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Research article

Determination of Crop Evapotranspiration (ETc) and Crop Coefficient (Kc) for Maize Using Drainage Lysimeter in Dry Season Period in Enugu State, Nigeria

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ABSTRACT

This study presents the determination of evapotranspiration and crop coefficient for maize using a locally made drainage lysimeter in the dry season period in Agbani, Enugu State, Nigeria. Maize was planted in the lysimeter, three seeds per stand, the planted seedlings were thinned to one seedling per stand, leaving only the most viable seedling to grow till maturity. ETc was determined from the lysimeter experiment using the water balance equation. Similarly, Kc was determined with an equation that expresses the relationship between Kc, ETc, and reference evapotranspiration. Moisture content (MC) was determined by the gravimetric method, effective rainfall, bulk density of the soil was also determined. ETo obtained for Enugu using 30 years of annual data was adopted. The result of the study gave ETc of 1.11 mm and 12.03 mm for the lowest and highest ETc respectively. On the other hand, Kc values obtained were 0.79, 0.96, and 0.91 for the months of January, February, and March respectively. The highest moisture obtained was 26.20 mm while the lowest was 3.21 mm. Soil bulk density was determined to be 1.43 g/cm3. More so, the highest and lowest effective rainfalls during the study period were 9.10 mm and 2.00 mm respectively. Irrigation water supplied during the period of study was within the range of 12.46 mm and 24.92 mm and lastly, the study revealed that the highest water need was during tasseling, cob setting, and filling because ETc obtained was highest at that point.

Keywords: *Evapotranspiration, Lysimeter, Bulk Density, Moisture content*

Introduction

Maize is an important staple food in Africa, and in Nigeria, aside from being consumed locally in roasted or boiled form; it is also consumed in other processed forms such as cornflakes, custard, pap (akamu in the Igbo Language), golden morn, and more. IITA (2003) reported that maize is the most consumed staple food in households at about 20%, followed by cassava - 16.5%, Rice - 11.9%, and cowpea – 11.8%. Maize is known to contain phytochemicals such as carotenoids, phenolic compounds, and phytosterols, which play important roles in disease prevention, including Galanthus Nivalis Agglutinin (GNA) which is believed to have potential anti-HIV activity (Shah *et al.*, 2016). Similarly, Olaniyi and Adewale (2012) say maize "is an important source of carbohydrate and if eaten in the immature state, provides useful quantities of Vitamin A and C". Therefore, good knowledge of evapotranspiration rate and crop coefficient of the crop is essential for year-round cultivation of maize in the study area.

Evapotranspiration (ETc) is one of the major factors that control the irrigation water requirements of crops. Quantification of ETc for a type of crop in any region and season is necessary for the proper design of irrigation systems, crop water balance studies, and seasonal irrigation water management. These factors play important roles in the effective management of irrigation water and the quantification of available water resources for future crop production, (Sharma and Irmak, 2012b; Djaman *et al*., 2018). Evapotranspiration is an important component of the irrigation system and irrigation is extremely important in the production of food, other agricultural products, ornamentals, and turf. Modern irrigation is a sophisticated operation, involving the monitoring and manipulation of numerous factors impacting crop production (Dean *et al*., 2021). However, properly designed and managed, modern irrigation methods can increase crop yields while avoiding waste, reducing drainage, and promoting the integration of irrigation with essential concurrent crop management operations. Effective management of an irrigation system requires the understanding and use of the basic concepts of soil water. Without an adequate understanding of these concepts, the irrigator will not know how much water to apply or when to irrigate.

Rawat *et al*. (2017) compared ETc from lysimetric studies and a surface balance algorithm (SEBAL) and the results were significantly correlated. Bayisa, *et al*. (2021) studied maize yield and water use efficiency under different irrigation levels and furrow irrigation methods in semiarid, tropical regions. Their study aimed to access the combined effects of different deficit irrigation levels and furrow irrigation methods on maize yield and water use efficiency and identify the optimal irrigation management practices that maximize the water use efficiency under climatic conditions of Melkassa and similar environments. The study involved three furrow irrigation methods (conventional, fixed, and alternate furrow irrigation) and three irrigation application levels (100% ETc, 75% ETc, and 50% ETc). The result of their study showed that the greatest yield was obtained under conventional furrow irrigation supplied with 100% ETc of water. Water use efficiency under the same treatment was lesser and shows no significant difference with fixed furrow irrigation and 50% ETc application. The greatest water use efficiency of maize was obtained from alternate furrow irrigation under 75% ETc application and showed no significant difference with 100% ETc application. Again, Xu *et al*. (2019) noted that the development of efficient irrigation plans as well as technologies was very important to ensure maize production in the agricultural region of Northeast China.

