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Research Article

Supplemental Irrigation Water Management Using Rainwater Harvesting Basin for Improving Soil Fertility, Maize Yield and Water Productivity in Semi-arid Climate of Burkina Faso

Aime Severin Kima[1], Bene-Wende Bernice Sandwidi[2], Moussa Waongo[3], Bruno Barbier[4], Etienne Kima[5], Yu-Min Wang[6, *]

[1]Environment and Agriculture Research and Training Center of Kamboinsé, Environment and Agriculture Research Institute, Ouagadougou, Burkina Faso

[2]High School of Sustainable Development, Yembila Abdoulaye Toguyeni University, Fada N'Gourma, Burkina Faso

[3]Training and Research Department, AGRHYMET Regional Center, Niamey, Niger

[4]French Agricultural Research Centre for International Development, Ouagadougou, Burkina Faso

[5]Directorate of Irrigation, Ministry of Agriculture, Ouagadougou, Burkina Faso

[6]Department of Civil Engineering, National Pintung University of Science and Technology, Pingtung, Taiwan

Abstract

Last decades, rainwater harvesting basins are promoted in Burkina Faso for securing rain-fed agriculture. However, sustainable water management is highly desired and crucial for agriculture in erratic climatic conditions exacerbated by soil degradation. In order to pinpoint suitable water depth optimizing sustainably land and water productivity while improving and/or maintaining soil fertility, an experiment was implemented in Gomtoaga village at Koubri district during two consecutive rain-fed cropping seasons (2023 and 2024). The study tested three irrigation water depths (D50%, D75% and D100%), representing 50%, 75% and 100% of the maize crop evapotranspiration (ETc), against a control of D0% through a randomized complete block design in three replications. The compost was applied at a rate of 7.5 t/ha during tillage and fertilizer NPK (14:23:14) and urea (46%) were applied respectively 15th and 50th days after transplanting. Irrigation was applied at two days interval in case of no rain. When rain occurred, irrigation was postponed to the following interval. The results revealed that soil chemical properties were not significantly affected by water fluctuation. No change was observed in pH, organic matter (%), C (%), N (%), P (mg/kg), K (mg/kg) and the ratio C/N in water treatments when compared to D0%. While the application of 100% ETc improved microbial biomass from 50%, the water level of 75% Etc increased the release of CO_2 from almost 99%. The optimal water depth (D50%) exhibited the highest yield (≈ 5957 kg/ha) with an increase of 24% compared to other treatments resulting in the highest water productivity (17 kg/m^3) and the lowest irrigation cost (111 f cfa/kg of maize). We advocate farmers could adopt the compromise supplemental water level of 50% of ETc in rain-fed maize system as a water-wise tactic to secure sustainably the production when collecting rainwater surmounting drought spells in dry prone area.

*Corresponding author: wangym@mail.npust.edu.tw (Yu-Min Wang)

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Keywords

Supplemental Irrigation, Soil Fertility, Water Efficiency, Semi-arid Climate

1. Introduction

Maize is one of the most important crops, from Burkina Faso agriculture products, ensuring food security, famer's revenues and is vital for the country economy [1]. Maize is a critical driver of Burkina Faso's economy [2], serving as a principal food source [3]; it is the most marketed cereal and an important Cash flow creator for farmers [4]. Maize plays multifaceted and energetic role in global agri-food systems and food/nutrition security [5-8]. It is widely recognized as adapted crop for numerous agro-eco-systems [9]. Maize is a very adaptable plant and can be produced across diverse agricultural environments [10], but its productivity and stability depend heavily on practices like water and soil management [11]. The water scarcity mostly due to the deficit of rainwater presents great challenges and major obstacles to maize production. The maize crop production is facing various constraints such as the rainfall uncertainty [12, 13]. Frequent droughts affect 25% of the maize area [14] and caused about 39% reduction of maize yield [15] leading to an economic fallout from 9 to $1.5 billion [16]. Recently, rainwater harvesting basins are promoted through the use of supplementary irrigation as a sustainable strategy to overcome the deficit of rainfall for securing rain-fed agriculture ensuring then food security. Rainwater harvesting technique is unaffordable [17-19] and Irrigation plays a vital role in ensuring optimal maize yield [20, 21]. Supplemental irrigation emerges as a viable solution for stabilizing yield and optimizing land productivity [22].

