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Performance Evaluation of Irrigation and Soil Moisture Retainer on Soil Conditioning, Growth and Yield of Tomato and Sweet Corn

S. Idris[1], L.J. Bamaiyi[2] and A. Abdulkadir[1]

[1]Department of Soil Science, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University, 1044 Samaru, Zaria, Nigeria

[2]Department of Crop Protection, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University, 1044 Samaru, Zaria, Nigeria

Correspondence Author's Email: sanidris2000@gmail.com; saniidris@abu.edu.ng

ORCID: https://orcid.org/0000-0002-7206-9889.

Abstract

This trial tested the effectiveness of Soil Moisture Retainer (SMR) product on improvement of soil conditions, tomato and sweet corn performances alongside different irrigation levels in order to identify the promising rates and levels. The experiment was conducted in two phases involving Padma tomato and Sugar-75 sweet corn varieties. Using the recommendations of the product, trials were set up in an experimental site situated in the Faculty of Agriculture, Ahmadu Bello University Zaria, which falls under northern guinea savanna agroecology. Atmospheric temperature and relative humidity recorded during the course of the research were 23 – 39.5°C and 10 – 28 %, respectively. Irrigation and SMR factors at 100 %, 75 % and 50 % levels and 0.00, 1.00, 2.00 mL and 3.00 mL m $^{-2}$ rates, respectively, were laid out in a randomized complete block design. Soil temperature, soil moisture and relative humidity were monitored and recorded in-situ and growth and yield variables of the test crops were measured. Statistical analyses outputs were generated using R software. According to the results, 2.00 and 3.00 mL m $^{-2}$ SMR rates indicated promising potential for improving soil moisture, soil temperature, growth and yield performances of the crops. Although 100 % irrigation level demonstrated best performance, 75 % level competed well, hence can serve as a water-saving alternative to 100%, especially in areas of acute water deficit or severe water demand competitiveness due to its comparable crop performance.

Keyword: Soil Water Retainer; Irrigation; Water; Climate resilience and water-saving.

Introduction

Tomato is an important member of *Solanaceae* whose fruit is one of the highly sought-after commodities, being a principal ingredient in several dietary recipes across locations and cultures (Olabisi and Nofiu, 2022; Gao *et al.,* 2023; Zeleke *et al*., 2024). Industrially, tomato seed which has about 25 % oil content is being used in the production of margarine and soap (Shakirat *et al*., 2025). Tomato, botanically referred to as *Lycopersion esculentium* serves 19.1 % of the vegetable consumption need in Nigeria (Babadara *et al*., 2023) and its production and processing line brings huge financial inflow, employing more than 3 million people in the country (Shakirat *et al*., 2025; Indexbox 2025; FAO, 2019).

Tomato thrives in diverse ecological settings and wide landscape designs, thus successfully grown in wetlands, plains and high hills (Idris, 2020; Abolusoro *et al*. 2014). For tomato to flower and produce optimally, it requires a minimum of 6 hours solar irradiance, 16-34 °C temperatures, and deep sandy loam, loam or sandy clay loam soils (Jaliya *et al*. 2016; Olabisi and Nofiu, 2022; Shakirat *et al*., 2025). Sweet corn (*Zea mays saccharata* L.) is a horticultural crop that is less popular in Nigeria, but with promising future due to increasing demand, courtesy of its dietary and nutritional value. Sweet corn, also referred to sugar corn provides instant energy, hydration and appetite due to its high sugar (46.1 %), moisture (72.7 %), carbohydrate (81.2 %), and protein (14.5 %) contents (Johari and Kaushik 2016; Ekka, and Verma, 2023). Its fresh kernel harvested at milky stage is eaten after boiling or roasting (Ekka, and Verma, 2023). Similar to maize, sweet corn prefers a deep, light textured soil (sandy loam, loam to clay loam) that is well-drained, and humus-rich (Fagge *et al*., 2023).

Production of the two crops (tomato and sweet corn) especially irrigation-based is likely to be challenged by water issue. This is because increasing water shortage specifically in the tropics is one of the topmost crop production challenges (Abu and Habib, 2018; Ibrahim *et al*. 2020; Idris and Yahaya, 2022; Nwokocha *et al*., 2023). According to Abu and Abdulkadir *et al*. (2018), crop production is the highest water-demanding activity, world-over. Idris *et al*. (2024) averred that climate-related realities typically frequent drought, unnoticed dryspell and non-uniform distribution and limited amount of rainfall further intensify water shortfall effect. Of recent, spatial expansion of crop production and its extensity as well as population surge amplify the agricultural and municipal freshwater demands in Nigeria (Worldometer, 2025; Thomas, 2025; Maiyaki *et al*., 2018). This necessitates the need for novel ways of managing soil water and optimizing its productivity in crop production. One way to achieve that is through application of soil conditioners, which have the potentials of improving soil water availability, alongside other hydro-physical variables which eventually cascades to better yields (Habib and Abu, 2018; Ibrahim *et al*., 2020). Shinde *et al*. (2019), defines soil conditioning as the application of practices or materials objectively to improve crop yields and soil functions. In essence, materials used to condition soil are contextually termed as soil conditioners (SC). SCs may be of organic or inorganic origin, and their examples include straws, stalks, peat moss, alluvial deposits, zeolites, lime, polymer materials and industrial by-products (Shinde *et al*., 2019; Liu *et al*., 2024). Largely, SCs are materials of negligible nutrient value but with remarkable ability to positively impact soil physical, biological and structural systems which enhance soil stability, aeration, permeability, resilience and thermodynamic properties. For example, Legese *et al*. (2024) characterized unmodified natural zeolite to have a water absorbance capacity of 57 %; swelling ratio of 2.12 g g^{-1} and an average water retention percentage of 94.14 %.

Habib and Abu (2018) reported that, AQUASORB® (a hydrophilic mineral polymer with characteristic water absorbance) improved soil hydro-physical properties by 10-22 %; enhanced crop water use efficiency by 7.09 % and increased grain yield of maize by 24.6 %. Similarly, Veldkamp (2023) found SC formulations applied at 2.35 L ha $^{-1}$. to have increased soil moisture retention by 9.51 %. Liu *et al*. (2024) observed yield improvement with biomass ash conditioner. The above studies showed that, addition of SCs have a multiplier effect which totaled to more productive soil functioning.

Despite the fact that Nigeria is endowed with vast surface and subsurface hydrologic resources, spatial and temporal distribution skewness limit water availability in the study area which affects agricultural crop production. Furthermore, increase in temperature which represents all-time high in the last 3 years (2023, 2024, 2025) put additional evaporative pressure on the water resources. This informed why this research focuses on soil water conservation measures. The research consisted of two open-field experiments conducted to assess the performance of a SC (Soil Moisture Retainer (SMR) product and different irrigation regimes on soil water improvement and crop productive performances. Soil Moisture Retainer is a viscous liquid that is characteristically brown. It has a viscosity of 1.32 ± 0.1 kg/dm^3; 70.0 m/m% dry material content; and 56.00 m/m% organic material content manufactured for addressing water shortage challenges. Consequently, alternate hypotheses were formulated as follows: application of SMR product significantly affects soil moisture content and crop growth and yield performances; different irrigation levels (IRL) significantly affect soil moisture content and crop growth and yield performances. In tandem with the hypotheses, the research targets to answer the following questions: does application of SMR improves soil water status and crop growth and yield? Which among the three candidates of the SMR rates (0.00 1.00, 2.00 and 3.00 mL m $^{-2}$) is the best or optimum for improving soil water availability and crop growth and yield? Does different irrigation levels affects soil water status and crop growth and yield?

2.0 Materials and Methods

2.1 Experimental Site

The research was executed in a mini research garden of the Faculty of Agriculture, Ahmadu Bello University, with the longitudinal and latitudinal coordinates of 11°9’55’’N 7°37’56’’E to 11°10’49’’ and 7°36’20’’E (Fig. 1). During the experiment, (December, 2024 to March, 2025) the recorded atmospheric temperature raged 23–39.5 ℃ and relative humidity of 10–28%.

