irrigation events were sufficient to replenish moisture in the soil root zone. This management approach ensures that okra plants have continuous access to water, which is vital for achieving optimal yields under the dry-season conditions of Ekiti State (Soomro et al., 2023; Ahmed et al., 2023). The absence of depletion bars dropping below the Readily Available Moisture line suggests that the CROPWAT model successfully optimised the timing of water application

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to ensure sustainable water use and crop productivity (Lakhiar et al., 2024; Solangi et al., 2022).

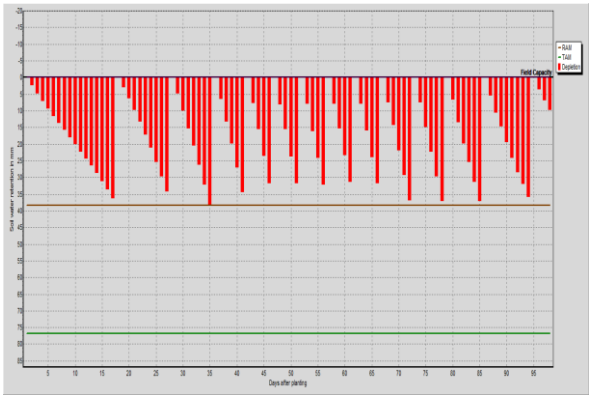

Fig. 5. Daily soil water depletion and moisture availability limits for okra

3.4 Comparison of Decadal Crop Evapotranspiration and Irrigation Requirement

The comparison between the decadal crop evapotranspiration (ETc) and the irrigation requirement for okra is illustrated in Figure 6. The results show that ETc and irrigation requirements are nearly equal across all decades of the growth period. This near-perfect correlation indicates that rainfall did not provide sufficient moisture to the crop throughout the dry season, making supplemental irrigation the primary means of meeting crop water needs (Solangi et al., 2022; Soomro et al., 2023).

Water demand showed a steady rise from the initial stage, reaching its maximum during the mid-season stage in the second decade of April, where ETc and irrigation requirement values peaked at approximately 80.5mm and 79.7mm, respectively. This peak corresponds to the period of highest vegetative and reproductive activity, which requires the most water to sustain physiological processes (Sharma et al., 2021; Aliku & Oshunsanya, 2016a). Following the peak in April, the water demand began to decrease during the late season decades of May and June as the okra plants reached physiological maturity. These decadal variations emphasise the need for a dynamic irrigation schedule that adjusts to the crop's physiological changes and the high evaporative demand of the Ekiti State climate (Ayejoto et al., 2023; Tunde, 2019).

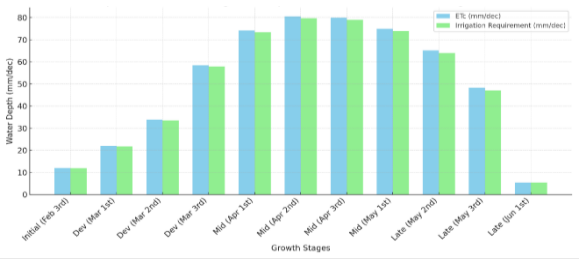

Fig. 6. Comparison of decadal crop evapotranspiration and irrigation requirement for okra

3.5 Comparison of Decadal Crop Evapotranspiration and Irrigation Requirement

The comparison between the irrigation volumes estimated by the CROPWAT model and the actual water applied during field operations is detailed in Table 2. The total simulated water requirement was 547.5 mm, whereas the total field application was 468.69 mm, resulting in an overall difference of 78.81mm and a total deviation of 14.4%. This variation suggests that while the model serves as an essential guide for planning, the actual water delivery is affected by the efficiency of the drip system and localised soil conditions (Aliku & Oshunsanya, 2016a; Lakhiar et al., 2024).

The analysis of stage-wise performance reveals a significant negative deviation of 161.3% during the initial stage, where the field irrigation of 31.08 mm far exceeded the model estimate of 11.9 mm. This difference was due to the necessary baseline water application required to ensure successful seedling emergence and establishment in the tropical climate of Ekiti State (Makinde et al., 2021; Ojo et al., 2011). Similarly, the development stage showed a 9.4% negative deviation, further indicating that early growth phases required slightly more water in the field to support robust plant establishment (Araba et al., 2025; Farhan & Sugirtharan, 2023). Conversely, the mid-season and late-season stages showed positive deviations of 18.1% and 45.6%, respectively. In the mid-season stage, the model predicted a requirement of 306.0 mm, while only 250.56 mm was applied in the field. This 34-day period remains the most water-demanding phase of the growth cycle due to peak flowering and fruit formation (Sharma et al., 2021; Aliku & Oshunsanya, 2016b). The high deviation at the late-season stage suggests that the model predicted a higher evaporative demand than the crop in the field required as it approached maturity.

Table 2. Comparison of CROPWAT-simulated and field-observed irrigation across growth stages

Growth Stage	No. of Days	CROPWAT Irrigation (mm)	Field Irrigation (mm)	Difference (mm)	% Deviation
Initial	14	11.9	31.08	-19.18	-161.3%
Development	31	113.1	123.69	-10.59	-9.4%
Mid-season	34	306.0	250.56	55.44	18.1%
Late-season	23	116.4	63.36	53.04	45.6%
Total	102	547.5	468.69	78.81	14.4%

This reduction in field application during the final 23 days was due to a management strategy aimed at preventing anaerobic conditions and maintaining fruit quality (Bouman et al., 2005; Ahmed et al., 2023). Overall, the results show that the CROPWAT model provides a reliable framework for estimating water needs while field adjustments remain important for

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optimising actual application in the specific agro-ecological environment of Ikole Ekiti (Roja et al., 2020; Solangi et al., 2022; Olaleye et al., 2026).

4 CONCLUSION

The present study confirms that dry-season okra production in Ikole Ekiti is almost entirely dependent on supplemental irrigation due to the extreme disparity between crop water requirements and effective rainfall. Simulation using the CROPWAT model revealed a total seasonal water demand of 554.4mm and a net irrigation requirement of 547.5mm, whereas the effective rainfall contributed only 7.3mm. These findings demonstrate that structured irrigation schedules are essential for mitigating the risks of moisture stress and ensuring sustainable vegetable productivity in the tropical rainforest agroecological zone. Analysis of physiological growth stages identified the mid-season stage in April as the period of peak water demand. During this phase, the daily evapotranspiration reached 8.05 mm per day, driven by high solar radiation and maximum canopy development. The results also demonstrated a strong correlation between the CROPWAT-simulated requirements and field-observed irrigation, with an overall deviation of 14.4%. Although the model provides a reliable baseline for planning, the initial stage required 161.3% more water in the field (31.08mm) than the predicted 11.9mm to support successful seedling establishment.

Therefore, integrating the CROPWAT model with drip irrigation technology offers a robust decision-support framework for smallholder farmers in Ekiti State. By synchronising water application with stage-specific requirements, farmers can optimise water use efficiency, reduce wastage, and stabilise crop yields during the dry season. This approach is vital for enhancing food security and promoting climate-resilient agricultural practices in the region. Future irrigation planning should account for higher water needs during the early establishment phase, while utilising model-based estimates to manage peak demand during the flowering and fruiting stages. However, further research is recommended to assess the irrigation water requirements of different okra cultivars under various soil types across southwest Nigeria to improve the local applicability of these results. It is also necessary to conduct studies over multiple dry seasons to account for year-to-year climatic variability and its effect on irrigation scheduling.

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