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I. Introduction

Peppers (*Capsicum annuum* L.) belongs to the family Solanaceae, which is an important group of vegetables cultivated extensively in Pakistan and also widely cultivated in almost every country of the world (Channabasavanna and Setty, 2000). It thrives best in warm climate, where frost is not a problem during the growing seasons. In general, it requires temperatures ranging from 25-35°C (Olalla and Valero, 1994). Peppers thrive in a wide range of soil types, but good drainage is essential. The soil should be worked over to break up large clods and any hardpan that prevents good drainage. A soil pH of 5.5 – 7.0 is desirable. Green peppers are less sweet and slightly bitter than yellow, orange, purple or red peppers. The taste of ripe peppers can also vary with growing conditions and post-harvest storage treatment. Green pepper is widely grown in the Northern parts of Nigeria as a result of its uses and application which in turns increases demand and consumption of the vegetable. However, the vegetable is considered as medicinal plant in some parts of Nigeria. All these values have led to developing technically-based precision farming of green pepper so as to boost the production in order to match its increasing demand.

Consumption water use of pepper must be accurately maintained for its growth, development and yield. This could be achieved by uniform water application. Irrigation is an artificial application of water to the soil. It is applied to assist in the growing of agricultural crops, maintenance of landscapes and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Irrigation also has a few other uses in crop production, which include protecting plants against frost (Snyder and Melo-Abreu, 2005), suppressing weed growing in grain fields (Williams et al, 2007) and helping in preventing soil consolidation. Various types of irrigation techniques differ on how the water obtained from the source is distributed within the field, irrigation design mechanism, cost and technicalities.

Sprinkler irrigation systems are increasingly being used in crop production in South-West of Nigeria. Sprinkler irrigation systems apply water directly to the surface of the crop as well as the soil around the roots of the crop. Studies have shown that sprinkler irrigation systems reduce the water use of crop by about 50% compared to that under seepage system (Pitts and Clark, 1991). Due to efficiency and maintainability of sprinkler irrigation, it is therefore considered as method of water application for the purpose of this research study which focuses on determining the growth, development and yield response of green pepper cultivated under monitored sprinkler irrigation system.

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II. Materials and Methods

a) Study Area

The study was carried out at the Research Farm of the Department of Agricultural Engineering, Federal University of Technology, Akure, Nigeria. Akure is located within the humid region of Nigeria on latitude 7°16'N; longitude 5°13'E. The field experiment was conducted during 2007/08 and 2008/2009 dry seasons respectively. The physical and chemical properties of the soil were determined. The experimental design was a Randomized Complete Block Design (RCBD) with three treatments and three replicates. The experimental plots were divided into 9 plots of 2 m by 2 m each. Each treatment was subjected to different water application of 50% Water Requirements (WR) as Low, 75%WR as Medium, and 100% WR as High irrigations.

b) The Crop

A variety of Pepper *(Capsicum annuum L.),* NHV1A, of drought resistance, was obtained from the National Institute of Horticulture (NIHORT), Ibadan to ensure the viability of the seeds used. Pepper seeds used were nursed at the farm site.

c) Water Supply at the Experimental Site

The water supply to the experimental site was mainly from a hand dug well located at about 50 m distance from the experimental plot. The water source has adequate water that could meet the irrigation water demand of the crop under study.

d) Experimental Design

Plot (10 m x 60 m) portion of the farm site was prepared for effective seed bed formation and (10 m x 10 m) part of the prepared land was divided into nine seed beds (micro-sprinkler plots), 2.0 m long, 2.0 m wide and 0.15 m deep and leaving 0.5 m spacing between beds. The micro-sprinklers were installed at the centers of the nine 2.0 m x 2.0 m plots. There were three treatments replicated three times in a randomized complete block design. Each treatment plot was connected to separate supplies (0.1 m^3 capacity reservoirs) placed adjacent to each of the beds at uniform pressure head of 1.5 m as shown in Figure 3.1. Treatments were based on different percentage of water requirements (WR) of pepper as 50% WR, 75% WR, and 100% WR. Irrigations were carried out at three- day intervals and the volume of water applied in each treatment was monitored. Rainfalls were measured during the experiment with the aid of automated rainguage. Pepper seeds were transplanted manually at a spacing of 45 cm x 60 cm between stands after having been nursed on seedbeds for six weeks. Water application rates (A) from sprinkler into the catch cans were determined using the following relationship (Michael and Ojha, 2003):

