GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 11, NO. 3, JUNE 2005: 323 - 326
COPYRIGHT(C) BACHUDO SCIENCE CO. LTD. PRINTED IN NIGERIA. ISSN 1118-0579

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

E. E. OKU, A. N. ESSOKA and S. I. OSHUNSANYA

(Received 15 November 2004; Revision accepted 18 January, 2005)

ABSTRACT

Infiltration 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 vetiver 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 = 0.97) for soils under vetiver 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, orgnomineral fertilizer*

INTRODUCTION

Infiltration 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 (1993): Wuddivira 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 (Haverkmp, *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 vetiver grass strip, organo-mineral 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 ($7^o 7^1$N of the equator and 3^o 5^1 E of the Greenwich meridian) (RECTA 1995). Mean annual rainfall is 1289.2mm recorded over a period of 27years (Alabi and Ibiyemi 2000). The natural vegetation is rainforest that has been transformed gradually into derived Savannah 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 vetiver 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)

$I = Ct^{\alpha}$ ...... Kostiakov model

$I = St^{1/2} + At$ .... Philps's model

Where I = cumulative infiltration

C = intial infiltration

α = index of soil stability

S= sorptivity

A= transmissivity

t= time in cm/hr

E. E. OKU, Crop and Soil Science Department, Cross River University of Technology, Calabar, Nigeria,
A. N. ESSOKA, Crop and Soil Science Department, Cross River University of Technology, Calabar, Nigeria,
S. O. OSHUNSANYA, Agronomy Department, University of Ibadan, Ibadan, Nigeria.

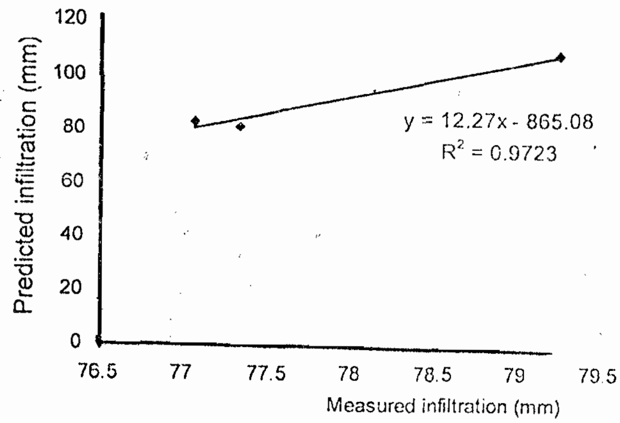

Fig. 1 Relationship betweenship predicted and measured infiltration under vetiver grass strip using Kostiakov model

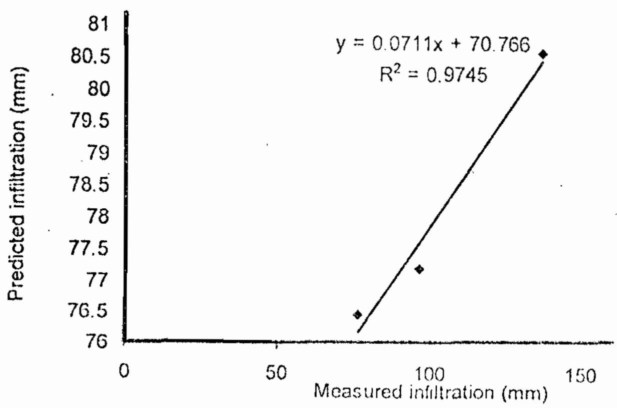

Fig 2 Relationship between predicted and measured infiltration under organomineral fertilizer treated soil using Kostiakov model

