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Development of Non – Weighing Lysimeter

M.O. Lasisi*, A. A. Rodiya and O. D. Isinkaye
Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic, Ado- Ekiti, Nigeria
**Corresponding Author: M.O. Lasisi*

ABSTRACT
Water is essence of life on which man depends not only for his direct consumptive need but also for producing his food, fibres and for various day-to-day requirements. Water is therefore one of the most important inputs essential for the production of crops because plants need it continuously during their life and in large quantities. In order to determine the water requirement of the crops, a non-weighing Lysimeter is required for estimating the consumptive use. The project aimed at developing a non- weighing Lysimeter using okra as a trial crop. The low cost non-weighing Lysimeter is affordable by low and medium scale farmers to give them the opportunity to know the water requirement of a particular crop before going into production. A non weighing Lysimeter has been developed locally and tested. All the materials used for fabrication were obtained locally. The total cost of development of the equipment was estimated to be N33, 980.00 which is affordable by small and medium scale farmers. Most of the existing equipments for carrying out this operation are complex, imported and expensive to acquire, assemble and maintain. The equipment was installed and the static tests carried out showed that it was working perfectly.
KEYWORD: Development, performance evaluation, non- weighing Lysimeter, consumptive use

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I. INTRODUCTION

Water is a critical resource in agriculture and supplying the right amount of it is essential for healthy plant and optimum productivity. With insufficient water, plants become stressed and unproductive and eventually die (Bryant and Frigard, 2006). In order to determine the water requirement of the crops, various methods can be used and in line with the scope of this project, Lysimeter is considered as the commonly and widely used in relation to other instruments for taking the water requirement by crops. One of the challenges of determining crop requirement represented by crop consumptive use at field level under rain-fed condition is the fact that the other output component of the soil-water balance e.g. runoff, deep percolation and capillary movement are very volatile and difficult to measure. However, this challenge can be overcome with the use of Lysimeter (Tim, 2003). Lysimeter is a method which provides complete information on the entire component of water balance. Lysimeter can be used not only for measuring evapotranspiration but also for checking empirical formulae for computing evapotranspiration (Rana G and N. Katerji). Pruitt and Angus (1998) confirmed that Lysimeter can be either weighing or non-weighing type. In non-weighing Lysimeter, changes in water balance are measured volumetrically, weekly or bi-weekly. No accurate daily estimators can be obtained. A weighing Lysimeter can provide precise information on soil moisture changes for daily or even hourly periods. Brady and well (2002) defined Lysimeter as a method used to study percolation and leaching losses of soil. They also explained that, Lysimeter can be used in a controlled experiment in which different soil- plant management systems are compared. In line with the scope of this project, the non weighing Lysimeter will be used to determine the water consumptive use of okra on sandy loam soil. Irrigation is the artificial application of water to the land or soil. It is used 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. In many areas of the world, agricultural production depends upon efficient irrigation. If the water necessary for plant growth is not uniformly, yield will be adversely affected. Furthermore, in many areas the waste available for irrigation is limited, so irrigation system must apply water so that plants can use it effectively (Snyder, 2005). Lysimeter which provides complete information on the entire component of water balance can be used not only for measuring evapotranspiration but also for checking empirical formulae for computing evapotranspiration (Rana and Katerji). The non weighing Lysimeter was used to determine the water consumptive use of okra on sandy loam soil. According to Brady and Well (2002), Lysimeter is a method used to study percolation and leaching losses of soil. It is used 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 (Snyder, 2005).
With an excess, they can suffer from diseases nutritional disorders and water logged soil (Shari, 2015). Okra (Abelmoschus esculentus) is a traditional vegetable crop with considerable area under cultivation in Africa and Asia with huge socio-economy potential in west and central Africa. It has been called a perfect villagers vegetable because of its robust nature, dietary fibres and distinct seed protein balance in both lysine and tryptophan amino acids (unlike the protein of cereal and pulses) it provides. However, Okra has been considered a minor crop and until recently no attention was paid to its improvement in the international research programme (Duzyaman, 1997). Okra is grown in home gardens for personal use and for fresh market sale. The fresh market sale includes local farmers market, road side stands and local stores. Okra is easily grown because it tolerates environmental stress well and still produces a crop. For most cultivars, flowering begins 35 days after planting. Normally, flowers are self-pollinated or are pollinated by insects. Okra grows best well on a well drained sandy loam soils (Muhammed, 2010). Okra is very sensitive to soils with a hard pan, and soil compaction can severely restrict plant growth. It is a hot weather crop that has a thick seed coat and doesn't germinate easily; germination may be enhanced by soaking for several (4-6) hours or overnight immediately before planting. Adequate soil moisture is necessary for optimum growth and yield. A regular watering is recommended for maximum yields, over watering may drown plants or cause excessive growth (Umer Rasheed, 2010).