In our local environment, the cultivation of crops is usually skewed towards the rainfall season because of the two major distinct seasons. This automatically affects the rate of production of several food crops produced in the locality as meaningful production of food can only be achieved during the rainy season period of the year alone (Chiwetalu *et al*., 2017). The practice in the study area is such that crop production stops at the end of the rainy season but the harvesting of some crops continues into the dry season. Again, year-round crop production is rarely practiced along the river banks due to the dry season and little or no information on irrigation and crop water requirements. So far, no study has been carried out in the study area to determine Maize ETc and Kc. Thus, the objective of the study is to determine ETc and Kc for maize using a drainage lysimeter during the dry season period of the year. Reliable information on the water need of the studied crop and irrigation management practices will help develop new strategies for dry-season maize production, thereby ensuring maize availability and as well food security in the locality and nation at large.

The Study Area

The study was carried out in the Faculty of Agriculture practicing farm, Enugu State University of Science and Technology (ESUT), Agbani is in Nkanu West L.G.A. of Enugu State, Nigeria. ESUT is situated in Agbani, the headquarters of Nkanu West L.G.A. of Enugu State. ESUT lies approximately between latitude 6° 51' 24" N and longitude 7° 23' 45" E. The annual rainfall in the area is between 1500 mm to 2000 mm, the mean monthly rainfall is about 140 mm (NIMET, 2015), the surface pressure is about 985.5hpa the relative humidity ranges between 40% and 89%. The temperature ranges from 26. 6°C to 32°C and the mean annual temperature is 27°C, (NIMET, 2015) though, in recent years, the temperature ranges, especially in the dry season period (November to March), approach 40°C. Agbani like the rest of other places in Enugu State has the tropical savanna type of climate, according to Koppen's (1987) climate classification. The two air masses that influence the climate of the area are the warm tropical maritime air mass which originates from the South Atlantic Ocean and the dry dusty tropical continental air masses associated with the dry rainy season experienced in the area. Agbani has some of the few characteristics of the rainforest zone, but due to human activities in the area, the natural rainforest has been destroyed (Okwu-Delunzu, 2018). The land area of Nkanu West L. G. A. is about 225 km^2 and population of about 146,695 (Census, 2006). In the north, Nkanu-West is bounded by Udi L. G. A. and bounded by Enugu South L. G. A. in the east, and west, it is bounded by Agwu L. G. A. It is equally bounded by Nkanu-East L. G. A. in the south. The people are predominantly farmers (Adekola and Nwoye 2016). Figure 1 is a map of Enugu State indicating the study location.

