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Crop Water Requirements and Irrigation Schedules using the FAO CROPWAT Model in Foumbot, West Region of Cameroon

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Abstract

Water is a key component in crop production, with a large portion of water resources allocated to agricultural irrigation. As global water scarcity increases, implementing water-saving agricultural practices is essential for optimizing water usage. This paper used the Food and Agriculture Organization (FAO) CROPWAT 8.0 software and the CLIMWAT 2.0 tool to determine crop water requirements (CWRs) and irrigation schedules for cabbage, tomatoes, and maize in Foumbot, West Region of Cameroon, based on climate data from 1980 to 2023. The FAO Penman–Monteith method was used to compute reference evapotranspiration (ET0), while the USDA Soil Conservation method estimated effective rainfall. The results revealed significant variation in irrigation needs across crop types and growth stages. Tomatoes had peak water requirements of 45.5 mm/day in the initial stage, followed by maize at 45.5 mm/day and cabbages at 37.8 mm/day. During the mid-season, water demand increased for all crops, with tomatoes requiring the most at 43.3 mm/day. Effective rainfall during the growth periods was minimal, averaging 0-10.3 mm/day. Irrigation deficits varied between 0 and 32.7 mm/day across the crops. The study recommends stage-specific irrigation schedules to optimize water use in Foumbot, especially in regions with unreliable rainfall patterns.

Keywords: CROPWAT, crop water requirements, effective rainfall, Foumbot, irrigation schedules, water scarcity.

1. Introduction

Water accounts for approximately 70% of global freshwater consumption (FAO, 2021). As the world grapples with the challenges of climate change, population growth, and urbanization, the demand for efficient water management in agricultural practices has never been more critical. Globally, many regions face the dual challenge of ensuring food security while managing limited water resources. According to the United Nations, by 2050, the global population is expected to reach 9.7 billion, intensifying the pressure on agricultural systems to produce more food with less water (UN, 2019).

In developing countries, the situation is particularly acute. Many farmers lack access to efficient irrigation technologies and face significant challenges related to water scarcity, leading to reduced agricultural productivity. Melesse *et al.,* (2016) illuminates the adverse impacts of inadequate water utilization on crop yields, exacerbating food insecurity and poverty. In sub-Saharan Africa, where agriculture is predominantly rain-fed, the erratic nature of rainfall adds complexity, making the adoption of effective irrigation systems essential for resilience and sustainability.

Agriculture remains a cornerstone of the Cameroonian economy, contributing approximately 25% to the national GDP and employing nearly 60% of the workforce (World Bank, 2020). Despite its agricultural potential, the country faces significant challenges, particularly in water management. Rain-fed agriculture dominates, making crop production highly susceptible to erratic rainfall patterns and prolonged dry spells. Moreover, inadequate irrigation infrastructure and inefficient water use have limited the sector's productivity. These issues are compounded by the impacts of climate variability, including shifts in rainfall patterns and rising temperatures, which threaten the livelihoods of rural farmers and overall food security.

The West Region of Cameroon stands out as one of the country's most agriculturally productive areas, characterized by fertile soils and favorable climatic conditions. This region supports a diverse range of crops, including maize, beans, potatoes, and various vegetables, which are essential for both local consumption and national food security. The agricultural productivity of the West Region is not only important for meeting the dietary needs of the population but also plays a significant role in the overall economy of Cameroon.

In Foumbot, farming is heavily reliant on rainfall, which exposes farmers to risks associated with seasonal variability and drought (FAO, 2021). This dependency on unpredictable weather patterns poses challenges to agricultural productivity and economic stability. Moreover, the lack of efficient irrigation systems in this agricultural hub further limits the potential for consistent crop production. Without adequate irrigation infrastructure, farmers struggle to maintain optimal moisture levels, leading to reduced yields and increased vulnerability to food insecurity (World Bank, 2020). The challenges of unreliable rainfall and inadequate irrigation practices highlight the urgent need for improved water management strategies in Foumbot.

Harnessing tools such as the FAO CROPWAT program in Foumbot could significantly revolutionize crop-water management practices and improve agricultural output. This paper focuses on three key crops—cabbage, tomatoes, and maize to analyze their specific water requirements and develop tailored irrigation schedules.

