GSJ: Volume 5, Issue 12, December 2017, Online: ISSN 2320-9186
www.globalscientificjournal.com

DETERMINATION OF CROP WATER USE OF OKRA USING MINI-LYSIMETER IN ILORIN, KWARA STATE, NIGERIA

James D, Makanjuola, M. B. and S. A. Adekeye

Department of Land and Water Engineering

NationalCentre for Agricultural Mechanization (NCAM) P. M. B. 1525,

Ilorin, Kwara State, Nigeria.

ABSTRACT

This study describes the use of mini-lysimeter to investigate the of crop water use of okra crop (*Abelmoschus esculentus).*The mini-lysimeter consist of plastic container which served as lysimeter tank and inner tyre tube filled with water connected to a glass U- tube manometer for the weighing system. The daily displacement of water in the glass U- tube manometer due to change in weight of lysimeter were translated to crop water use. The average daily water use ranged from 1.18 to 5.11mm/day. This increased from 1.81mm/day at the early growth season to 5.11mm/day at the mid-season and declined to1.18mm/day at the end of the season. This information will serve as a guide to our farmers as to the amount of water to apply to okra crop for optimum performance.

Key words: crop water use, mini-lysimeter, okra.

1. INTRODUCTION

Okra (Abelmoschus esculentus) is a vegetable cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds (National Research Council, 2008). It is among the most heat- and drought-tolerant vegetable specie in the world and will tolerate soils with heavy clay and intermittent moisture, but frost can damage the pods. In cultivation, the seeds are soaked overnight prior to planting to a depth of 1–2 centimeters (0.39–0.79 in). Germination occurs between six days (soaked seeds) and three weeks. Seedlings require ample water. The seed pods rapidly become fibrous and woody and, to be edible as a vegetable, must be harvested when immature, usually within a week after pollination (Thanaverdan *et al*., 2009). Okra is available in two varieties, green and red. Red okra carries the same flavor as the more popular green okra and differs only in color. When cooked, the red okra pods turn green (Martin *et al.*, 1982).

The products of the plant are mucilaginous, resulting in the characteristic slime when the seed pods are cooked; the mucilage contains soluble fibre. Pods are cooked, pickled, eaten raw, or included in salads. Okra may be used in developing countries to mitigate malnutrition and alleviate food insecurity. Raw okra is 90% water, 2% protein, 7% carbohydrates and negligible in fat. In a 100 gram amount, raw okra is rich (20% or more of the Daily Value) in dietary fibre, vitamin C and vitamin K, with moderate contents of thiamin and magnesium (Gemede, 2015).

It was reported that out of an expanded list of twenty-four indigenous leaf vegetables that are eaten in Nigeria, thereare only scanty information concerning water management of indigenous leafy vegetables (Adebooye *et al.* 2003). For proper irrigation scheduling and high level agricultural production, a precise knowledge of crop water use under field conditions is required. Since the micro-climate during the wet season differs from that of the dry season, it is most expected that crop water requirements for irrigation should differ from that under rain-fed condition (Igbadun, 2012).

To estimate the amount of water required for crops, it is necessary to know the amount supplied by rainfall, the amount used in evapotranspiration and the amount lost to deep percolation. One of the practicable methods for measuring evapotranspiration rate and determining the deep percolation is by using lysimeter which has been described as probably the best for determining the actual crop water requirement (Adeogun *et al.,* 2013).

A lysimeter is a device which enables the isolation of a soil column for the purpose of studying water inflow and outflow in the system. The soil column can be isolated from the surrounding using a container of regular shape (the lysimeter tank) and planted to a crop. The water input to grow the crop can be measured and the crop water use and other output components of the soil water balance (runoff, deep percolation and moisture retained in the soil column) can also be quantified (Igbadun, 2012).

There are two basic types of lysimeter namely Weighing Lysimeters for agricultural purposes and Non Weighing Lysimeters for chemical analysis on drainage water (Garcia *et al.,* 2004). To obtain a reliable hourly evapotranspiration measurement, the ideal instrument is a high precision weighing lysimeter with accuracy better that 0.1 mm of water. The dimension of lysimeters used for estimation of water consumption of herbage and trees is usually about 3 – $10m^3$, in order to avoid rim effect; moreover, Mini-Lysimeters, characterized by reduced soil volume (less than 1 m^3), have been recently adopted due to reduced installation and managements costs and good accuracy of measurement (Simone *et al.,* 2017).