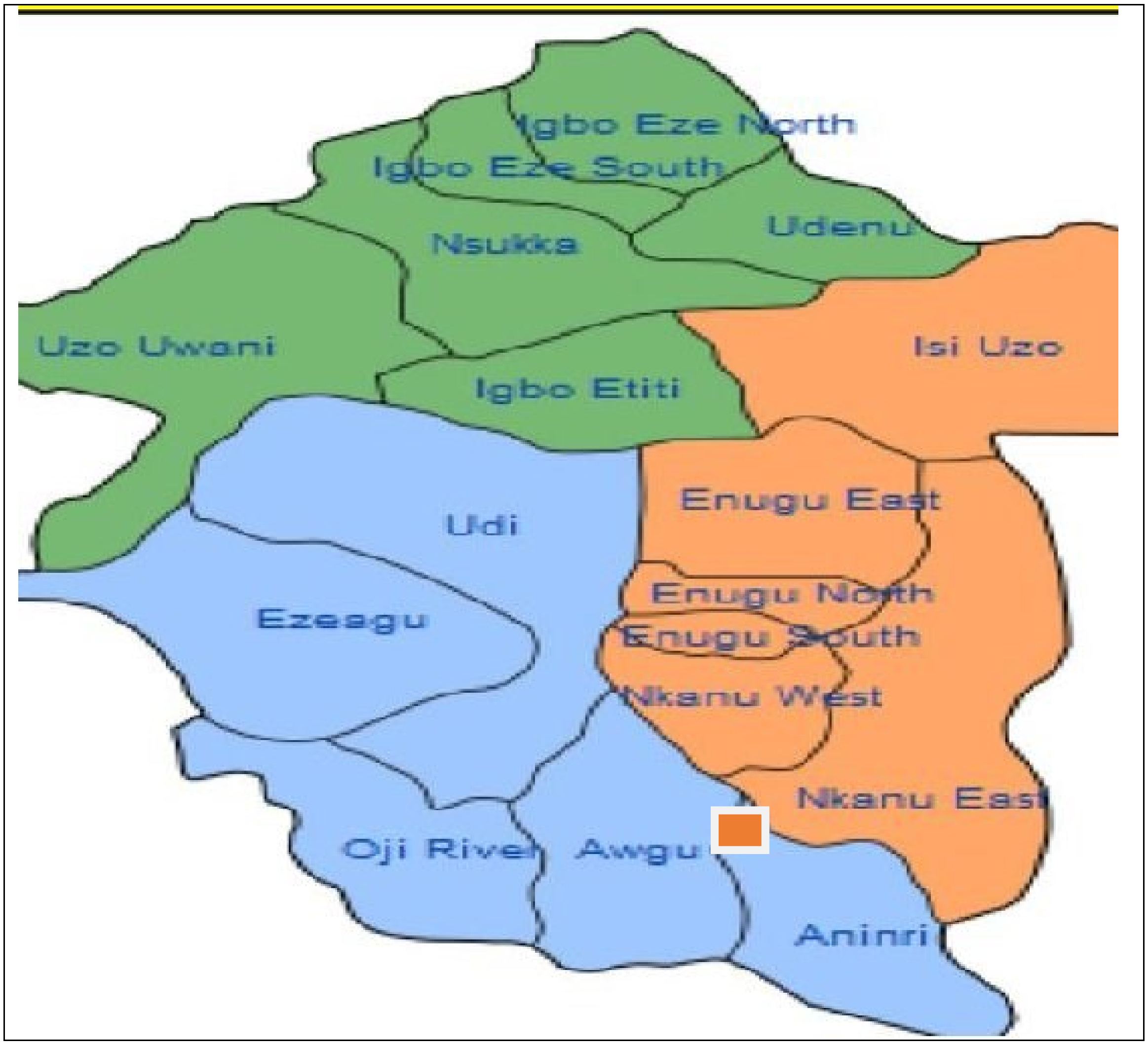

Figure 1: Map of Enugu Showing the 17 Local Government Areas in the State; The Local Government Area Where the Study was Carried out is Marked with Red
Source: nigerianinfopedia.com.ng

Materials and Equipment used for the Study

The crop used for the study was maize (Zea Mays) Oba super 11. This was obtained from Enugu State Agricultural Development Programme, Enugu (ENADEP). This variety is Striga and drought tolerance with high yielding capability. The cropping period is about 80 - 90 days, however, can mature earlier than the stated crop period based on the soil condition, nutrient availability, and others. The stages of growth are always based on the phonological development of crops, and the Kc curve is usually divided into four stages: initial, crop development, midseason, and late-season (Doorenbos and Pruitt, 1977).

Lysimeter

Lysimeters are foremost devices, typically tanks or containers that define a specific boundary to contain soil-water and allow measurement of either the soil-water balance or the volume of water percolating vertically and its quality. Lysimeter can be a percolating lysimeter (drainage lysimeter) or weighing lysimeter. Drainage or percolating lysimeter is used in conjunction with a soil water profile measurement method to estimate indirectly the water use in evaporative processes. A drainage lysimeter was used for this study because the accuracy of the evaporative water balance is directly related to the precision of the soil-water measurement and its integration through the vegetation root zone (Howell, 2005). Since lysimeter study can be used to determine the quantity of water used by a crop from planting to maturity or a particular growth stage. A lysimeter with both width and length of 90 cm and a depth of 60 cm was constructed and installed above the ground level. The lysimeter was planted with the maize in three rows and three columns. Each stand was sown with about three seeds of maize which were later weaned to one. The weaning act was done in such a way that the most viable seedling was left in each stand to grow for the study purpose. The study was carried out during the dry season period when there was little water input by rainfall. A measured quantity of water was applied to the system on daily basis using calibrated plastic buckets. Similarly, daily drainage discharges were as well collected and measured. Figures 2, 3, and 4 are a picture of the locally made drainage lysimeter, Lysimeter containing experimental crops, and soil sample collected for moisture analysis respectively.