2. Materials and Methods

Foumbot Subdivision is situated in the Noun Division of the West Region of Cameroon, approximately 25 km northwest of Bafoussam, the regional capital. Geographically, it lies between latitudes 5˚16' and 5˚35' N and longitudes 10˚30' and 10˚45' E. It shares borders to the north with the Koutaba, to the northwest with Kouoptamo, to the south with the Bangangte, to the east with Massangam, to the west with Bafoussam, and to the southwest with Pete Bandjoun (Figure 1). The Sub Division covers an area of approximately 1,044 km², with a population density of 114 inhabitants per km² (CDP Foumbot, 2022). Foumbot is part of the Noun Valley, located between the Bamileke and Bamoun plateaus. The Noun Valley, spanning 10 to 20 km in width, serves as a significant geographic feature that influences the region's climatic and agricultural patterns.

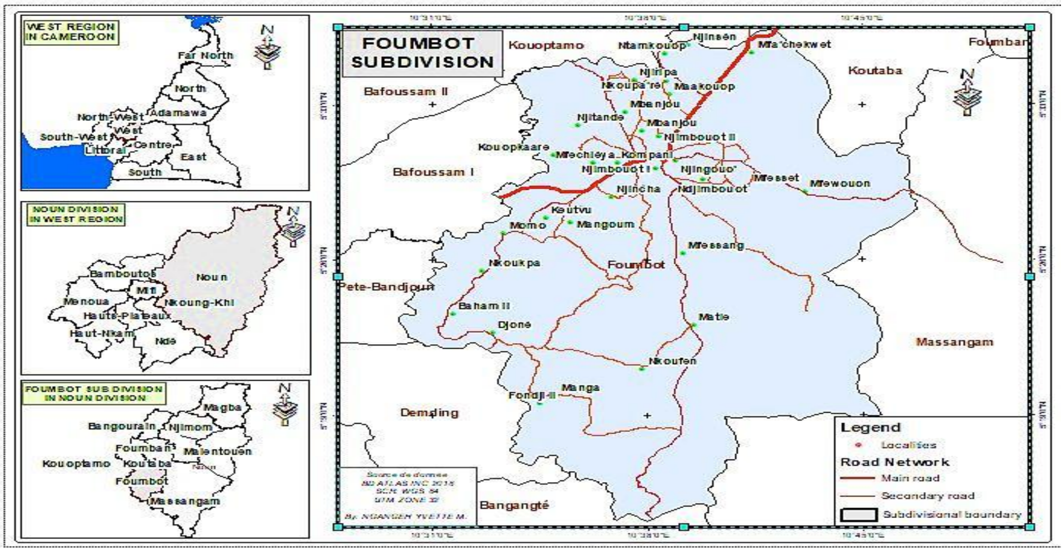


Figure 1: Location of Foumbot

Source: NIS Yaounde, 2020 and Fieldwork 2023

2.1 CROPWAT 8.0 Model Description

CROPWAT 8.0 is an FAO-developed decision-support tool designed to calculate reference evapotranspiration (ET0), crop water requirement (CWR), irrigation scheduling, and irrigation water requirement (IR). It utilizes data on rainfall, soil, crops, and climate to improve irrigation efficiency.

2.2 Data Requirement

The CROPWAT analysis for this study utilized four main types of datasets: rainfall, climate, soil, and crop data. Climatic information spanning 30 years (1980–2023) was gathered from the Koundja Meteorological Station using CLIMWAT 2.0. This tool provides detailed long-term monthly climatic parameters essential for modeling, including maximum and minimum temperatures, wind speed, relative humidity, sunshine duration, and rainfall. These parameters help to establish a reliable foundation for determining evapotranspiration and other water-related calculations.

Data for cabbage, tomatoes, and corn were obtained from the FAO Manual 56. This included vital details such as rooting depth, crop coefficients, yield response factors, and the duration of each growth stage. These parameters were input into the CROPWAT program to simulate irrigation requirements accurately. Planting dates were determined based on the agricultural calendar provided by the Cameroon Ministry of Agriculture and Rural Development, ensuring the data aligns with local practices. Soil characteristics, such as total available moisture, initial depletion, and maximum rooting depth, were derived using the CROPWAT model. The USDA Soil Conservation method was employed to classify the soil in the study area, providing a detailed understanding of its water-holding capacity and infiltration rates.

2.3 Reference Evapotranspiration (ET0)

ET0 combines water loss from plants (transpiration) and soil (evaporation). It was calculated using the FAO Penman–Monteith equation, which incorporates climatic variables such as temperature, wind speed, and vapor pressure.