In the actual land degradation context, the lack of rainfall cannot be addressed regardless to soil fertility. Among rain-fed agriculture difficulties, the degradation of soil fertility harms crop yield [23, 24]. The climate change has exacerbated these hurdles highlighting the request of wise irrigation water application minimizing ecological damage [25, 26].

Sustainable water management strategies should be defined and implemented considering soil fertility issues. Since the application of irrigation may induce nutrient leaching leading to the decline of soil fertility, finding suitable and the optimal supplemental water depth that may increase both waters use efficiency and yield while maintaining or improving soil fertility should be pinpointed and adopted for resilient agriculture. The excess or the decline of water exposes crops to stress resulting in poor nutrient uptake or losses and consequently decreases yield [27, 28]. Sustainable amount of water should be applied for increasing production and protecting environment [29, 30]. Efficient water management strategy is crucial in achieving optimal yield while saving water and protecting environment [31, 32]. Effective water management is imperative for maize crop productivity [29-33]. Kima et al suggested that balanced irrigation water depths may sustainably improve water productivity with less yield penalty [34].

Therefore, this study evaluates supplemental water levels for optimizing maize yield and water productivity while improving or maintaining soil fertility. It also appreciates the cost of irrigation supply for suggesting sustainable approach for rain-fed maize production.

2. Materials and Methods

2.1. Description of Study Area, Experimental Design and Water Management

Figure 1. *Sketch of Rainwater Harvesting Basin Implemented in the Experimental Site.*

The trial site (latitude 12.08 N, longitude 1.24 W) was located at Gomtoaga village in the District of Koubri, Central Burkina Faso. The ten last year average of rain ranged from 400 and 800 mm. The average of maximum and minimum temperatures was 17℃ and 36℃ respectively. Rainwater harvesting basin (Figure 1) was installed at 10 m from the trial and served for collecting for irrigation. The experiment was conducted during two consecutive years (2023 and 2024) of rain-fed cropping season from June to October. The design was a randomized complete block in three replications. Three supplemental water depths (D100%, D75% and D50%), representing respectively 100%, 75% and 50% of maize crop water requirement (ETc) respectively, were field-tested against D0% which was the control plots where the maize crop was exclusively grown under rain-fed conditions. The water depths were randomly assigned in each plot.

2.2. Irrigation Water Calculation

Twenty years (from 2003 to 20222) meteorological data from the experiment site, retrieved from FAO WAIPOR data base, were employed using the standard FAO Penman-Monteith formula to estimate reference evapotranspiration (ETo) by running CROPWAT 8.0 software. The maize water requirement (ETc) was obtained using single crop coefficient (Kc). Kima et al suggested that for irrigation scheduling, single Kc is suitable [25]. The water requirement at each growth stage was calculated according to equation (1):

$$ETci = ETo \times Kci \quad (1)$$

ETci stands for crop water requirement (mm) at each growth stage; i represents the growth stages (initial, development, reproductive and final stages); ETo is the reference evapotranspiration (mm); Kci is the crop coefficient at different stages given by FAO 56- Penman-Monteith.

In this study, the soil stress coefficient was not considered in estimating crop water requirement. In supplemental irrigation, water can be just adjustable to find out suitable depth [27-34]. Since water was pumped from basin and directly applied in furrows, the irrigation efficiency was supposed to be 1 so that the applied water depths for each irrigation were equal to 50%, 75% and 100% ETci in each treatment.

2.3. Soil Sampling and Analysis

Soil samples were collected, at the depth of 0.20 m, from the experimental site before and after the two-year experiment and analyzed in the laboratory to characterize the soil initial status and evaluate eventual changes induced by the treatments. Before implementing the experiment, soil was sampled following diagonals and medians methods. At the harvest, samples were taken in each plot.