The objective of this study reported herein is to estimate crop water use of okra crop using a weighing type mini-lysimeter.

2. MATERIALS AND METHODS

2.1 Description of Study location

The field trial was carried out during the 2015 rainy season at the experimental fields of the Land and Water Engineering Department of National Centre for Agricultural Mechanization, Ilorin (Longitude 40, 30' East and Latitude 80, 26' North) Nigeria. It is located within the forest savannah ecological zone. The climate can be described as moderately dry and wet seasons, with heavier rains falling in September and October. The weather data of the study location for the period when the study was carried out is presented in Table 1. The soils of the study area are Sandy Loamy based on the USDA classification. The soil texture of the experimental site was predominantly sandy loam. The textural properties of the site are given in Table 2.

2.2 Mini-Iysimeter Construction

A mini-lysimeter was assembled and used for this study. The mini-lysimeter consisted of a plastic container of 40 cm diameter and 30 cm depth which served as the lysimeter tank where the crop was planted, the weighing system, the runoff and the drainage systems. The weighing system consisted of a vehicular tyre tube filled with water and connected with a rubber hose to a manometer glass tube of 2 m long. The manometer glass tube was fixed to a calibrated pole in a vertical position so that water in the vehicular tube rose to a height in the calibrated manometer glass tube depending on the pressure exerted on it. The vehicular tube was placed on a flat wooden platform and the lysimeter tank was placed on the tube directly so the change in weight of the lysimeter tank due to inflow and outflow of water into the tank causes a displacement of the water level in the manometer glass tube. The runoff system consisted of a plastic bucket of 30 cm diameter and 35 cm depth which serves as the collector. The runoff collector was connected with a rubber hose to an outlet fitting made on the top edge of the lysimeter tank. The collector was placed at a lower elevation so that the runoff water from the lysimeter tank flowed by gravity into the collector. The runoff collector was covered with a lid to prevent rainwater from entering into it. The drainage system consisted of a plastic bowl of 20 cm diameter and 10cm depth which collected the drained water from the bottom of the lysimeter tank. The lysimeter tank was perforated at the bottom to allow for drainage of water beyond what the soil can hold. An opening was made in the center of the platform upon which the tube rested, into which the drainage collector was fitted such that the collector was suspended above the ground surface

2.3 Field experimental procedures

Okra was planted on a field of 20m by 40m. A set of the mini-lysimeter was installed in the midst of the okra field. The lysimeter was set up in an excavated pit at a depth such that the level of soil in the lysimeter tank was at the same level with the soil surface in order for the cropped field and the lysimeter to be under the same weather conditions.The okra field was planted on 9thJune, 2015. The okra field and the lysimeter were given the same attention which included weeding and fertilizer applications. Plate 1 shows the lysimeter setup in the okra field mid-season. The Okra crop attained physiological maturity within 90 days.

2.4 Determination of crop water use from the lysimeters

Each rainfall added water to the lysimeter tank. As a result, the pressure exerted on the tubes due to increase in weight of the lysimeter tank caused a rise in the water level in the manometer glass tube. Excess water beyond what could infiltrate into the soil in the container went into the runoff collector while water beyond what the soil could hold drained by gravity through the bottom of the lysimeter tank into the drainage collector. A rain gauge was installed on the field to measure daily rainfall depth. As evaporation took place and the crop used water for its metabolic activity on daily basis, the weight of the lysimeter tank and consequently the level of water in the manometer glass tube decreased. The levels of water in the manometer glass tubes were monitored 24 hourly throughout the crop growing season between 9:00 and 10:00 am. The runoff and drainage collectors were also inspected daily, and the depths of water found in them were also noted. The difference in weight of the lysimeter tank between two consecutive measurements indicated by the difference in the level of water in the manometer glass tube was as a result of the water added from rainfall, crop water use (evapotranspiration), water drained or runoff. When there is no rainfall, runoff or drainage, the difference in weight would be due to crop water use. The weight of the lysimeter tank on any given day was determined from the level of water in the manometer glass tube using a relationship earlier developed in the laboratory between height of water in the manometer glass and known weight packed into the lysimeter tank. The relationship was obtained as:

$$W = 0.448 * h + 1.023 \quad (r^2 = 0.897) \qquad (1)$$

where, W is weight of lysimeter in kg and h is the height of water in the manometer glass tube in cm.