Figure 2: Drainage Lysimeter

Figure 3: Experimental Crops

Figure 4: Soil sample for Mc test

Planting, Weeding, and Other Agricultural Practices

After setting up the experiment, maize seeds, three seeds per stand were sown in the lysimeter in 3 columns and 3 rows. These seeds or rather seedlings after germination and establishment were thinned to one seedling, leaving the healthiest seedling in each stand. That is a total of nine maize crops were monitored till the crop period was attained. Weeding was carried out in the set lysimeter experiment daily to make sure that the planted crops are not competing for the supplied water with weeds. In the same vein, the crops were closing monitored to ensure that they are not affected by pests and diseases.

Theory

The theory for the study is based on the water balance equation. The concept of the water balance equation is based on the conservation of mass, balancing inputs and outputs from a soil profile. Inputs in the water balance equation are taken to be positive signs (+) while outputs are taken as negative signs (-). Soil water storage, Ws is known to be the equivalent depth of water stored in a certain soil depth while changes in storage are determined for a given time interval depending on the researcher's intent. Equation 1 is the water balance equation.

$P + I = ET + DR + RO - \Delta WS$--Equation 1

Where:

P = Precipitation
I = Irrigation
ET = Evapotranspiration
DR = Drainage
RO = Surface runoff
ΔWS = Change in soil water storage within the soil profile (lysimeter)

However, the water balance equation given in equation 1 cannot be adopted for the study because the study was carried out during the dry season period and there was little input from rain, and the crops' water requirement was met mainly by irrigation, the effective part of the rain was determined. Surface runoff (RO) was eliminated from equation 1 to yield equation 2 because there was no runoff because of the amount of rain received and freeboard added to the lysimeter.

$I = ET + Pe + DR - \Delta WS$---Equation 2

Where;
P_e = Effective precipitation

Nonetheless, equation two can be used to determine the evapotranspiration rate of the understudied crop by making ET (evapotranspiration) the subject of the formula in equation 2. Thus, ET can be estimated using equation 3.

$ET = I + Pe - DR - \Delta WS$--Equation 3

Data Collection Method

The study adopted secondary and primary data for the study. The primary data include physical observations and direct measurements (drainage water and moisture content measurement etc.). Similarly, secondary information and data used for the study were obtained from published materials and the internet on related topics. Thus, reference evapotranspiration (Eto), climatic data e.t.c. was also obtained as secondary data.

Soil Classification

Soil samples were collected randomly at the site and taken to the Agricultural and Bio-resources Engineering Department and analyzed for soil class and bulk density. Particle size analysis of the soil was carried out using different types of sieves to obtain the class of the soil. The soil sample was air-dried, pulverized, and sieved using a set of sieves ranging from 9.5mm to 75µm in size. The physical property of the soil was determined and the soil was classified using AASHTO M 145. Figs. 5, 6, and 7 show a picture of the lysimeter where drainage water was collected, moisture measurement using a moisture meter, and growing maize crop at its vegetative stage respectively.

Figure 5: Collection of Drainage Water from the Lysimeter

Figure 6: Soil moisture Measurement

Figure 7: Healthy Growing Maize

Determination of Actual Evapotranspiration (ETO) and Crop Coefficient (KC)

Okechukwu and Mbajiorgu (2020) determined daily actual evapotranspiration for three different crops (Spinach, Maize, and Yellow Pepper) in Enugu, South-East Nigeria. The crop's ET_o was obtained using the Penman-Monteith model and thirty years climate parameters for South-Eastern States of Nigeria of which Enugu state is inclusive were adopted for this study. Crop coefficient which is the ratio of evapotranspiration of a crop type and the reference evapotranspiration (Doorenbos and Pruitt, 1977; Sharma and Irmak, 2012b) was determined using an equation that expresses the relationship between K_C, ET_o, and ET_C as given in equation 4.