$$Application\ rate\ (A) = \frac{KQ}{a} \qquad 3.1$$

A = Application rate mm/hr
Q= Sprinkler discharge, l/min, determined from the volume of water applied divided by the period of application
a = Wetted area of sprinkler; m^2 (surface area of can) ($3.01 \times 10^{-3} m^2$)
K = Unit constant (K=60.0 for A in mm/hr, Q in l/min and a in m^2), at a constant pressure head.

The uniformity coefficient of the sprinkler system was determined to ascertain the efficiency of the uniformity in the sprinkling of water using the Christiansen's formula (Michael and Ojha, 2003).

$$C_u = 100\left[1 - \frac{\sum|x_i - \bar{x}|}{\bar{x}n}\right] \qquad 3.2$$

where
C_u = Christiansen's uniformity coefficient, percent;
n = number of collecting cans placed on the bed;
xi = water measurement in the ith collecting can (I = 1,2,…..,n);
$\bar{x}$ = mean of n measurements in the area under consideration;
$\sum|x_i - \bar{x}|$ = sum of absolute deviations from the mean measurement.

Field Layout

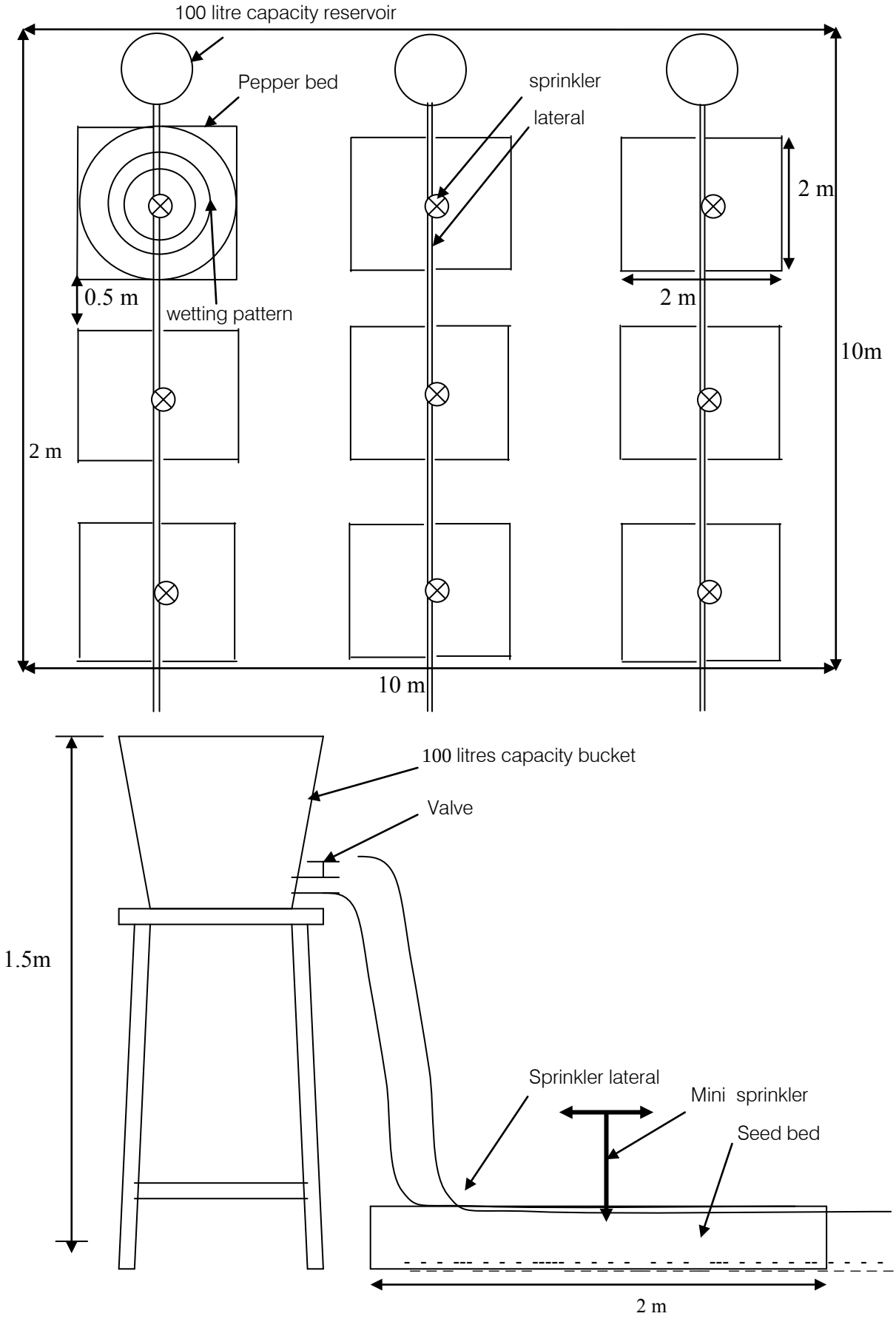


Fig 3.1: Layout of the sprinkler irrigation system in the field of experiment

e) Evapotranspiration (Crop water use)

The consumptive use of each treatment at various stages of the crop was estimated using the Water Balance Equation (FAO 56):

$$ET = P + I \pm \Delta S + R + D \quad 3.3$$

P = Precipitation (Rainfall) in mm
I = Irrigation (mm)
ΔS = Change in moisture storage (mm)
R = Runoff (mm)
D = Drainage (mm)

f) Agronomic Measurements

Leaf area, leaf area index (LAI), plant height, stem diameter, fruits width, fruits length, number of fruits and root depths were measured on weekly basis beginning from 29 days after transplanting (DAT) to the maturity stage, that is, 65 DAT when harvesting began. A representative plant was selected weekly for the measurement of LAI. Leaf area index according to Gong et al., (1995) was estimated from the relationship:

