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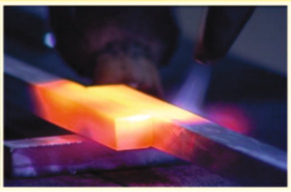


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Lysimeter Determination Of Crop Coefficient Of Drip Irrigated Jatropha Curcas

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Key words: Mini-drainage lysimeter, soil water balance, Jatropha crop coefficient and drip irrigation

ABSTRACT

The study was designed to examine the actual evapotranspiration and crop coefficient (Kc) of eight months old Jatropha curcas grown in mini-drainage lysimeter with a cylindrical drum of circular cross-sectional area of 0.246 m^2, diameter 0.56 m and 1.0 m depth. Investigation was conducted with drip irrigation system using five mini lysimeters. Each lysimeter contained one pressure compensating emitter of 4L/hr. Climatic variables were obtained for the determination of reference evapotranspiration (ETo) using the FAO-Penman Monteith model. The value for the crop evapotranspiration (ETc) was determined from the lysimeter using the soil water balance method on daily basis and the crop factor (Kc) was estimated from the ratio of ETc / ETo. The ETo estimated from weather data for the crop growing season ranged from 19.3 to 33.1 mm/day. The average crop coefficient (Kc) values at different growth stages were 0.6, 0.9, 1.2 and 0.8 for the initial, development, mid-season and late season respectively. The research output will enhance the productivity of farmers with optimum water management on large scale Jatropha cultivation.

1.0 INTRODUCTION

Jatropha curcas L. is a multipurpose shrub that belongs to a very large family of *Euphorbiaceae*. It is native to South America but now thrives in many parts of the tropics and subtropics in Africa and Asia (Niu *et al.,* 2012; Kumar and Sharma, 2008). The crop contains approximately 170 known species. It has numerous common names depending on the country where it is found, but it is commonly referred to as physic nut, Barbados nut or purging nut (Gush and Moodley, 2007). The crop is a potential source of biofuel, medicinal herb and it can alleviate soil degradation, desertification and deforestation (Genhua *et al.,* 2012). Interest in growing Jatropha has attracted the attention of investors and policy-makers worldwide for the purpose of producing biofuel as alternate to fossil fuel, reducing CO_2 emissions and promoting sustainable development (UNDESA, 2007).

However, water is a key input in Jatropha production just like other crops. Crops need to get adequate water at various stages of growth to give satisfactory yield. Scarcity of water is becoming a major challenge in many regions of the world. The conflict of water problem being experienced today is not about having too little water to satisfy our needs especially in agriculture but consequence of proper management (Akinbile and Sangodoyin, 2011). Rightful application of water to a crop is very important especially during drought. Irrigated agriculture helps in stabilizing agricultural produce in many countries of the world and the contribution of irrigation to increase food production worldwide has been enormous especially with drip system that applied right quantity of water needed for increasing crop yield and quality (Ewemoje *et al.*, 2006). However, information on crop water use and crop coefficient (K_c) are very vital when planning, designing, scheduling and managing irrigation system (Igbadun and Agomo, 2014).

Crop water use can be estimated as sum of water that goes into the atmosphere from the soil surface through evaporation

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process, water that goes through the plant leaves into the atmosphere through the process of transpiration, plus the fraction used in metabolic activities by the plants (Igbadun and Agomo, 2014). The percentage of water used in metabolic activities by plant is negligible, so crop water use is directly related to (ET) evapotranspiration (Ted, 2001; Larry, 1998). Crop coefficient (K_c) on the other hand is essential as this will help in the irrigation management and also provides precise water applications for a region. It is defined as the ratio of crop evapotranspiration (ETc) and reference evapotranspiration (ETo) (Ted, 2001). When K_c value is known for a given crop, then ETc can be calculated from ETo. Detailed knowledge of crop evapotranspiration from the period of crop emergence to maturity is very essential for the assessment of water resources and storage requirements, the capacity of irrigation systems, optimal allocation of water to crops and for decision making in agriculture (Oguntunde, 2004).

