IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 9, September 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Assessment of Infiltration Capacity of Agricultural Soil in ADO-EKITI South Western Nigeria Using Selected Empirical Models

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ABSRACT

This study compared the infiltration capacities of the irrigation field in the Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria. A double ring infiltrometer was used to measure the infiltration rate. Two experiment runs were carried out at each of the locations. Soil samples were collected from the sampling points using a soil auger at a depth ranging from 10 – 30 cm. Sample on soil types were collected because it is believed that soil type greatly influences the rate of infiltration in the soil. Two infiltration equations (Kostiakov and Horton) were adapted to ponded and infiltration condition were evaluated for their ability to predict infiltration into the predominant soil. The prediction of infiltration by the infiltration equations reflect fair to good agreement with observed values while overall rating shows that the Kostiakov equation performed better than the Horton equation. The study of the infiltration characteristics of the irrigation field will provide useful information on the mechanisms that may be responsible for either high or low infiltration rates in the soil and hence provide a better insight into soil water management, irrigation scheduling and soil conservation.

KEYWORD: Assessment, infiltration capacity, agricultural soil and empirical models

INTRODUCTION

Infiltration is a measure of the speed at which soil is able to absorb water and it is one of the most important parameters required in the design and evaluation of irrigation system, watershed modeling and prediction of surface runoff (Zerihun *et al*., 1996, Oyonarte *et al*., 2002 and Idike, 2002). It also plays an important role in planning water conservation techniques, and in land evaluation for liquids and effluent waste disposal (Mbagwu, 1993). Restricted infiltration and ponding of water on the soil surface results in poor soil aeration, which leads to poor root function and plant growth as well as reduced nutrient availability and cycling by soil organisms (Lowery *et al*., 1996). If rainfall intensity of irrigation application rate at the soil surface is such that exceed the infiltration capacity ponding begins and is followed by runoff over the soil surface once depression storage is filled, and this can lead to serious soil erosion problems (Amusan and Anderson, 2005). Wood and Finger (2006) reported that rainfall or irrigation at rates greater than the infiltration capacity will result in surface runoff. According to Holzapfel *et al*., (2004), the steady infiltration rate represents the minimum capacity as the soil can absorb additional amounts of water in and on the soil. The steady infiltration rate is a conservative design criterion and its use for predicting risk of runoff includes ample safety margin. The steady infiltration rate is a function of the pore configuration of the soil.

Soil can be excellent temporary medium for water, depending on the type and condition of the soil, proper management of the soil can help maximize infiltration and capture as much water as allowed by a specific soil type (Duiker *et al*., 2001). Agnihotri and Yadav (2002) reported that if water infiltration is restricted or blocked, water does not enter the soil and it either pond on the surface or surface runoff of the land.

Infiltration rate is generally estimated as millimeters of water that infiltrates the soil in 1 hour (Dalta *et al*., 2004). There are two different terms, which express the infiltration rate, the initial infiltration rate, which indicates the fast entry of water into dry soil and the equilibrium infiltration rate, which expresses the steady state infiltration rate (Zerihum *et al*., 1996). At first, water commences to penetrate the soil swiftly at an increasing rate but, as time passes, the infiltration rate comes near to a steady state, which nearly equals the saturated hydraulic conductivity of soil (*K*S). The initial infiltration rate will be high when water is applied to dry soil (Holzapfel, 2004). Commonly, the infiltration rate tends to be high in the first time when the soil is completely dry, and afterwards it declines gradually to attain approximately a steady state (Idike, 2002).

Information on infiltration characteristics of soil is vital to irrigation agriculture. Preservation of farmland are as from potential degradation and loss of water that could have been useful for agriculture requires that a thorough study be conducted on the hydraulic conductivity properties of soil and factors that may influence its occurrences and alterations (Ayoade, 2004). According to Dalta (2004), study of the infiltration characteristics of the irrigation field will provide useful information on the mechanisms that may be responsible for either high or low infiltration rates in the soil, hence provide a better insight into soil water management, runoff water harvesting, and irrigation scheduling and soil conservation.

