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Assessing the impact of deficit irrigation and effective microorganisms (EM) for optimizing water productivity on bell pepper production in arid climatic area of northern Ghana.

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ABSTRACT
Deficit irrigation strategy that are combined with other organic fertilizer amendments like effective microorganisms (EM) play a major role in vegetable production, specifically in the water scarcity area of Northern Ghana, where long-term erratic and uneven distribution of rainfall is observed annually. In recent years, few studies have been conducted on assessing the impact of deficit irrigation and effective microorganisms (EM) to maintain high vegetable yields while at the same time increasing water productivity. In this context, an experiment was designed during the two cropping seasons (May 2023 to February 2024) at the WACWISA field plot in a Randomized Complete Block Design (RCBD) with three replicates whereby 90% ETc, 75%ETc, 50%ETc and 35%ETc of crop evapotranspiration were applied. Four EM treatments, T1 (0.8L/m^2/d), T2 (0.60L/m^2/d), T3 (0.4L/m^2/d) and T4 (0L/m^2/d) (Control) were applied to the crop at the initial, development, middle, and late stages of the crop growing seasons.

CROPWAT 8.0 Software was used to estimate crop water requirements during the entire crop season. Meteorological data for 20 years (2004–2024) was obtained from the Savannah Agricultural Research Institute (SARI) in Ghana, Northern Region. Climatic, soil, and crop parameter data were used to calculate the crop water requirement, irrigation amount needed during each growth stage, and finally the irrigation scheduling of bell peppers using the Penman-Monteith method as described by FAO Paper 56.

In this study, the results revealed that bell pepper yields due to the application of effective microorganisms (EM) and deficit irrigation were higher and consistent in both cropping seasons, even though there were significant differences between deficit irrigation regimes of 50% ETc and 35% ETc. The study revealed that by utilizing T1 (0.80L/m^2/d) and T2 (0.60L/m^2/d) EM treatments, high pepper market yields were observed at 16.6 tons/ha and 15.3 tons/ha, respectively, with reasonable increased water productivity of 28% and 15%, respectively. To put into conclusion, deficit irrigation regimes of 90% ETc and 75% ETc were comparatively recommended for increasing pepper yield production and maximizing water productivity scenarios under the arid climatic conditions of northern Ghana.

Keywords: deficit irrigation, effective microorganisms (EM), CROPWAT 8.0 software, water productivity and Bell pepper

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1. INTRODUCTION

Bell pepper (*Capsicum annuum L.*) is the most common cultivated vegetable crop in the world and belongs to *Solanaceous* family. In northern Ghana, bell pepper is counted as a very important vegetable crop, especially during the dry season (Rose et al., 2023) Bell pepper is amenable to fruit physiological disorders such as sunscald and blossom end rot (BER) that result in significantly poor yields (Coolong et al., 2019; Hagassou et al., 2019; Lang et al., 2020). The biggest obstacle to the growth of agriculture in arid and semi-arid regions is water scarcity. In the long run, crop responses to water deficits will help with crop management strategy planning and reduce the likelihood of crop failure in drought and water scarcity environments (Java & Yunus, 2018). In deficit irrigation, crops are watered with less water than they need for optimum plant growth to be achieved (Fereres et al., 2007). In order to balance crop production and environmental preservation, organic fertilizer, which contains a range of nutrients and microorganisms, is frequently used to increase crop yield and improve soil water and nutrient holding capacity (Wu et al., 2020). In water scarce regions, the most important consideration is to obtain the maximum yield with the minimum unit of water, which is the improvement in water use efficiency (WUE). Deficit irrigation strategies open opportunities for increasing WUE (Acar, 2019).

1.1 Deficit irrigation

Deficit irrigation is recognized as a practice in agricultural water management whereby the amount of irrigation water applied is lower than the actual water requirement of the crops (Bayabil et al., 2023). It has been reported that deficit irrigation management is one of the strategies that saves 12% of total water input and improves water productivity when compared to full irrigation (Tsakmakis et al., 2018). According to the findings of Alipour and Amini (2022), it was discovered that common beans can attain higher water productivity when subjected to 80% irrigation as opposed to full irrigation. Teferi et al. (2022) reported that utilizing a 75% ETc irrigation treatment produced a comparable green bean pod yield as a full irrigation treatment.