One method of direct estimation of ETc in order to develop Kc is by using lysimeters (Simon *et. al,* 1998; Haman *et al.,* 1997; Clark *et al.,* 1996). Two types of lysimeters available are weighing and non-weighing otherwise called drainage type. In weighing type which is also classified as mechanical and hydraulic (Igbadun and Agomo, 2014), the changes in the total weight of the soil sample are measured. The crop water use is calculated from the changes in weight of the lysimeter tank and changes are adjusted to account for weight changes caused by factors other than crop water use such as drainage or runoff and water input (Malone *et al.,* 2002; Igbadun and Agomo, 2014).

In non-weighing or drainage lysimeters, estimation of ET is done by computing the water balance. The water balance involves measuring all the water inputs and outputs to and from the lysimeter and the change in storage (soil moisture) over a stipulated period of time. These lysimeters provide viable estimates of ETc for longer periods such as weekly or monthly (Sanjay *et al.*, 2007). The dimension of a lysimeter is very vital in its controlling the accuracy. According to Clark and Reddell (1990) the lysimeter surface area and its depth must be large enough to minimize plant root restrictions. Sanjay *et al*., (2007) reported that accuracy of lysimeters increases with an increase in their surface area. The researchers also emphasized the need to surround lysimeters by a buffer area of the same crop that is of the same age, growth stage, and density for reliable estimates of crop water use.

Findings have shown that Kc for the same crop may vary from place to place based on factors such as climate and soil evaporation (Allen *et al.,* 1998 and Kang *et al.,* 2003). Also Doorenboss and Pruitt (1977), Kang *et al*., (2003) and Sanjay *et al.,* (2007) had agitated for the need to develop regional K_c for accurate estimation of water use, under a specific climatic condition. Some researchers over the years have developed K_c for Jatropha using literatures for validation (Garg *et al.,* 2014, Arisoa *et al*., 2012 and Gush *et al.,* 2007). However, unlike many other crops, no standard crop coefficient values have been developed for different growth stages of Jatropha, globally and specifically in Nigeria. These standard crop coefficient values are often affected by temporal variability of climate. Therefore, the study was designed to develop regional crop coefficients (K_c) specific to multiple phenololgical stages for Jatropha grown in the south west region of Nigeria for accurate irrigation scheduling.

2.0 METHODOLOGY

2.1 Description of the Experiment site

Experimentation was carried out at Federal College of Agriculture, Akure, Ondo State located on latitude 7^{0}15'58.4" N, longitude 5^{0}14'17.2" E and on elevation 352.4 m above sea level. The site was relatively flat with slope of about 1.0%. The soil is sandy clay loam (USDA). The site had been used for the cultivation of yam, maize and cassava for the past eight years and under fallow for two years before the commencement of the study. Rainy season commences around April and ends in late October or early November with an annual rainfall amount of approximately 1300 mm and it is well distributed throughout the year with peak rainfall experienced in July. Mean minimum and maximum monthly temperatures are about 20 and 36 ^{o}C, respectively (Fasinmirin et al., 2009).

Relative humidity is generally high, ranging between 80 and 100 % in the morning and during precipitations, while in the afternoon it values range between 60 and 80 %. Akure is affected by two air masses in the course of a year. The air masses are the Tropical Continental (TC), which is hot, dry and dusty. However, during the Harmattan haze spells of November to February, relative humidity values of 40 to 50 % are possible especially after mid-day. Temperature begins to subside at this time while relative humidity increases to attain higher values in the range of 60 to 80%. The weather data during the crop period was collected from the Akure Airport Meteorological Station which was very close (approximately 950 m) to the experimental field except rainfall data which was obtained from a locally fabricated rainguage installed directly on the field. The weather data are presented in Figs.1– 3.