Chemical (pH, Organic Mater, Carbon Nitrogen, the ration C/N, Potassium and Phosphorus) and microbial (microbial biomass, microbial activity) properties were analyzed. Soil pH was determined using standard approach of AFNOR [35]. OM and C were determined through Walkley and Black methods [36]. Kjeldahl et al methods performed by spectrophotometer were used to quantify N and P [37]. The fumigation-extraction method described by Jenkinson and Powlson [38] served to measure microbial biomass and activity. The soil sample was first fumigated with $CHCl_3$ vapor. The $CHCl_3$ was then extracted and the soil was incubated. The soil biomass was obtained by calculating the difference between the amounts of CO_2 evolved in the incubation by fumigated and unfumigated soil.

2.4. Crop Management

The Barka variety of maize cultivation practices package recommended by the national research institute was utilized and served as the base of all crop management tasks such as tillage, sowing, compost and fertilizer application, pest and disease control and weeding.

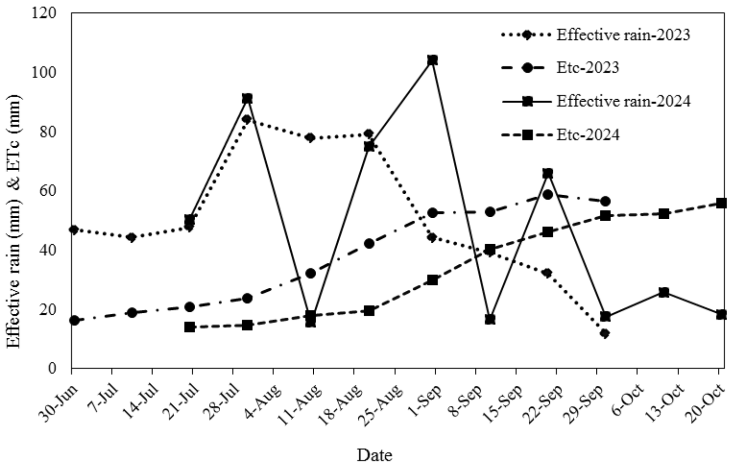

Figure 2. *Effective Rain and Maize Water Requirement (ETc) During the Cropping Season.*

Land was manually tilled at 0.15 m depth and compost was applied at the rate of 7.5 t/ha a week before sowing. Plots were then leveled and maize seeds were sown, at a spacing 0.80 between rows and 0.40 between plants, depending on rainfall occurrence with indicates the beginning of rainy season. For the first season, sowing was done on June 28 in 2023 and the harvest occurred on September 26. During the second season, seeds were sown on July 23 in 2024 and maize was harvested on October 20. Fifteen days after sowing (DAS) fertilizer NPK (14:23:14) was applied at a rate of 150 kg/ha. 100 kg/ha of urea (46%) was applied at 50 DAS. Pests were intensively controlled with EMACOT pesticide and weeding was hand made with a hoe when needed. Plants were irrigated through the furrow and water was directly applied using a connected pipe with water meter. The plots were watered at two days interval in absence of rain; the irrigation was postponed to the next following two days when rain occurred as defined as and suggested in semi-arid rain-fed agricultural systems by [27]. During the experiment period, the effective rain (obtained through the USDA method), could not fulfilled the crop water requirement especially from the reproductive stage to the harvest (Figure 2).

2.5. Measurement of Agronomic Parameters and Water Efficiency

After seeds emergence, tree plants per row except those in edges with a total of 12 plants per plot were selected and marked for the analysis of agronomic parameters. Growth parameters such as leave number, plant height and stem diameter were determined at 30th, 45th and 60th days after sowing. Leaves were counted individually and the number was obtained. Plant height was measured from the base to the tip of highest leave. The stem diameter was determined using caliper.

At harvest, yield components (ears weight per plant and grain weight per ears) and yield were assessed on the same selected 12 plants. The ears were cut, separated from the straw, and let dried. Ears were hand threshed and grains weight was adjusted to 14% of humidity. Ears and grain weight were obtained using electronic scale. Grain yield was estimated using the following formula:

$$GY = GW \times 625 \quad (2)$$

GY is the grain weight expressed in kg/ha; GW is the grain weight in g while 625 is the correction factor.