$$K_c = \frac{ET_c}{ET_0} \text{---Equation 4}$$

Where:
K_C = Crop coefficient
ET_0 = Actual evapotranspiration

Soil Moisture Determination

Knowledge of the moisture content of the soil is essential in irrigation scheduling. The moisture content of the soil was determined using a moisture meter and gravimetric method of moisture determination. An in situ moisture meter that measures soil moisture and pH was used the determination of the soil moisture content and pH. On the other hand, soil samples were collected randomly from the lysimeter experimental pot within the root zone of the planted crops and put in an air-tight container to avoid moisture loss from the collected samples. Thereafter, the samples were taken to the Soil and Water Resources Engineering Laboratory in the Agricultural and Bio-Resource Engineering Department, Enugu State University of Science and Technology for soil moisture determination following the gravimetric approach of moisture determination. The soil moisture content which was determined in percentage by weight was converted to volume basis using equation 5.

$$Mc\ (\%\ by\ vol.) = Mc\ (\%\ by\ wt) \times Bulk\ density \text{--Equation 5}$$

Bulk Density

Bulk density of the soil reflects the mass or weight of a certain volume of soil. Soil bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. It determines the infiltration, available water capacity, soil porosity, rooting depth/restrictions, soil microorganism activity, root proliferation, and nutrient availability. Bulk density affects the pore diameter and its distribution and resultantly affects the soil hydraulic properties (Dec et al., 2008; Fuentes et al., 2004; Buczko et al., 2006). Bulk density is expressed in g/cm^3. The bulk density of the soil sample used was determined following the Core Cylindrical Method described in the Soil Quality Test Kit Guide by (Arshad et al., 1996).

Irrigation Water

The water needs of the planted crops were supplied mainly by irrigation. A known quantity of water was applied to the planted crops daily till the crop attained maturity. This is because the experiment was carried out during the dry season period of the year (January to March). This period is known to be the dry season as the study area has two major distinct seasons, the Rainy season (April - November) and the dry season (November - March). However, there was little rainfall in the study area during the period of this study that slightly contributed to the water need of the under-studied crop. These rainfalls that contributed to the water need of the planted crop were accounted for by determining the effective part of the rain.

Effective Rainfall (E_{RF}) or Effective Precipitation (P_e)

This is known to be that portion of rain that contributes to the water need or requirement of any growing crop under field conditions experiment. Thus, Dastane (1978) defined it to be the utilizable rainfall knowing very well that rainfall is not useful at all times, as some may be lost and some part of the rain be used by the crops. Nonetheless, the determination of the effective rainfall was successfully done with the aid of the formula proposed by The Food and Agricultural Organization (FAO, 1986; Chiwetalu *et al*., 2017; Ali and Mubarak, 2017). The formula proposed by FAO given in equation 6 was used for the calculation of effective rainfall.

$P_e = 0.6P - 10$ (if P < 75 mm per month) ---6

Where;

P_e is the effective precipitation
P is precipitation received within the experimental period

Results and Discussion

The physical observations conducted on the soil before adding organic manure (chicken droppings) indicated that the soil is a lateritic soil, reddish with fine texture at feel and non-plastic when wet. However, after the addition of organic manure and the soil well wetted allowed to stay for about two weeks, the color changed (darkened). This is can be attributed to the presence of a large quantity of organic matter in the soil. The potential hydrogen test carried out showed that the pH range of the soil was within 7.0 – 7.85 for the entire duration of the experiment and soil bulk density was 1.43 g/cm^3. Table 1, is the result of the sieve analysis carried out on the sample.

Table 1: Result of Particle Size Analysis of the Soil Sample

Sieve sizes	Weight Retained	% Wt Retained	% Passing
9.5 mm	Nil	Nil	100.00
4.75 mm	0.4	0.2	99.8
2.36 mm	1.2	0.6	99.2
1.18 mm	1.4	0.7	98.5

600 µm	6.0	3.0	95.5
425 µm	17.3	8.65	86.9
300 µm	32.7	16.35	70.5
150 µm	91.6	45.8	24.7
75 µm	21.2	10.6	14.1
Inference: the soil is fine sand with a small percentage of silt soil, not plastic			

The percentage of a soil sample that passed through the 75µm sieve was less than 35% while 100% of the sample passed through the 9.5 mm sieve size. More so, 86.9% of the soil sample passed sieve size 425 µm and a good percentage of the soil sample also passed sieve sizes 300 µm and 150 µm, and about 14% of the soil sample was retained in sieve size 75 µm. AASHTO M-145-91 (2003) classified soil samples passing through a 425 µm sieve and retained in a 75 µm sieve to be fine sand. Table 2, gives the observed drainage water from the lysimeter experiment, quantity of irrigation water supplied, effective rainfall, and moisture content reading.