1.2 Effective microorganisms (EM)

Professor Teuro Higa from Ryukyus University, Okinawa, Japan, first developed effective microorganisms (EM) technology, which consists of mixed cultures of beneficial naturally occurring microorganisms such as photosynthetic bacteria (Rhodopseudomonas), lactic acid bacteria (Lactobacilli), yeast, actinomycetes, and fermenting fungi (Javaid, 2010). This combination is commonly used as an organic fertilizer inoculant to enhance soil fertility and promote plant growth. Many researchers have revealed that the application of EM technology promotes early fruiting and root growth in tomatoes (Nchube et al., 2011). Meanwhile, Ayan et al. (2022) revealed in their study that EM technology had a positive effect on physiological variables of crops such as chlorophyll, photosynthesis rate, relative humidity, and transpiration rate. The role of effective microorganisms in vegetable production includes several positive effects on soil health, nutrient availability, and overall plant performance. It was revealed by many researchers that effective microorganisms (EM) help in the decomposition of organic matter in the soil. As eco-friendly biofertilizers, effective microorganisms (EM) have remarkable capabilities for improving plant growth and enhancing crop productivity, thus contributing to food security (Naik et al., 2020). EM are made up of a wide variety of naturally occurring useful microorganisms, including lactic acid bacteria, photosynthetic bacteria, actinobacteria, fungi, and yeasts (Hu and Qi, 2013; Naik et al., 2020). EM have a stimulating effect on plants because they function as soil activators and biostimulants (Iriti et al., 2019; Alkaabi et al., 2022). The microorganisms break down organic materials, releasing nutrients in a form that is more readily available to plants. Effective microorganisms (EM) play a pivotal role in enhancing tomato yield and growth by fostering a synergistic relationship with the soil and plants. EM is a blend of beneficial microorganisms, including lactic acid bacteria, yeast, and photosynthetic bacteria, which work in concert to improve soil health and support plant development. Through the breakdown of organic matter in the soil, EM promotes nutrient availability, facilitating the absorption of essential elements by tomato plants and contributing to their overall robust growth (Quiroz et al., 2019).

The objective of this study was to assess the impact of deficit irrigation and effective microorganisms (EM) for optimizing water productivity on bell pepper production in an arid climatic area of northern Ghana.

2. MATERIALS AND METHODS

2.1 Area of Study

This study was conducted at West Africa Centre for Water Irrigation and Sustainable Agriculture (WACWISA) experimental plots in Nyankpala, Northern region of Ghana. The area location is under the (Latitude. 9º 24'

39.90’’N and Longitude 0º 58’ 51.63’’ W. Study location elevation is about 165m above the sea level) as shown on (**Figure 1**). The soil type was Sandy Loam with a pH of 6.1 and a bulk density of 1.18g/cm^3. The area is within Guinea Savannah agro-climatic zone, having rainfall range of unimodal rainfall 700-1000mm per year. More rainfall was recorded on June 2023 compared to the other past two years (Figure 4). The agrometeorological parameters from the study area revealed the reference evapotranspiration, ETo range: > 4.73mm per day. In this study 20 years climatic meteorological data from 2003 to 2023 obtained from the Council for Scientific and Industrial Research (CSIR)- Savanna Agricultural Research Institute (SARI) which is located 1 kilometre from the study area.

Drip irrigation was used in the experimental study area. Inline tape drips of 1.2 L/hour after every 30cm interval were installed in the 1600L tank, and water was distributed to each treatment. Irrigation water was controlled through 16-mm gate valves mounted at the drip lateral to the plots. CROPWAT 8.0 software was used to estimate the crop water requirements of bell peppers, and irrigation scheduling was also calculated.

2.2 Soil sampling and analysis

In this experiment, soil samples were taken from the depth (0–60 cm) and sent to the soil laboratory for analysis. Soil texture, bulk density, moisture content, water retention characteristics at field capacity and permanent wilting, soil organic matter content, soil pH, ECs, total nitrogen, available phosphorous, and percentage of organic carbon were analyzed (Table 2).

2.2.1 Soil texture and bulk density

Samples of soil were obtained diagonally at various depths and places. We employed the hydrometer approach in accordance with Mostara and Roy's (2008) instructions. Using the soil textural triangle, the textural classes were ascertained from the proportions of sand, clay, and silt. For the bulk density, the following formula was used:

$$\rho_d = \frac{W_s}{V_c} \quad \text{……………………………………………………………………………(1)}$$

Where; ρ_d =soil bulk density

W_s= dry weight of the soil (g)

V_c= total volume of the core sampler (cm^3)

2.3 Agronomic growth parameters

2.3.1 Plant height

Following two weeks of applying deficit irrigation treatments for both seasons, a weekly assessment of plant height and stem diameter was carried out.