The irrigation water productivity (kg/m^3) was determined dividing the grain yield by irrigation water used [33]. Since the agricultural water price is not precise and uniformed across Burkina Faso, in this study the irrigation cost was calculated multiplying the total amount of irrigation water (m^3) by the official drinking water cost (1104 f cfa per m^3) considering the relation gain-losses defined by [22].

2.6. Statistical Analysis

The statistical analysis of variance was performed by using the SPSS 18 software (IBM, Armonk, New York, United States). The difference between treatments was observed using Duncan's test at 95% level of confidence.

3. Results

3.1. Effect of Treatments on Soil Properties, Microbial Biomass and Activity

Tables 1 and 2 exhibited the effect of treatments on soil pH, organic matter and carbon. The statistical analysis revealed no significant difference between treatments. The application of different amount of irrigation water or not did not affect soil properties after two years when compared with initial soil.

The results of the effect of irrigation water levels on soil nitrogen, phosphorus, potassium and the ration C/N are summarized in Table 2. No significant different was observed through the statistical analysis. The fluctuation of water levels did not affect above mentioned properties across the consecutive two-year growing seasons.

Table 1. *Effect of Treatments on Soil pH. Organic Matter and Carbon at 0-20 cm Soil Layer.*

Treatments	**pHeau**	**OM (%)**	**C (%)**
Initial soil	6.85 ±0.00	1.27 ±0.01	0.73 ±0.01
D0%	6.50 ±0.44	1.34 ±0.13	0.77 ±0.07
D50%	6.86 ±0.77	1.15 ±0.06	0.67 ±0.03
D75%	7.35 ±0.69	1.13 ±0.14	0.65 ±0.08
D100%	7.43 ±0.32	1.14 ±0.06	0.66 ±0.03
Probability	0.71	0.49	0.49

Treatments	pHeau	OM (%)	C (%)
Signification	ns	ns	ns

Legend: OM (%): organic matter content; C (%): organic carbon content. Initial soil: soil before experimentation; D100%: compost + 100% of water requirements; D75%: compost + 75% of water requirements; D50%: compost + 50% of water requirements; D0%: Compost under strict rainfall conditions. ns: non-significant difference
ns: non-significant difference

Table 2. *Effect of Treatments on Nitrogen, Phosphorus, Potassium and the C/N Ratio at 0-20 cm Soil Layer.*

Treatments	N (%)	Total P (mg/kg)	Total K (mg/kg)	C/N
Initial soil	0.07±0.01	340.69±8.89	2287.48±267.19	10.91±1.64
D0%	0.08±0.01	282.30±9.32	2177.29±286.48	9.06±0.26
D50%	0.07±0.01	318.60±55.62	2133.22±122.69	9.94±1.77
D75%	0.07±0.01	284.21±42.03	2155.25±198.33	9.35±0.98
D100%	0.06±0.00	238.91±21.41	2023.02±132.22	10.73±0.21
Probability	0.7	0.3	0.93	0.75
Signification	ns	ns	ns	ns

Legend: N (%): nitrogen content; C/N: ratio of organic carbon content to nitrogen content; Total P: Total phosphorus in mg/kg; Total K: Total potassium in mg/kg; Initial soil: soil before experimentation; D100%: compost + 100% of water requirements; D75%: compost + 75% of water requirements; D50%: compost + 50% of water requirements; D0%: Compost under strict rainfall conditions. ns: non-significant difference

The influence of different water treatments on soil microbial biomass and activity is presented in Table 3. Treatments significantly affected globally microbial respiration and biomass. The increases of supplemental water depth up to 100% of ETc shoot up the biomass and the respiration when compared to initial soil. The highest biomass was registered in treatment D100% while the great activity was recorded in both D75% and 100%. The application of D100% increased biomass from 72% and 29% as opposed to the initial soil and the average of D0%, D50% and D75% respectively. However, the supply of D75% lead to an augmentation of 159% and 38% in microbial respiration in comparison with the initial soil and the average of D0% and D50% subsequently.