$$Leaf\ area\ index\ (LAI) = \frac{Area\ of\ leaf\ per\ plant}{Area\ of\ soil\ covered\ per\ plant} \quad 3.4$$

g) Pepper Yield

Harvestable yields of Pepper (*Capsicum annum*) were determined on weekly interval starting from the day harvesting began (65DAT). Fresh peppers were harvested from the treatment plots for ease of measurement of fresh biomass. The weight of the harvested fresh biomass was determined using an electronic weighing device that could measure up to 0.01 level of accuracy.

III. Results and Discussion

a) Soil properties at the experimental site.

Table 4.1 shows the description of the soil properties at the experimental site. The micro-sprinkler irrigation site has a mean soil texture (USDA method) of sandy loam in the top soil which forms mainly the agricultural layer required for the cultivation of most vegetables. The textural class was determined through the use of the USDA soil textural triangle on the basis of particle –size analysis (Figure 4.1). Minimum and maximum organic carbon content of 0.69% and 1.04% respectively were observed within the top 0.3 m depth of the soil. The top soil average carbon content falls within the range (0.6-1.2%) given by Young (1976) as desirable for tropical crop production. The soil PH varies from acidic to neutral on the surface soil (5.95 - 6.4). The mean of the P.H. falls within the slightly acidic range (6.2) and is below the average value of (6.5) which was considered ideal for good availability of plant nutrients in the mineral soils (Foth and Ellis, 1997). The bulk density of the experimental site was 1.25g/cm^3 at the first 0.3 m depth of soil. This is below the critical value of 2.1 g/cm^3, beyond which plant growth is severely limited.

Table 4.1 : Description of the soil properties at the experimental site.