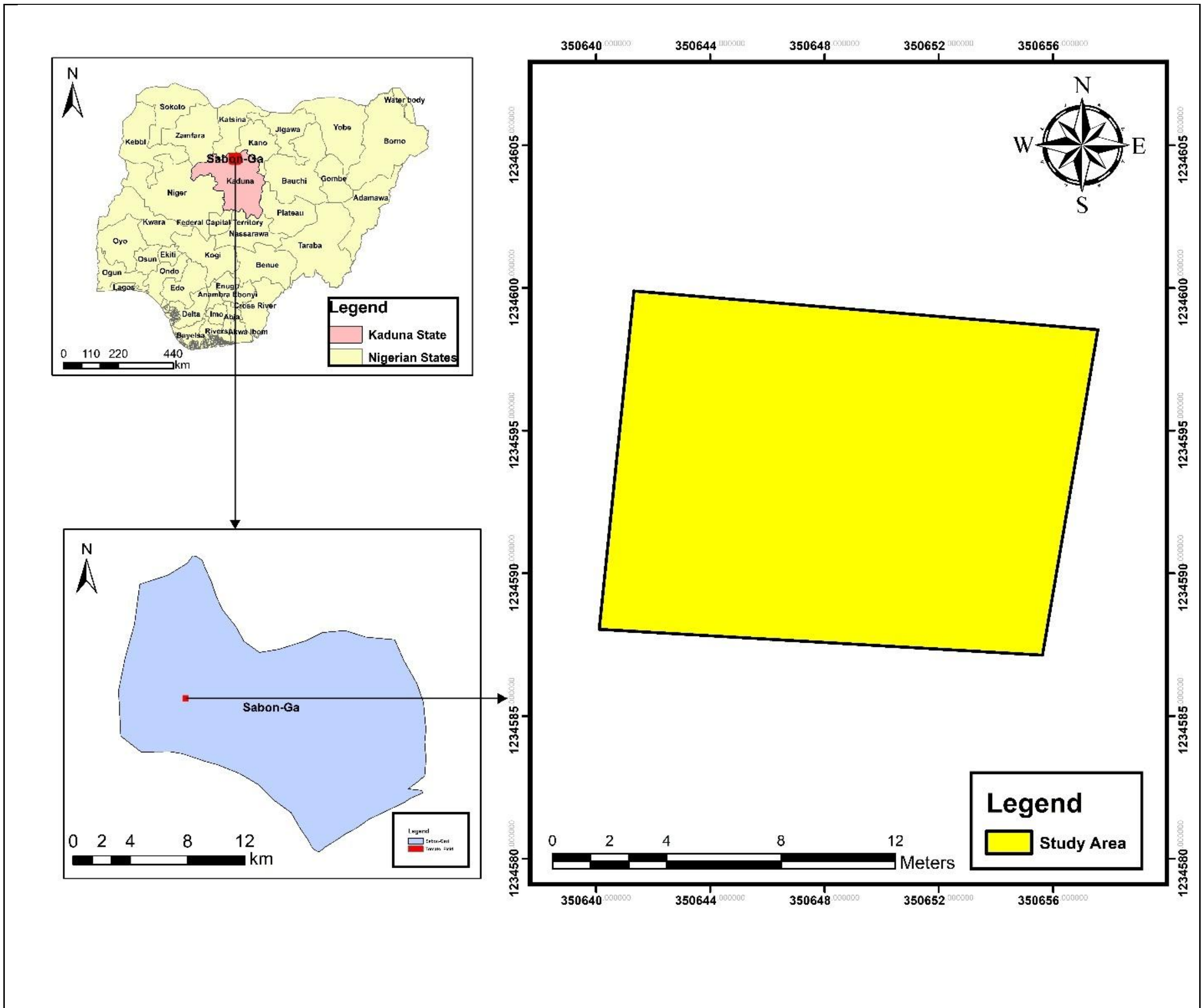


Figure 1: The study area in a cluster map indicating the State (pink), local government (sky blue) and the study location (yellow), agro-ecologically situated in Northern Guinea savannah.

2.3 Nature of the Experiment, Layout and Treatment Imposition

The trial is a two-phase experiment that considered the effects of irrigation levels and SMR rates on tomato and sweet corn crops, separately. The experiment tested two treatment factors -irrigation (three levels) and soil moisture retainer (four rates) using the completely randomized block design in a spilt plot layout. The irrigation levels (100%, 75%, 50%) were imposed in the main plot, while SMR rates (0.0, 1.0, 2.0 and 3.0 mL) were imposed in the sub-plot. Each treatments plot was replicated three times.

2.4 Field Marking out, Preparation and Transplanting

In the first experiment (tomato), 14-days old seedlings of Padma tomato variety were transplanted at 50 x 50 cm spacings. In the second experiment, 14-days old seedlings of Sugar-75 sweet corn variety were transplanted at 1 seedling per hole and 4 seedlings per ridge at 40 x 90 cm intra and inter row spacings. In both experiments, only healthy and vigorous seedlings were transplanted and adequate daily crop water requirement was supplied for seven days after transplanting until full establishment was attained, before transitioning to various irrigation levels.

2.5 Weed and Pest Management and Fertilizer Application

First and second weeding were done manually at 3 and 6 weeks after establishment. White flies and *Tuta absoluta* emergence were noticed in experiment 1, and was managed using SUN-LAMBDA chemical at a rate of 200 mL ha^{-1} and Ampligo at a constitution rate of 1 sachet per knapsack. Both were applied two times to ensure optimum control. Upon persistence of *Tuta absoluta,* Ememectin and Tihan pesticide brands were applied. Nutrient demand was satisfied by applying 200 kg ha^{-1} of NPK 15:15:15 in two split doses for experiment 1 and 120 – 60 – 60 kg ha^{-1} NPK 15:15:15 and urea for experiment 2.

2.6 Data Collection and Analysis

Soil data measurements were carried out in-situ using portable meters. ThetaProbe – HH2 moisture meter (Delta – T Device model), HTC – 2 digital hygrometer and multi-thermometer MEXTECH were used to measure soil moisture content, relative humidity and soil and ambient temperatures, respectively. Plant height, and stem girth, biomass weights and number of leaves were measured with the help of 5m-Hua Nan Power tape, sensitive weighing balance and through hand counting, respectively. Data analysis was performed using R 4.2.3 (2025) following data curation. Data were analyzed by ANOVA and mean separation was performed using Tukey's HSD at 5% probability. All graphical presentations were generated using OriginPro 2025 software.

Results

Experiment One

3.0 Tomato Growth and Yield Indicators

According to Table 1., range for the different irrigation levels (IRL) were 7.25 to 11.7 for number of fruits, 12.00 to 18.99 g $fruit^{-1}$ for fruit weight, 56.37 to 86.40 g $plant^{-1}$ for total biomass and 17.52 to 21.51 cm for root length. 100 % IRL recorded the best performance in number of fruits, fruit weight and biomass outputs, while 50 % deficit contrastingly became the lowest. Furthermore, 100 % irrigation regime was 26.3 %, 10.5 %, and 21.2 % greater in the mentioned yield parameters compared to 75 % IRL, respectively. Among the three IRL, only 50 % deficit compromised root development, by causing 18.5 % reduced root length compared to the rest.

With respect to the SMR, ranges of 6.88 – 12.88 number of fruits, 14.02 – 18.35 g $fruit^{-1}$ fruit weight, 59.86 – 80.13 g $plant^{-1}$ total biomass and 15.97 - 23.55 cm root length were recorded. 2.00 mL SMR outcompeted the other rates, especially in the number of fruit and total biomass. 3.0 mL demonstrated a close competition by having a statistical similarity with the 2.00 mL in fruit weight and total biomass but recorded 31.1 % lesser number of fruits. Additionally, root of the tomato under 3.00 mL was 11.6 % shorter than those under 2.00 mL.