When rainfall, drainage or runoff events occurred, their depths were first subtracted from the change in weight of the lysimeter tank, and the reminder was the crop water use. The expression used for the computation of daily crop water use is given as:

$Cu_i= P_i- R_{fi}- D_i- [(W_{i+1}- W_i) * cf]$ (2)

CU_i = Crop water use of day i

P_i, = Rainfall amount (mm) of day i collected in the rain gauge

Rfi= Runoff (mm) of day *i*

W_i = Weight of the lysimeter soil on day i.

W_{i+1} = Weight of the lysimeter soil the next day at an interval of24 hours.

cf= A factor converting weight to equivalent depth of water

3. RESULTS AND DISCUSSION

3.1 Water use of okra Crop

Figure1 shows the trend of the total weekly crop water use of the okra crop during the growing season. The total weekly crop water use of the okra crop varied from 10.53 to 35.79 mm/week. The water use increased from 10.53mm per week at the early growth of the crop to 35.79mm per week at the mid-season and then declined to 12.43mm per week at the end of the season with the same trend of average daily water use which ranged from 1.18 to 5.11mm/day as shown in figure 2. This increased from 1.81mm/day at the early growth season to 5.11mm/day at the mid-season and declined to1.18mm/day at the end of the season. This trend agrees with the estimation of crop water use of rain-fed maize and groundnut crop using mini-lysimeter where the average daily water use of maize increased from 2.70 mm/day at the early crop growth stages to 6.00 mm/day at the mid-season and declined to 3.30 mm/day at the end of the season while that of groundnut crop increased from 2.66 mm/day at the early growth season to 4.83 mm/day at the mid-season and declined to 2.70 mm/day at the end of growth season of the crop (Igbadun, 2012).

(Ademiju *et al.*, 2017) reported average daily water use of three vegetable using mini-lysimeter, the results showed that average daily water use of the Lagos Spinach increased from 0.16 mm/day at the early crop growth stages to 5.23 mm/day at mid-season and declined to 1.08 mm/day at the late season of the crop. The leafy Amaranths shows that the average daily water use increased from 0.13mm/day at the early growth stage of the crop to 4.96 mm/day during the mid-season and declined to about 1.60 mm/day at the late season. While Jute mallow shows that average daily water use increased from 0.11mm/day at the early growth stage of the crop to 4.44 mm/day during the mid-season and declined to 1.67 mm/day at the late season. The trends of the average daily water use of these three vegetables agreed with the average water use of okra.

Figure 3 shows the trend of the actual daily crop water use of okra during the growing season. The daily crop water use of okra varied from 0.00 to 12.11mm/day. There was no definite pattern for the actual daily crop water use with respect to crop age as the values kept rising and falling throughout the crop growing season. This is typical of daily evaporation during the rainy season as higher evaporation does happen on very sunny and cloudless days and lower evaporation on cloudy and rainy days (Ademiju *et al*., 2017 and FAO, 2005).

4. CONCLUSION

The study has demonstrated the use of mini-lysimeter to estimate the crop water use for okra crop (*Abelmoschus esculentus).*This information will serve as a guide to our farmers as to the amount of water to apply to okra crop for optimum performance. There is, however, a need for further studies on the potential crop water use of okra estimate from weather crop coefficient data. This will make it possible to effectively plan and manage water for an all year round production of okra which will ultimately lead to stability in the price of this crop and ensure more economic gains to farmers.