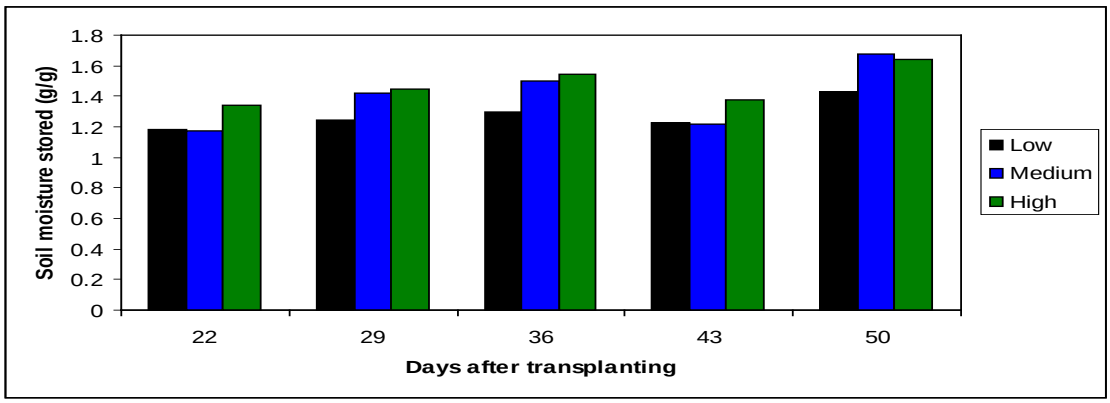
Samples	PH in water(1:2)	Organic carbon (%)	Organic matter (%)	% N	P (mg/kg)	K	Na	Ca	Mg	Textural class
1	6.10	1.02	1.92	0.46	10.85	0.07	0.11	0.45	0.31	Sandy loamy(SL)
2	6.26	0.84	1.46	0.42	11.73	0.09	0.12	0.96	0.40	SL
3	6.17	0.73	0.62	0.44	8.45	0.06	0.10	0.23	0.21	SL
4	6.10	1.04	1.89	0.40	9.29	0.05	0.14	0.21	0.28	SL
5	6.20	0.82	2.12	0.46	10.21	0.06	0.13	0.30	0.23	SL
6	6.35	0.71	0.74	0.43	9.85	0.06	0.12	0.40	0.31	SL
7	5.95	1.00	1.65	0.42	10.70	0.05	0.11	0.47	0.30	SL
8	6.25	0.79	0.14	0.40	11.05	0.06	0.10	0.41	0.28	SL
9	6.40	0.69	1.45	0.41	11.15	0.05	0.13	0.40	0.26	SL
Min	5.95	0.69	0.14	0.40	8.45	0.05	0.10	0.21	0.21	
Max	6.40	1.04	2.12	0.46	11.73	0.09	0.14	0.96	0.40	
Mean	6.20	0.85	1.33	0.43	10.36	0.06	0.12	0.43	0.29	
S.D.	0.40	0.14	0.68	0.02	1.04	0.01	0.01	0.22	0.06	

Source: Field study, 2009

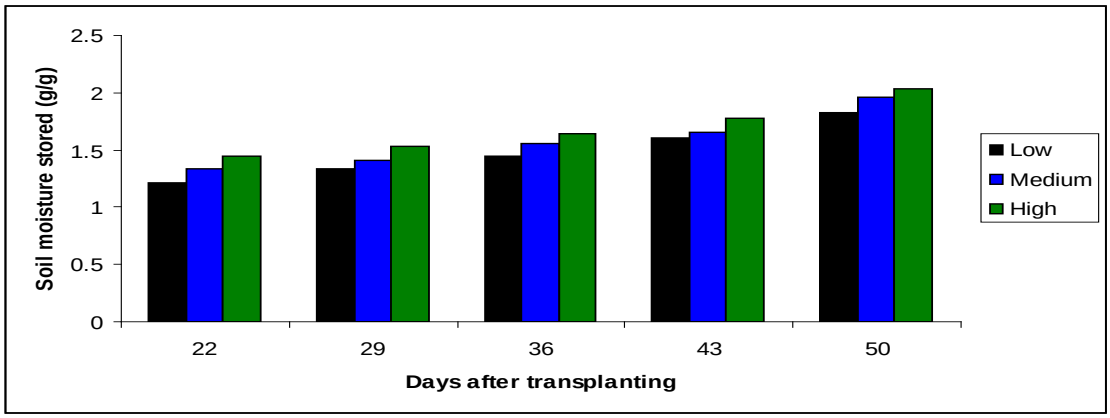
The soils in the irrigation plots have a high sand content with mean value of 63.6% in the top soil. The clay content has a mean value of 18.9%, this does not change so much from one point to the other around the sampled points indicating similar soil textural classification within the 0-30 cm soil depth.