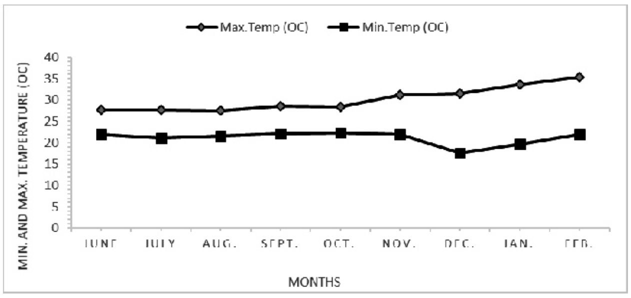

Fig. 1. Monthly maximum and minimum air temperatures during 2015-2016 crop cycle.

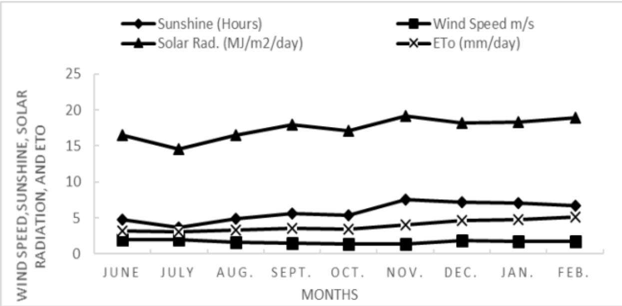

Fig. 2. Monthly wind speed, sunshine hours, ETo during 2015-2016 crop cycle.

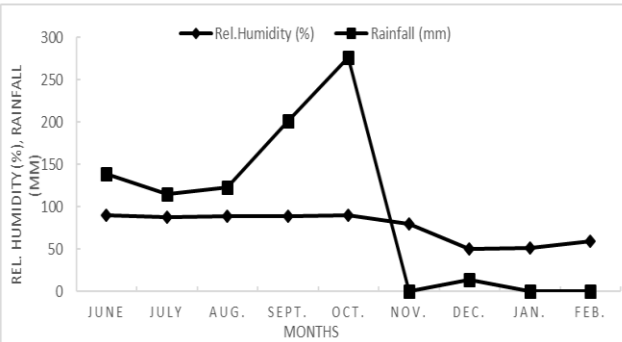

Fig. 3. Monthly relative humidity, rainfall during 2015-2016 crop cycle.

2.2 Lysimeters Design and Experimental Setup

Five mini-drainage lysimeters were constructed and used for this study. Each set of mini lysimeters consisted of cylindrical drum, slightly tapered at the bottom to allow good drainage of water. A drum of 56 cm diameter and 110 cm deep served as the lysimeter tank where the crop (Jatropha*)* was grown. The lysimeters were filled with repacked soil based on the weight of soil obtained from the surface area of the lysimeters and bulk density of each of the 0-20, 20-40, 40-60, 60-80 and 80-100 cm layers. The soil depth in the lysimeter was 100 cm, additional 10 cm layer for gravel and a sheet of mosquitoes net underneath which collects excess water from the upper soil and discharge it to the drainage collector. The gravel and sheet of mosquitoes net were placed at the bottom of each lysimeter to facilitate water drain and prevent entrance of soil from blocking the perforated drainage pipe. The pipe was connected to water collecting container (25 litres bucket) placed underneath the lysimeter. The heights of the lysimeter rims are maintained near the ground level to minimize boundary layer effect in and around the lysimeter.

However, the rims of lysimeter were protruded 20 cm above the soil surface so that no surface runoff water enters into the lysimeter. Another vessel (25 litres) was used in collecting the runoff water. The runoff collector was connected with a pipe extended with rubber hose to an outlet fitting made on the top edge of the lysimeter tank. This runoff collector was placed at a lower elevation so that the runoff water from the lysimeter can flow by gravity into the collector. Both the runoff and drainage collectors were covered with lid to prevent additional water from rain and also evaporation from taking place in the collectors. Drainage was collected daily from the container that collected water underneath the lysimeter using graduated bucket likewise was the runoff water. Plants in lysimeters were irrigated in the same way (i.e., drip irrigation) as those plants in the surrounding areas to maintain a favorable moisture regime in the root zone.