Table 1. Effects of Irrigation and Soil Moisture Retainer on Selected Crop Growth Parameters

Treatment	No. Fruit	Fruit Weight g plant $^{-1}$	Total Biomass g plant $^{-1}$	Root Length cm
Irrigation				
100 %	11.75a	18.99a	86.40a	21.508a
75 %	8.66b	17.01b	68.08b	20.041a
50 %	7.25b	12.00c	56.37c	17.52b
SE±	0.826	0.462	2.652	0.634
Soil Moisture Retainer				
0.00 mL	6.88b	14.84b	59.86c	15.97d
1.00 mL	8.22b	14.02b	67.25bc	18.41c
2.00 mL	12.88a	17.5ab	80.133a	23.55a
3.00 mL	8.88b	18.35a	73.88ab	20.82b
SE±	0.954	2.804	3.0633	0.732
Interaction				
I x SMR	*	**	*	*

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$. I = irrigation, SMR = soil moisture retainer and SE = standard error, * and ** = significance at 5 and 1% probability level, respectively.

Plant height index demonstrated a significant variability across the IRL and SMR treatments in week 3, 6, 9 and 12. Tomato subjected to 100 %, 75 % and 50 % IRL had a final height of 39.1, 35.7 and 27.7 cm, respectively. 100 % IRL consistently exceeded the rest and was seconded by 75 % IRL. For the SMR, Table 2 indicated that 0.00, 1.00, 2.00 and 3.00 mL m^{-2} recorded respective final height of 33.6, 33.9, 37.1, and 32.2 cm. 2.00 mL was the best candidate reaching the highest tallness, 12.2% greater than the other rates

Table 2. Effects of Irrigation and Soil Moisture Retainer on Plant Height (cm) over the Growing Period

Treatment		Plant Height	(cm)	
	Week 3	Week 6	Week 9	Week 12
Irrigation				
100 %	18.20a	21.79a	37.00a	39.10a
75 %	16.30b	19.0b	30.66b	35.72b
50 %	13.44c	16.27c	25.49c	27.73c
SE±	0.534	0.515	0.781	0.678
Soil Moisture Retainer				
0.00 mL	15.33b	19.07a	28.38c	33.55b
1.00 mL	15.47b	18.35a	28.93c	33.92b
2.00 mL	17.64a	20.02a	34.94a	37.08a
3.00 mL	15.46b	18.64a	31.04b	32.17b
SE±	0.617	0.594	0.902	0.7830
Interaction				
I x SMR	ns	ns	ns	ns

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$. I = irrigation, SMR = soil moisture retainer and SE = standard error.

Stem girth (SG) mean value of tomato under 100, 75 and 50 % IRL stood at 5.51, 4.45, and 5.21 cm, respectively (Table 3). The parameter under the different IRL depicted a slight increase from week 3 to week 9, but shoot up in week 12. 100 % and 75 % demonstrated statistical similarity at week 3, 6 and 9 but differed significantly at week 12 when 100 % IRL outcompeted the 75 % IRL by 19.2 % increase. On the other hand, all the SMR rates showed statistical similarity throughout the experiment in terms of SG with a mean final value of 5.12 cm.

Table 3. Effects of Irrigation and Soil Moisture Retainer on Stem Girth (cm) over the Growing Period

Treatment		**Stem Girth**	**(cm)**	
	Week 3	Week 6	Week 9	Week 12
Irrigation				
100 %	3.24a	3.28a	3.56a	5.51a
75 %	3.25a	3.16a	3.39ab	4.45b
50 %	2.97b	3.10a	3.29b	5.20a
SE±	0.079	0.945	0.0703	0.173
Soil Moisture Retainer				
0.00 mL	3.31a	3.38a	3.45a	5.24a
1.00 mL	3.26a	3.28a	3.30a	4.72a
2.00 mL	3.22a	3.47a	3.71a	5.11a
3.00 mL	3.19a	3.98a	3.20a	5.14a
SE±	0.091	0.762	0.811	0.210
Interaction				
I x SMR	*	ns	ns	ns

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$. I = irrigation, SMR = soil moisture retainer and SE = standard error.

Table 4 shows that IRL treatment ranged from 102.37 to 144.75 in number of leaves. According to the results, significantly highest number of leaves was observed in crops under 100 % IRL which was consistently followed by a clear trend of 75% > 50% IRL in all the weeks. From week 3 to week 9, 0.00 mL and 2.00 mL outperformed other SMR rates, but, at week 12, 0.00 mL dropped to the lowest. Consequently, 2.00 mL produced 17.14 % more leaves than 3.00 mL at week 12.

Table 4. Effects of Irrigation and Soil Moisture Retainer on Number of Leaves over the Growing Period

Treatment	Number of Leaves			
	Week 3	Week 6	Week 9	Week 12
Irrigation				
100 %	53.66a	70.75a	79.91a	144.75a
75 %	38.75b	64.50b	70.25b	111.5b
50 %	27.5c	47.75c	63.75c	102.37c
SE±	1.127	1.281	1.281	3.452
Soil Moisture Retainer				
0.00 mL	41.44a	63.0a	72.77a	109.77c
1.00 mL	36.11b	60.44ab	69.33a	111.66b
2.00 mL	40.55a	63.44a	70.23a	140.00a
3.00 mL	41.77a	57.11b	72.88a	116.72b
SE±	2.001	1.942	1.471	3.9863
Interaction				
I x SMR	***	ns	ns	**

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$, SE = standard error, I = irrigation, SMR = soil moisture retainer, *, ** and *** = significant at 5, 1 and 0.1% probability level

Based on the obtained results, number of flowers were, 5.0, 3.2, and 3.0 for 100 %, 75 % and 50 % IRL, respectively. As per SMR, 0.00, 1.00, 2.00 and 3.00 mL m^{-2} recorded 3.5, 3.4, 4.4, and 3.2 average number of flowers, respectively (Table 5). The crop entered flowering phase in week 6 which proceeded up to week 12. However, the flower production has not demonstrated a steady pattern. While 100 % IRL and 2.00 mL SMR produced highest number of flowers in week 6, 75 % IRL and 3.00 mL SMR recorded the highest flower production at week 9. 2.00 mL SMR was only statistically higher than 3.00 mL at week 3.

Table 5. Effects of Irrigation and Soil Moisture Retainer on Number of Flowers over the Growing Period

Treatment	Number of Flower			
	Week 3	Week 6	Week 9	Week 12
Irrigation				
100 %	0.00	6.75a	6.42a	1.42ab
75 %	0.00	3.41b	5.17b	1.08b
50 %	0.00	1.83c	4.70c	2.50a
SE±	-	0.593	0.366	0.006
Soil Moisture Retainer				
0.00 mL	0.00	3.44b	4.88a	2.11a
1.00 mL	0.00	3.22b	5.44a	1.66a
2.00 mL	0.00	5.77a	5.85a	1.66a
3.00 mL	0.00	3.55b	4.88a	1.22a
SE±	-	0.684	0.423	0.544
Interaction				
I x SMR		ns	ns	ns

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$. I = irrigation, SMR = soil moisture retainer and SE = standard error.

According to Table 6, the number of fruits at week 12 were 4.52, 3.33 and 4.66 for 100, 75 and 50 % IRL, respectively, whereas SMR treatment showed a range of 4.33 to 5.66. The number of fruits indicated no statistical difference among the various SMR rates at week 9 and 12. The IRL only differed in the number of fruits at week 12 where 50 % IRL got the highest by 29.9 % over 100 %. Likely, the fruit setting in 50 % IRL was physiologically hastened in response to extreme water stress.

Comparing the flowers and fruits produced in Week 6 and 9, respectively, a huge abortion representing 62.5 % occurred. This resulted from severe *Tuta absoluta* infestation which was painstakingly handled resulting in fruit setting in week 12, albeit not satisfactory. The infestation was a pandemic that affected many tomato-producing area in Nigeria (NAN, 2025).