3.3.2 Number of flower per plant

Shortly after the first day of flowering, the number of flowers on each plant was tallied in order to track the bell pepper's flowering stage until the end.

2.3.3 Stem diameter

Using a Digital Vernier hand calibrator (AP-961), the average stem diameter of each individual plant was measured to assess the stem thickness of bell peppers.

2.3.4 Number of leaves per plant

Starting at the bottom of the plant and working your way up to the top, the number of leaves was counted. For every plant, the number of leaves was noted. Over the course of the growing season, this procedure was carried out once every fourteen days.

2.3.5 Leaf area and leaf area index (LAI)

Utilizing the higher quality camera on your smartphone, snap some pictures of the intact, healthy bell pepper leaves. This was carried out once the crop reached a point before noticeable senescence where the leaves had fully expanded. Following that, ImageJ was used to analyze the picture. Utilizing an empirical formula, LAI was also computed by multiplying LA by the number of plants per unit area.

2.3.6 Chlorophyll content

The amount of chlorophyll in leaves was measured using the SPAD meter (Soil Plant analysis Development) instrument. A calibrated SPAD meter was used prior to any measurements. The SPAD meter is held at several leaf parts (upper, middle, and lower regions), and the device is gently pressed to capture multiple readings and, in the end, the average value.

2.3.7 Days to flowering

Three samples were chosen for daily monitoring in each row of the experimental plots. The first date when a flower bud was observed was noted. The planting date was subtracted from the first flowering in order to determine the number of flowering days.

2.4 Marketing yields and water productivity

2.4.1 Yields

Three harvests were carried out 90, 100, and 120 days after transplanting to gauge crop productivity and bell pepper quality after the late stage of crop growth and maturity. Using a balancing scale, the picked bell pepper was weighed (0–20 kg). In this manner, three fruits were chosen at random after harvesting in order to measure their diameter and length with a digital Vernier calliper.

2.4.2 Water use efficiency (WUE)

Water Use Efficiency (WUE) is the ratio between crop yield productivity (kg/ha) and the total irrigation water used during full crop growing season (m^3/ha) (Santos et al., 2020). This relationship from equation 2 was used to determine water use efficiency (WUE);

WUE (kg/m^3) =harvested yield (kgha^{-1}) / total water consumption (m^3ha^{-1}) ……………(2)

2.5 Experimental setup

2.5.1 Planting Material

The experiment involved testing the Yolo Wonder kind of bell pepper (Capsicum annuum L). The crops in the study were planted according to a precise spacing scheme, with 0.5 meters separating rows and 0.3 meters separating individual plants. With a 30 cm spacing and a 16mm flat tape inline dripper producing 1.2 L per hour, the drip irrigation system was used. For the best plant density and effective use of the field's available space, this planting arrangement is essential. The spacing between plants and rows are important variables that affect crop management in general, air circulation, light interception, and other aspects.

2.5.2 Experimental design

This study used a randomized block design with three replicates to test the effects of deficit irrigation regimes and effective microorganisms (EM) dosage treatments throughout the full crop growth stages. The date of the bell pepper planting was September 30, 2023. In experimental weeding were managed in accordance with the guidelines of farm practices from WACWISA experimental plots.

Crop water requirements during the growing seasons was estimated using CROPWAT 8.0 model as developed by FAO using Penman-Monteith formula (equation 6 below)

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_{n}(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_n)} \dots\dots\dots\dots\dots (3)$$

Where ETo= reference evapotranspiration (mm/d), Rn = the net radiation at crop surface (MJm^{-2}/day), G =the soil heat flux density (MJm^{-2}/day) , T =the mean air temperature at 2 m height, U_2 = the wind speed at 2 m height (m/s), es = the saturation vapour pressure(KPa) , e_a = the actual vapour pressure(KPa), $e_s - e_a$ = the saturation vapour pressure deficit (KPa), γ = the psychometric constant (KPa/ºC) (Ge at al.,2022).

The 1998 suggestions from Allen et al. led to the adoption of the reference evapotranspiration and crop coefficients for bell pepper. The Food and Agriculture Organization (FAO) recognizes CROPWAT as a popular software application for estimating crop water requirements. It makes use of crop coefficients and reference evapotranspiration data to calculate the real water requirements for ideal crop development in a given area and climate. Crop evapotranspiration was calculated using equation (3).