Plate 1: Installation of a drainage lysimeter

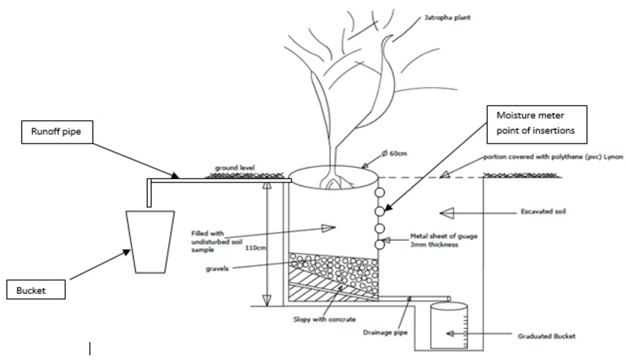

Figure 4: Schematic diagram of the drainage lysimeter

2.3 Experimental Set up and Lysimeter Soil Moisture Monitoring System

Five irrigation treatment blocks were adopted for the five mini-drainage lysimeters constructed and used for this study. Water application was 2 litres per plant per irrigation using drip emitter that discharged at 4 litres per hour as presented in Table 1. The dimensions of each treatment block were 4.5 m x 22.5 m. It consisted of three laterals. One lysimeter was installed at the center of each block, contained one plant and surrounded by Jatropha plants (to maintain a similar atmosphere condition) spaced 1.5 m by 1.5 m apart. Plants in lysimeters were irrigated in the same way (i.e., surface drip irrigation) as those plants in the surrounding areas to maintain a favorable moisture regime in the root zone.

The surface drip irrigation consisted of the following: an electrically operated submersible pump of 5 horse power to pump water from open well to storage tank of capacity 40 m^3, screen filter, pressure gauge, main line of 32 mm diameter (high density polyethylene) pipe, sub-main line of 25 mm diameter PVC pipeline, lateral pipe of 16 mm (low density polyethylene plastic) pipe, flow meter, control valves, 4 litre / hour pressure compensating drippers inserted into the 16 mm lateral at a space of 150 cm apart. Well water was used for the irrigation. Efficiency parameters based on drip system efficiency and emission uniformity were taken into consideration, however, this ranged between 94% and 90% based on the actual discharge rate of 4.0 L h^{-1} along the drip lines.

Table 1: Experimental treatment descriptions

Treatments No.	Treatments Codes	Description
1	T_D	Daily water application
2	T_4	Four times weekly water application
3	T_3	Thrice weekly water application
4	T_2	Twice weekly water application
5	T_C	Control (rain-fed as practiced by local farmers)

The crop was irrigated in accordance to the design of the treatments (Table 1). The amounts of water were measured by flow meters, which were fixed to the sub main lines, and Jatropha were daily-irrigated using one emitter with a water volume determined by the emitter discharge, time of application and plot area. Flow control valves were used to control the amount of water delivered to the laterals. The study was conducted on seven months old Jatropha plantation. Jatropha curcas (locally sourced) seeds were planted on June 30th and a pre-irrigation of 25 mm was applied in the field for proper seed germination and plant establishment. The crop was harvested between 6th of December, 2015 to 23rd January, 2016. The experiment was terminated at exactly 208 days after planting making first cropping season.