Table 3. *Effect of Treatments on Biomass and Microbial Activity at 0-20 cm Soil Layer.*

Treatments	Microbial biomass (mg/100g of soil)	Microbial CO2 release (mg/100 g of soil)
Initial soil	14.48±0.57c	9.75±0.40c
D0%	18.46±0.57b	17.08±0.65b
D50%	19.59±0.57b	19.72±1.27b
D75%	19.96±0.57b	25.30±0.83a
D100%	24.95±0.57a	23.61±1.08a
Probability	0.0001	0.0001
Signification	***	***

Legend: Initial soil: soil before experimentation; D100%: compost + 100% of water requirements; D75%: compost + 75% of water requirements; D50%: compost + 50% of water requirements; D0%: Compost under strict rainfall conditions;
***: very highly significant difference.

3.2. Effect of Treatments on Growth Parameters

The growth parameters, such leaves number, plant height and stem diameter, as influenced by the water treatments are highlighted in Figure 3. Different irrigation levels significantly affected the two-year average values of growth parameters at 30 and 45 days after sowing. Lowest values of leaves number (Figure 3a) and stem diameter (Figure 3c) were observed under rain-fed conditions at both two growth stages. On the other hand, lowest plant height (Figure 3b) was recorded in highest water amount. The increase of supplement irrigation level up to 75% of ETc rise growth parameters followed by a reduction at 100% ETc. The number of leaves and the stem diameter increased respectively from 10% and 9% followed by a decline of 4% and 6%. A diminution of 7% in plant height was observed as well.

