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Adoption of Kostiakov Model to Determine the Soil Infiltration for Surface Irrigation Methods under Local Conditions

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ABSTRACT

An experiment was conducted to determine the soil infiltration for surface irrigation methods using the Kostiakov model. The infiltration rate was measured using a single infiltrometer. The infiltrometer was installed in the border filled with water and the depth of water was noted after frequent intervals, until the infiltration rate became constant. The cumulative infiltration observed from the field was very less in the beginning as compared to that given by Kostiakov equation. At the elapsed time of 180 min. the calculated infiltration rate became equal to the observed infiltration rate. The observed and calculated rates of infiltration approached the same value at the end of 180 min. The kostiakov model was calibrated using the infiltration and time data. The new values of constants were determined and used in the model. The predicted values of cumulative infiltration with calibrated model when plotted against observed data gave a good fit.

Key Words: Soil; Infiltration; Irrigation; Kostiakov Model

INTRODUCTION

Surface irrigation methods are most widely used throughout the world (Smerdon *et al*., 1988). These include basin, border and furrow irrigation methods. Recent advances in the theoretical description and model simulation of surface irrigation methods permit the evaluation of existing procedures and the development of new technologies of irrigation systems and their management. Such developments are now underway for their refinement and adoption of local conditions of soil, climate, crop and economic considerations.

Free water at the soil – atmosphere interface is a source of great importance to man. Efficient management of this water will require greater control of infiltration. Increased infiltration control would help to solve such wide ranging problems as upland flooding, pollution of surface and ground-waters, declining water tables and inefficient irrigation of agricultural lands.

The primary objective of this study is to assess the predictability of the Kostiakov Model Equation under local conditions and to compare the observed and predicted cumulative infiltration and infiltration rate using calibrated Model.

MATERIALS AND METHODS

During irrigation, the infiltration rate was measured using a single infiltrometer. The infiltrometer was installed in the border filled with water and the initial reading was noted. The depth of water in the infiltrometer was noted after frequent intervals until the rate of infiltration became constant. The infiltration and the cumulative infiltration were plotted against time on the log-log paper. The values of time interval and cumulative infiltration were used to find the coefficients of Kostiakov equation using non-linear regression analysis by computer program GEN-STAT (1988).

RESULTS AND DISCUSSION

The observed values of cumulative infiltration from the field compared with those predicted by the Kostiakov equation for 2nd and 3rd irrigations have been plotted in Figs. 1 and 2, respectively. The cumulative infiltration observed from the field was very less in the beginning as compared to that given by the Kostiakov equation. Two minutes later, the observed cumulative infiltration increased only by 0.079 inches while the Kostiakov equation gave 0.3 in. At elapsed time of 180 min, the calculated infiltration became equal to the observed infiltration. This shows that the Kostiakov model predicted the cumulative infiltration for most of the period utilized for accomplishing irrigation.

The rate of infiltration after 2 min was found to be 9 inches/hr as given by the Kostiakov Equation and that observed in the field was only 2.36 inches/hr. The observed and calculated rates of infiltration approached the same value at the end of 180 min. The results for 2nd and 3rd irrigation are plotted in Figs. 3 and 4, respectively. From the figures it can be concluded that Kostiakov model tended to over predict the rate of infiltration. Consequently, the Kostiakov model was calibrated to match the observed data.

Calibration of Kostiakov Model. The Kostiakov model was calibrated using the infiltration and time data by computer software (GENSTAT, 1988). The new values of constants a, b and c were found for each irrigation. The predicted values of cumulative infiltration with calibrated model when plotted against observed data gave a good fit. The results are plotted in Figs. 5 and 6 for 2nd and 3rd irrigation respectively. Similarly, the observed infiltration

Fig. 1. Comparison of observed and predicted cumulative infiltration using Kostiakov model for 2nd irrigation