5. REFERENCE

Adebooye O. C., Ogbe, F. M. D. and J. F. Bamidele, (2003). Ethno botany of indigenous leaf vegetables of Southwest Nigeria. Delpinoa, University of Naples, Naples, Italy: 45

Ademiju, T. A, Osunbitan, J. A and , G.A. Ali (2017).Determination of crop water use for vegetables in southwestern Nigeria using lysimeter. *European Journal of Engineering and Technology* Vol. 5 No. 2, 2017:33-46

Adeogun E. O. and A. O. Ogunlela (2013). Determination of crop coefficients for okra using lysimetric evaluation during dry season. *Journal of Agricultural Engineering and Technology* (JAET). Volume 21(No. 1). 67-71

Food and Agriculture Organization (FAO) (2005). Fruit and Vegetable for health. Report of a joint FAO/WHO workshop.

Gemede, H. F.; Haki, G. D.; Beyene, F; Woldegiorgis, A. Z.; and , S. K Rakshit. (2015). "Proximate, mineral, and antinutrient compositions of indigenous Okra (Abelmoschus esculentus) pod accessions: Implications for mineral bioavailability". Food Science & Nutrition.**4** (2): 223–33.

Garcia, M., O. Raes, R.G. Allen, and C. Herbas. (2004).“Dynamics of Reference Evapotranspiration in the Bolivian Highlands”.*Agricultural Forest Meteorology*.125:67 - 82.

Igbadun, H.E. (2012). Estimation of Crop Water Use of Rain-Fed Maize and Groundnut Using Mini-Lysimeters. *Pacific Journal of Science and Technology*. 13(1):527-535.

Martin, Franklin W. (1982). "Okra, Potential Multiple-Purpose Crop for the Temperate Zones and Tropics". Economic Botany.**36** (3): 340–345.

National Research Council (2008)."Okra". Lost Crops of Africa: Volume II: Vegetables.. National Academies Press. ISBN 978-0-309-10333-6.

Simon C.M., E.I. Ekwue, F.A. Gumbs, and C.V. Narayan (1998).“Evapotranspiration and Crop Coefficients of Irrigated Maize (Zea mays L.)in Trinidad”. *Tropical Agriculture*. 75(3):342-346.

Thanaven, G. and S. Jeyarani (2009). Biointensive management of okra fruit borers using braconidparasitoids (Baraconidae Hymenoptera). *Tropical Agric. Res*., 21:39-50

Plate 1: A typical set up of the mini-lysimeter.

Table 1: Average monthly weather data of Study area for June-September, 2015

Weather Parameters	JUNE	JULY	AUGUST	SEPTEMBER
Rainfall	15.7	147.8	82.3	168.7
Relative Humidity	86.0	91.0	88.0	89.0
Maximum Temperature	25.0	24.0	23.9	25.5
Minimum Temperature	24.5	23.6	23.4	24.2
Wind Speed	2.9	2.9	2.7	2.7

Table 2: Particle size distribution (%) of the soil of the study site

Soil Depth(cm)	Sand(%)	Silt(%)	Sand(%)	Textural Class
0-7	67.74	29.03	3.33	Sandy loam
7-14	70.58	23.18	5.79	Sandy loam
14-21	72.00	21.00	7.00	Sandy loam