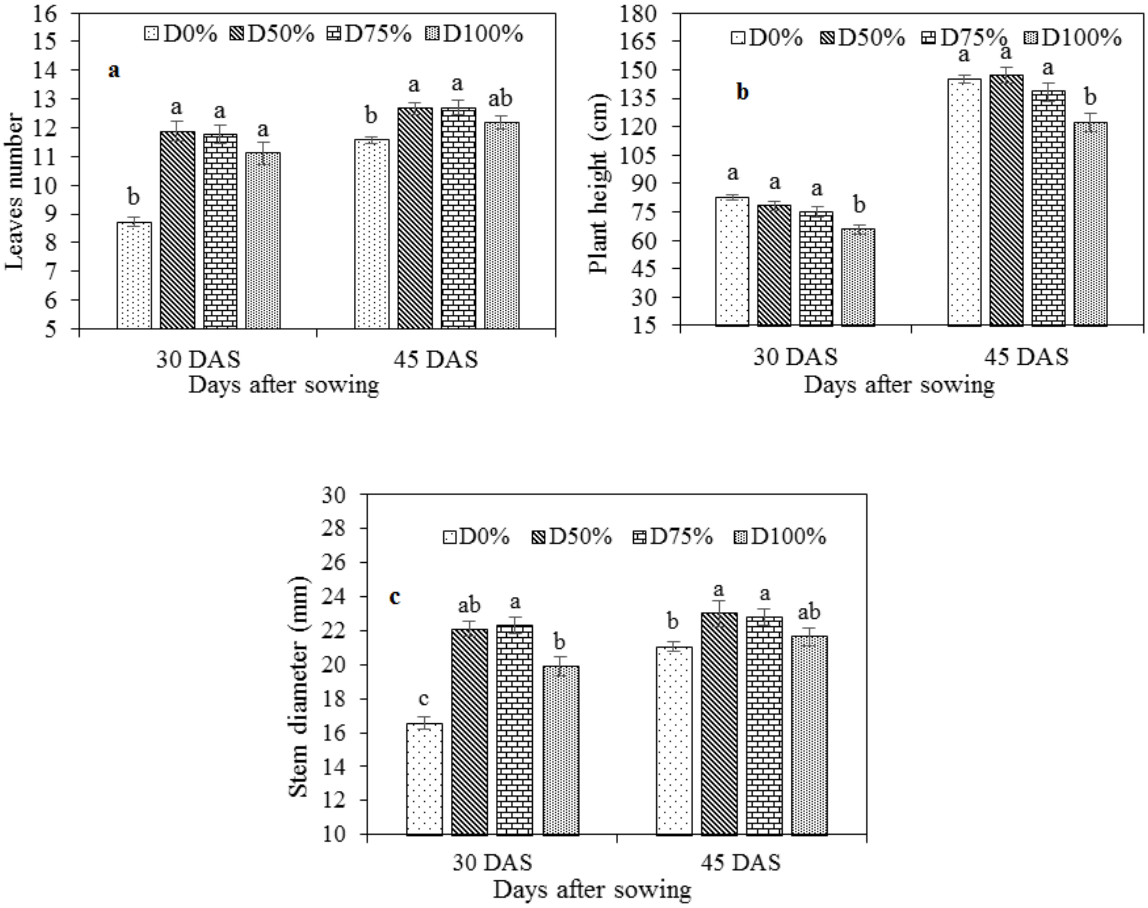

Figure 3. *Effects of Water Treatments on Leaves Number (A), Plant Height (B) and Stem Diameter (C).*

3.3. Yield Components and Yield Response to Treatments

Table 4. *Effect of Treatments on Dry Ear Weight Per Plant and Grain Weight Per Ear.*

Treatments	Weight of dry ears/plant (g)			Grain weight per ear (g)		
	2023	**2024**	**Average**	**2023**	**2024**	**Average**
D0%	88.58 ±4.60	79.74 ±6.85 [b]	84.51 ±4.02	71.34 ±3.82	61.08 ±5.10 [b]	66.61 ±3.16 [a]
D50%	95.29 ±6.02	92.33 ±6.31 [ab]	93.90 ±4.33	76.87 ±5.05	65.22 ±5.33 [b]	71.51 ±3.70 [a]
D75%	82.37 ±4.76	106.19 ±5.62 [a]	93.65 ±3.88	65.20 ±3.90	81.16 ±4.71 [a]	72.76 ±3.15 [a]
D100%	92.95 ±5.97	109.25 ±5.00 [a]	100.57 ±4.03	72.26 ±4.70	84.83 ±3.78 [a]	78.14 ±3.13 [a]

Treatments	Weight of dry ears/plant (g)			Grain weight per ear (g)		
	2023	2024	Average	2023	2024	Average
Probability	0.35	0.002	0.051	0.32	0.001	0.104
Signification	ns	**	ns	ns	**	ns

Legend: Initial soil: D100%: compost+100% of water requirements; D75%: compost+75% of water requirements; D50%: compost+50% of water requirements; D0%: compost without irrigation
**: Difference highly significant (p< 0.001)
ns: non-significant difference

The results summed up in Table 4 illustrated the impact of the variation of water volume on maize yield components. Water levels influenced ear weight and grain weight per ear depending on the year. No statistical difference was observed in 2023 while the treatments significantly affected yield components in 2024. The rain-fed treatment and the lowest water application resulted in lower values in 2024; the augmentation of water level increased the weight of ear and the grain weight from 25% and 31% respectively. However, on average no difference was underlined throughout the two years.

The fluctuation of water level significantly affected maize yield over the two years (Table 5). In 2023, the greatest yield was obtained under D50% while D100% exhibited the best one in 2024. The application of 50% of ETc usually yielded the highest production. On average, an increase of 28% and 19% was perceived when compared to D0% and D75%.

***Table 5**. Effect of Treatments on Grain Yield.*

Treatments	Grain yield (kg/ha)		
	2023	2024	Average
D0%	5349.74 ±305.39^{b}	3817.85 ±319.28^{b}	4644.26 ±236.41^{c}
D50%	7561.58 ±504.85^{a}	4076.78 ±333.68^{b}	5956.74 ±369.87^{a}
D75%	4944.00 ±293.10^{b}	5072.91 ±294.58^{a}	5005.06 ±206.76^{bc}
D100%	5929.16 ±405.41^{b}	5302.08 ±236.47^{a}	5635.98 ±243.70^{ab}
Probability	0.0001	0.001	0.003
Signification	***	**	**

Legend: D100%: compost+100% of water requirements; D75%: compost+75% of water requirements; D50%: compost+50% of water requirements; D0%: compost without irrigation
**: Difference highly significant (p< 0.001)
***: Very highly significant difference (p< 0.0001)

3.4. Effect of Treatments on Water Productivity

***Table 6**. Effect of Treatments on Irrigation Water Productivity.*

Treatments	Water productivity (kg/m^3)			Irrigation water cost (f cfa/kg of maize)		
	2023	2024	Average	2023	2024	Average
D0%	-	-	-	-	-	-