2.4 Crop Water Requirement (CWR)

The crop water requirement is the amount of water equal to what is lost from a cropped field by the ET and is expressed by the rate of ET in mm/day. Estimation of CWR is derived from crop evapotranspiration (ETc) which can be calculated by the following equation:

$$ETc=Kc\times ET0$$

Where Kc is the crop coefficient. It is the ratio of the crop ETc to the ET0, and it represents an integration of the effects of four essential qualities that differentiate the crop from reference grass, and it covers albedo (reflectance) of the crop–soil surface, crop height, canopy resistance, and evaporation from the soil. Due to the ET differences during the growth stages, the Kc for the crop will vary over the developing period that can be divided into four distinct stages: initial, crop development, midseason, and late season

2.5 Irrigation Water Requirement (IR)

The irrigation water requirement was calculated by balancing water inputs and losses in the soil root zone. Daily changes were monitored using the equation:

$$Dr,i=Dri-1-Pi+ROi+Ii-Cri-ETci-Dpi$$

Where Dr,i is the root zone depletion at the day's end i (mm), Dr,i−1 is the water content in the root zone at the previous day's end (mm), Pi is the rainfall on day i (mm), ROi is the surface soil runoff on day i (mm), Ii is the net irrigation depth on day i which infiltrates the soil (mm), Cri is the capillary rise from the groundwater table on day i (mm), ETci is the crop evapotranspiration on day i (mm), and DPi is the lost water of the root zone on day i (mm).

2.6 Irrigation Schedule

CROPWAT computes irrigation schedules based on ET0, CWR, and IRs to optimize water application timing and quantity.

3. Results and Discussion

3.1 Results

Using the CROPWAT 8.0 and CLIMWAT 2.0 tools, the study yielded varying results for cabbage, tomatoes, and maize. The water requirements and irrigation schedules were highly dependent on the specific crop type and growth stages. For each crop, peak water requirements, effective rainfall, and irrigation deficits varied significantly throughout the growing periods.

3.1.1 Climate characteristics, rainfalls, and ET0 of Foumbot (average for 1980–2023 period)

The climate of Foumbot plays a significant role in shaping the region's agricultural productivity, with distinct wet and dry seasons that influence crop water requirements. The data for the period from 1980 to 2023 highlights the average rainfall distribution and ET0 values, providing details into how these factors interact to impact water availability for crops (Figure 2).

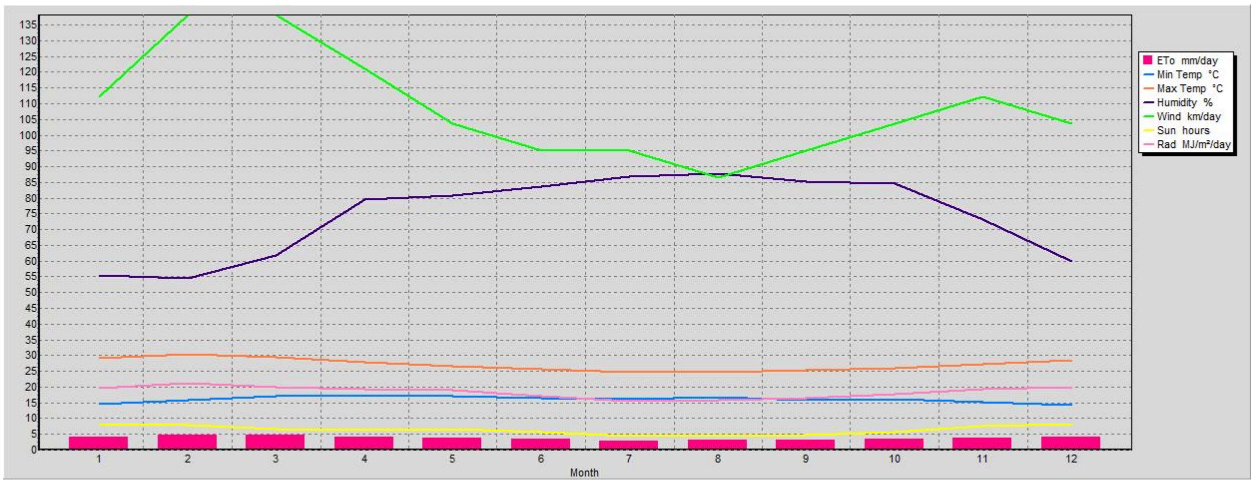


Figure 2: Climate characteristics, rainfalls, and ET0 of Foumbot

Source: Koundja Meteorological station via FAO CLIMWAT tool

According to Figure 2, there exist distinct seasonal variations that significantly influence agricultural water requirements. The reference evapotranspiration (ET0), a key indicator of water demand, fluctuates throughout the years, with higher values recorded during the drier and sunnier months. ET0 peaks in months characterized by high temperatures, longer sunshine hours, and lower humidity, reflecting an increased demand for water in agricultural systems.. The average maximum temperature, which rises during the drier months, coincides with increased ET0 values. In contrast, the average minimum temperature remains relatively stable, showing only minor seasonal fluctuations. These temperature dynamics highlight the influence of heat on evaporation rates, particularly during the hotter months when crop water requirements are at their highest.