MATERIALS AND METHODS

Site Description

The research was conducted at the Irrigation field of the Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic Ado-Ekiti between February, 2015 and March, 2015. The pattern of rainfall is bimodal, the first peak occurring in June and July, and the second in

September, with a little dry spell in August. The mean annual rainfall ranges from 3,500mm to 5,133mm. The soils are light textured, fine sandy loam to fine sandy clay loam. The soil is moderately well supplied by organic matter and nutrients. Moisture holding capacity is moderately good. The soil generally becomes dry during the dry seasons which fall within November and March.

Experimental Procedures and Measurements

An area of 60 cm by 2 mm was cleared for the experiment and infiltrometer experiment was performed at 20 m apart. The field infiltration experiment was conducted in two different locations on the demonstration plot. The main experiment was to monitor the infiltration rate of soil and the experiments were performed per location to make a total of two measurements. The particle size distribution of the samples from the different locations was determined using the hydrometer method as described by Agbede and Ojeniyi (2009). The bulk density and total porosity were determined by placing the can containing the soil samples in an oven at 105^0 C, and dried to a constant weight. The moisture content was determined by weighing the soil samples collected at different depths before and after oven dried at 105^o C for 48 hours.

RESULTS AND DISCUSSION

Field Measurement of Infiltration Rate and Infiltration Capacity

The result of infiltration rate obtained from two different locations is presented in Figures 1, 2 3 and 4. Figures 5 and 6 showed the total average of infiltration rate in each location was estimated as the total accumulated infiltration. It was observed that infiltration rate reduces with time until constant values were obtained. At first, water commences to penetrate the soil swiftly at an increasing rate but, as time passes, the infiltration rate comes near to a steady state, which nearly equals the saturated hydraulic conductivity of soil (*K*S). Commonly, the infiltration rate tends to be high in the first time when the soil is completely dry, and afterwards it declines gradually to attain approximately a steady state. The average infiltration rate of soil in locations A and B are 1.7 and 1.08 cm/min, respectively. The infiltration constant a, b and α value for plot A are 2.63, -0.5 and 0.819 respectively, and those for plot B are a, b and α value are 29.5, 0.2, 0.559, respectively.

The analysis of the collected data of soil moisture, particle density, porosity and bulk density of the two locations is presented in Figure 5. It showed that Plots A and B have average moisture contents of 13.59% and 11.18%, respectively. The value obtained showed that plot A had higher moisture content and this was responsible for the lower infiltration rate observed in plot B. The Figure 5 also revealed that Plots A and B has the average porosity of 16.67 and 18.50%, respectively. Mean bulk density values of 1.42, 1.60, 1.38 g/cm^3 were obtained at depth 10, 20 and 30 cm, respectively in plot A, while the mean bulk density of plot B are 1.38, 1.41, and 1.42 g/cm^3 at depth of 10, 20, and 30 cm respectively, into the soil.

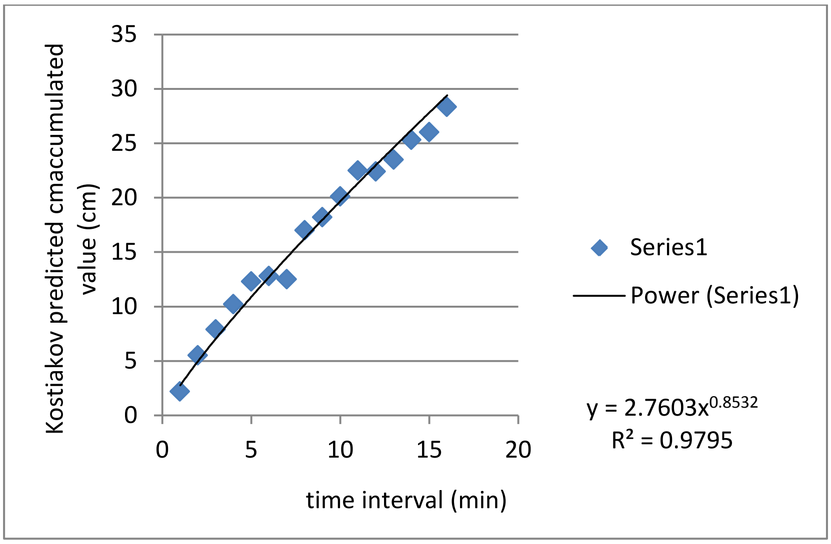

Figure 1: Kostiakov Predicted Value (cm) against Time Interval (min)