2.4 Determination of crop evapotranspiration (ETc)

In other to estimate the value of crop evapotranspiration (ETc), daily average water balance was computed for the lysimeters using energy balance equation as shown in equation 1:

$$ETc = P + I - Do - Ro \pm \Delta SM \qquad \text{……... (1)}$$

Where: ETc = Crop evapotranspiration

P = Rainfall (mm)

I = Irrigation (mm)

Do = Drainage (mm)

Ro = Runoff (mm) and

ΔSM = Change in Soil Moisture (mm)

The change in storage is accounted for by the change in soil water storage (SWS) in the entire lysimeter for a given period of time. No further replication of the treatments was done for estimating ETc since the lysimeter was a controlled structure from surrounding soil (Islam and Hossain, 2010).

Daily volumes of water inputs and outputs to the lysimeters were totaled and average values were obtained to compute the daily input and output volumes (expressed in mm). The soil water storage (SWS) was computed using daily soil moisture reading (θ) obtained using the digital moisture meter PMS -714 developed in Australia. The moisture meter was calibrated against gravimetric method before it was inserted into lysimeter's wall. The average absolute error (percent difference between the Lutron PMS – 714 and gravimetric) was 15%. The readings obtained from the PMS – 714 meter were converted to volumetric soil water content (θv) which was determined by multiplying soil water content from each layer with their respective bulk density. The volumetric soil water was then converted into mm of water so as to account for each incremental soil depth (d) by (θv ×d) (Mehmet *et al.*, 2005; Foroud *et al.*, 1993; Stone *et al.*, 1987). Plasticines were used in covering the perforated holes after daily measurements to prevent moisture loss.

The SWS was computed for every 20 cm increment up to depth of 100 cm. The difference between two consecutive days gives the change in soil water storage as:

$$S_i = \{\theta_{0-20} + \theta_{20-40} + \theta_{40-60} + \theta_{60-80} + \theta_{80-100}\} * d \qquad \text{……... (2)}$$

Where θ is soil water content and is soil water storage, mm for weeks I; $\theta_{0-20}, \theta_{20-40}, \theta_{40-60}, \theta_{60-80}$ and θ_{80-100} are the volumetric soil water contents of the different soil layers cm^3 cm^{-3} and the d is the depth of each soil layer in mm.

$$\Delta S = S_{i+1} - S_i$$

$$\Delta SM = SM_t - SM_{t-i} \qquad \text{……... (3)}$$

Where SM_t and SM_{t-i} are the storage soil moisture at time instants t and t-1, respectively.

2.5 Reference crop evapotranspiration (ETo)

The reference evapotranspiration (ETo, mm week^{-1}) was computed following the FAO Penman Monteith method given as FAO 56 (Allen *et al.*, 1998).

$$ET_0 = \frac{0.408\Delta(R_n - \gamma\frac{900}{T-273}u_2(e_s-e_a)}{\Delta+\gamma(1+0.34u_2)} \quad \ldots\ldots 4$$

Where ETo = reference evapotranspiration (mm /day),
Rn = net radiation at the crop surface (MJ m^{-2} day^{-1}),
G = soil heat flux density (MJ m^{-2} day^{-1}),
T = mean daily air temperature at 2 m height (°C),
u2 = wind speed at 2 m height (m s^{-1}),
es = saturation vapour pressure (kPa),
ea = actual vapour pressure (kPa),
es-ea = saturation vapour pressure deficit (kPa),
Δ = slope vapour pressure curve (kPa °C^{-1}),
γ = psychrometric constant (kPa °C^{-1}).

2.6 Determination of the Crop Coefficient (Kc)

The growing period (208 days) was divided into four distinct growth stages: initial (43 days), development (60 days), mid-season (30 days) and late-season (75 days). The crop coefficient (Kc) was determined by dividing the estimated crop evapotranspiration (ETc) by a weather-based reference evapotranspiration (ETo), using equation (5) as stated in Fasinmirin *et al*. (2009) and Allen *et al*. (1998).

$$K_c = \frac{Crop\ Evapotranspiration\ (ETc)}{Reference\ Evapotranspiration\ (ETo)} \quad \ldots\ldots\ldots (5)$$

The Kc values were computed on daily basis and later expressed as average of the four growth stages of the Jatropha (Doorenbos and Pruitt, 1977; Igbadun and Agomo, 2014). The stages are: initial, development, mid and late season.