Relative humidity further illustrates the seasonal contrast in climatic conditions. Higher humidity levels are observed during the wet season, contributing to reduced ET0 values, while the dry season experiences a notable drop in humidity, leading to heightened water loss through evaporation and transpiration. This inverse relationship between humidity and ET0 reinforces the importance of aligning irrigation schedules with the seasonal variability in atmospheric moisture. Wind speed and solar radiation also play significant roles in determining water demand. Increased wind intensity during certain periods accelerates evaporation, further raising ET0. Similarly, solar radiation peaks during the dry season, driving up temperatures and evapotranspiration rates.

3.1.2 Crop water requirement for cabbage

Cabbage is a high water-demand crop, particularly during its mid-season growth stage when evapotranspiration rates peak. Accurate estimation of crop water requirements (CWRs) is critical for ensuring optimal growth and yield while avoiding water wastage (Table 1).

Table 1: Crop water requirement for cabbage

Month	**Decade**	**Stage**	**Kc**	**ETc**	**ETc**	**Eff rain**	**Irr. Req.**
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Feb	1	Init	0.7	3.25	32.5	0.9	31.6
Feb	2	Init	0.7	3.39	33.9	0.6	33.3
Feb	3	Init	0.7	3.34	26.7	10.3	16.4
Mar	1	Init	0.7	3.28	32.8	22.7	10.2
Mar	2	Deve	0.72	3.31	33.1	32	1.1
Mar	3	Deve	0.77	3.41	37.5	34.6	2.9
Apr	1	Deve	0.83	3.48	34.8	37	0
Apr	2	Deve	0.88	3.52	35.2	40.7	0
Apr	3	Deve	0.93	3.65	36.5	41.5	0
May	1	Deve	0.98	3.78	37.8	42.1	0
May	2	Mid	1.01	3.81	38.1	43.3	0
May	3	Mid	1.01	3.66	40.3	43.7	0
Jun	1	Mid	1.01	3.51	35.1	43.3	0
Jun	2	Mid	1.01	3.36	33.6	43.4	0
Jun	3	Mid	1.01	3.24	32.4	46.3	0
Jul	1	Late	0.97	3	30	50.2	0
Jul	2	Late	0.91	2.72	13.6	26.5	0

Source: FAO CROPWAT, 8.0

According to Table 1, the water requirements for cabbage cultivation in Foumbot follow a distinct pattern across different growth stages, with varying demands for irrigation and effective rainfall. In the initial growth stage, which spans from February to March, the crop requires significant amounts of water, ranging from 3.25 mm/day to 3.39 mm/day. During this period, effective rainfall contributes minimally, resulting in a notable irrigation requirement. As the crop enters the development stage in March and April, its water needs increase, with evapotranspiration rates (ETc) rising from 3.31 mm/day to 3.78 mm/day. Effective rainfall during this period increases significantly, reaching up to 41.5 mm per decade, reducing the irrigation requirement to zero by the end of April. By May and June, as the crop progresses to the mid-growth stage, water requirements stabilize, with daily evapotranspiration ranging between 3.24 mm/day and 3.81 mm/day. Effective rainfall continues to meet the crop's needs, eliminating the need for irrigation. As the crop approaches the late growth stage in July, water requirements drop to 2.72 mm/day. Despite a significant reduction in effective rainfall, the crop reaches maturity, and the irrigation requirement remains zero.

3.1.3 Crop water requirement for tomatoes

Tomatoes are water-sensitive crops with varying water needs across their growth stages (Table 2). They require consistent and adequate moisture, particularly during the flowering and fruit development stages, to maximize yield and quality.