Treatments	Water productivity (kg/m^3)			Irrigation water cost (f cfa/kg of maize)		
	2023	2024	Average	2023	2024	Average
D50%	17.28 ±1.15^a	16.45 ±1.35^a	16.90 ±0.87^a	93.63 ±17.01^a	130.89 ±41.52	110.82 ±21.16^a
D75%	5.65 ±0.33^b	10.08 ±0.58^b	7.75 ±0.41^b	237.05 ±20.87^{ab}	127.63 ±9.71	185.22 ±13.41^{ab}
D100%	4.51 ±0.30^b	7.19 ±0.27^c	5.77 ±0.25^b	442.09 ±149.26^b	160.27 ±6.77	310.33 ±80.70^b
Probability	0.0001	0.0001	0.0001	0.021	0.584	0.016
Signification	***	***	***	*	*	*

Legend: D100%: compost+100% of water requirements; D75%: compost+75% of water requirements; D50%: compost+50% of water requirements; D0%: compost without irrigation.
***: Very highly significant difference (p< 0.0001)

The results in Table 6 demonstrated that the effects of water levels were significant and impacted the efficiency of water use during the two consecutive years. The application of D50% displayed the highest water productivity with an increase of 150% in comparison with the average of D100% and D75%; in addition, lessening the irrigation water cost from 180% and 67% in contrast with D100% and D75% respectively.

4. Discussion

In this study, the fluctuation of supplementary irrigation water affecting soil fertility, maize crop growth, yield components and yield was scrutinized to optimize the use of water and secure sustainably rain-fed production in dry prone area.

In the two-year span, the variation of supplemental irrigation water level from 0% ETc to 100% ETc, at the interval of 50%, did not distinctly impact soil properties including pH, organic matter, carbon, nitrogen, ratio C/N, phosphorus and potassium. The two-year duration was certainly not sufficient to detect noticeable shifts in soil nutrients status since the same amount of compost was applied in all plots. Without the application of organic matter, Dessie et al observed over two years that different water regimes induced nitrate runoff with severe impact in higher irrigation level [31]. Bowles et al mentioned that availability of soil moisture improved nutrient uptake by plants [39]. In addition, the study pointed up that P and K are more sensitive to water levels. Wang et al also noticed water amounts affected both soil and wheat plant nitrogen content [40]. The soil nitrogen content and its uptake by wheat depends on both water flows and the amount of applied fertilizer [41].

The application of the compost may have hidden and/or delayed changes in soil chemical properties due to probably leaching induced by irrigation regimes. Long-running assessment may be required to perceive the incidence of water levels fluctuation on soil chemistry indicators. Rasool et al suggested multi-years monitoring to capture real changes in soil chemistry [42]. Fadl et al emphasized that long-term irrigation has increase soil organic carbon and the stocks of nitrogen [43].

The study indicated a distinct linkage between supplemental water levels and soil microbial biomass as well as microbial respiration. The gain of microbial biomass is analogous to watering strategy. Increasing irrigation regimes up to 100% ETc substantially contributed to higher microbial biomass. Optimal soil moisture content produced by increased watering may have been favorable to the development of micro-organisms resulting in a peak of biomass. Soil moisture is fundamental for microbial life. It enhances nutrient and substrate movement. It also supports nutrient cycling that stimulates microbial activity. Optimal soil moisture levels are conducive to a greater diversity and abundance of microbial communities, leading to more robust and functional ecosystems [44]. The microbial quantity, heterogeneity and community structure is strongly correlated to irrigation [45-50]. Kumar et al argued that soil microbial biomass carbon increased when increasing irrigation frequency likely due to the availability of nutrient induced by the presence of water [51]. However, the microbial respiration maintained a peak at 75% ETc indicating that beyond a certain level addition water has adverse effect on microbial activity. The optimal water level of 75% ETc may have created ideal moisture and oxygen conditions for microbial processes in breaking down organic matter into essential plant nutrients. Surpassing that level may have inhibited and/or suspended microbial metabolism triggering a decline of CO_2 release. Water levels affected nitrogen cycling [52] and excessive water impeded oxygen diffusion since the microbial process is attenuated in water than in air [53, 54].

