The Influence of Initial Soil Moisture Content on Field Measured Infiltration Rates

D P TURNER* AND M E SUMNER**
[DEPARTMENT OF SOIL SCIENCE AND AGROMETEOROLOGY, UNIVERSITY OF NATAL, P O BOX 375, PIETERMARITZBURG, 3200]

Abstract

Steady state infiltration rates have been measured between a time period of approximately 30 minutes to 120 minutes using a set of twelve double-ring infiltrometers. Variability in measured infiltration rates between individual infiltrometers is large, consequently practical significance can only be attached to the mean steady infiltration rate. Linear or curvilinear functions have been evaluated by plotting mean steady infiltration rate against initial soil moisture content, the latter parameter being an initial boundary condition in a theoretical analysis. A close similarity in shape between these empirically derived functions relating mean steady infiltration rate to initial soil moisture content spanning a range in soil moisture potentials important in agriculture and hydrology have been obtained for a Zwagershoek, Balmoral, Griffin and Shortlands soil series. Similar functions spanning a part of this range have been evaluated for a further eighteen sites representing eleven soil series. The influence of initial soil moisture content on mean steady infiltration rate is conveniently summarized in tabular form with reference to the fundamental pressure potential unit.

Correlation coefficients between mean steady infiltration rate at -lOJ/kg initial soil moisture potential, and various soil physical and chemical parameters were poor. Reasons for the poor correlation were the large variability in infiltration rates often arising from soil structural cracking and faunal activity.

Accurate prediction of infiltration rate from a model is thus ineffective. Alternatively where infiltration parameters for a particular site are required they could be estimated from available infiltration data while taking into account important pedological and site factors.

Theoretical Considerations

Soil water infiltration is a highly variable parameter dependent on non-static conditions prevailing in the soil matrix (including initial soil moisture content, and soil structural conditions at the surface) prior to and during flow processes. For structurally stable soils (implying those soils which do not show dispersion or acute aggregate breakdown on wetting, or severe crusting) moisture content appears to exert the most important influence on infiltration. Initial moisture content is probably the only single and simply measured parameter which is covariant with soil colloid swelling and sorption properties of the soil matrix. It is also the only simply measurable parameter to embody the important aspects of microbial activity and of air entrapment, some of which may be of microbial origin (Poulovassilis, 1972).

Hofton (1941) referred to the influence of moisture content stating that infiltration in wet soils was almost invariably less than that of drier soils. Tisdale (1951) found linear and curvilinear relationships between infiltration and initial moisture content for a non-cracking and cracking soil respectively. Philip (1957c, 1969) theoretically documented the influence of initial moisture boundary condition, 0_O, in the general equation of flow. Various theoretical attempts describing infiltration in swelling soils have been made (Zaslavsky, 1964; Philip & Smiles, 1969) but to date their practical success has been limited.

Although both the experimental approach of Tisdale (1951) and that adopted in this paper, on one hand, and the theoretical approach (Philip, 1957c) on the other exhibit similar trends, the shape of the infiltration versus moisture content curves differ slightly (Fig. 1). The exact solution of Philip (1957c) although also curvilinear is slightly convex (Fig. 1). The close similarity is particularly significant since it demonstrates the importance of initial moisture content on the mean steady infiltration rate. Minor differences in shape are explained below.

Firstly, the theoretical approach makes the assumption (amongst others) of a rigid matrix with little or no colloid swelling (Philip, 1969). It also omits possible complications due to soil air. In contrast, field infiltrometer measurements incorporate the more rapid flows arising from cracking of dry soils. These cracks probably persist to a greater or lesser degree when soil moisture remains below saturation and are an extremely important facet of infiltration. However, lateral flows, particularly in dry and structured soils could tend to overestimate infiltration rates and could to some extent account for the concave curvilinear shape of curve 'a' in Figure 1.

***Present Address: Soil and Irrigation Research Institute, Private Bag X79, Pretoria.**
****Present Address: Department of Agronomy, University of Georgia, Athens, Georgia 30602, U.S.A.**