II. MATERIALS AND METHODS

The non-weighing Lysimeter was made from a readily available material. The tank was truncated plastic drum, cylindrical in shape with a surface area as shown in Figure 1. The cylindrical plastic drum was slightly tapered at the bottom to allow good drainage of water. The receiving vessel was a calibrated bucket. Sufficient space was made at the bottom to allow collection of the percolated water and the water collected from the calibrated bucket as drained water from the pipe directly was measured using a measuring cylinder. Pipes were used for the connections from the tapered bottom of the non-weighing Lysimeter tank. The non-weighing Lysimeter tank was filled with sandy loam soil and a known quantity of water was applied to saturate it. This was to determine the holding capacity of soil in the non-weighing Lysimeter. Okra seeds were planted and the agronomic parameters were monitored and recorded in the non-weighing Lysimeter until the harvesting period.

Design Consideration

i. Cost: The available local materials were used to reduce the cost of production. The materials used in fabricating most of the parts of the machine were obtained from disused and abandoned machines.
ii. Strength and rigidity: The material used for constructing its frame was an angle mild steel of 5mm thickness to ensure adequate strength and rigidity.
Durability and transportability: Mild steel pipes, plastic drums, plastic buckets and low pressure hose were considered for its durability and it was easy to transport to the field. This problem has been considered by making the parts of the non-weighing Lysimeter detachable and not buried in the soil for easier removal at any time.

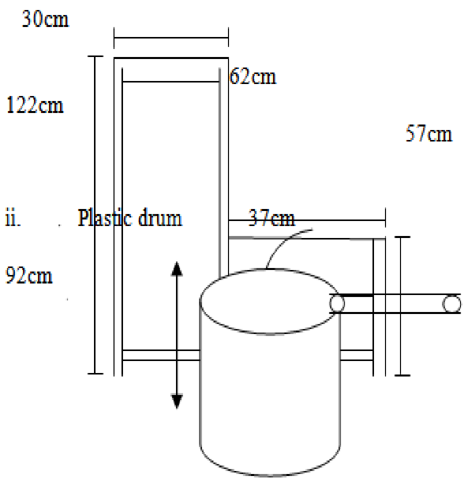
Materials Selection

The materials for non- weighing Lysimeter were sourced locally to reduce the cost of construction. The materials include; mild steel, flat bar, PVC pipe, PVC fittings and accessories.

Construction Procedure

This was done by marking out the angle bar (frame), plastic drum, PVC pipes and hose into the required dimensions with the use of steel tape. The angle bars, pipes, hose and the plastic drum were cut into their required dimensions. The angle bars were welded to the required length and heights. A calibrated bucket was placed at the top flat area while plastic drum rested on the one below. The calibrated bucket was perforated at the base and a tap was fixed for easy delivery of water into the plastic drum that was perforated at the base. Another pipe was fixed for easy delivery of water from the drum filled with soil into another calibrated bucket. The stand provides support for the non-weighing Lysimeter to withstand soil and water.

i. Construction of stand



$$V = \pi \frac{d^2 h}{4}$$

$$= \frac{3.142 \text{ X } (37^2)92}{4}$$

$$= 98932.154 \text{ m}^3$$

Installation Procedure

The non-weighing Lysimeter was installed under the green house in the Department of Agricultural and Bio-environmental Engineering, The Federal Polytechnic Ado- Ekiti, Nigeria. The non-weighing Lysimeter was well positioned and properly assembled. The perforated plastic drum was filled with sandy loam soil as illustrated in Figure 2.

Figure 2: Installation of Lysimeter

Figure 3: Eight Days Old Okra

Figure 4: Maturity Stage

Agronomic Measurement

The heights of the plants, number of leaves, flowers, fruits, quantity of water supplied and water consumptive use were measured, counted and recorded.

III. CONCLUSION

The need to determine the consumptive use for various typical irrigated crops (okra) in order to know the amount of water that is required for irrigation at any period necessitated this experiment. The results showed that Non-weighing Lysimeter can be used to determine the consumptive use of okra and the total water consumptive use of okra was estimated as 367.5mm. The highest value of plant height was 69 cm and the highest leaf number was 35. FAO CROPWAT model software gives better and more accurate information on estimating the water consumptive use of crops. The plant responded well to the water application as well.

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