Table 2: Crop water requirement for tomatoes

Month	**Decade**	**Stage**	**Kc**	**ETc**	**ETc**	**Eff rain**	**Irr. Req.**
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Feb	1	Init	0.6	2.79	27.9	0.9	26.9
Feb	2	Init	0.6	2.91	29.1	0.6	28.4
Feb	3	Init	0.6	2.86	22.9	10.3	12.5
Mar	1	Deve	0.65	3.03	30.3	22.7	7.6
Mar	2	Deve	0.77	3.56	35.6	32	3.6
Mar	3	Deve	0.91	4	44	34.6	9.4
Apr	1	Deve	1.04	4.38	43.8	37	6.7
Apr	2	Mid	1.11	4.45	44.5	40.7	3.8
Apr	3	Mid	1.11	4.37	43.7	41.5	2.2
May	1	Mid	1.11	4.28	42.8	42.1	0.7
May	2	Mid	1.11	4.2	42	43.3	0
May	3	Late	1.09	3.97	43.7	43.7	0.1
Jun	1	Late	0.98	3.43	34.3	43.3	0
Jun	2	Late	0.86	2.88	28.8	43.4	0

Jun	3	Late	0.77	2.49	12.5	23.2	0

Source: FAO CROPWAT, 8.0

Table 2 reveal that the water requirements for tomatoes vary significantly across growth stages, with the highest demand occurring during the development and mid-season stages. In the initial stage (February), minimal effective rainfall results in high irrigation needs, reaching up to 28.4 mm/dec. During the development stage (March to early April), increasing crop coefficients (Kc) and evapotranspiration (ETc) drive water demands up to 44 mm/dec, with irrigation requirements peaking at 9.4 mm/dec despite improved rainfall. The mid-season stage (April-May) sees peak water demand, but substantial rainfall reduces irrigation needs to as low as 0.7 mm/dec. In the late stage (June), declining Kc values and sufficient rainfall eliminate the need for irrigation.

3.1.3 Crop water requirement for maize

Maize, being a water-intensive crop, exhibits dynamic water requirements across its growth stages, heavily influenced by climatic conditions and crop development factors. The crop coefficients (Kc) for maize vary throughout its lifecycle, affecting the evapotranspiration (ETc) rates and overall irrigation needs (Table 3).

Table 3: Crop water requirement for maize

Month	**Decade**	**Stage**	**Kc**	**ETc**	**ETc**	**Eff rain**	**Irr. Req.**
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Feb	1	Init	0.3	1.39	13.9	0.9	13
Feb	2	Init	0.3	1.45	14.5	0.6	13.9
Feb	3	Deve	0.41	1.95	15.6	10.3	5.3
Mar	1	Deve	0.63	2.95	29.5	22.7	6.8
Mar	2	Deve	0.87	4.02	40.2	32	8.2
Mar	3	Mid	1.1	4.88	53.6	34.6	19
Apr	1	Mid	1.15	4.85	48.5	37	11.4
Apr	2	Mid	1.15	4.62	46.2	40.7	5.5
Apr	3	Mid	1.15	4.53	45.3	41.5	3.8
May	1	Late	1.12	4.34	43.4	42.1	1.3
May	2	Late	0.9	3.4	34	43.3	0
May	3	Late	0.62	2.24	24.7	43.7	0
Jun	1	Late	0.4	1.41	7	21.6	0

Source: Source: FAO CROPWAT, 8.0

Table 3 illustrate the water requirements for maize cultivation in Foumbot. During the initial stage in February, the water demand is relatively low, with ETc values ranging from 1.39