Table 2: Irrigation Water Used, Drainage Water Collected, Effective Rainfall, Moisture Content, and Lysimeter Evapotranspiration

Days	I_w (mm)	Dr_w (mm)	P_e(mm)	MC (mm)	ET_C (mm)
1.	12.46	4.16		6.88	1.42
2.	12.46	4.26		6.01	2.19
3.	12.46	4.03		5.23	3.20
4.	12.46	3.68		3.87	4.91
5.	12.46	3.56		3.21	5.69
6.	12.46	2.95		3.53	5.98
7.	12.46	2.15		3.50	6.81
8.	12.46	3.39		4.21	4.86
9.	24.92	5.93		13.72	5.27
10.	24.92	5.80		13.22	5.9
11.	24.92	4.07		12.36	8.49
12.	24.92	3.46		12.02	9.44
13.	24.92	2.72		11.87	10.33
14.	24.92	2.96	9.10	24.31	6.75
15.	24.92	4.98	5.00	19.82	5.12
16.	24.92	0.62		19.23	5.07
17.	24.92	0.25		17.92	6.75
18.	24.92	0.12		16.46	8.34
19.	24.92	0.00		15.46	9.46
20.	24.92	0.00		15.03	9.89
21.	24.92	0.00	7.0	26.20	5.72
22.	24.92	0.00		22.15	2.77
23.	24.92	0.00		21.11	3.81
24.	24.92	0.00		20.61	4.31
25.	24.92	0.00		19.37	5.55
26.	24.92	0.00		18.88	6.04
27.	24.92	0.00	4.0	20.06	8.86
28.	24.92	0.00		21.61	3.31

29.	24.92	0.00		20.14	4.78
30.	24.92	0.00		18.73	6.19
31.	18.52	0.00		17.41	1.11
32.	18.52	0.00		16.39	2.13
33.	18.52	0.00		15.18	3.34
34.	18.52	0.00		14.39	4.13
35.	18.52	0.00		13.16	5.36
36.	18.52	0.00		12.36	6.16
37.	18.52	0.00		11.17	7.35
38.	18.52	0.00		10.21	8.31
39.	18.52	0.00		9.72	8.80
40.	18.52	0.00		9.06	9.46
41.	18.52	0.00		8.91	9.61
42.	18.52	0.00	5.0	15.93	7.59
43.	18.52	0.00		13.75	4.77
44.	18.52	0.00		12.66	5.86
45.	18.52	0.00		12.00	6.52
46.	18.52	0.00		11.47	7.05
47.	18.52	0.00		10.72	7.80
48.	18.52	0.00		9.58	8.94
49.	18.52	0.00	2.0	13.96	6.56
50.	18.52	0.00		12.85	5.67
51.	18.52	0.00		11.56	6.96
52.	18.52	0.00		10.44	8.08
53.	18.52	0.00		9.39	9.13
54.	18.52	0.00		8.37	10.15
55.	18.52	0.00		7.29	11.23
56.	18.52	0.00		7.00	11.52
57.	18.52	0.00		6.49	12.03
58.	12.46	0.00		5.66	6.80
59.	12.46	0.00		5.22	7.24
60.	12.46	0.00		5.01	7.45
61.	12.46	0.00		4.72	7.74
62.	12.46	0.00		4.28	8.18
63.	12.46	0.00		6.17	6.29
64.	12.46	0.00		6.68	5.7
65.	12.46	0.00		6.81	5.65
66.	12.46	0.00		7.23	5.23
67.	12.46	0.00		6.39	6.07
68.	12.46	0.00		6.44	6.02
69.	12.46	0.00		6.37	6.09
70.	12.46	0.00	2.0	10.05	4.41
71.	12.46	0.00		9.27	3.19

Note: Day 1 from Table 2 is Seven Days after Planting i.e., Day Eight of the Crop Period

I_w = irrigation water applied, Dr_w = drainage water collected, P_e = effective precipitation, Mc = moisture content of the soil, and ETc = lysimeter evapotranspiration readings.