$ETc = ETo \times Kc$ ……………………………………………………………………..…… (4)

Where; ETc = the crop evapotranspiration, ETo = the reference evapotranspiration and Kc = the crop coefficient and Table 3 shows the crop coefficient of bell pepper at different growth development stages, as adapted from Puku et al., 2023

3. DATA ANALYSIS

The SAS statistical package was utilized in this study for the analysis of variance (ANOVA) on the collected data. The means were then separated using the least significant difference (LSD) at a significance level of 5%.

3.1. RESULTS AND DISCUSSION

3.1.1. Weather Climatic data in the study area

Minimum and maximum temperatures, rainfall, solar radiation, wind, relative humidity, and sunshine hours were among the meteorological data gathered in the research region. The growth and yield of bell peppers are directly impacted by these meteorological parameters. For bell peppers, a moderate temperature is preferred in order to minimize fruit abortion and prevent blossom end rot (BER). December 2023 had the highest recorded temperature (35.7ºC), while September 2023 had the lowest (31.8ºC) readings (Figure 2). Increased temperatures also directly impact crop water requirements and evapotranspiration, which in turn impacts irrigation water scheduling.

3.1.2. **Soil moisture measurement**

In this study, HydroSense II Campbell was used to measure soil moisture content in the study experimental area. The study revealed that, there a close correlation between simulated and observed soil moisture content for the entire growing season. The maximum recorded soil moisture content was 42.12% and minimum was 3.72%.

3.1.3. Plant height

Meteorological data collected in the research region included minimum and maximum temperatures, precipitation, solar radiation, wind, relative humidity, and daylight hours. These meteorological factors have a direct effect on the growth and productivity of bell peppers. A temperate temperature is ideal for bell peppers to reduce fruit abortion and stop blossom end rot (BER). Figure 2 shows that the highest temperature ever recorded was 35.7ºC in December 2023 and the lowest temperature was 31.8ºC in September 2023. Elevated temperatures have a direct effect on crop water requirements and evapotranspiration, which then affects the scheduling of irrigation water.

3.1.4. **Leaf number per plant**

In this study, deficit irrigation regimens at 5% intervals had a substantial impact on the number of leaves per plant (Table 4). The study revealed that T1 (90%ETc) had the greatest number of leaves per plant (192) because of its excellent water usage efficiency and capacity to absorb nutrients for cell development and plant growth. The findings also demonstrated that as the deficit irrigation level rose, the number of leaves per plant decreased. In this sense, plant water stress and inadequate cell development in other parts of the plant, such as leaves and branches, resulted in the lowest number of leaves per plant (64) from T4(35%ETc) and the lowest number from all deficit irrigation regimes. This outcome is consistent with previous research.

3.1.5 Number of flower per plant

The number of fruit per plant was found to be significantly affected by treatment ($p \sim 0.05$) according to the results. In this instance, compared to the control (without EM), treatments 1 (90% ETc, 80% EM) and treatment 2 (75% ETc, 60% EM) produced 45 and 40% more fruited plants, respectively.

3.1.6 Stem diameter

Treatment T1 (14.2 mm) recorded the maximum stem diameter value during the trial, whereas treatment T3 (12.8 mm) recorded the lowest value (Table 4). Reduced plant cell count and poor development, which were both influenced by water stress, had an impact on stem diameter. This supports the data showing that stem diameter increases progressively as deficit irrigation levels rise (Souza et al., 2019).

3.1.7. Leaf area Index (LAI)

The total treatment exhibited significantly greater leaf area (LA) and leaf area index (LAI), according to the results (Table 5). There were no appreciable variations in the treatments. This helped the bell pepper grow to the stages when no insects, fungi, or pests were seen to be impacted. The leaf was sound and in good shape throughout the entire crop development cycle. For Treatments T1 and T2, the leaf area findings were 18.16 and 16.42 m^2/plant, respectively. Additionally, the leaf area index for treatments T1 and T2 was 1.65 and 1.58 m^2/m^2, respectively.

3.1.8. Chlorophyll content

When compared to other treatments, treatment 1 and treatment 2 had much greater leaf chlorophyll contents (39.5µmol/m2 and 38µmol/m2, respectively), according to the SPAD recorded data. Table 6 shows that the control treatment had the lowest chlorophyll level. This was because the soil did not contain enough water for plants to photosynthesise.