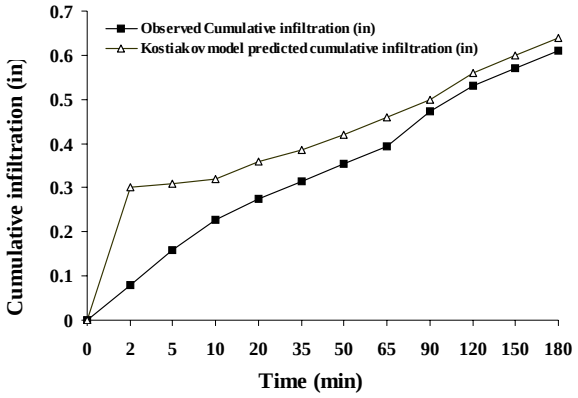


Fig. 2. Comparison of observed and Kostiakov model predicted values of cumulative infiltration for 3rd irrigation

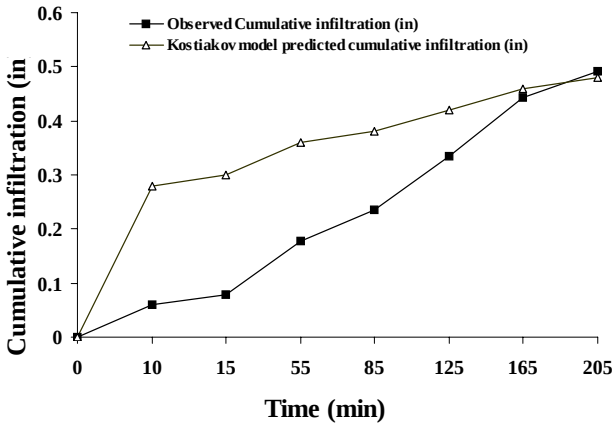


Fig. 3. Comparison of observed and predicted infiltration rate using Kostiakov model for 2nd irrigation

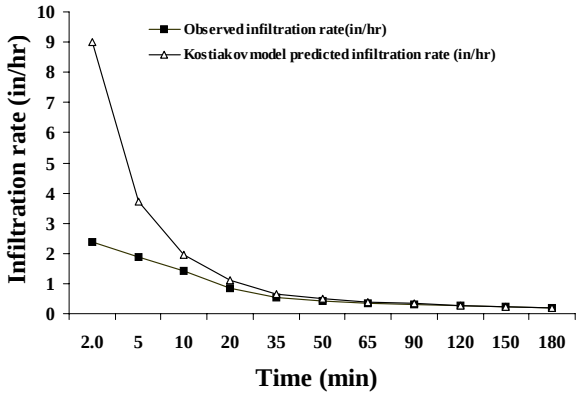


Fig. 4. Comparison of observed and Kostiakov model predicted values of infiltration rate for 3rd irrigation

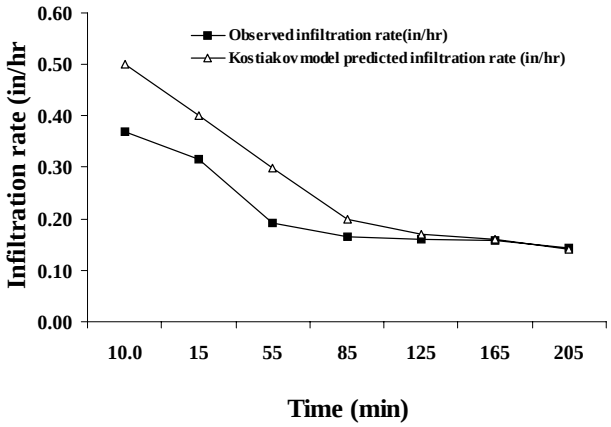


Fig. 5. Comparison of observed and predicted cumulative infiltration using calibrated Kostiakov model for 2nd irrigation