At 208 days after sowing, the data on plant height were recorded from each lysimeter. The fruit yield and yield contributing data such as number of seed/plant were collected during harvest.

2.7 Statistical Analysis.

Analysis of variance (ANOVA) was computed to evaluate treatments effects on the growth and yield parameters. Turkey tests were used to compare and rank the treatment means and differences were declared significant at $P < 0.05$.

3.0 RESULTS AND DISCUSSION

3.1 Growth and Yield Parameters of Jatropha

The result of analysis of variance of growth and yield parameters of Jatropha are presented in Table 2 below. The result indicated that both growth and yield attributes of Jatropha were significantly influenced by varying water application in all treatments. For the growth parameters, treatment T_D (daily irrigation) produced the highest plant height (215.0 cm) and number of leaves (167.0) while treatment T_C (zero irrigation) had the minimum plant height (105.0 cm) and number of leaves (61.0). Although, in case of plant height from the Table 2, there were no significance difference in treatments T_D and T_4, while there were significance difference with other treatments T_3, T_2, T_C at 0.05 probability, using Turkey Test. The study results was in agreement with the findings of these researchers: Anil *et al*., (2017); Azza *et al.,* (2010) and Sarhan et al., (2010).

Also on yield parameters, treatment T_D (daily irrigation) gave statistically superior number of fruits, number of seeds and fruit yield (t/ha) while treatment T_C (zero irrigation) gave the least statistical values number of fruits, number of seeds and fruit yield (t/ha). Treatment T_D (daily irrigation) produced the highest number of fruits (113.0), fruits yield (0.778 t/ha) and number of seeds (309.0) while treatment T_C (zero irrigation) had the minimum number of fruits (23.0), fruit yield (0.25 t/ha) and number of seed (58.0). This is in agreement with Anil *et al.,* (2017) and Azza *et al.*, (2010) findings that Jatropha responded very well to irrigation in terms of yield.

However, treatments responded differently due to varying water application. The reason behind the response of the treatments in relation to vary water application was that treatment T_D got the most favorable soil moisture conditions to produce healthy plants as seen from the data of growth and yield parameters (Table 2). For the calculation of the crop coefficient values for different growth stages in a crop, Doorenbos and Pruitt (1977) recommended that the best growing plants producing the highest yields should be selected and adopted. Treatment T_D was therefore selected for determining the crop coefficient values of Jatropha in this study.

Table 2. Effect of irrigation on growth and yield parameters of Jatropha

Treatments	Plant height (cm)	No. of leaves	No. of fruits	Jatropha fruit yield (t/ha)	No. of seeds
T_D	215.0a	167.0a	113.0a	0.778a	309.0a
T_4	211.0a	146.0b	82.0b	0.562b	212.0b
T_3	199.0b	127.0c	51.0c	0.459c	141.0c
T_2	132.0c	99.0d	35.0d	0.360d	92.0d
T_C	105.0d	61.0e	23.0e	0.250e	58.0e

Mean in the same column followed by the same letter(s) are not significantly different at 0.05 probability, using Turkey Test.

3.2 Crop evapotranspiration (ETc)

Figure 4 shows the results of the daily ETc and ETo values for the Jatropha crop during the growing season. The Jatropha ETc daily values ranged from 9.6 to 32.1 mm and ETo daily values ranged from 19.3 to 33.1 mm. Higher ETc values were recorded between 84 to 154 days after planting which corresponds to mid - season growth stages as compared to the values obtained in other parts of the crop life cycle or growth stages. Changes occurred in the ETc throughout the season and this was likely due to change in the crop development and daily changes in weather parameters such as wind speed, radiation, temperature and humidity during the cropping season. Also, from the computation shown in Table 3 below, the water requirement of Jatropha from the study varied throughout the crop development and it is a function of the crop growth stages totalling 208 days from early to late season stages. The values obtained during the initial, development, mid-season and late season stages were 67.9 mm, 187.4 mm, 116.1mm and 240.6 mm, respectively. The values obtained was not in agreement with the findings of Garg *et al*., (2014) as they obtained higher values in all the various growing stages and developments of the crop.