3.1.8. Fruit diameter

The fruit diameter data demonstrated that there is a highly significant variation in bell pepper fruit diameter between the deficit irrigation regimes. Plots that received treatment 1 (90% ETc) had the highest fruit diameter (5.96 cm), whereas treatment 4 (35% ETc) had the shortest fruit diameter (2.48 cm) when compared to other treatments (Table 5). The fruit with the smallest diameter suggested a little imbalance in the water supply, which may be the primary cause of the decline in fruit growth. Given that the bulb diameter was reduced during the plant's development and bulb formation growth stages in response to an irrigation water deficit, this conclusion was consistent with that of Gobena et al. (2017), who found substantial bulb diameter with 25%ETc deficit application.

3.1.9. Number of fruit per plant

Counting the fruits on each plant during harvesting allowed researchers to classify the experiment's yield into two categories: marketable (no defects) and unmarketable (some defects). On the two treatments, the average fruit per plant was substantially higher. Low average fruit yields of 38 and 29 bell peppers per plant, respectively, were obtained by treatments T3 at Plot III and T4 at Plot II (Table 7). Due to the limited number of fruits per plant, there was a significant water stress during the vegetative stage and a high degree of deficit irrigation, which increased the crop's water requirements during the water-sensitive development stage.

3.1.9. Days to flower set

This study showed that the combined effects of effective microorganisms (EM) and deficit irrigation significantly accelerated the time it took for bell pepper flowers to set and for the first harvest to occur. Comparing treatment T1, treatment T2, and treatment T3 to control T4, the highest acceleration in the time of flower set was 16.5%, followed by 12.8% and 10.7%, respectively.

3.2. Water use efficiency (WUE)

Effective microorganisms (EM) and deficit irrigation had a highly significant impact on crop water use efficiency (WUE) across treatments.

Water use efficiency (WUE) during treatment T3 and T4 was found to be low, with respective values of 5.96 and 3.37 kg/m^3 (Figure 5). This shown that when more deficit irrigation regimes were used, water use efficiency decreased and a corresponding drop in crop yield was observed. The findings indicated that bell pepper deficit irrigation programs were beneficial. Our results were comparable to those of Arebu et al. (2019), who found that applying 50% of the crop's water requirements resulted in the highest water use efficiency (WUE). For greater financial gains and water productivity in the later stages of the crop, Yang et al. (2022) suggested a 50% water deficit.

3.3. Marketable Yields

The total yield was calculated by adding the marketable and unmarketable yields together. Yield data from each treatment was gathered, weighed on a scale balance, and translated to kg/ha. Green peppers with a marketable yield were sorted based on size, quality appearance, color, shape, and flaws caused by pests and other crop diseases. After scaling, the total weight was converted to kg/ha and subsequently tons/ha. In our study on bell pepper production significant variation was recorded between Treatment 1 and Treatment 4, where by yield ranging from 16.6 to 9.4 t/ha, respectively (Table 8), with reasonable increased water productivity of 28% and 15%, respectively. This yield variations was comparable to another study by Rocha et al. (2018) that found that the use of mulch treatment in conjunction with deficit irrigation of 50% and 75% of ETc increased bell pepper production by an average of 24.4 t/ha.

4. CONCLUSION

The effect of deficit irrigation and effective microorganisms (EM) on bell pepper growth and yield was studied. The results showed that both deficit irrigation regimes and effective microorganisms (EM) have significant influence on growth parameters, yields and crop water productivity of the bell pepper. Highest plant height (cm), number of flower/plant and marketable yield were recorded from T1 as 45cm, 56 flower/plant and 16.6 tons/ha respectively and T2 as 38cm, 49 flower/plant and 15.3 tons/ha respectively. This records was significant higher than the remaining treatment T3 and T4. In this context, we can conclude that deficit irrigation of 90% ETc and 75% ETc was recommended for optimizing crop yield of the bell pepper. In addition to that, optimal water productivity was significantly contributed to the EM dosing rate and irrigation management practices of the bell pepper throughout growing season.

This study proved that, the combination of effective microorganisms with deficit irrigation regimes have significant influence on growth and yield of bell pepper.

Future research is highly needed especially to test different bell pepper varieties with different deficit irrigation regimes and environmental conditions.