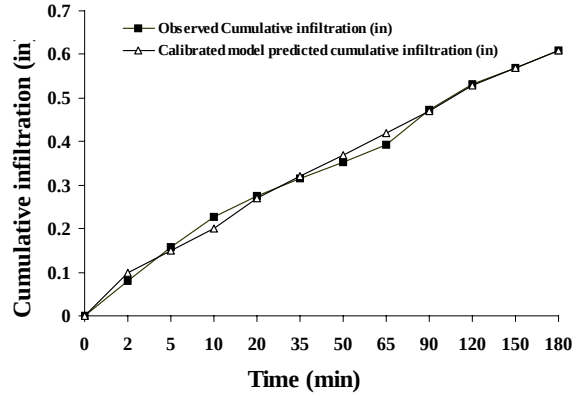
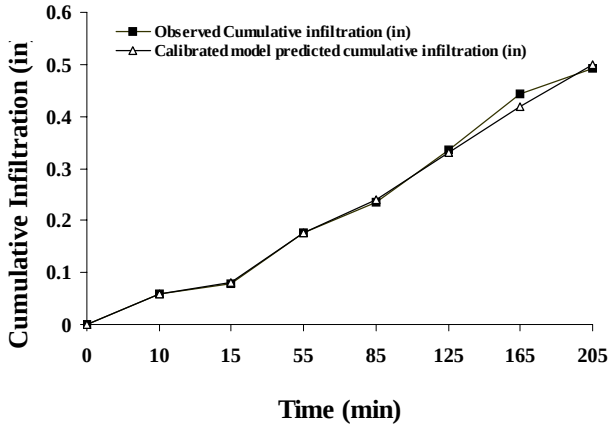


Fig. 6. Comparison of observed and predicted cumulative infiltration using calibrated Kostiakov model for 3rd irrigation



rate versus predicted infiltration rates were determined and plotted in Figs. 7 and 8, respectively. The graph between observed data and calibrated model data gave a perfect fit.

The calibrated Kostiakov models for infiltration derived by GENSTAT (1988) for 2nd and 3rd irrigation are given below.

Fig. 7. Comparison of observed and predicted infiltration rate using calibrated Kostiakov model for 2nd irrigation

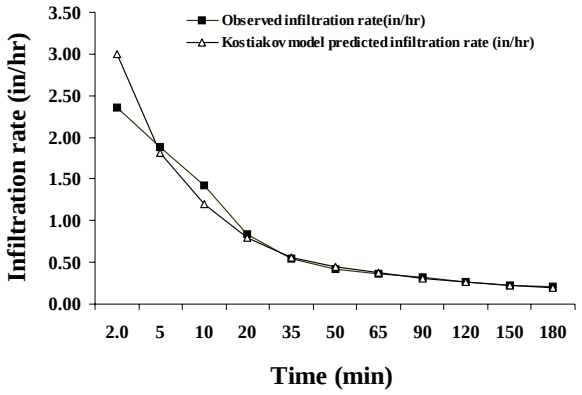
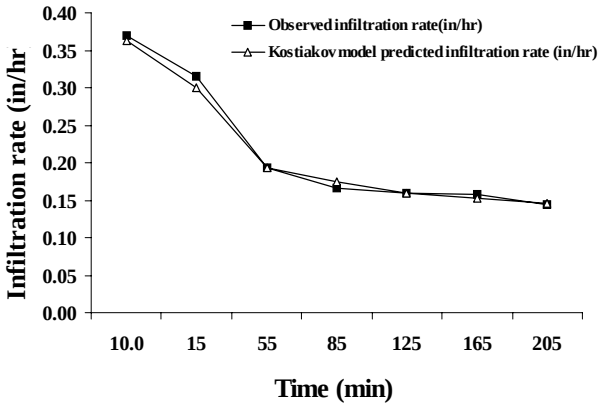


Fig. 8 Comparison of observed and predicted infiltration rate using calibrated Kostiakov model for 3rd irrigation



$$F = 0.0989t^{0.375} + 0.0251$$

$$F = 0.00437t^{0.8816} + 0.0272$$

CONCLUSION

The Kostiakov model over predicted the infiltration parameters a, b and c in the 2nd and 3rd irrigation but after calibration, the new model predicted the data satisfactorily.

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