Table 6. Effects of Irrigation and Soil Moisture Retainer on Number of Fruits over the Growing Period

Treatment		**Number of Fruits**		
	Week 3	Week 6	Week 9	Week 12
Irrigation				
100 %	0.00	0.00	1.83a	4.50ab
75 %	0.00	0.00	1.08a	3.33b
50 %	0.00	0.00	1.50a	4.66a
SE±	-	-	0.343	0.561
Soil Moisture Retainer				
0.00 mL	0.00	0.00	1.00a	4.33a
1.00 mL	0.00	0.00	1.33a	4.55a
2.00 mL	0.00	0.00	1.77a	5.66a
3.00 mL	0.00	0.00	1.77a	4.44a
SE±	-	-	0.396	0.532
Interaction				
I x SMR	-	-	ns	ns

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$, SE = standard error, I = irrigation, SMR = soil moisture retainer

3.1 Soil Variables

Under IRL regimes, soil moisture ranged from 14.42 to 19.81 % and soil temperature was from 17.8 to 25.3℃. The level of moisture retained and temperature modified by each treatment depicted significant variations as contained in Table 7. Result for 100 % IRL exhibited the highest moisture level, while plots treated with 2.00 mL and 3.00 mL SMR demonstrated best moisture retention capability compared with the control and 1.00 mL. Temperature variable was comparably lower in 100 % IRL and in 2.00 and 3.00 mL relative to other IRL and other SMR rates, respectively. This implied that 2.00 and 3.00 mL have proven promising in moisture retention and temperature modification performances which probably led to better performances of the crops.

Table 7. Effects of Irrigation and Soil Moisture Retainer on Soil Moisture and Temperature

Treatment	Soil Moisture (%)		Soil Temperature (°C)	
	December	January	December	January
Irrigation				
100 %	19.11a	19.80a	17.83c	25.33b
75 %	17.10b	16.65b	19.45b	24.43ab
50 %	14.42c	14.43c	21.00a	25.33a
SE ±	0.298	0.4219	0.230	0.506
Soil Moisture Retainer				
0.00 mL	15.04b	16.21b	20.82a	24.77a
1.00 mL	15.19b	16.11b	19.69b	24.16a
2.00 mL	17.77a	17.85a	18.15c	20.03b
3.00 mL	17.89a	17.66a	18.33c	20.10b
SE±	0.344	0.487	0.266	0.667
Interaction				
I x SMR	ns	ns	ns	ns

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$. I = irrigation, SMR = soil moisture retainer and SE = standard error.

Experiment two

3.2 Sweet corn Growth and Yield Indicators

For the IRL factor, plant height variable was 109 to 131 cm, and it took a trend better illustrated as 100 % > 75 % > 50 % IRL (Fig. 4). Root length values across IRL ranged from 15.26 to 18.29 cm, with 100 % and 50 % demonstrating statistical similarity. The root elongation observed in 50 % IRL is likely a coping strategy to water stress, since highly stressed crops prioritize root extension for water scouting. SMR treated plots had a mean of 119.5 cm at week 12 and 2.00 and 3.00 mL took a consistent pattern of plant height greatness throughout the experiment (see Fig. 3). All SMR rates have statistical similarity in term of number of leaves averaging 7.67 and 13.13 in week 4 and week 12, respectively. Furthermore, SMR rates showed a range of 14.13 to 18.27 cm root length. As presented in Fig. 5, 0.00 mL, 1.00 mL and 2.00 mL were statistically identical and had the longest root compared to 3.00 mL by 16.96 %. Total biomass data across IRL ranged 225 to 361 g plant $^{-1}$ and was highest in 100 % IRL and comparatively lowest in 50 % IRL (–37.7 %) as in Fig. 6. This informs that, 50 % water deficit had remarkably impacted negatively on the biomass output. The 100 % IRL sustained the performance greatness in cob diameter, cob weight and cob length, followed by 75 %. According to the Fig. 6 results, SMR depicted a narrow range of 276.00 to 301.00 g plant $^{-1}$ and a mean of 290.1 g plant $^{-1}$ of total biomass. 2.00 mL outshined other rates in total biomass by being higher than 3.00 and 1.00 mL by 10.00 % and 8.31%, respectively.

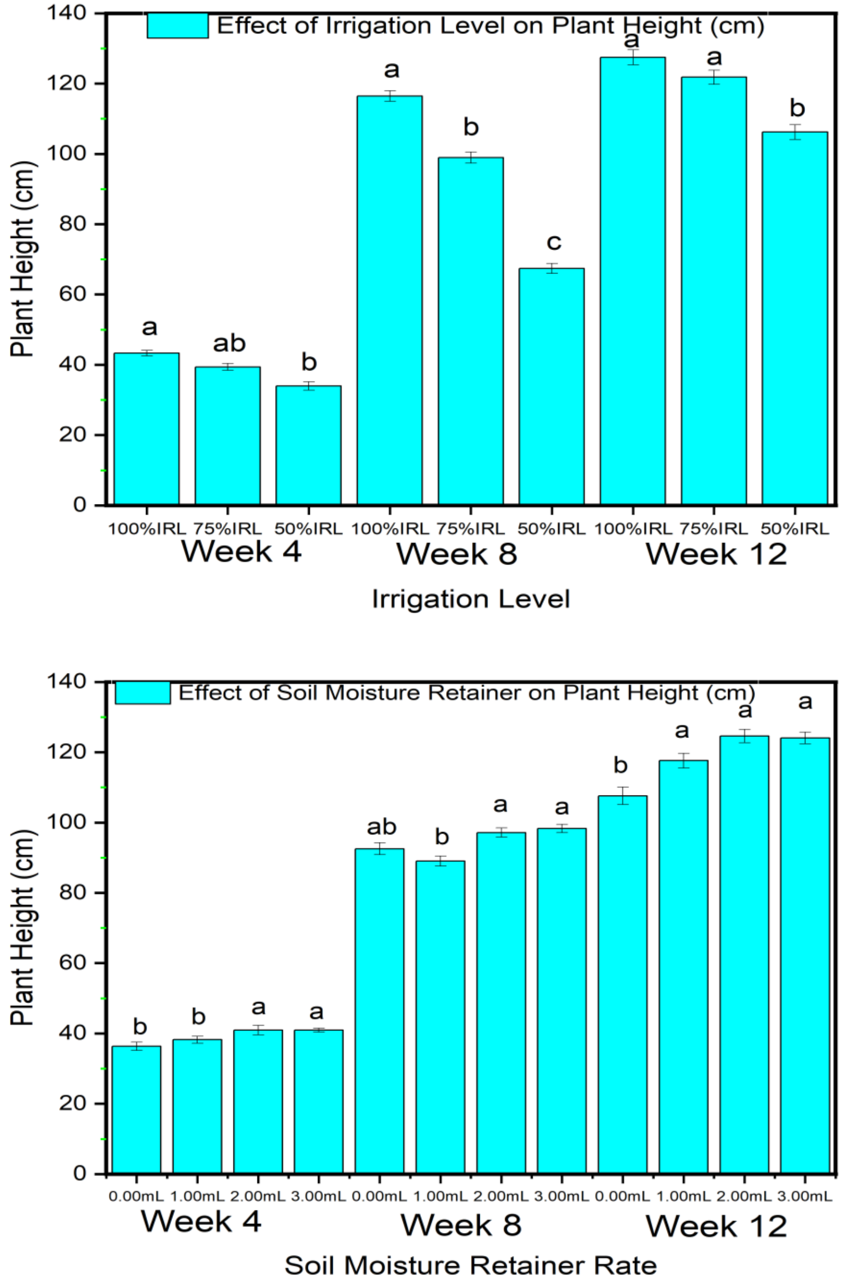


Figure 4.: Effects of irrigation level and Soil Moisture Retainer on Plant Height over the Growing Period