b) Moisture Storage in the Soil Profile.

The variations in the volumetric soil moisture content (SMC) in the *capsicum annum* field up to a depth of 60cm is shown in Figure 4.1



(a)



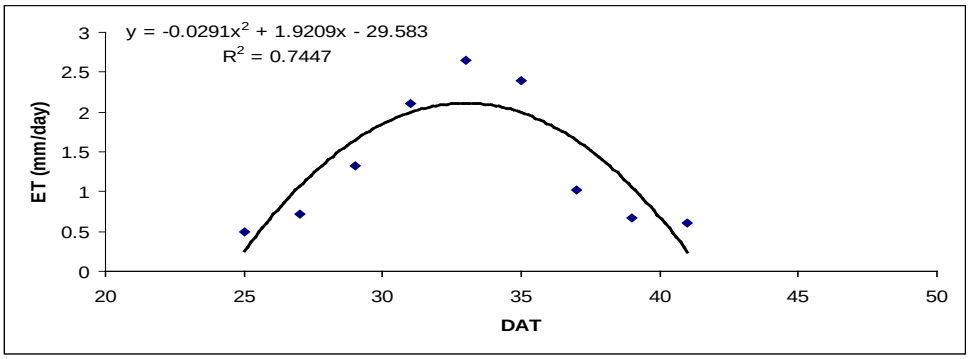
(b)

Figure 4.1: Soil moisture stored under different treatments in (a) 2008 and (b) 2009 seasons respectively

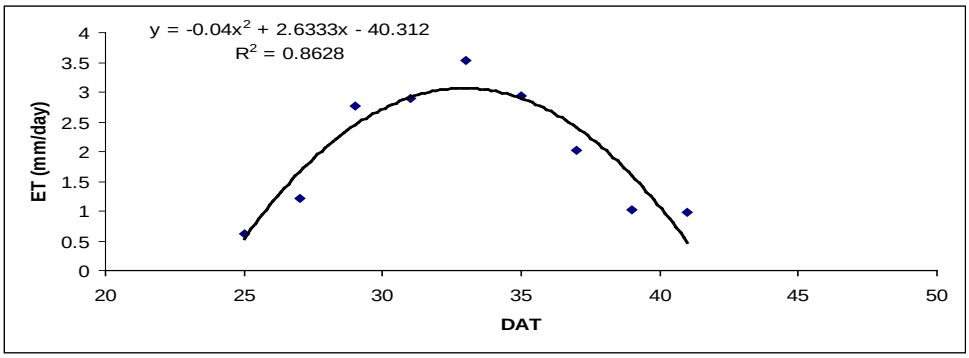
The soil moisture in the soil profile was observed to increase down the soil profile in both seasons, but there was a decline at 43DAT due to high evaporation rate, and increased at 50DAT in 2008 season. However, the moisture regime under high irrigation treatment was highest among all the three treatments. This must have been resulted due to the application of irrigation water was at the highest rate, thus, allowing water to have enough time to accumulate around the root zone of the crop thereby permitting moisture build up at the topsoil. The differences of moisture stored for all the three treatments were significant at 5% level at different growth stages.

c) Crop Water Use (Evapotranspiration)