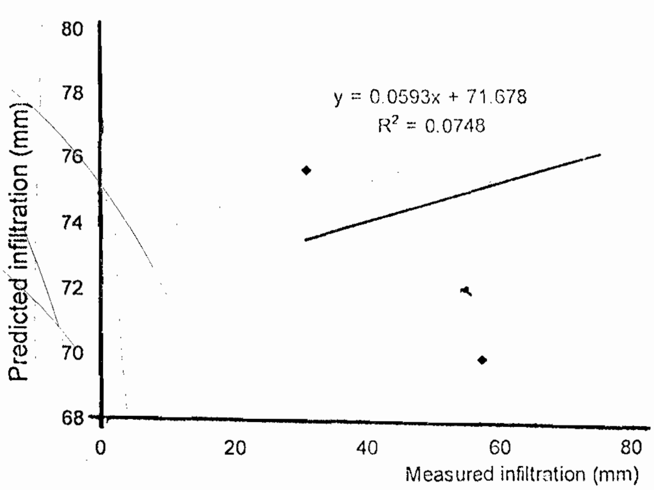

Fig 3 relationship between measured and predicted infiltration under bare soil using Kostiakov model

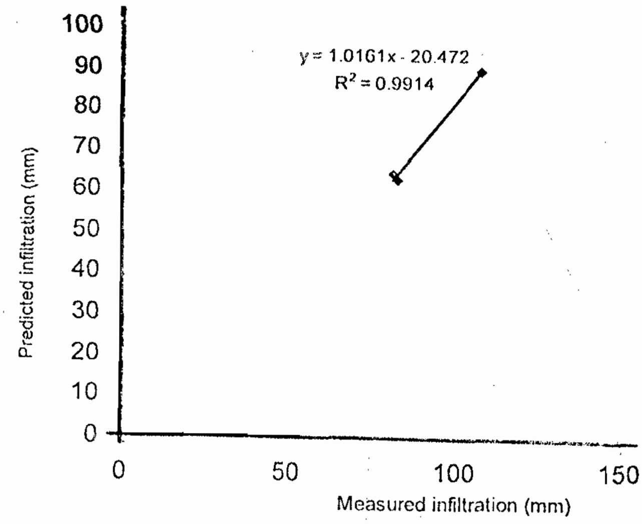

Fig. 4 Relationship between measured and predicted infiltration under vetiver grass strip using Philip model

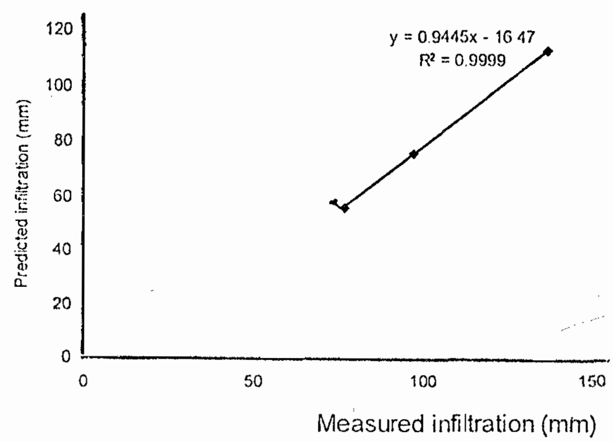

Fig 5 Relationship between measured and predicted infiltration under organomineral fertilizer treated soil using Philip model

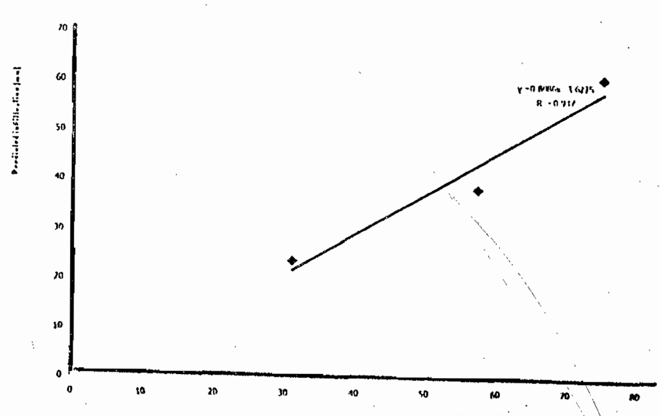

Fig. 6 Relationship between measured and predicted infitration under bare soil using Philip model

Table 1: Physical and Chemical properties of the soil used for the study.