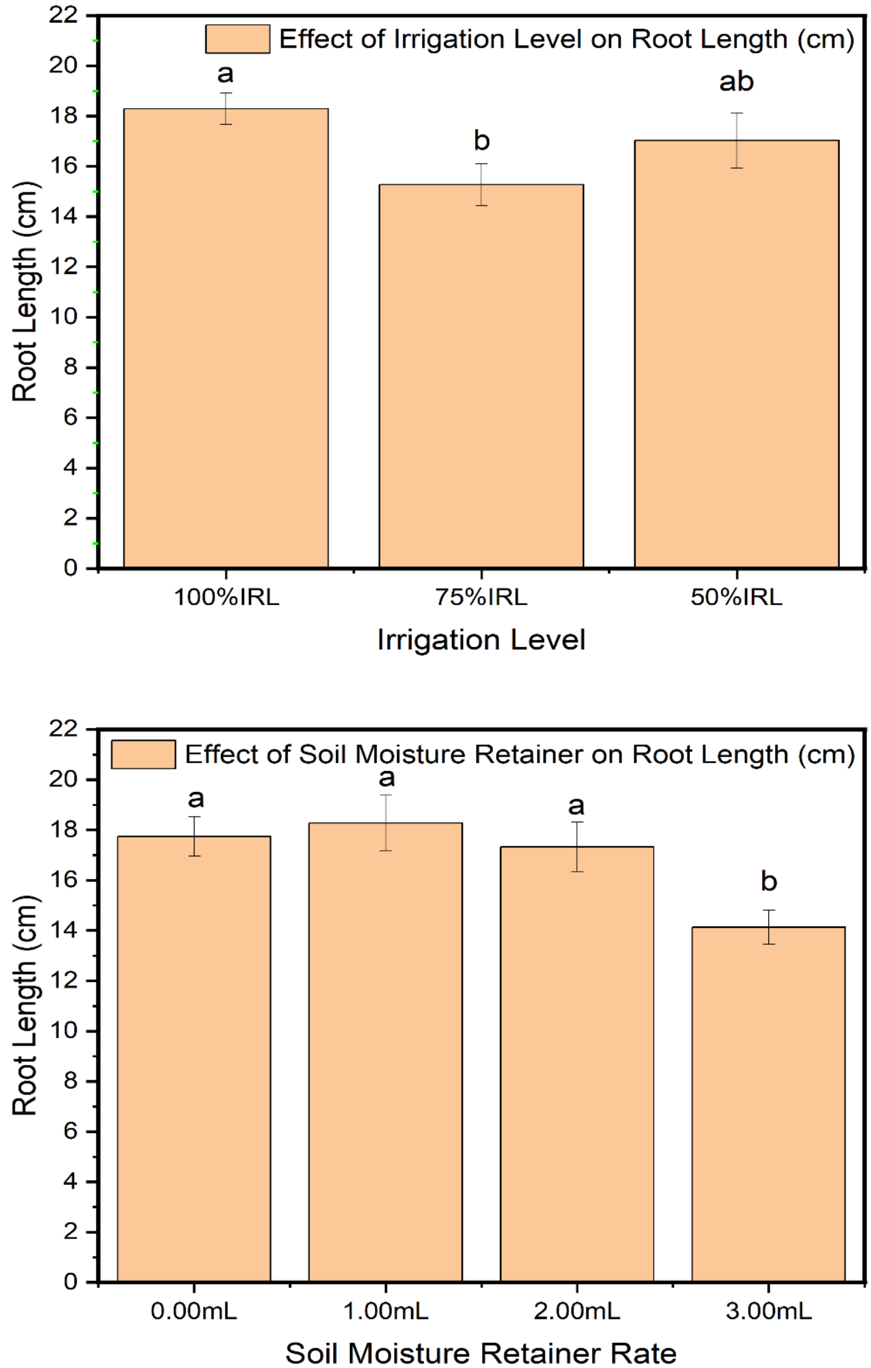
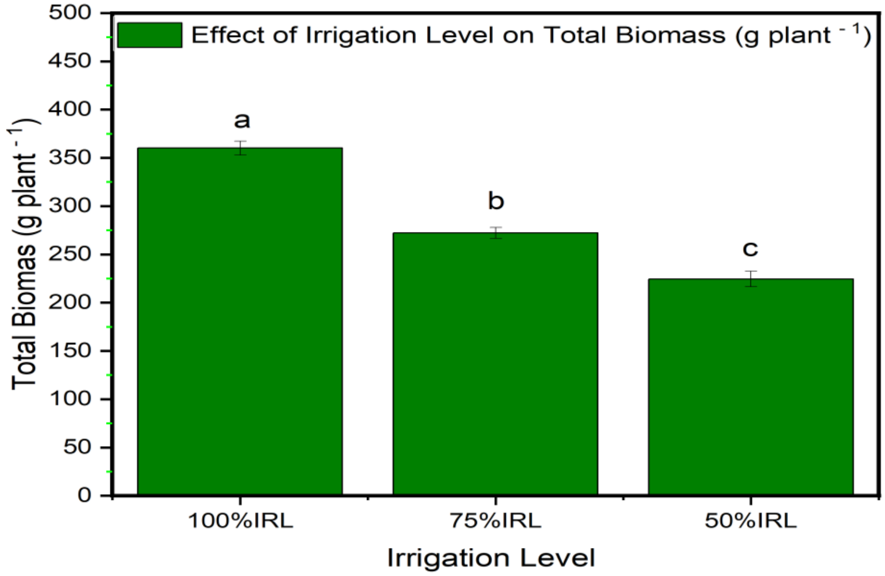


Figure 5.: Effects of Irrigation and Soil Moisture Retainer on Root Length



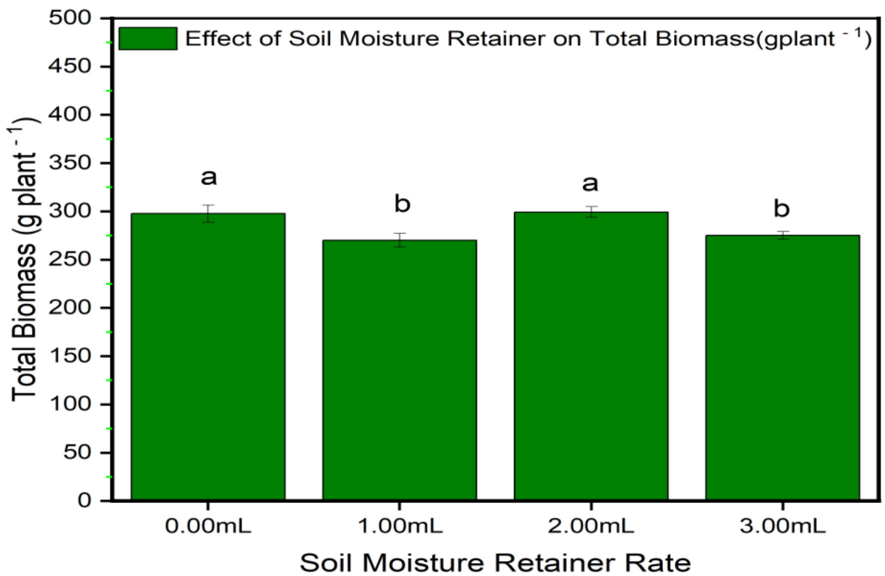


Figure 6.: Effects of the Irrigation and Soil Moisture Retainer on Total Biomass (g plant $^{-1}$)

Cob diameter variable (Fig. 7), cob weight (Fig. 8) and cob length (Fig. 9) parameters were significantly affected by IRL and had range values of 9.4 – 10.8 cm, 262 – 363 g plant $^{-1}$, and 20.6 – 22.3 cm, respectively. 100 % IRL outperformed 75 % and 50 % IRL in the three parameters. Similarly, the SMR performances varied in the three cob characteristics with 2.00 mL recording highest in cob diameter (10.7 cm), cob weight (324.3 g plant $^{-1}$), and cob length (21.7 cm). Yield parameters showed interesting results, where

2.00 and 3.00 mL produced cobs with the highest diameter and weight suggesting how the rates caused optimum support for bigger and well-filled cobs development. In contrast, cob length and stem girth were not influenced by SMR thus indicated similarity across the rates as in Table 9. Total number of cobs has not shown significant variation in both treatments with a mean value of 2.00 for each IRL and SMR (Table 10). This fundamentally indicates that, number of cob is a function of genetic composition.