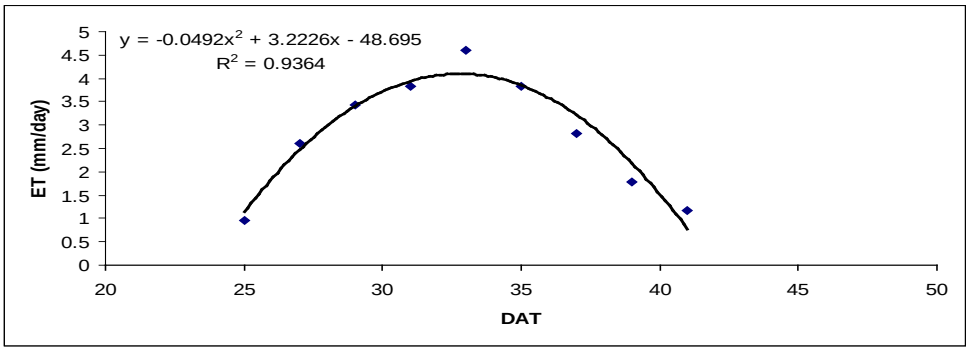
Evapotranspiration from the micro-sprinkler plots depended mostly on irrigation water applied and also on rainfall amount. There were variations in the crop water use in both seasons and this was largely due to the different irrigation schedules for all the treatment plots. Plots with high water applications have enough water to meet evapotranspiration demand, that is, evapotranspiration increases as the irrigation rates increases. This observation was confirmed by Hanks et al., (1976). The highest evapotranspiration value of 4.61mm/day was obtained in 2008, while 4.70mm/day was obtained in 2009. The variations between evapotranspiration (ET) with days after transplanting (DAT) for various treatments are shown in the figures below:



(a)

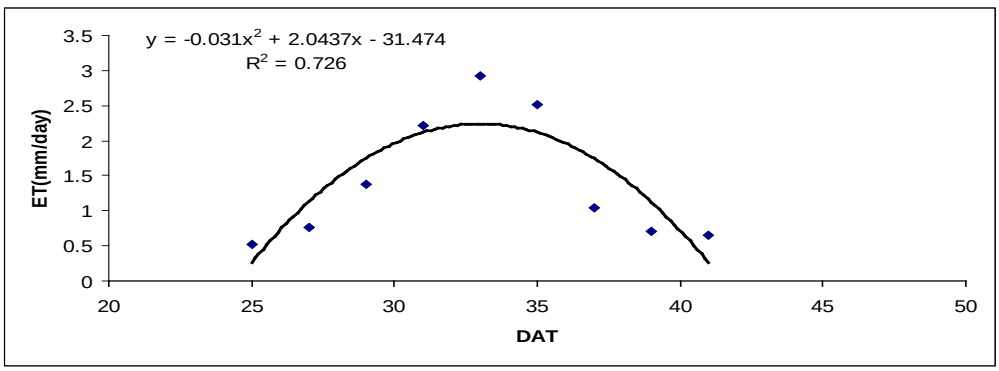


(b)

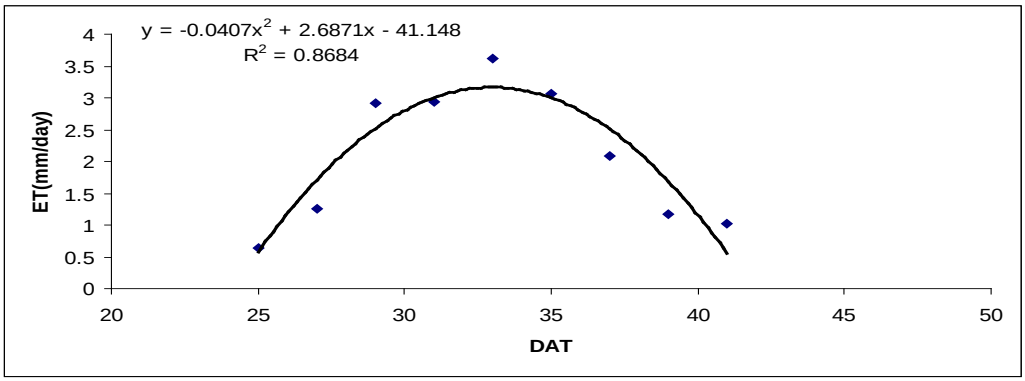


(c)