Figure 1. The weekly crop water use of okra crop

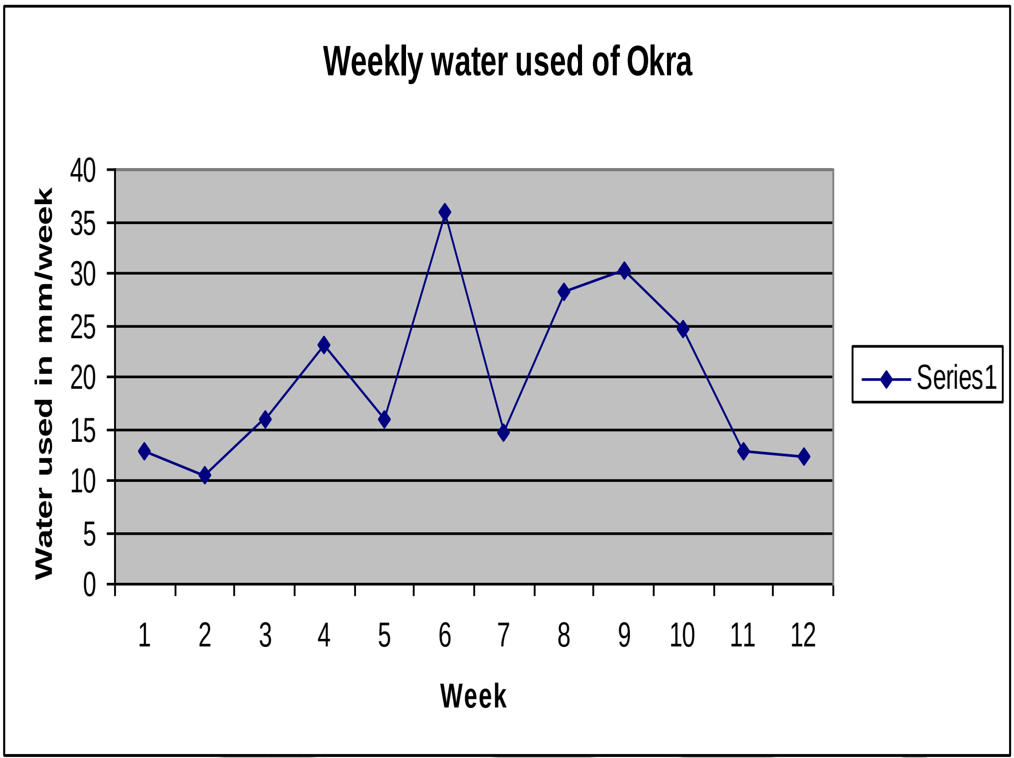

Figure2. The average daily crop water use of okra crop

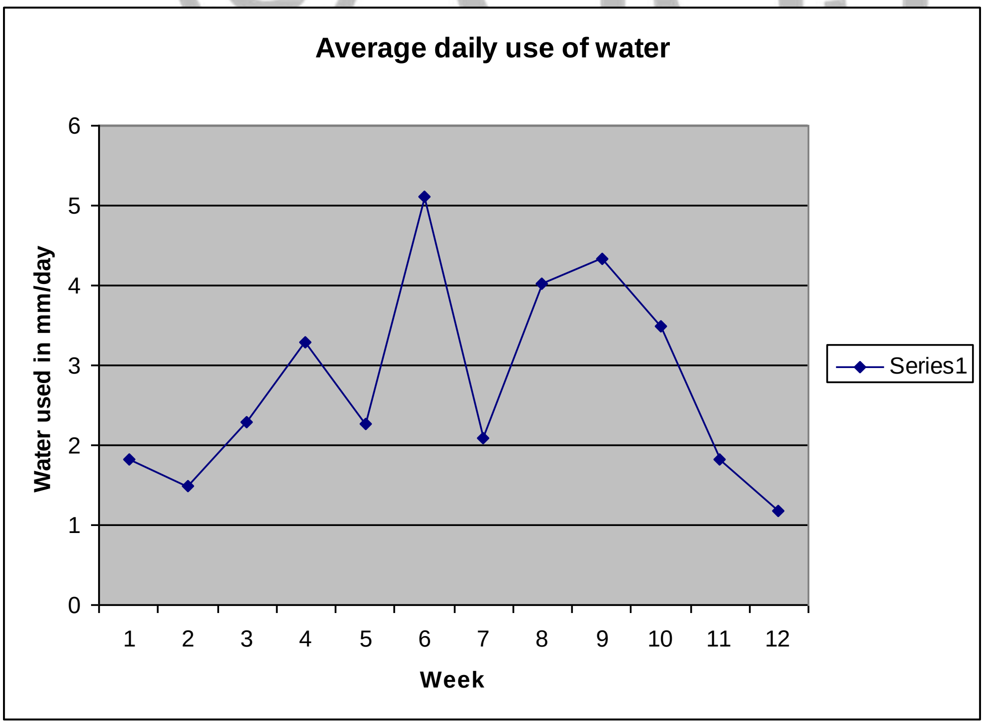

Figure 3. The daily crop water use of okra crop