The application of optimal irrigation of 75% ETc has simultaneously influenced plant growth when creating well-watered conditions for microbial activity. The increase of water up to that level has surged growth parameters such as leaves number, stem diameter and plant height. Optimizing irrigation is crucial for maize plant [55, 56] and can foster the growth and the development by supplying optimal water and nutrients [31]. Previous studies highlighted that adjusting irrigation up to optimal levels can create suitable soil moisture conditions, ensuring thereby efficient nutrients absorption [57, 58].

In 2023, the effective rain was higher than the crop water requirement during a long period inhibiting the effect of water restriction on yield components. Since yield components are sensitive to water stress at early grain filling stage, the high fluctuation of effective rain in 2024 affected the weight of ears and grain. Water stress induced at repining stages differently affected yield components at harvest [27, 59]. Although no significant difference appeared in the two-year period average values of ear and grain weight, the application of 50% of ETc yielded the highest production and water productivity while diminishing the cost of irrigation. The supply of D50% may have make available appropriate amount of water and accessible nutrients leading to effective absorption by plant. Maize yield is regulated by a various factor including water and extractable nutrients [60, 61] and a compromise between water application and nutrients leaching is decisive for increasing both production and water productivity [62, 25]. Irrigation management considering optimal water depth is strongly correlated with the increase of production and water productivity [63-67].

5. Conclusion

The study spotlights the concern of optimizing irrigation for maintaining soil fertility, sustaining maize yield and water use efficiency, while increased supplemental water depth improved microbial biomass and microbial activity, optimal irrigation led to higher yield and greater water use efficiency with lowest irrigation cost, underlining the necessity for balanced irrigation tactic to strengthen sustainably production and water use. The application of supplemental water at 50% ETc level optimized maize yield and water consumption while maintaining soil fertility. We claim that the supplemental irrigation level of 50% ETc could be implemented and adopted country-wide as a sound strategy to secure sustainably rain-fed maize production when collecting rainwater to overcome dry spells in semi-arid climate conditions.

Abbreviations

Etc	Crop Evapotranspiration
Eto	Reference Evapotranspiration
Kc	Crop Coefficient
D0%	Compost Under Strict rainfall Conditions
D50%	Compost + 50% of Water Requirements
D75%	Compost + 75% of Water Requirements
ns	Non-Significant Difference
D100%	Compost + 100% of Water Requirements
DAS	DAYS After Sowing
GY	Grain Yield
GW	GRAIN Weight
NPK	Nitrogen, Phosphorus, Potassium
OM	Organic Matter
C	Carbon
N	Nitrogen
P	Phosphorus
K	Potassium
C/N	Carbon/ Nitrogen
NS	No significant Difference
FAO	Food and Agriculture Organization of the United Nations
WAIPOR	Water Productivity Open-Access Portal
FCFA/Kg	Francs CFA per kilogram

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Author Contributions

Aime Severin Kima: Conceptualization, methodology, data curation, formal analysis, software, validation, visualization, Writing – original draft, Writing – review & editing

Bene-Wende Bernice Sandwidi: Data collection, Writing – review & editing

Moussa Waongo: Writing – review & editing

Bruno Barbier: Writing – review & editing

Etienne Kima: Writing – review & editing

Yu-Min Wang: Validation, visualization, Writing – review & editing.

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Data Availability Statement

Data cannot be made publicly available; readers should contact the corresponding author for further details.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research field

Aime Severin Kima, Agriculture, Hydraulic, Hydrology, Irrigation, Agricultural hydraulic, Water management.

Bene-Wende Bernice Sandwidi, Agriculture, Hydraulic, Hydrology, Irrigation, Soil fertility, Water management.

Moussa Waongo, Agriculture, Hydrology, Agrometeorology, Water management.

Bruno Barbier, Water management, Agricultural economics and natural resource management, Irrigation.

Etienne Kima, Agriculture, Hydraulic, Hydrology, Irrigation, Agricultural hydraulic, Water management.

Yu-Min Wang, Agriculture, Hydraulic, Hydrology, Irrigation, Agricultural hydraulic, Water management.