PROPERTIES	SOIL
Sand (g. kg $^{-1}$)	824
Silt (g. kg $^{-1}$)	100
Clay (g. kg $^{-1}$)	76
Texture	Loamy sand.
Bulk density (Mg. m $^{-3}$)	1.53
Porosity (%)	42
Soil reaction (Kcl; 1:1)	6.0
Organic carbon (g. kg $^{-1}$)	154
Organic matter (%)	2.79
Total nitrogen (g. kg $^{-1}$)	5.88
Available phosphorus (mg. kg $^{-1}$)	16.48
Exchangeable potassium (Cmol . kg $^{-1}$)	5.71

Table 2. Infiltration characteristics of Philip and Kostiakov models

Treatment	Kostiakov's model			Philip's model		
	C	∝	R^2	A	S	R^2
Vetiver I	0.339	0.770	0.99	0.615	1.999	0.98
Vetiver II	0.459	0.788	0.99	0.864	2.754	0.98
Vetiver III	0.374	0.767	0.99	0.599	2.413	0.98
OMF I	0.515	0.801	0.99	1.096	3.020	0.99
OMF II	0.389	0.761	0.99	0.531	2.734	0.95
OMF III	0.440	0.768	0.99	0.725	2.722	0.98
Bare I	0.348	0.753	0.99	0.224	1.082	0.91
Bare II	0.307	0.790	0.99	0.580	2.102	0.96
Bare III	0.378	0.694	0.99	0.354	2.595	0.91

C – initial infiltration, ∝ = index of soil stability, A = Transmissivity S = Sorptivity

Vetiver = vetiver grass strip, OMF = organomineral fertilizer treated soils.

Bare = bare soil

Table 3. Measured and predicted values of Cumulative Infiltration (cm)

Treatment	Time (mins)	Measured	Cumulative infiltration Kostiakov Predicted	Philip predicted
Vetiver I	100	81.30	77.34	63.50
Vetiver II	100	107.80	79.26	89.15
Vetiver III	100	82.90	77.07	62.31
Mean		90.67	77.89	71.65
SD		14.86	1.19	15.16
CV		16	2	21
SE		± 8.59	± 0.69	± 8.77
OMF I	100	136.80	80.62	112.62
OMF II	100	10076.80	76.49	55.83
OMF III	100	96.70	77.24	75.22
Mean		103.43	78.117	81.22
SD		30.56	2.20	28.88
CV		30	3	36
SE		± 17.67	± 1.27	± 16.69
Bare I	100	31.10	75.65	23.48
Bare II	100	75.20	79.31	60.10
Bare III	100	57.50	69.78	38.00
Mean		54.60	74.91	40.53
SD		22.19	4.81	18.44
CV		41	6	46
SE		± 12.83	± 2.78	± 10.66

CV = Coefficient of variation, SD = Standard deviation, SE = Standard error.

RESULTS AND DISCUSSION

Results of some physio – chemical properties of soil of the study area is shown in Table 1. The soil texture was a loamy sand. Soil parameter (sorptivity, 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, organomineral 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 organomineral fertilizer treated soil and R^2 = 0.91 - 0.96 under bare soil. Kostiakov's 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 organomineral 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. Philips' model showed medium variability for infiltration under the influence of veitver grass strip (CV = 22 %) whereas, organomineral fertilizer treated soil and bare soils showed high variability (CV = 36 % and 46 % respectively). Similar spatial variability of infiltration in alfisol of samaru northern guinea savanah, Nigeria have earlier been reported by Kureve *et al.*, (1995); Wuddivira *et al.*; (2000); Wuddiviria 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, organomineral fertilizer treatment R^2 = 0.97 whereas under bare soil treatment R^2 = 0.07 this shows that Kostiakov model could be used as predictive tool for soils under the influence of vetiver grass strip and organomineral 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 compare measured and predicted infiltration by Philip model under 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, organomineral 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 Wuddiviria and Abdulkadir (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 organomineral fertilizer treated soils Philip's model was again superior to kostiakov model (R^2 = 0.99 and 0.97 respectively). For the bare soils Philips 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 organomineral fertilizer. Only Philip model should be used in predicting infiltration into bare soils of the experimental area and similar soil else where.