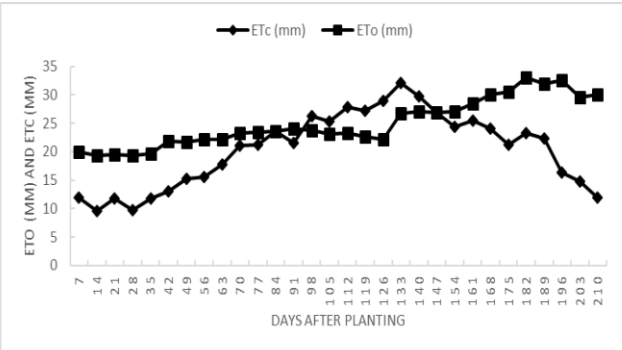

Fig. 4. Crop evapotranspiration (ETc) and potential evapotranspiration (ETo) of Jatropha during the growing season.

3.3 Reference Evapotranspiration (ETo)

The reference evapotranspiration values varied with the time period (Table 3), depending on the atmospheric temperature and other climatic parameters. Minimum values of ETo were obtained during the initial crop growth stage and this could be attributed to cooler weather resulting from the increased rainfall, decreases in intensity of solar radiation and temperature drops during the period. This could result in lower evaporative demand and high relative humidity of the atmosphere as indicated in the above (Figure 4). Gradual increase in ET_o started after 35 DAP and decreased from 98 DAP to 126 DAP and thereafter increased. The increased in ET_o from 126 DAP to 210 DAP was due to lack of rainfall which resulted in increased sunshine hours and the intensity of radiation during the growing season. The fluctuating trend was attributed to the variability of climatological factors during the growing season.

Table 3. Estimation of crop coefficient of Jatropha.

Growth Stage	Time periods (days)	Crop ET (ETc) (mm)	Reference ET (ETo) (mm)	Average Crop coefficient (Kc)
Initial season	43	67.9	119.4	0.6
Development	60	187.4	207.2	0.9
Mid-Season	30	116.1	94.7	1.2
Late season	75	240.6	327.2	0.7
Total	208			

3.4 Determination of crop coefficient

According to Doorenbos and Pruitt, (1977); Smith *et al.,* (1992) and Akanda *et al.,* (2017), the length of growing season of a particular crop and climate determined the duration of crop growth stage. The total duration of the Jatropha growth stages was 208 days and from Table 3, the maximum values of ET_c and ET_o were noted in the flowering stages (mid-season). The trend of crop factor for Jatropha during the different phonological stages at full irrigation was shown in Fig. 5. The shape of the curve represents the changes in the vegetation and ground cover during plant development and maturation that affect the ratio of ETc to ETo.

The Kc curve for Jatropha developed in this study followed the trend of a typical Kc curve, where Kc is small at the beginning of the season and increases as the plant grows until it reaches a maximum value at crop maturity (Allen et al., 1998). The Kc value shows a curve with peaks during the flowering/fruiting (mid-season) of the crop. The Kc ranged from 0.6 to 1.2. The values for emergence (initial stage), Vegetative, Mid-season (flowering and pod formation) and senescence (late season) were 0.6, 0.9, 1.2, and 0.7. The values are far from those reported in literature by Garg *et al*., (2014) in the studies they conducted in some States of India and Suhas *et al.,* (2012) which ranged from 0.10 to 0.95 and 0.01 to 0.9 respectively. However, the values obtained are in conformity with the results of Arisoa *et al.* (2012) which ranged from 0.6 to 1.2, in a study conducted on potential of waste water use for Jatropha cultivation in arid environments. Although Arisoa *et al*., (2012) findings was based on literature review. The values of crop coefficient (K_C) obtained by Bruno, (2016) ranged from 0.15 to 1.25 for a drip irrigated Jatropha of first to fourth year old. These K_C values was not in agreement with the findings of this present study. Bruno, (2016). All these values depend on the growth stages of the crop. However, variations in Kc values could be attributed to environmental conditions, crop genetic differences, age differences and different planting date.