Irrigation started seven days after planting as the soil was wetted to saturation and allowed for free drainage to commence before planting maize seeds. The initial time of irrigation was because corn uses very little water during the emergence and establishment stage and it is in line with the study conducted by (Udom and

Kamalu, 2019). The initial moisture content of the soil at the start of irrigation in the lysimeter experimental setup was 6.88 mm, drainage water collected was 4.16 mm and the calculated ETc from the experimental setup was 1.42 mm and irrigation water supplied was 12.46 mm. This is because the first irrigation took place seven days after the emergence of maize seeds and the seedlings were still very young with about 5 leaves per maize seedling, the leaf number also has a great effect on the rate at which evapotranspiration occurs.

Again, the number of leaves developed and the extent of leave development will influence the rate of transpiration occurring in the plant system. However, the result obtained is consistent with the study conducted by Broner and Schneekloth (2003) and Bob (2015) that related the development stages of crops and associated canopy density to crop water requirement and irrigation scheduling. The roots of the crops were also few and shallow at that stage which also influenced the water absorption capacity of the plant resulting in high moisture content of the soil. More so, on the 18th day of the crop period, drainage water collected from the lysimeter was 4.07 mm as against 5.81 mm of water on the previous day, this showed that the maize seedlings were requiring more water for their growth and development.

On the 18th day, the seedlings were two seedlings per stand and were later thinning to one seedling per stand three days later. The number of seedlings also affected the evapotranspiration rate in the system as seen in Table 2 because planting density is a major factor influencing water use in the soil. Thinning was done to allow the most viable seedling to grow, develop, and be used for the study. The contribution made by rainfall is reflected in the moisture status of the soil and lowering the evapotranspiration with exception of day 27th from the start of irrigation, this is also seen in Table 2. From Table 2, it was observed that drainage water dropped to zero from day 19th till the last day of the crop period, this can be attributed to a high increase in the demand for water by the growing crops. Similarly, the quantity of irrigation water supplied, the high temperature received and stored by the material used for the construction of the lysimeter (metal), and other climatic factors like wind speed and velocity resulted in high moisture loss and zero drainage.

On day 31st from the start of irrigation evapotranspiration was lowest in response to the quantity of irrigation water applied (reduced irrigation). Again, evapotranspiration was highest during the tasseling, silking, and cob(s) development. It is because crop water requirement tends to increase at the stage of maximum vegetative growth and yield formation, which is consistent with the reports of Allen *et al*. (1998) and Barhom (2012). Table 3 is computed total lysimeter ETc at the different growth stages of maize and total moisture at different stages of maize growth.

Table 3: Computed Total Lysimeter ETc at Different Growth Stages and Total Available Moisture at the different Growth Stages

Growth stages in Days	**ETc (mm)**	**Mc (mm)**
0 - 21 (Establishment)	81.24	123.94
21 - 37 (Vegetative)	88.44	276.61
37 – 70 (Tasseling,Cob setting and filling)	239.13	392.51
77 and above (Maturity/harvest)	56.83	69.69

The result of table 3 shows that evapotranspiration is less at the early stage of plant growth and that the total water content of the soil during the early stage was also the lowest. This is because less water was used for irrigating the crops at the early stage of growth, as the crop requires little quantity of water during the establishment stage. More so, the crops received no irrigation water from emergence time to about seven days. This as well influenced the soil moisture content at that stage. On the other hand, the high value of ETc obtained during tasseling, cob setting and filling was a result of the stage of growth. More water is required during the developmental stage for metabolic activities. Moisture content obtained is also highest at that stage, indicating that the availability of soil moisture influences the rate of evapotranspiration. Fig. 4 is a plot of lysimeter ETc obtained during the different growth stages and analyzed soil moisture during the growth stages of the experimental crops.