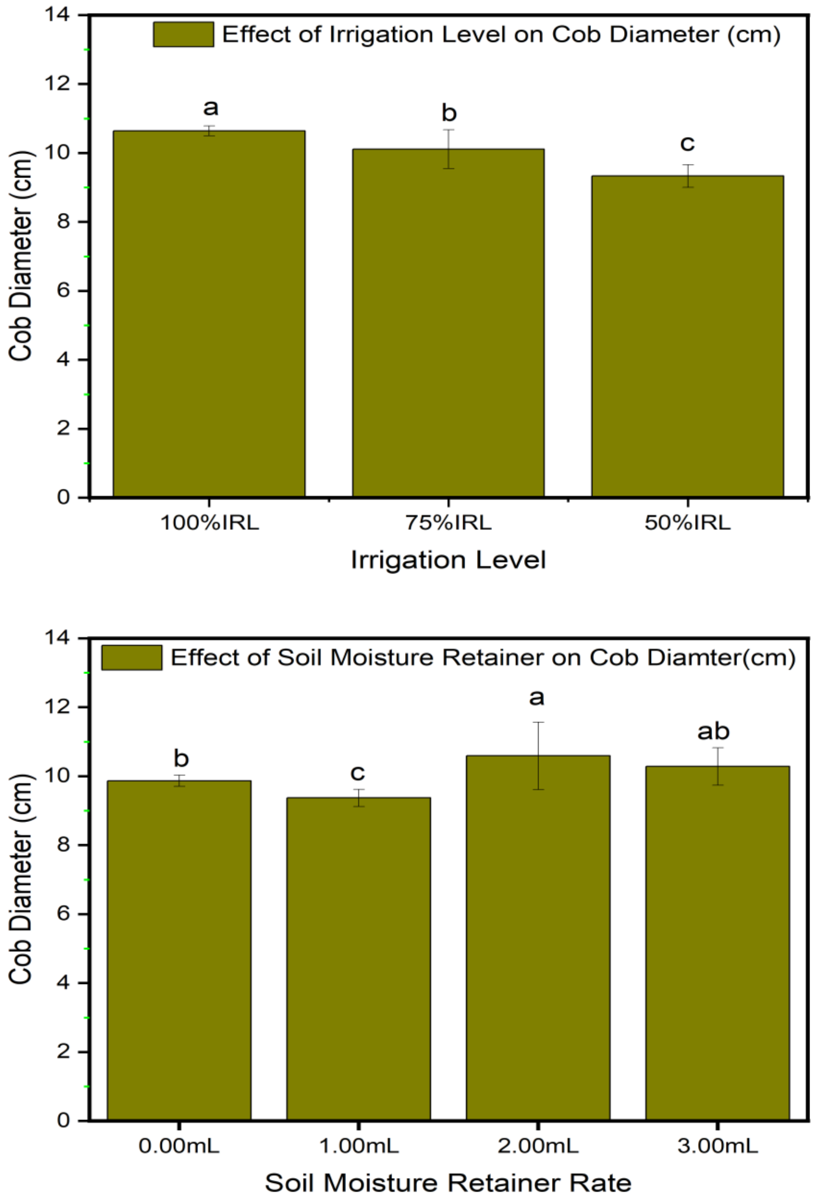


Figure 7.: Effects of the Treatments on Cob Diameter Parameter

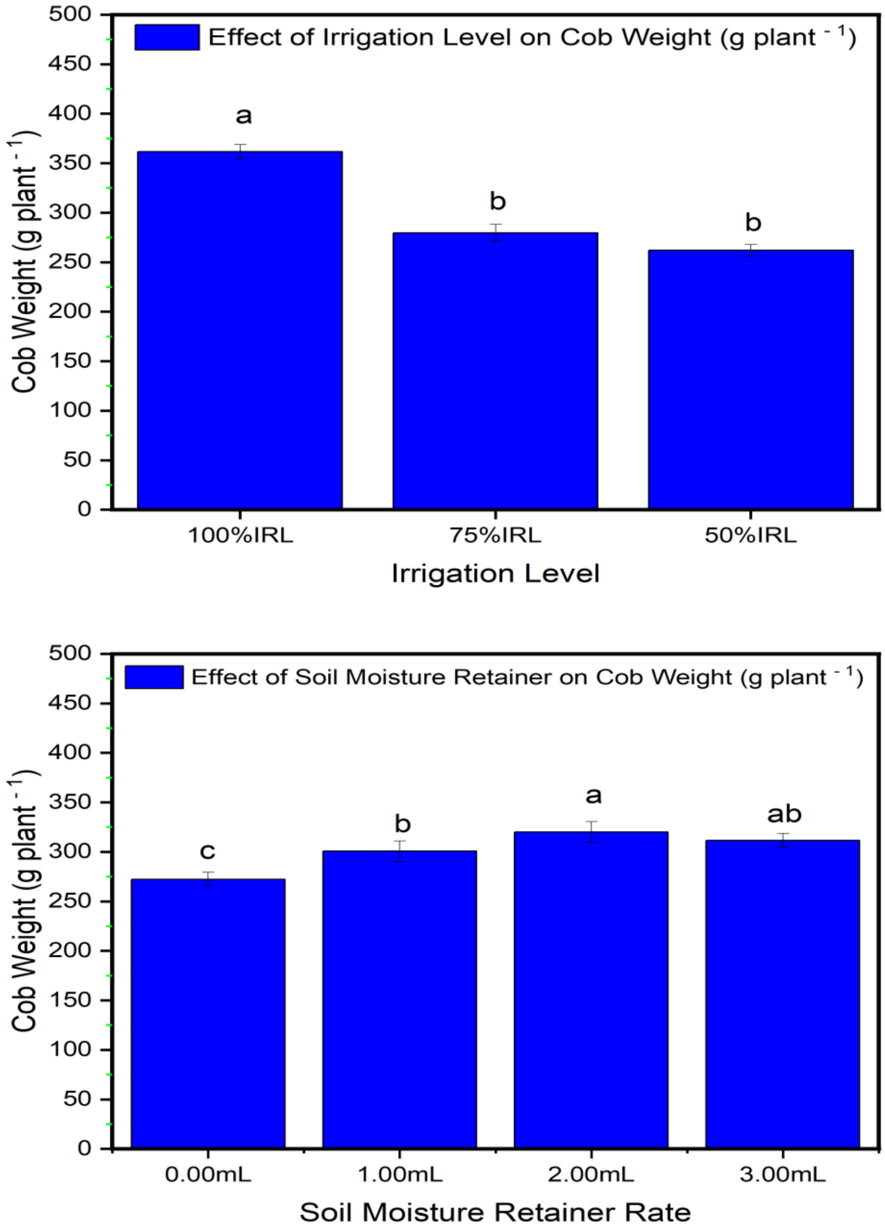


Figure 8.: Effects of the Treatments on Cob Weight Parameters

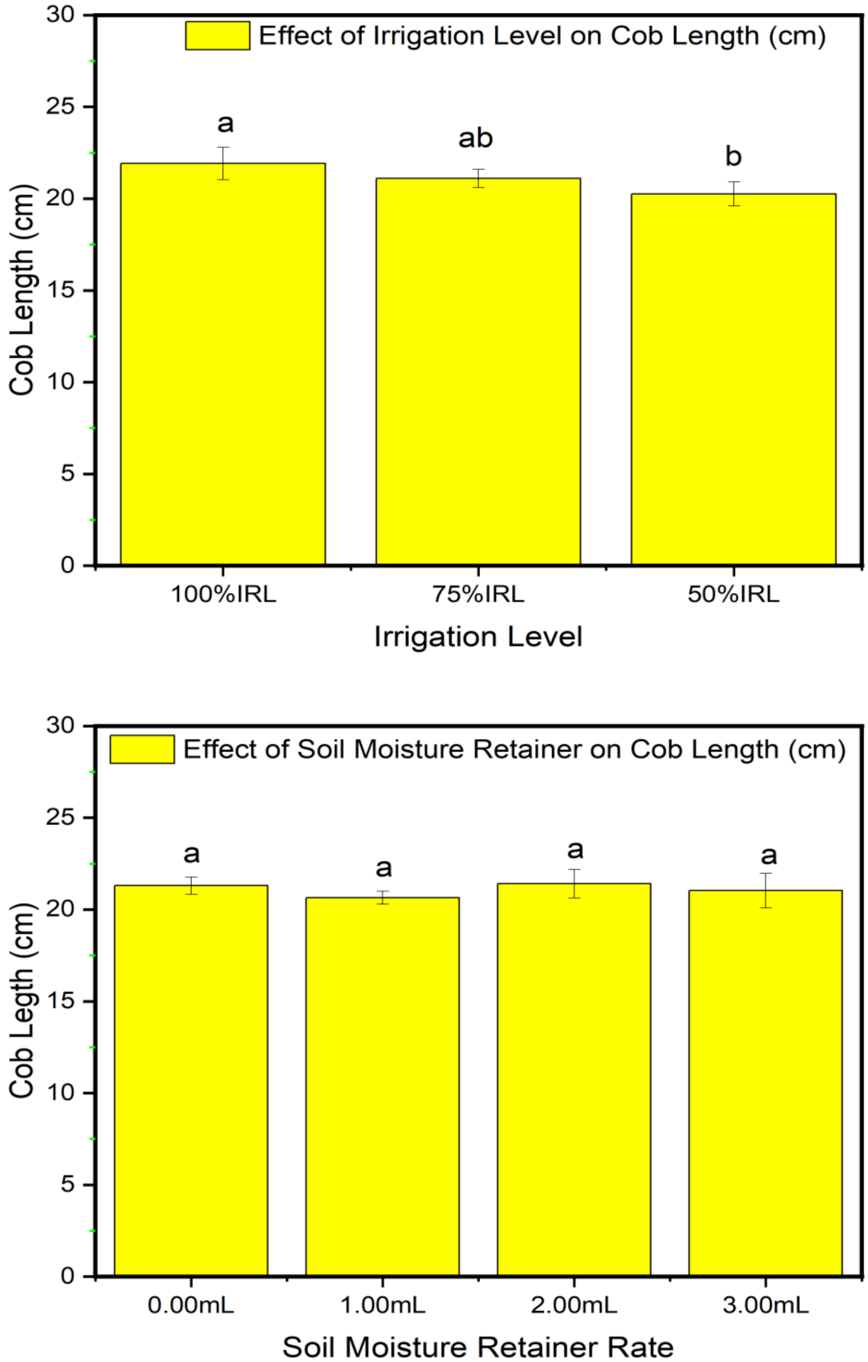


Figure 9.: Effects of Irrigation and Soil Moisture Retainer on Cob Length

Table 8. Effects of Irrigation and Soil Moisture Retainer on Stem Girth (cm) over the Growing Period

Treatment	Stem Girth (cm)		
	Week 4	Week 8	Week 12
Irrigation			
100 %	6.96	16.14b	16.14b
75 %	6.88	16.12b	16.12b
50 %	7.42ns	18.20a	18.20a
SE ±	0.997	0.989	
Soil Moisture Retainer			
0.00 mL	7.22	17.32	17.32
1.00 mL	7.12	16.16	16.61
2.00 mL	6.96	17.41	17.41
3.00 mL	7.01ns	16.40 ns	16.40 ns
SE±	0.16	0.669	0.674
Interaction			
I x SMR	ns	ns	ns

Means bearing the same letter are column-wise per treatment not significantly different at $P \leq 0.05$ and ns = not significantly different at $\alpha \leq 0.05$, I = irrigation, SMR = soil moisture retainer

Table 9. Effects of Irrigation and Soil Moisture Retainer on Number of Leaves over the Growing Period

Treatment	Number of Leaves		
	Week 4	Week 8	Week 12
Irrigation			
100 %	7.83	14.50a	14.51a
75 %	7.83	14.25a	14.25a