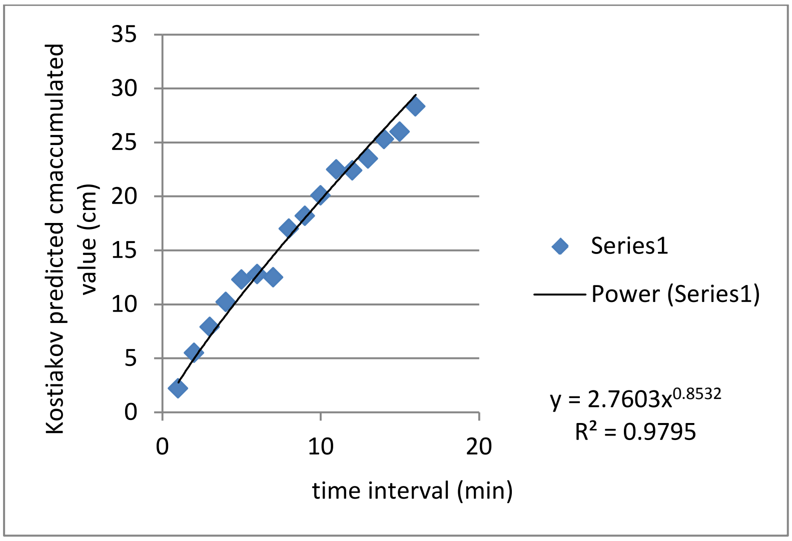

Figure 2: Holton predicted Value (cm) against Time Interval (min)

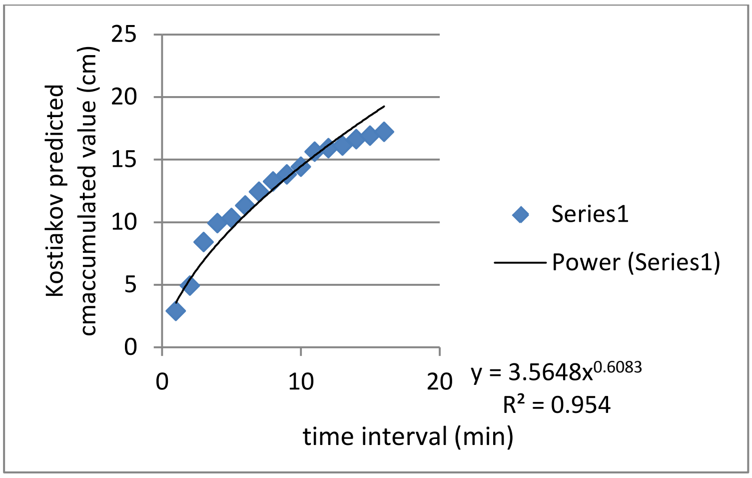

Figure 3: Kostiakov Predicted Value (cm) against Time Interval (min)

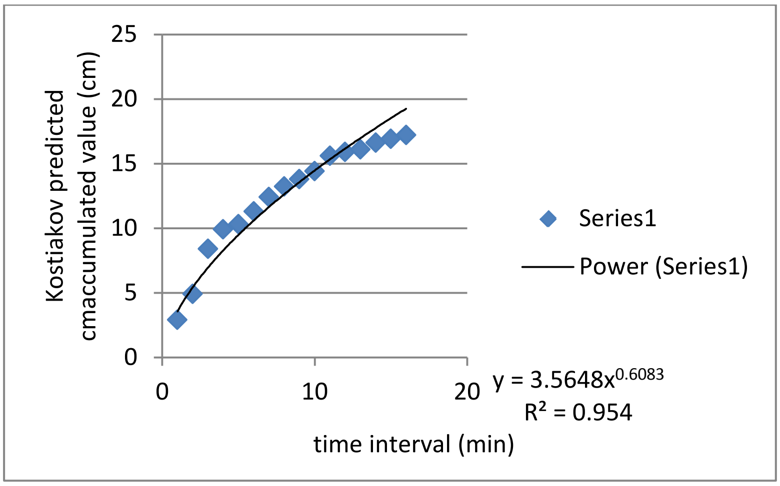

Figure 4: Holton predicted Value (cm) against Time Interval (min)