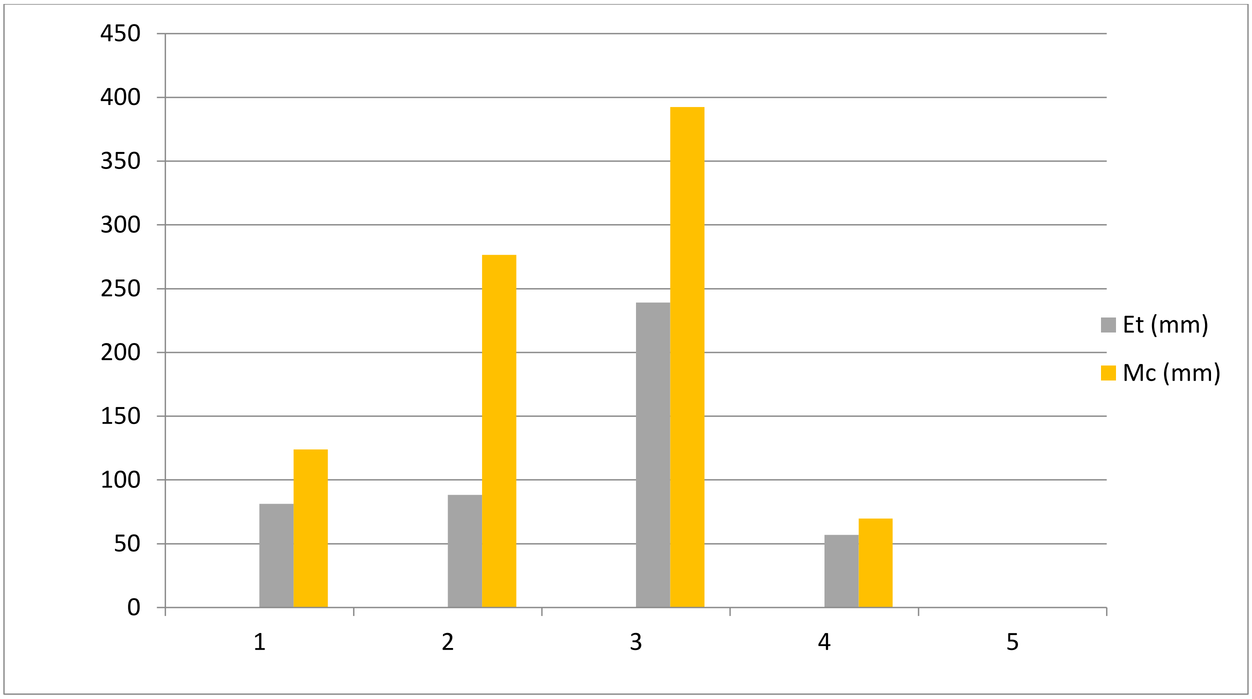

Figure 8: A Plot of the Etc and the Mc Obtained During the Different Growth Stages

K_C, PH For the Study Area

The observed pH during the entire study period was within the range of 7.0 - 7.8. The initial pH of the soil was 7.8, which is slightly above the neutral point. But days after planting, the pH of the soil started reducing which can be attributed to the organic manure that was used in the cultivation of the crop (Chiwetalu et al., 2021). Similarly, Kc obtained for the study was 0.79, 0.96, and 0.91 for the months of January, February, and March respectively with an average Kc of 0.89. This result is in line with the study conducted by Okechukwu and Mbajiorgu (2020) who obtained the average Kc for maize in Nsukka, Nsukka L. G. A., Enugu State, Nigeria to be 0.82. The little disparities in the result may be in the soil type, variety of maize, and other properties.

Conclusion

It can be concluded that the amount of irrigation water supplied influenced the availability of moisture since most of the water needed for the crops was actualized through irrigation. However, there was little input by rainfall which also raised the moisture content of the soil at all the times rainfall was received. The average crop coefficient obtained for the study was 0.89 which is consistent with results found in other literature. The study revealed also that the highest water need was during tasseling, cob setting, and filling. The infiltration rate of the soil is moderately high with moderate to low water retention capacity good for maize production (Jeans, 2003). From Table 2, drainage water was recorded as zero from the 19th day till the last day of irrigation. This can be attributed to many factors; high demand for the water needs of the crops, soil properties, climatic effects, and even the material used for the construction of the lysimeter. Metal has the ability to conduct high heat as such can influence the available moisture in the system. Nonetheless, it is recommended that the lysimeter should be lined with a material that has less heat conduction properties to avert water loss through heat conduction by a lysimeter made of metals and other good conductors of heat.

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