DETERMINATION OF INFILTRATION CHARACTERISTICS AND SUITABILITY OF KOSTIAKOV AND PHILIP INFILTRATION MODELS IN PREDICTING INFILTRATION INTO SOILS UNDER DIFFERENT TREATMENTS.

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ABSTRACT

Infiltiration is the key to soil and water conservation. Management and conservation activities as flood, erosion control, irrigation planning, distribution of precipitation and water economy within rooting zone are exceedingly important role played by infiltration. Nine infiltration runs replicated 3 times each, under the influence of velivar grass strip; soil treated with organomineral fertilizer (OMF) and a bare soil, were determined by means of double ring infiltrometer. This was to test the simple infiltration models and compare the performances of these models in predicting infiltration and characteristics of soils under these different soil treatments. Infiltration values were subjected to Kostiakov and Philip's model to obtain the soil parameters. Measured and predicted infiltration were further subjected to simple linear regression analysis. Philip's model showed better accuracy ($R^2 = 0.99$) than Kostiakov's model ($R^2 = 0.87$) for soils under velivar grass strip influence. Philip's model ($R^2 = 0.99$) was superior to Kostiakov's model ($R^2 = 0.97$) for soils under influence of organomineral fertilizer treatment. For bare soils, Philip's model was superior in predicting infiltration ($R^2 = 0.94$) compared to kostiakov's model ($0.07$).

KEYWORDS: Infiltration, western Nigeria, infiltration models, vetiver, organominaler fertilizer

INTRODUCTION

Infiltiration is the key to soil and water conservation because it determines the amount of runoff which forms over the soil surface and hazard of erosion during rainstorms (Babalola, 1988). In Nigeria efforts are being directed towards water management and conservation activities such as irrigation, flood and erosion control. The role played by infiltration in the distribution of precipitation is an exceedingly important one, because total infiltration is a good means of estimating effective rainfall (Ahmed and Duru, 1985). Data on rates of infiltration of water into soils under various soil treatments and conditions can be used to supplement other information which could help soil scientists, engineers, conservationists, agronomists, hydrologists and others, to deal more effectively with a wider spectrum of water resource management and soils conservation problems.

Ahmed and Duru (1985), Hume (1991); Wududdiva and Abdulkadir (2000) maintained that infiltration measurement is laborious and tiresome and could be very expensive where water is limited. These researchers call for a less cumbersome method to predict infiltration rate without actual point to point measurement. Such a method they reported is desirable and must be simple time dependent models. As a result of this (several calls) several infiltration studies world over have used several models (Haverkamp, et al., 1988; Hume, 1993), but few are commonly used particularly in the topics to characterize water infiltration into soils.

Some of the existing models are not applicable under all conditions and therefore test on their applicability and accuracy in predicting infiltration characteristics into soils under different conditions and treatments are essential. Therefore the objective of this work was to test the two commonly used infiltration models; Philip (1957) and Kostiakov (1932) to determine their suitability in predicting infiltration characteristics under the influence of velivar grass strip, organomineral fertilizer treated soil, and a bare soil in southwestern Nigeria.

MATERIALS AND METHODS

The experiment was carried out in 2003 at the University of Ibadan Teaching and Research farm (7°27′N of the equator and 3° 5′ E of the Greenwich meridian) (RECTA 1995). Mean annual rainfall is 1280.2 mm recorded over a period of 27 years (Alabi and Ibiyemi 2000). The natural vegetation is rainforest that has been transformed gradually into derived Savanna due to human activities such as farming. The slope of the plot is 6%. The plot have been established in 1999 and the effect of velivar grass hedge as erosion control method and the ability of organomineral fertilizer (OMF) in improving soil structure and enhancing water infiltration into soil investigated (Babalola et al., 2003). A total of nine-infiltration test was made across the middle slope. Each run was replicated three times giving a total of 27 runs in all, by ponding water in a double ring infiltrometer (Anon 1991). The two infiltration models selected to determine their suitability in predicting cumulative infiltration (I) at one point over time are Philip (1957) and Kostiakov (1932)

\[ I = \frac{Cl}{1 + \frac{C}{I_{sat}}} \quad \text{Kostiakov model} \]

\[ I = St^{1/2} + A \quad \text{Philip's model} \]

Where

- $I =$ cumulative infiltration
- $C =$ intial infiltration
- $S =$ index of soil stability
- $A =$ transmissivity
- $t =$ time in cm/hr