50 %	7.58ns	10.66b	10.66b
SE ±	0.722		0.369
Soil Moisture Retainer			
0.00 mL	7.55	12.44	12.44
1.00 mL	7.33	12.88	12.88
2.00 mL	8.11	13.66	13.66
3.00 mL	8.00ns	13.55ns	13.55ns
SE±	0.866	0.426	0.426
Interaction			
I x SMR	ns	ns	ns

Means bearing the same letter column-wise per treatment are not significantly different at $P \leq 0.05$ and ns means not significantly different at $\alpha \leq 0.05$, I = irrigation, SMR = soil moisture retainer

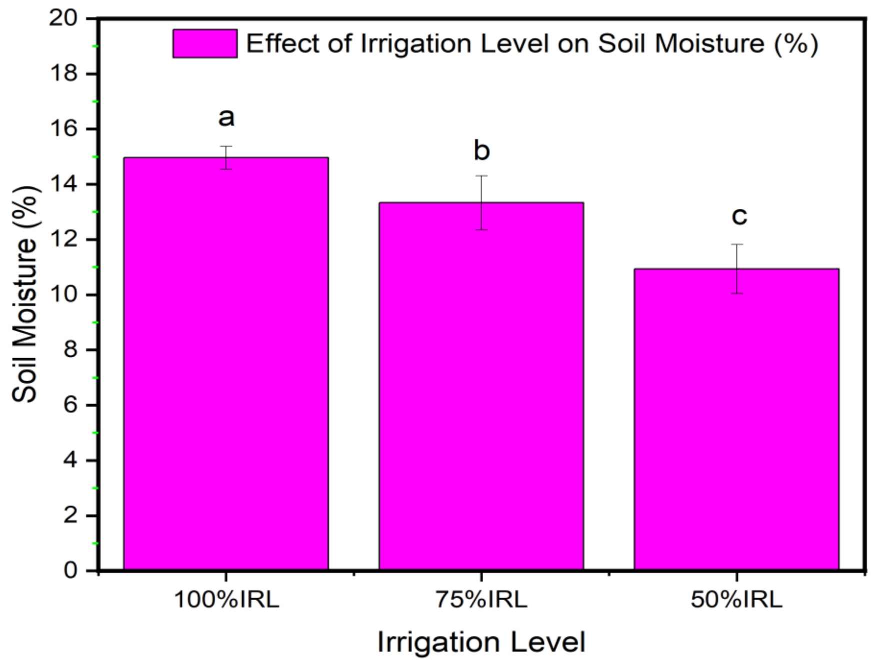
Table 10. Effects of the Total Number of Cobs Parameters

Treatment	Number of Cobs
Irrigation	
100 %	2.00
75 %	2.00
50 %	2.00
SE±	0.000
Soil Moisture Retainer	
0.00 mL	2.00
1.00 mL	2.00
2.00 mL	2.00
3.00 mL	2.00
SE±	0.000
Interaction	
I x SMR	ns

SE = standard error, ns = non-significant, I = irrigation and SMR = soil moisture retainer

3.3 Soil Variables

Soil under 100 % and 50 % IRL retained highest and lowest moisture, respectively (Fig. 10). A sharp contrast of that was noted in soil temperature variable (Fig. 11). As envisaged, soil plots treated with 2.00 and 3.00 mL demonstrated better water retention compared to 1.00 mL. This was further reflected in the treatment soil temperature which was reduced by 6.13%.