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Table 1. Average monthly Climatic data in the study area

Month	Tmin	Tmax	R.H	Wind	Sun(hr)	Radiation	ETo
Units	(°C)	(°C)	(%)	(km/d)	(hours)	(MJ/m2/day)	(mm/d)
Jan	19.5	35.4	36	2	7.6	18.7	2.78
Feb	22.1	37.7	27	2	7.6	19.9	3.18
Mar	26.3	37.7	36	3	7.5	20.8	3.86
Apr	26.2	36.1	49	3	7.3	20.8	4.17
May	25.0	34.6	58	3	7.2	20.2	4.10
Jun	24.2	32.5	63	3	10.4	24.4	4.73
Jul	23.5	30.4	70	2	5.1	16.8	3.39
Aug	22.8	29.8	70	2	4.5	16.2	3.21
Sep	23.2	31.8	72	2	5.5	17.7	3.53
Oct	23.	32.	64	2	7.8	20.4	3.86

	3	6					
Nov	22.8	35.4	47	2	8.2	19.7	3.49
Dec	20.1	35.7	33	2	7.2	17.7	2.85
Avg.	23.3	34.1	51	2	7.2	19.4	3.60

Table 2. Soil physical properties at the experimental study area (depth 0 – 60cm)

Depth (cm)	**Texture**	**Silt (%)**	**Sand (%)**	**Clay (%)**	**FC (%)**	**BD (g/cm^3)**	**pH -**
0-15	Sandy Loam	66.8	11.2	13.4	28.7	1.18	6.1
15-30	Sandy Loam	64.5	14.9	10.8	28.5	1.18	5.8
30-45	Sandy Loam	61.2	15.6	11.5	28.4	1.14	5.3
45-60	Sandy Loam	58.9	16.10	12.6	28.1	1.14	5.1

Table 3. Bell pepper crop coefficient

Growth stage	Crop coefficient, kc
(i) Initial stage	0.60
(ii) Crop development stage	0.81
(iii) Mid-season stage	1.00
(iv) Late season stage	0.86

Table 4. Number of flower, leaf number per plant and Stem diameter measurements during crop growing season before harvesting

Treatment	No. of flower per plant	Leaf number per plant	Stem diameter(mm)
T1	40	192	14.2
T2	52	185	13.8
T3	48	72	13.1
T4	35	64	12.8

Table 5. Leaf area (LA) and Leaf area index (LAI) for bell pepper

Treatment	Leaf area(m^2/plant)	Leaf area index(m^2/m^2)
T1	18.16	1.65
T2	16.42	1.58
T3	15.08	1.42
T4	11.15	1.26

Table 6. SPAD average data during crop growing season before harvesting

Treatment	Average SPAD Value (µmol/m^2) – Chlorophyll	Performance
T1	39.5	Excellent
T2	38	Good
T3	31.8	Fair
T4	26.5	Poor

Table 7. Number of fruit per plant during experiment study

Treatment	Average number of fruit per plant		
	Plot I	Plot II	Plot III
T1	75	70	65
T2	60	58	55
T3	56	52	38
T4	35	29	35

Table 8. Bell pepper yield and Water use efficiency (WUE)

Treatment	Yield (t/ha)	WUE(kg/m3)
T1	16.6	12.65
T2	15.3	8.08
T3	12.4	5.96
T4	9.3	3.37