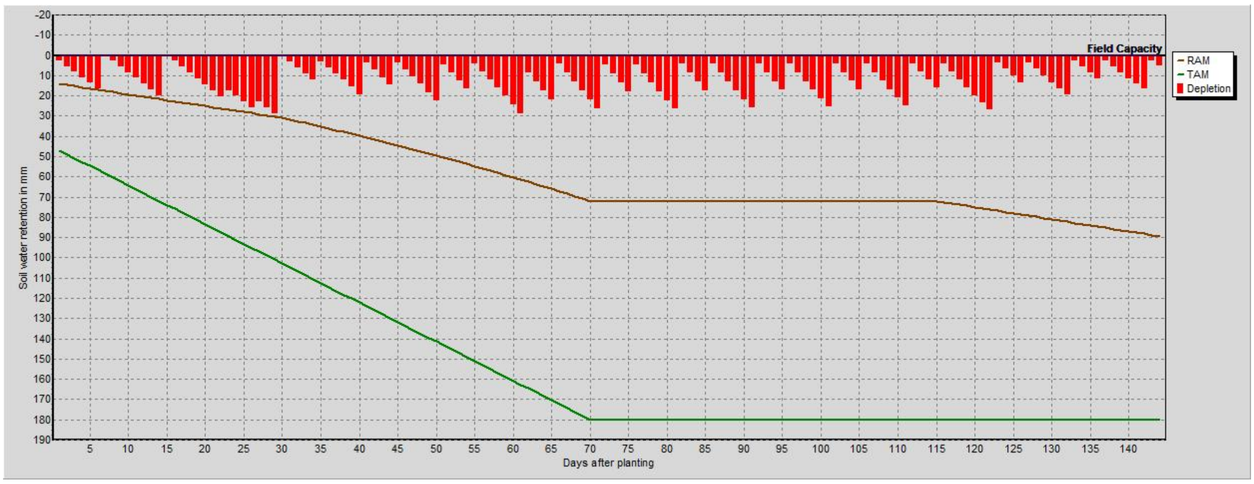
mm/day to 1.45 mm/day. However, minimal effective rainfall results in moderate irrigation needs of up to 13.9 mm/decade in the second decade. As the crop enters the development stage in late February and March, water requirements increase significantly. By mid-March, ETc values rise to 4.02 mm/day, and while rainfall improves, irrigation remains necessary, with demands peaking at 19 mm/decade in the third decade of March when the crop reaches the mid-growth stage. During April, water demand remains high as the crop is in its mid-growth stage. With ETc values stabilizing between 4.85 mm/day and 4.53 mm/day, effective rainfall meets a significant portion of the water needs, reducing irrigation requirements to 11.4 mm/decade in early April and just 3.8 mm/decade by the end of the month. In May, during the late growth stage, the water demand gradually declines, with ETc values dropping to 3.4 mm/day by the second decade. Effective rainfall becomes sufficient to fully meet the crop's needs, eliminating irrigation requirements from the second decade onward. By June, when the crop nears maturity, ETc values fall further to 1.41 mm/day, and rainfall exceeds the water demand, maintaining zero irrigation needs.

3.1.4 Irrigation schedules for cabbage

Cabbage requires precise irrigation scheduling to maintain optimal soil moisture levels for its growth and development. The irrigation schedule varies across growth stages, with water demands increasing during the mid-season due to higher evapotranspiration rates (Table 4). Effective rainfall plays a minimal role in meeting water requirements, necessitating supplemental irrigation to address deficits.

Table 4: Irrigation schedules for cabbage

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow	
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha	
7-Feb	7	Init	0.3	1	100	32	19	0	0	27.1	0.45	
15-Feb	15	Init	0	1	100	31	22.9	0	0	32.7	0.47	
2-Mar	30	Init	0	1	100	31	31.9	0	0	45.5	0.35	
25-Jun	End	End	0	1	100	3						



Source: FAO CROPWAT, 8.0

Table 4 reveals the intricate balance between natural rainfall and irrigation needs throughout the cabbage growth cycle in Foumbot. During the initial stage in early February, minimal rainfall of 0.3 mm was recorded. Despite this slight rainfall, the soil moisture depletion (Depl) was relatively high at 32 mm, necessitating a net irrigation of 19 mm to meet the crop's water requirements. This initial irrigation helped prevent water stress, ensuring that the seedlings established robust root systems. By mid-February, no additional rainfall was observed, and the soil moisture depletion slightly decreased to 31 mm. However, the net irrigation increased to 22.9 mm, indicating a proactive approach to maintaining adequate soil moisture levels despite the absence of natural rainfall. The gross irrigation flow rate also saw a minor increase to 0.47 l/s/ha, reflecting a steady effort to sustain the crop's water needs.