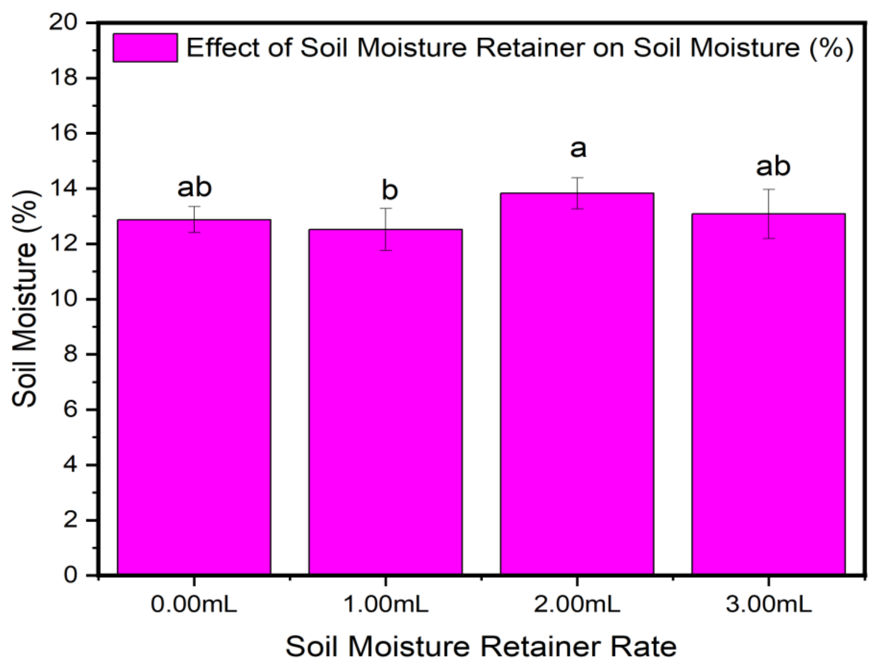
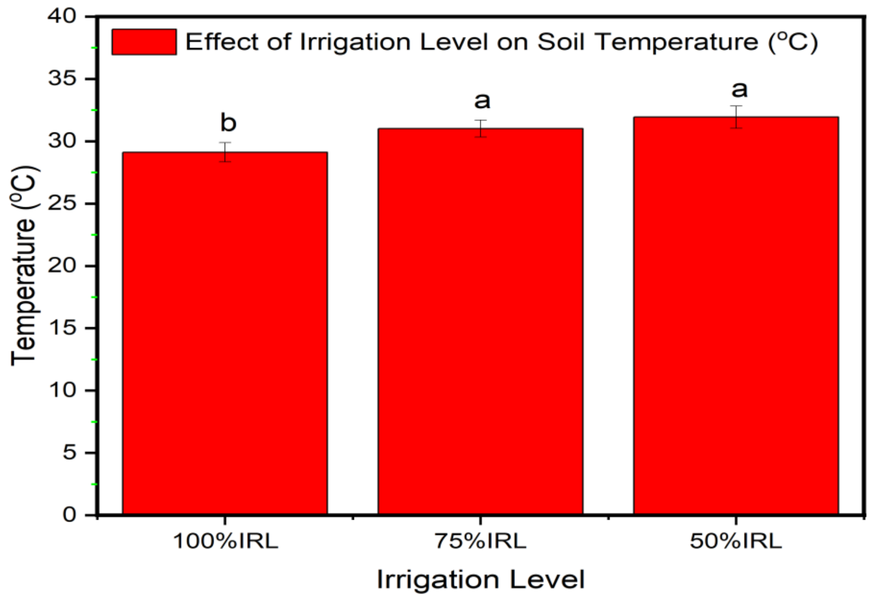


Figure 10.: Effects of Irrigation and Soil Moisture Retainer on Soil Moisture Content



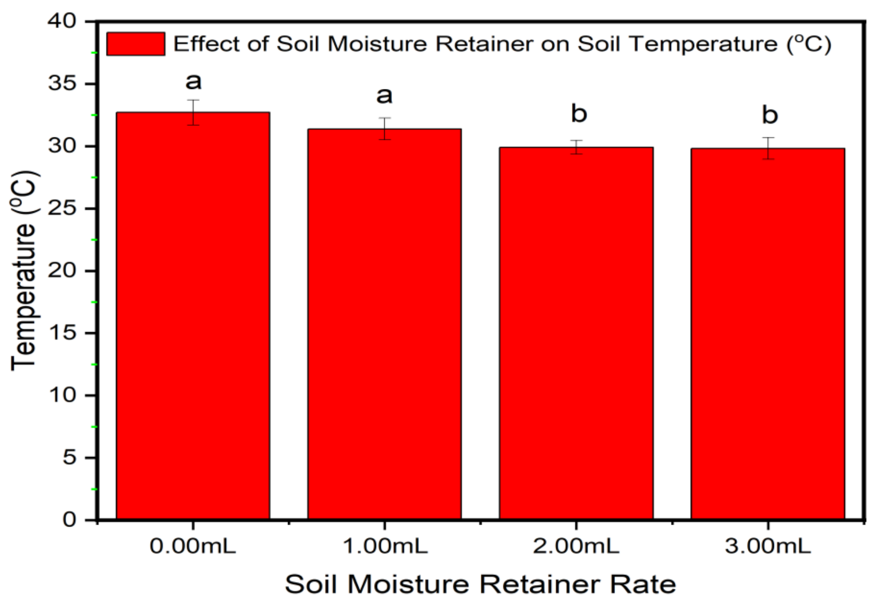


Figure 11.: Effects of Irrigation and Soil Moisture Retainer on Soil Temperature

Discussion

Findings of this study indicated that water-stressed crops (50 % IRL and 0.00 mL SMR) demonstrated highly competitive performance in stem girth and root length variables. This can be explained using optimal partitioning theory (Poorter et al., 2012) which suggests that, resource allocation preference is given to organs that are responsible for sourcing resource-limiting variable. Therefore, in this study more biomass was likely allocated to root and stem development in sweetcorn that experienced water and nutrient resource deficits. De Battisti (2024) had reported similar cases for species in dryland steppe where stem and root mass fractions outweighed leaf mass fraction in order to support below-ground resource mobilization.

Furthermore, from week 1 to week 8, lower stem girth values were recorded in the water-stressed tomato. Morphologically, stem of tomato is highly herbaceous, therefore subjecting it to water stress lowered moisture level in its stem tissue thereby reducing its plumpness. The lower performance in yield and growth parameters observed in 50 % IRL and 0.00 mL SMR may be attributed to severe oxidative stress undergone by the stressed crops which normally trigger accumulation of antioxidant particularly vitamin C, Lycopene (μg/g) and β-Carotene. According to Robaszkiewicz *et al*. (2010), the latter two compounds serve as impactful antioxidants, that protects crops against oxidative stress from solar irradiation and free radicals. Poor fruit yield performances recorded in experiment 1 of this study was complicated by *Tuta absoluta* infestation which is a common pest reported to cause more than 50 % of yield loss in tomato (Sanda *et al*., 2018). British Broadcasting Corporation (BBC) (2025) has reported wide spread menace of *Tuta absoluta* which resulted in remarkable tomato yield loss in the year. The various treatments have not affected number of ears (cob) of the sweet corn, but affected other properties such as weight, diameter and length. This is expected considering that, cob number is genetically controlled trait. Zaitsev et al. (2021) stated that environmental factors do exert influence on certain cob parameters such as number of grains on a cob row but not the number of ears.

The findings of this study, agree with to Braga *et al*. (2024) who experimented the effects of sediment soil conditioners (SC) collected from two different reservoirs (SãoNicolau and São Joaquim) applied at 100, 75, 50, and 25 ton ha $^{-1}$. The results revealed that all the treatments caused significant positive effect in plant height, plant diameter, leaf area, and dry matter weight of maize compared to those in unconditioned soil (negative control). For instance, 100 ton ha $^{-1}$ of the sediment collected from São Joaquim (SJ100) was 35.1 % and 40.2 % greater in leaf area index and dry matter weight than negative control (soil only), respectively. Most expectedly, the growth effect emanated from the nutrient richness of the SJ and SN SCs which surpassed the negative control, particularly in Ca and P by 47.4 %, and 77.2 % and 62.5 %, and 97.3 %, respectively. Furthermore, the addition of sediment SC translated into increased chlorophyll content, and photosynthesis in relation to the unconditioned soil. Undoubtedly, increased clay and silt proportion which were averagely higher by 53.0 %, and 32.4 % in the two tested SCs, respectively must have contributed to the better water availability to the maize crop (Braga *et al*., 2024). Similarly, findings of this study were in concord with Legese *et al*. (2024) who concluded that two zeolite SCs caused significant plant growth improvement largely due to their porous structure which effectively sorbed moisture and essential macro and micronutrients and enabled their gradual release.

Conclusions and Recommendations

As presented in the results section, 2.00 and 3.00 mL m $^{-2}$ soil moisture retainer (SMR) supported improved soil moisture, and temperature conditions as well as tomato and sweet corn growth and yield performances, however, with inconsistency. As such, it is recommended that multi-locational validation trials be carried out on the 2.00 and 3.00 mL m $^{-2}$ SMR to ascertain their potentiality for soil conditioning and crop growth improvement. Although full irrigation (100 % IRL) outperformed others IRL, 75 % IRL competed well, thus can serve as an alternative in water-challenging environments.

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Conflict of Interest

There is lack of conflict of interest whatsoever among the authors that may have appear to affect the outcome of this work.

Authors' Contribution

All the authors have contributed technically in the research work and article development.

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