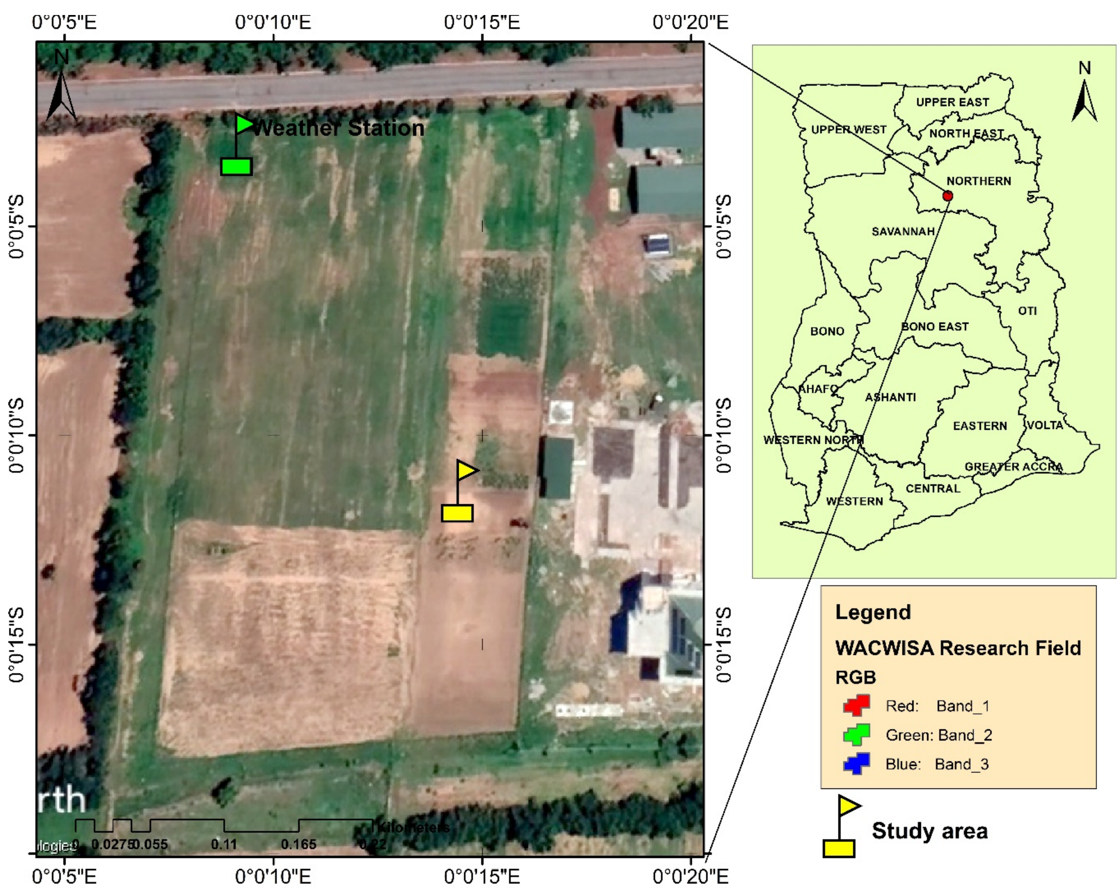

Figure 1. Experimental study area location, WACWISA, Northern Ghana

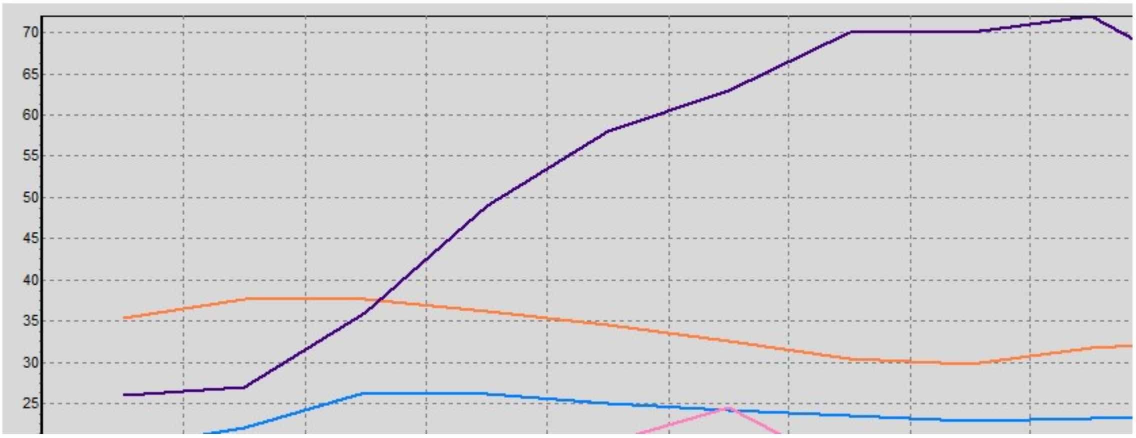

Figure 2. Crop water chat which shows detailed of ETo, min. and maximum temp., Rh, solar radiation and sunshine hour at the experimental area.