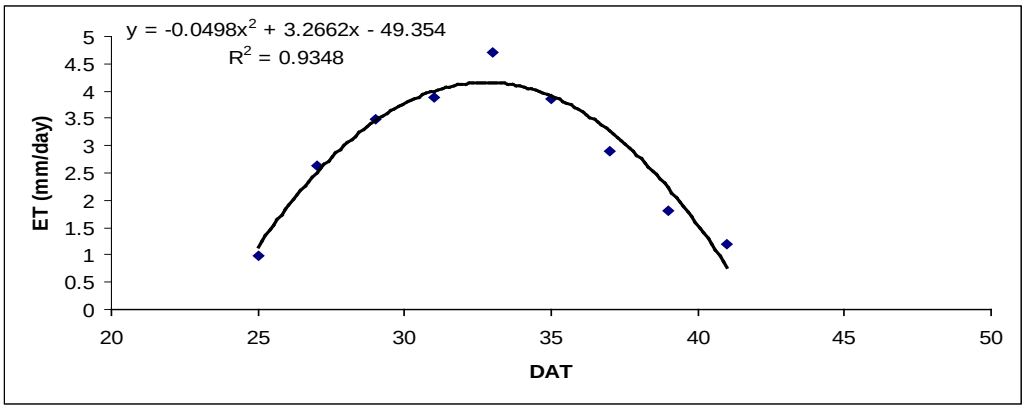
Figure 4.3 (a): Crop water use of *capsicum annum* under different growth stages in (a) low, (b) medium and (c) high irrigation treatments in 2008.



(d)



(e)



(f)

d) Water Use of pepper and Yield relationship in the treatments

It was evaluated that irrigation treatments had significant effect on the yield of green pepper. The output of the experimentation shows that average yield of green pepper is proportional to the volume of water applied. Treatment with low water application, the total yield obtained was 14.9 t/ha in 2008 and 15.3 t/ha in 2009, while for treatment with high water application, total yield obtained was 20.1 t/ha in 2008 and 21.1 t /ha in 2009. Significant correlations were obtained ($p<0.05$) between yield and crop water use and shown in Figure 4.4:

Table 4.2 : Total Water Used (mm) by Pepper for each treatment in 2008

Treatment	25	27	29	31	33	35	37	39	41
Low	12.5	31.9	70.2	135.6	223.1	307.1	344.8	371.0	396.0
Medium	15.3	48.2	128.2	217.8	334.6	437.2	511.9	552.1	592.3
High	24.0	94.5	193.7	312.4	464.5	598.6	703.3	772.7	821.1

Table 4.3 : Total Water (mm) Used by Pepper for each treatment in 2009

Treatment	25	27	29	31	33	35	37	39	41
Low	13.3	34.0	74.1	142.6	238.9	326.8	365.6	392.9	420.0
Medium	15.8	49.8	134. 2	225.3	344.4	451.5	528.1	577.3	626.1
High	24.5	95.5	196. 4	317.0	472.1	606.9	713.8	784.0	833.6