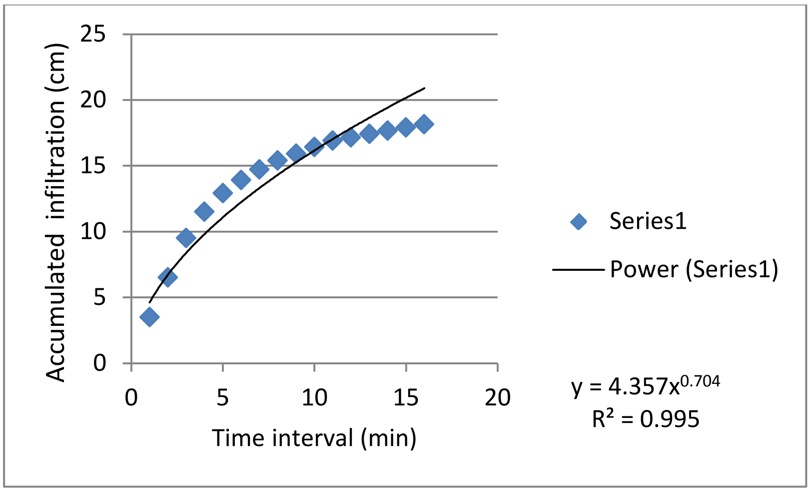

Figure 5: Accumulated Infiltration (cm) against Time Interval (min) on plot A

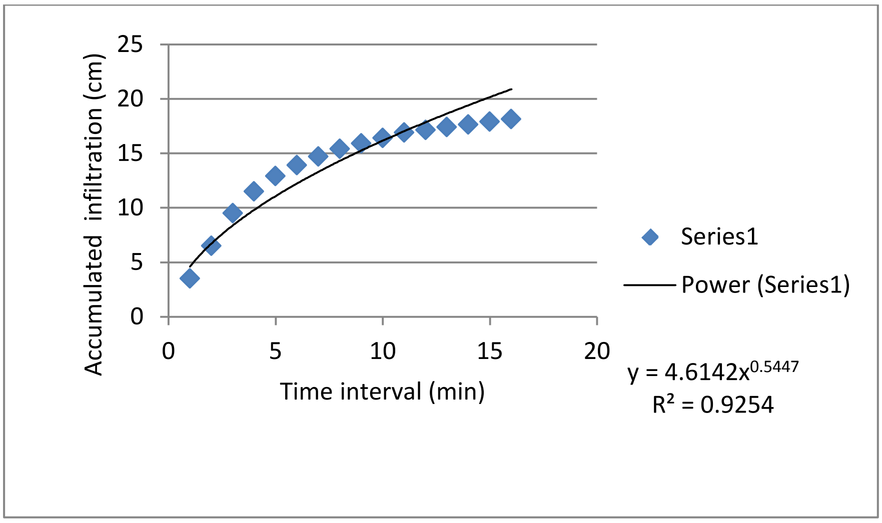

Figure 6: Accumulated Infiltration (cm) against Time Interval (min) on plot B

CONCLUSION

A double ring infiltrometer was used to carry out the field values of infiltration capacity with those of empirical models (Kostiakov and Horton) at the irrigation field in the Department of Agricultural and Bio-Environmental Engineering, The Federal Polytechnic Ado-Ekiti, Ekiti-State. The field experiment generated acceptable infiltration data which were used in evaluating the parameters of the infiltration equations. The prediction of infiltration rate by the infiltration equation reflect fair to good agreement with observed values. The performance rating of the infiltration equation shows that Kostiakov equation performing better in the order of performance by Hortons equation.

The fact that the value of the evaluated parameters in the Kostiakov and Hortons equations agree favorably with the values obtained in another work in the general area of the study (Mbagwa 1997) is a reasonably favorable measure of the confidence in the parameters of the equations evaluated in this study. Consequently, the study has contributed to the gradual build-up of the evaluated parameters of existing infiltration equations that can be used in the study area. Due to the peculiarity of the project to the commercial farmers, especially those who are into irrigation practice, the following recommendation are hereby given. More research should be done to actualize or ascertain the rate of infiltration of various available soil types and also in the areas of formulating and comparing the models.

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