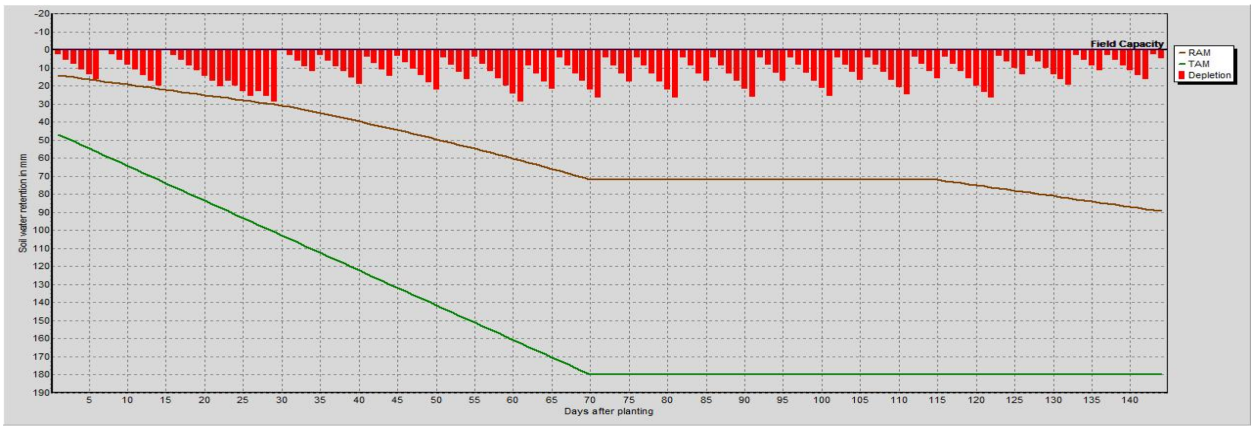
On March 2nd, still within the initial growth stage, rainfall remained absent, and soil moisture depletion stayed consistent at 31 mm. This stability means that the irrigation practices were effective in maintaining soil moisture without further depletion. The net irrigation surged to 31.9 mm, demonstrating a significant investment in water application to support continued crop growth. The gross irrigation flow rate increased substantially to 0.35 l/s/ha, indicating the necessity of sustained irrigation during periods of low rainfall. By the end of the growing season in June, the situation had markedly changed. With the crop reaching maturity, soil moisture depletion had drastically reduced to just 3 mm, indicating that the majority of water needs had been met through both effective irrigation and the crop's natural water uptake. At this final stage, irrigation ceased entirely, as reflected by the absence of net irrigation, deficits, and losses. The culmination of the growth cycle required no additional water, allowing the crop to mature fully without further irrigation inputs.

3.1.4 Irrigation schedules for tomato

Effective irrigation scheduling for tomatoes aims to ensure that water is supplied based on the crop's specific requirements at each growth stage, minimizing stress caused by over- or under-irrigation (Table 5).

Table 5: Irrigation schedules for tomato

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
7-Feb	7	Init	0.3	1	100	32	19	0	0	27.1	0.45
15-Feb	15	Init	0	1	100	31	22.9	0	0	32.7	0.47
2-Mar	30	Init	0	1	100	31	31.9	0	0	45.5	0.35
25-Jun	End	End	0	1	100	3					



Source: FAO CROPWAT, 8.0

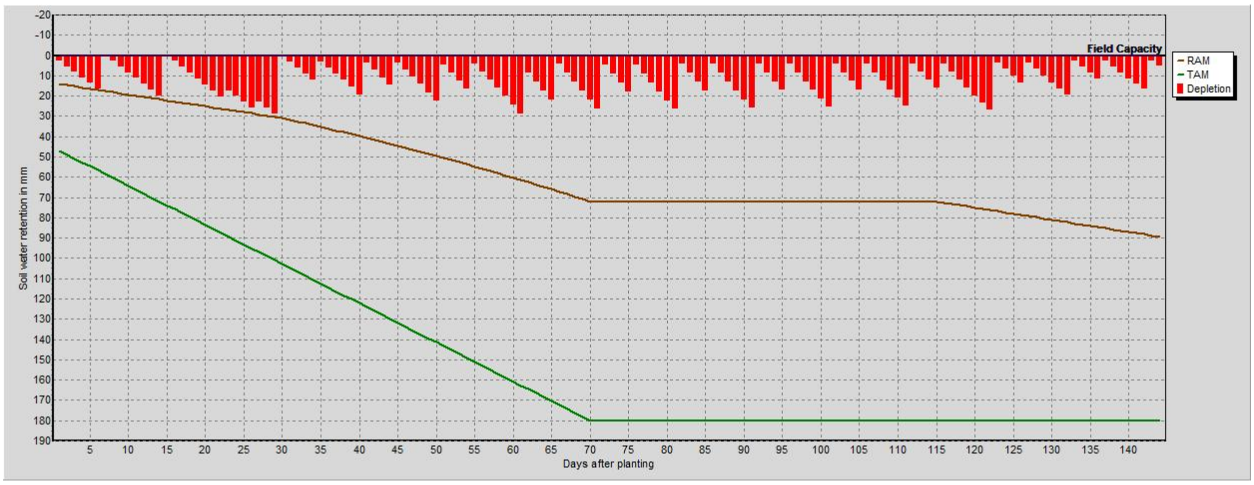
According to Table 5, during the initial stage (7-Feb to 2-Mar), the tomato crop exhibited high water demands due to significant soil moisture depletion (31-32 mm). Minimal rainfall during this period necessitated substantial irrigation, with net irrigation ranging from 19 mm to 31.9 mm and gross irrigation flow rates between 0.35 and 0.47 l/s/ha. This reflects the importance of providing sufficient water to support germination and early growth. By contrast, at the end stage (25-Jun), soil moisture depletion drastically reduced to 3 mm, indicating a significant decline in water requirements as the crop approached maturity. No additional irrigation was needed during this phase, showcasing the effectiveness of prior irrigation efforts and the crop's reduced water demand.