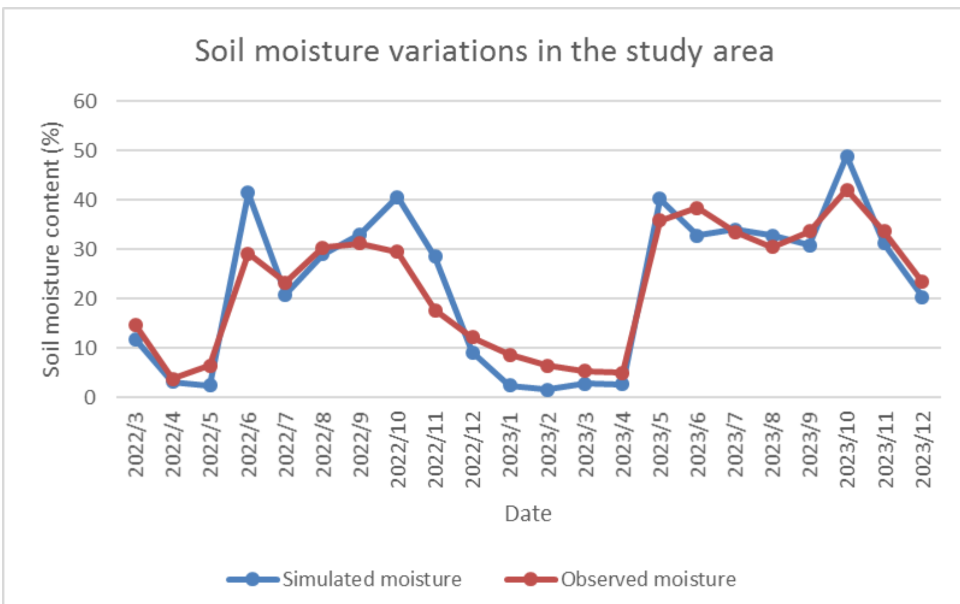

Figure 3. Simulated and Observed Soil moisture in the experimental area

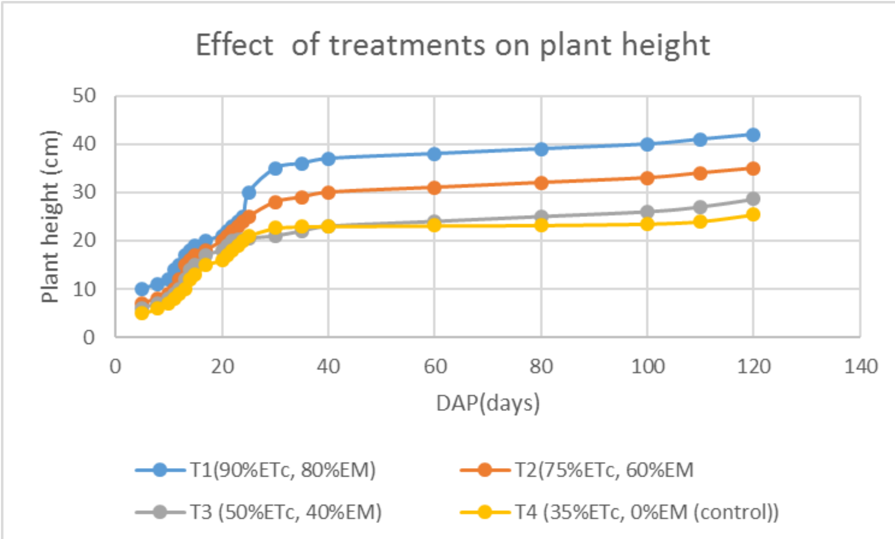

Figure 4. Effects of treatment to the bell pepper plant height

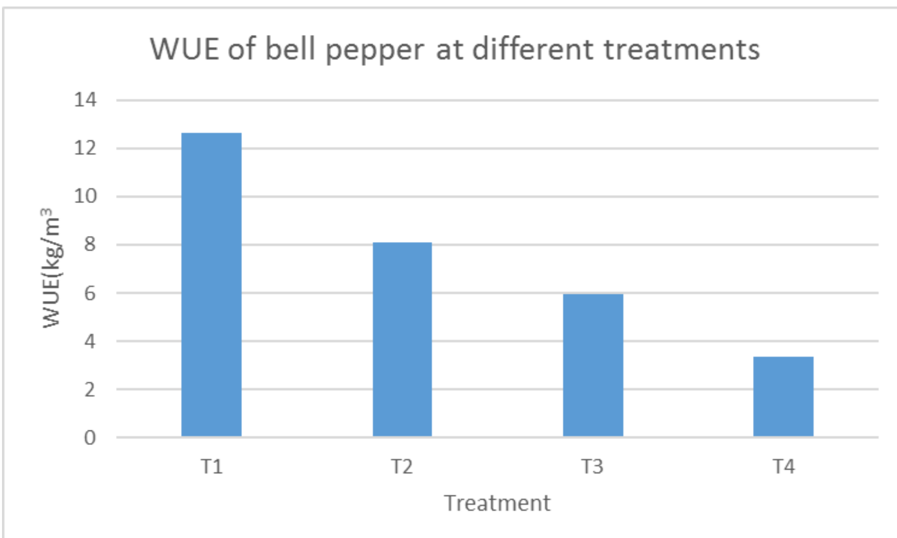

Figure 5. Water use efficiency of bell pepper during growth stage