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Fig. 1 Relationship between predicted and measured infiltration under vetiver grass strip using Kostiakov model

\[ y = 12.27x - 865.08 \]
\[ R^2 = 0.9723 \]

Fig. 2 Relationship between predicted and measured infiltration under organomineral fertilizer treated soil using Kostiakov model

\[ y = 0.0711x + 70.766 \]
\[ R^2 = 0.9745 \]

Fig. 3 Relationship between measured and predicted infiltration under bare soil using Kostiakov model

\[ y = 0.0593x + 71.078 \]
\[ R^2 = 0.9746 \]

Fig. 4 Relationship between measured and predicted infiltration under vetiver grass strip using Philip model

\[ y = 1.0161x - 20.472 \]
\[ R^2 = 0.9914 \]

Fig. 5 Relationship between measured and predicted infiltration under organomineral fertilizer treated soil using Philip model

\[ y = 0.9445x - 16.47 \]
\[ R^2 = 0.9999 \]

Fig. 6 Relationship between measured and predicted infiltration under bare soil using Philip model
RESULTS AND DISCUSSION

Results of some physico-chemical properties of soil of the study area is shown in Table 1. The soil texture was a loamy sand. Soil parameter (sorption, transmissivity, soil stability) of the infiltration models were obtained after curve fittings (Table 2). \( R^2 \) value of > 0.99 was obtained for Kostiakov model under the different treatments (vetiver grass strip, organo-mineral fertilizer and bare treated soils). Whereas \( R^2 \) value for Philip’s model was > 0.98 for soil under the influence of vetiver grass strip, \( R^2 = 0.95 - 0.99 \) under organo-mineral fertilizer treated soil and \( R^2 = 0.91 - 0.96 \) under bare soil. Kostiakov model seems to account more for the variation in infiltration with greater accuracy than did Philip’s model for the test soils. (Ahmed and Duru, 1985).

Table 3 shows the measured and predicted infiltration using Kostiakov and Philip’s models. Measured infiltration under vetiver and organo-mineral fertilizer treated soils showed medium variability of CV = 16 % and 30 % respectively, whereas that of bare soil high variability (CV = 41 %).

Kostiakov models showed low variability in all the treated soils. Philip’s model showed medium variability for infiltration under the influence of vetiver grass strip (CV = 22 %) whereas, organo-mineral fertilizer treated soil and bare soils showed high variability (CV = 36 % and 46 % respectively). Similar spatial variability of infiltration in allsoil of samaru northern guinea savana, Nigeria have earlier been reported by Kureve et al., (1995); Wududiva and Abdukadir (2000).

The linear regression models were used to compared the measured and predicted infiltration by Kostiakov under the different treatments (Fig. 1, 2 and 3). \( R^2 \) values under influence of vetiver grass strip was 0.97, organo-mineral fertilizer treatment \( R^2 = 0.97 \) whereas under bare soil treatment \( R^2 = 0.67 \) this shows that Kostiakov model could be used as predictive tool for soils under the influence of vetiver grass strip and organo-mineral fertilizer (OMF) but not in predicting infiltration into bare soils of both the experimental site and similar soils elsewhere.

The linear regression model used to compared measured and predicted infiltration by Philip model towards the three different treated soils are shown in Fig. 4, 5 and 6. \( R^2 \) values under the influence of vetiver grass was 0.77, organo-mineral fertilizer treatment, 0.99 and bare soil = 0.94. This shows Philip model is an excellent and more effective predictive tool. Comparable results have been reported by Wududiva and Abdukadir (2000), Kureve et al., 1995.

CONCLUSION

From the study when measured (infiltration) and predicted infiltration for both models were compared it could be concluded that Philip infiltration model excellently predicted infiltration into the soils under the influence of vetiver grass strip (\( R^2 = 0.99 \)) than Kostiakov model (\( R^2 = 0.97 \)). Under organo-mineral fertilizer treated soils Philip’s model was again, superior to Kostiakov model (\( R^2 = 0.99 \) and 0.97 respectively). For the bare soils Philip model again was superior in predicting infiltration \( R^2 = 0.94 \) compared to Kostiakov’s model (0.07). However both Kostiakov and Philip model can be use for soil under the influence of vetiver grass strip and organo-mineral fertilizer. Only Philip model should be used in predicting infiltration into bare soils of the experimental area and similar soil else where.