The trend in Fig. 5 showed that crop coefficients decreased from about 0.6 to about 0.5 just after planting. The relatively high initial coefficients were probably caused by rainfall several days before planting. The initial values of Kc obtained during 0 - 35 DAP (Kc > 0.60) for Jatropha developed in this study was a little higher than values reported by Garg *et al.,* (2014). Between 42 DAP and 126 DAP, crop coefficients increased rapidly with time to values between 0.6 and 1.2. Thereafter, there were fluctuations in between 84 – 96 DAP which were likely due to the effect of rainfall and drainage (Steele *et al.,* 1996). The increased Kc from 42 DAP to 126 DAP could be as a result of increased evaporation (Ea) as the soil remained wet from rainfall or irrigation (Allen *et al.,* (1998). While high Kc during 112 – 133 DAP could also be as a result of crop maturity or increased evaporation (Ea) due to rainfall and irrigation. Declining Kc values during maturity stage (140 – 210 DAP) might be due to reduced sensitivity of the stomata as leaves begin to senescence (Fraust, 1989). The Kc result showed that the highest water requirement occurred at flowering and pod formation which was (mid-season) stage.

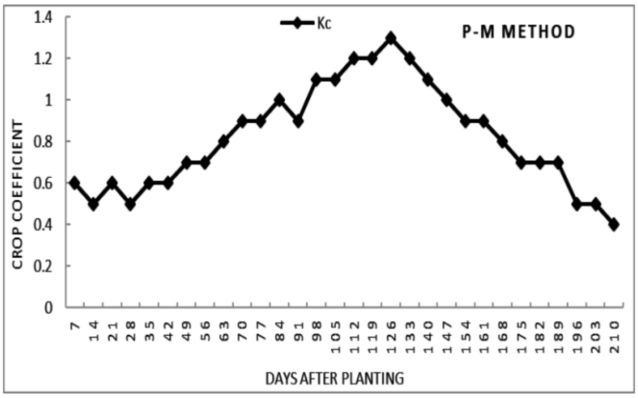

Fig. 5. Crop coefficient values of Jatropha during the growing season.

4.0 CONCLUSION

The study estimates crop evapotranspiration (ET_C) and crop coefficients (K_C) of Jatropha grown inside a mini-lysimeter in an open field. Results obtained showed that the ETc increases rapidly during the vegetative and flowering stages, indicating that crop water requirement was highest during this crop growth stages. Seasonal K_C values varied from 0.6 mm day^{-1} in the emergence stage to peak values of 1.2 mm day^{-1} during the vegetative and flowering stages. Also, crop coefficient (K_C) values obtained indicated that *Jatropha curcas L.* requires much more application of water during the vegetative and flowering stages than at emergence and senescence. The results indicate that Kc values can be different from one region to the other. Allen *et al.*, (1998) stated that different environmental conditions between regions allow variation in variety selection and crop developmental stage which affect K_C. On this note, the results of this finding will be useful in providing precise water applications in area where high irrigation efficiencies are required for the establishment of large scale commercial cultivation of *Jatropha curcas* and for predicting crop water irrigation needs using meteorological data from weather station.

It is therefore recommended that K_C developed from this study should be used for irrigation scheduling and developing water budgeting procedures for drip irrigated Jatropha production in a humid region of south west Nigeria.

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