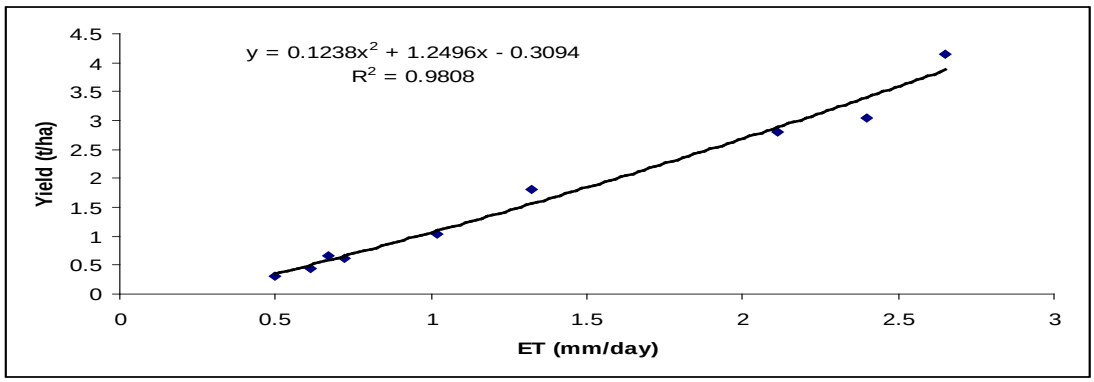


Fig. 4.4 : Yield-Water use calibration curve

e) Yield of pepper in the treatments

The first fruit was harvested 65 days after transplanting (DAT) of seedlings and there were 9 harvests during the growing season that lasted for121 days. Treatment 3 (high irrigation) recorded highest total yield of 20.1 t/ha in 2008 season and 21.1 t/ha in 2009 season. In treatment 2 (medium irrigation), the total yield obtained was 16.1 t/ha in 2008 and 17 ton/ha in 2009 season respectively. Treatment 1 (low irrigation) with the least amount of water recorded the lowest total yield of 14.9 t/ha and 15.3 t/ha in 2008 and 2009 respectively. Thus, the yields of pepper produced depend on the amount of irrigation water applied.

Table 4.3 : Total yield of pepper produced under the treatments.

Plot area (m^2)	Treatments	Yield (ton/ha) (2008)	Yield (ton/ha) (2009)
4	Low	14.886	15.260
4	Medium	16.146	16.955
4	High	20.101	21.062

Source : Field study, 2009

IV. Conclusion

The research study was carried out to evaluate the response of *capsicum annum* to water application via micro sprinkler irrigation system. Observations throughout the entire growing period indicated that maximum yields was obtained at the treatment 3 plots (high) which were 20.1 t/ha in 2008 and 21.1 t/ha in 2009 season respectively. The relationship between crop water use and yield showed that treatment 3 plot (high) has the highest coefficient of determination of 0.93 and 0.93 for the two seasons, while the coefficient of determination for treatment 1 (low) and treatment 2 (Medium) are 0.91 and 0.89 in 2008;0.90 and 0.87 in 2009 seasons respectively. It was however shown that the total crop water use of treatment 3 is the highest with values of 821mm and 834mm for the two seasons, while treatments 1(low) and 2 (Medium) has a total crop water use of 396 mm and 420 mm in 2008; 592 mm and 626 mm in 2009 seasons. Therefore, the outputs of the study adequately indicated that green pepper requires sufficient amount of water for its growth and expected productivity and yield. Since the demand for green pepper on the increase due to its multiple usage and medicinal applications, this study however conclude that technically-monitored sprinkler or drip irrigation systems should be encouraged to supply to the root nodes of the plant to boost it growth, development and yield.

References Références Referencias

1. Channabasavanna, A. S and R. A Setty, (2000). Influence of different Irrigation interval on growth and yield of pepper pp 9.
2. Foth, H. D. and Ellis, B. G. (1997): Soil Fertility. Second Edition, pp 290. CRC Press Boca Ration, Florida.
3. Monteith, J. L. (1965). " Evaporation and environment". The state and movement of water in living organism. 19th Symp. Of Soc. Exp. Biol. Cambridge University Press, Cambridge.
4. Olalla, F and J. A Valero (1994). Growth and production of bell pepper under different irrigation intervals. Research series Arkansas – Agric Experimental Station. Pp 125 -128
5. Pitts, D. J. and G. A. Clarke (1991). Comparison of drip irrigation to sub- irrigation for tomato production in southwest Florida. Applied Engineering Agric 7 (2): 117 -184.
6. Snyder, R.L; Melo-Abreu, J.P. (2005). Frost protection: Fundamentals, practice, and economics – Volume 1. (PDF). Food and Agriculture Organisation of the United Nations
7. Williams, J.F; S.R.Roberts, J.E.Hill, S.C.Scardaci, and G. Tibbits. (2007). Managing Water for Weed Control in Rice. UC Davies, Department of Plant Sciences. Retrieved 2007-03-14.
8. Young, A. (1976). Tropical soils and survey. Cambridge University Press. Pp. 467.