3.1.5 Irrigation schedules for maize

Maize is a staple crop in some villages within the Foumbot Sub Division, characterized by substantial water requirements that fluctuate significantly across its growth stages, from germination to grain filling (Table 6).

Table 6: Irrigation schedules for maize

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow	
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha	
7-Feb	7	Init	0.3	1	100	32	19	0	0	27.1	0.45	
15-Feb	15	Init	0	1	100	31	22.9	0	0	32.7	0.47	
2-Mar	30	Init	0	1	100	31	31.9	0	0	45.5	0.35	
25-Jun	End	End	0	1	100	3						



Source: FAO CROPWAT, 8.0

According to Table 6, the irrigation schedule for maize cultivation in Foumbot reveals the crop's water requirements and soil moisture dynamics throughout its growth stages. During the initial stage (7-Feb to 2-Mar), rainfall was negligible, leading to significant soil moisture depletion of 31-32 mm. To compensate, irrigation was crucial, with net irrigation demands ranging from 19 mm to 31.9 mm and corresponding gross irrigation flow rates between 0.35 and 0.47 l/s/ha. By the end stage (25-Jun), soil moisture depletion dropped to 3 mm, reflecting the reduced water demand as the crop matured. No further irrigation was required at this stage, indicating that earlier irrigation effectively met the crop's water needs.

3.2 Discussion

Efficient irrigation scheduling is critical for optimizing crop water use, improving productivity, and ensuring sustainability in water-scarce regions. For all crops analyzed, the initial growth stages demonstrated high sensitivity to soil moisture depletion. For example, maize recorded soil moisture depletions of up to 32 mm during the early growth stages in February, necessitating net irrigation requirements ranging from 19 mm to 31.9 mm. Similarly, tomatoes and cabbages required substantial irrigation during their initial and developmental stages due to limited effective rainfall. These findings align with the general principles of crop water use, where early growth stages are critical for root establishment, canopy development, and minimizing stress that could compromise yield potential (Allen *et al.,* 1998).

The paper also highlights the limited role of rainfall during critical periods. Rainfall contributions ranged from 0.3 mm to 0.9 mm during the initial stages for maize and were insufficient to meet crop water demands. This reliance on irrigation accentuates the importance of supplemental water sources, particularly in semi-arid regions or during dry seasons when rainfall is sporadic or inadequate. Efficient irrigation systems such as drip or furrow irrigation can minimize water losses and ensure uniform distribution, supporting optimal crop growth (FAO, 2012).

Stage-specific water management emerged as a key factor in reducing water wastage and optimizing water use efficiency. During the mid and late stages of crop growth, water requirements reduced significantly, with net irrigation demands dropping to nearly zero for tomatoes and maize. This decline reflects the reduced evapotranspiration rates as the crops mature, emphasizing the need for adaptive irrigation scheduling that adjusts water supply based on real-time crop water needs (Doorenbos & Pruitt, 1977).

Conclusion

This paper demonstrates the essential role of well-planned irrigation schedules in boosting agricultural productivity, particularly in water-limited environments. tailoring irrigation to the specific needs of cabbages, tomatoes, and maize at their various growth stages, water resources can be allocated more effectively, ensuring optimal crop development and yield. The findings Illuminates the value of precise, data-driven approaches like those facilitated by CROPWAT in addressing water deficits during critical phases of crop growth. In Foumbot and similar regions, where rainfall patterns often fall short of meeting agricultural demand, adaptive irrigation planning is key to mitigating the impacts of inconsistent water availability. Addressing these challenges through careful timing and allocation of irrigation, farmers can minimize losses and maintain soil quality, thereby ensuring more reliable harvests. These efforts, in turn, contribute to both food security and the preservation of environmental health. This paper reinforces the necessity of integrating scientific tools and methodologies into farming systems.

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